UNIV. OF
TORONTO
LIBRARY

Electrical Journal

THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

VOLUME LXXVII.

(Second Series.)

FROM APRIL 7, 1916, TO SEPTEMBER 29, 1916.

ALSO

"THE ELECTRICIAN"
COMMERCIAL AND INDUSTRIAL SUPPLEMENT,

APRIL 7, 1916, TO SEPTEMBER 29, 1916.

141025
13/12/16

ALL RIGHTS RESERVED.

LONDON:
Printed and Published by the Proprietors, "THE ELECTRICIAN" PRINTING AND PUBLISHING CO., LTD., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, E.C.

1916.

TK
1
E43
v.77

INDEX TO "THE ELECTRICIAN."

VOL. LXXVII.

(Second Series.)

SPECIAL INDEXES.

	PAGE
*COMMERCIAL AND INDUSTRIAL SUPPLEMENT	10
*Municipal, Foreign and General Notes	7
Companies' Meetings, Reports, Dividends, Statutory Returns, &c.	8
Companies (New Electrical, &c.) Registered	9

* *Entries in these Indexes are* not *included in the* GENERAL INDEX.

SUB-HEADINGS IN GENERAL INDEX.

	PAGE
Accounts	3
Institution of Electrical Engineers	4
Legal Intelligence	5
Obituary	5
Parliamentary Intelligence ..	6
Personal	6
Railways, Electric	6
Reviews of Books	6
Telegraphy	7
Telephony	7
Wireless Telegraphy and Telephony	7
Works, Description of	7

Names of Authors of Articles and Papers are indexed alphabetically in the GENERAL INDEX, *and not under the sub-headings.*

General Alphabetical Index.

Heavy figures **denote that the subject matter is a "Leading Article" or in the "Editorial Notes." When the letter (C) is placed after a title it signifies that the article in question appeared in the Correspondence columns.**

A

Abacs for Electrical Calculations, [Howard] (C) 574
Accessories, Elec., British Made, 409

ACCOUNTS—
Aberdeen, 684, 752, 962
Accrington, 267, 302
Aldershot, 717
Ayr, 928
Barrow-in-Furness, 337
Belfast, 267
Birmingham, 371
Blackburn, 201, 337
Bolton, 515
Bournemouth, 267
Bradford, 515, 894
Brighton, 446, 616, 651
Bristol, 928
Burnley, 515
Burton-on-Trent, 446
Bury, 337, 481
Carlisle, 581
Chester, 414
Colchester, 371
Coventry, 481, 616
Croydon, 651
Dover, 65
Dundee, 651
Eastbourne, 616
Exeter, 786
Glasgow, 515, 616, 717
Gloucester, 651
Greenock, 684, 752
Grimsby, 337
Hammersmith (London), 582, 616
Hampstead (London), 549
Hereford, 446
Heywood, 718
Hove, 685
Huddersfield, 65, 337
Hull, 582
Ilford, 65
Ipswich, 481
Islington (London), 550
King's Lynn, 753
Launceston (Tasmania), 515
Leeds, 267, 371
Lincoln, 371
Liverpool, 302
Loughborough, 515
Lowestoft, 651, 963
Luton, 515
Maidstone, 928
Manchester, 372, 482
Marylebone (London), 65, 651
Middleton, 582
Newcastle-under-Lyme, 685
Oldham, 65, 414, 582, 718
Penang, 786
Poplar (London), 446
Portsmouth, 928
Preston, 201
Redditch, 786
Reigate, 928
Rochdale, 66, 447
Rugby, 718
Salford, 894
Shanghai, 202
Sheffield, 550, 718
South Shields, 616, 685, 894
Southwark, 753
Stafford, 338
Stockton-on-Tees, 515
Stoke-on-Trent, 582
Sunderland, 415, 515

Accounts—*continued.*
Swansea, 616
Taunton, 786
Tunbridge Wells, 894
Tynemouth, 302
Walsall, 446, 516
Warrington, 894
West Ham, 616
West Hartlepool, 516
Wigan, 66
Willesden, 685
Winchester, ,753
Wolverhampton, 718, 963
Worcester, 446
Yarmouth, 786, 894, 929
York, 516

Accumulator Electrodes, Testing Individually, 771
Accumulators, Loan Periods for, **69**
Accumulators of the Past, [Crawter] 829
ACKERMANN, A. S. E.: Neglect of Science (C), 575
Aeronautical Institute of Great Britain, 174
Agricultural Purposes, Application of Electricity to, [Kerr] 386, (*Discussion*) 406
Air Raids and Elec. Tramways, **932**
ALDRICH, C. H.: Treatment of Silver Furnace Fume by the Cottrell Process, 559
ALEXANDERSON, E. F. W., and NIXDORFF, S. P.: Magnetic Amplifier for Radiotelephony, 312
Alien Enemy Firms, 510, 611
Alien Enemy Property, Claims on, 611
Aliens, Employment of, 958
Allies and Trade after the War, **375**
Allies' Economic Conference, 163
Allotropic Changes in Iron or other Metals, Thermo-Electric Method of Studying, 535
Alloy Steels, Manufacture and Uses of, 275
Alternating-Current Theory, Complex Quantities in, 933
Alternators, Three-Phase, with Cylindrical Rotors Third Harmonics in the Phase Pressure, [Clayton] 216
Alternators, Turbine-driven, 346
Aluminium Industry for India, 688
Aluminium Overhead Conductors, 791
Aluminium Power Lines, Clamp Joints on, 654
Aluminium, Properties of, 309
"A.M.I.E.E.": Institution of Electrical Engineers, (C) 228
Amateur and Professional, **70**
American Electrical Machinery, 791
American Engineers Prepared, 418
American Output of Elec. Machinery, 747
American Profit-sharing Scheme, 59, 713
American Specifications and Foreign Trade, 2
American Trade with Australia, 197
American Westinghouse Works Strike, 206
Analogies, Mechanical, in Electricity and Magnetism, [Franklin] 556, **570**
Anglo-Italian Trade Relations, 577
Anglo-Portuguese Commercial Relations, 922
Apprentice, The, Nation and the Polytechnic, [Walmsley] 871
Apprentices, Training of, [Fleming] 874
Arcs in Gases between Non-Vapourising Electrodes, [Mackay-Ferguson] 254
Architect in Relation to Electric Lighting, **256**, 274
"Archives d'Eletcricité Medicale," 70
Armature Coils, Connection to Commutator Segments, [Knoll] 770
ARNDT, K.: Electrically-heated Furnaces for the Laboratory, 637
Arsem Vacuum Furnace, 363
ASCOLI, M.: Dimensions of Electrical Units, 17
ASHTON, A. W.: Technical Education, 195
Association of British Chemical Manufacturers, 454
Association of Consulting Engineers (Inc.), 355
Association of Supervising Electricians, 174
Asymmetrical Rotors, 342
Australia, Enemy Goods in, 889
Australia, United Kingdom Trade with, 95
Australia, War Time Profits, 441
Australian Commonwealth Traders' Commission, 520
Australian Dockyard, Power Plant for, 486
Australian Electrical Trade, 59
Australian Enterprise, New, 645
Australian Industries, 957
Australian Metal Scheme, 545
Australian Ores, Alien Control of, 230
Australian Trade Outlook, 577
Australian Zinc Concentrates, 713
Awakening, The, **687**

B

BAIRSTO, G. E.: Edge Effect of Plate Condensers, (C) 23
Bakelite Gear Wheels, 756
Binks, British and Trading Facilities, 25
BARNETT, S. G.: Magnetisation by Rotation, 76
BARRATT, T.: Elec. Capacity of Gold Leaf Electroscopes, 407
Battery-room Floors, 328
Battery Vehicles and Refuse Collection, 129
BAUER, B.: Tests on Oil-Switches, 588
BAYLEY, G. L.: Design of Million-volt Experimental Transformer, **35**, 42
"Beama" Journal, 104
Beardmore, Sir William, on Science and Industry, **171**, 195
Bearings of Electrical Machinery, 308
BEAVER, C.: Recent Practice in Manufacture, Laying and Jointing of 33,000-volt three-phase Paper-insulated Underground Cables, **376**, 389
BEAVER, C. J.: Elec. Light and Power Cables, 826
Bedford College, Royal Visit to, 418
Belfast Association of Engineers, 242
Belt Dressing, 418
Bettington Boiler, 568
Bill, An Extraordinary, **120**
Birmingham and District Elec. Club, 757
Birmingham House of Commerce, 921
Birthday Honours, 309
Blind Leading the Blind, **206**
Board of Scientific Societies, 656
Board of Trade and Commercial Enquiries, 129
Board of Trade Elec. Standards Laboratory, Improvements in the Sensitiveness of Apparatus, [Trotter] 851
Board of Trade Regulations for Non-Statutory Elec. Undertakings, 586
Boiler Development, [Wilson] 840
Boiler Explosions, 791
Boiler-house Design and Operation, [Lackie] 381, (*Discussion*) 404
Boilers, Economical Load, 756
Bonecourt Boiler, 403
BOUTHILLON, L.: Generation of High-tension Continuous Current, (C) 195
Bradford, Railless Trolley Battery Vehicle at, 225
BRADLEY, LINN: Solution of Smoke, Fume and Dust Problems by Electrical Precipitation, 152
Brake Solenoids, Totally-enclosed, 604
Bridge Method for Comparing the Mutual Inductance between Two Coils with the Self-Inductance of One of them, [Lees] 123
BRIGHT, C.:
S. P. Thompson, (C) 473, 540
Story of Submarine Cable, 801
British Association, 310
British Association, Mr. Gerald Stoney's Address to the Engineering Section, **755**, 773
British Association at Newcastle, 877
British Association Radiotelegraphic Investigations, 791
British Capital in Ontario, 747
British Companies and Enemy Influence, 957
British Industries and the War, 441
British Industries in Enemy Countries, 679
British Property in Enemy Countries, 889
British Science Guild, 242, 620
British Thomson-Houston Report, 509
BROCKLEHURST, H. J.: Speeding-up in an Engineering Factory, (C) 161, 226
BROUGHTON, H. H.:
Two Notable Floating Cranes, 561
Electrically-driven Coal-handling Plant, 843
Brush Company's Progress, 95
BURDICK, R. H.: Performance of Diesel Engine Plants, 84
Bureau of Standards, Development of, 17
Business Side of Science: Its Part in the Coming Economic Crisis, 50

C

Cable Joints, High-tension Construction of, **376**, 391
Cables, Elec. Light and Power, [Beaver] 826
Cables, Three-core, [Höchstadter] 209
Cables, Very High Insulation Resistances in, Measurement of, [Fischer-Hinnen] 506
Cables, 33,000-volt three-phase Paper-insulated Underground, Recent Practice in Manufacture, Laying and Jointing, [Beaver] **376**, 389
Callender's Annual Report, 229
Canada, Company Tax in, 679
Capital and Labour, 545, 790
Capital and Labour After the War, 475
Capital and Labour, Union of, **948**
Captains of Industry, Training of Our, [Hadfield] 467, **468**
Carbon Tetrachloride (Benzino), Use of, with High-tension Switches, [Vogelsang] 540
CARNEY, H. A.: Speeding-up in an Engineering Factory, (C) 160, 194, 261
CARTER, T.: Determination of the Dimensions of Commutators, 257
Cash on Delivery System, 442
CASTEX, A.: Graphic Determination of Hysteresis Loss, 488
Cells, Dry, [Cooper] (*Concluded from* Vol. LXXVI.), 19
Cells, Leclanché, Depolarisation in, [Thompson and Crocker] 124
Cells, Sulphated Storage, Regeneration of, 37
Chaffee Gap, 688
Chambers of Commerce and Engineering, 365
Channel Tunnel, 620
CHAPMAN, F. T.: Air-gap Field of the Polyphase Induction Motor, 663, 705, **722**, 730, 904, 936
Chargers, Coke Oven, Electrically-driven, 688
Chemical Engineers, **653**
Chemical Laboratories at Oxford, 377
Chemical Manufacturers, British, 263
Chemical Trade Combination, 263
Chicago Generating Stations, 791
City and Guilds' Examination, **172**, (Dover) (Maycock) (C) 228, 241
"CIVIS ROMANUS SUM": "Parturiunt Montes Nascetur Ridiculus Mus," (C) 506
CLAYTON, A. E.: Third Harmonics in the Phase Pressure of Three-phase Alternators with Cylindrical Rotors, 216
CLOUGH, W. & HOLFORD, G.W.: Utilisation of Tramways for Goods Traffic, **931**, 943
Coal and Coke Supplies, 475
Coal, British, 790
Coal-Cutting by Electrical Plant, 172
Coal Economy, **205**
Coal-handling Plant, Electrically-driven, [Broughton] 843
Coal Mine Illumination, 620
Coal, Moisture in, 452
Coal Output, Increase of, 229
Coal Output Restrictions, 197
Coal Supplies, 138, 453
Coal Tar Products, Future of, 621
Coal Trade, Future of, 331
COBLENTZ, W. W., and EMERSON, W. B.: Absolute Thermopile, 606
COHEN, B. S.:
Telephonometry, 244, 276
Long-distance Telephony, 814
COHEN, B. S., and HILL, J. G.: Long-distance and Cable Telephony (Underground and Submarine), 627, 660, 691, **721**, 724
COHEN, S.: (C) Vacuum Detectors, 951
Colliery Electrification; Existing Plant Problems, 605

Collisions at Sea, 376
Collision at Sea, Avoiding, 71
Colour Vision, 621
Colwyn Bay and the Board of Trade, 36, 63
Commerce, Minister of, 713
Commercial and Industrial Policy, 957
Commercial Competition after the War, 722
Commissions in the Engineers, 222
Committees, Uncoordinated, 486
Commutators, Dimensions, Determination of, [Carter] 257
Companies, Enemy Controlled, 451
Companies, Enemy, Sale of Shares in, 475
Company Returns, 679
Condensers, Electrolytic, 364
Condensers, Steam, 452
Conductors, Inductance of, at Close Spacings, [Stubbs] 945
Congratulations from Prof. E. Thomson and Prof. A. E. Kennelly, 796; Electrical World, 932
Consular Service (British), 129, 747, 921
Contact Potentials and Electrochemical Action, 695
Continuous-current Generators of High Tension, [Boutigny] (C) 195
Contraband of War, 95, 475
Contracts, Electricity, Preferences in, 889
Controlled Establishments, 475, 611, 781
Converter, Polyphase Continuous-current, of 3,000 kw. Capacity, [Holmboe] 108
Cooking, Elec., Development in U.S.A., 25
Cotter, W. R.:
Dry Cells (*concluded from* Vol. LXXVI.), 19
Milestones on the Path of Progress, 793
Copper, German Trade in, 452
Copper Oxide, Light Sensitiveness of, 308
Copper Prices Fall In, 297
Copper Steel, Corrosion Resistance of, 173
Copper Sulphate Solutions, Composition and Density of, 343
Corbin, W.: Power Requirements and Resources of N.S.W., 491, 522
Corrosion Investigation, 756
Corrosion, Electrolytic, 3
Cory, P. R.: Methods Employed for the Wireless Communication of Speech, 7
Cossor, F. A., and Pridmore, M.: Automatic Protective Devices for Direct-current Systems, 189
Crane, Horizontal Luffing, with Balanced Jib, 138, 145
Cranes, Braking, New Method of, [Lutt] 949
Cranes, Electric Slipyard Tower, 688
Cranes, Floating, Two Notable, [Braunholtz] 561
Cranes, Standard, of the Rotterdam Dockyard Co., [De Gelder] 178
Crawter, F.: Some Accumulators of the Past, 829
Crocker, F. C., and Thomson, M. De Kay: Depolarisation in Leclanché Cells, 124
Crompton, C. L. R. E.: Some Notes on the Early Developments of Electrical Engineering, 796
Crosse, C. W.: Electric Water Heating as Applied to Domestic Service, 762
Crosby, F. B.: Motor Drive for Steel Mills, 451, 458
Crown Mines Heat Installation, [Stone] 913
Crystal Palace School of Practical Engineering, 36
Culture, Liberal and Industrial, 2

D

Daniell, Electrolyte for Mercury Oxide Ballistic Galvanometer, 695
Darwen Supply, 171, [Darby] (C) 509, [Hodgkinson] (C) 577, 774
Day Wages, Flour Mills, 541
Dean, G. R.: Predetermination of Higher Harmonics in the Alternating-current Transformer when the Impressed E.M.F. is a Simple Harmonic Function of the Time, 325
De Gelder, M. G.: Standard Cranes of the Rotterdam Dockyard Co., 178
"Demountable": Demountable Boiler for Electric Vehicles (C), 643
113, 147, 191
Denton, F. W.:
Technical Education (C), 857
Transformer Design, 43, 78
Insurance Premiums, 716
Directors, Electrical [Reconstruction], 178
Diesel Engine Combustion, Photography of, with Application to Finding the Life of, [Smith], 643
Diesel Engine Plants, Performance of, [Bacon], 884
Diesel Engine Users' Association, 9, 101, 908, 957, 997
Diesel-engined Merchant Ship, Launch of, [Carruthers and Ellis], 969
Dietzenbacher Accumulator Factories, Destruction of, [Rodenhuis and Cassel], 189
Dietzenbacher Electrical Transport Vehicles, 681
Dimmer, Type of, for Use in A Museum of Science, 168, 408
Dixon, A.: City Centre Extensions, (C), 238, 281
Dock Fire, Hamburg, 864
Dolezalek, C. V.:
Measuring Instruments, 680
New Laboratory Instruments, 619, 659
Dolezalek, Wenzel Traugott, Obituary of, [Jaeger], 281
Dye Stuffs, Research, 888
Dynamitards' Anniversary Meeting and Dinner, 4
Dynamo-Electric Machinery, 1876-1916, [Walker], 81

E

Earth, Our, a Magnet, 343
Earthing Protective Device, Automatic, [Thieme], 726
Ebgrall, A. C.: S. P. Thompson, (C), 506
Eccentric Coils, Coefficient of Mutual Induction of, 306
Eccles, W.: Recent Patents in Radiotelegraphy and Radiotelephony, 571, 595
Economy, Real, 376
Edge Effect of Plate Condensers, [Bairstow] (C), 23
Education After the War, 722
Edser, M. T. C.: Engineering Industry in the Economic War, 225
Electric Enterprise in the Far East, 365
Electric Supply Undertakings, Interconnection of, 241
Electrical Engineers and Public Policy, 197
Electrical Engineering Notes on the Early Developments, [Crompton], 796
Electrical Manufacturing Companies in 1916, 297
Electrical Trades' Benevolent Institution, 378
Electrical Wholesalers' Federation, 174
Electricity Defined, 377
Electricity or Energy: Which? 69
Electricity Regulations, 472
Electricity Supply, 586
Electricity Supply, Charges for, 297
Electricity Supply [Lackie], 458
Electricity Supply Publicity, 95
Electrochemistry, [Perkin], 867
Electrolytic Corrosion, 3
Electromagnetic Machines, Notes on Design, [Smith], 280, 290, 320, 360, 427, 461, 493, 528
Electroscopes, Gold-Leaf, Elec. Capacity of, [Barratt], 407
Electrostriction in Condensers, 364
Ellis, A. G.: Engineering Education and Research, (C), 505
Ellis, H. S.: Generation of Electricity on a Small Scale or Bulk Supply, 383, 398, (*Discussion*), 405
Emerson, W. B., and Corbentz, W. W.: An Absolute Thermopile, 606
Employment, Emergency, of Women in Industry, 419
Enemy Goods and Trade-Marks in Australia, 747
Engineering and the Empire, 275
Engineering Education and Research, 451, 470, [Ellis], (C), 505
Engineering Factory, "Speeding-up," [Rankin], 90
Engineering Industry After the War, 262, 645
Engineering Industry, British, Organising, 2
Engineering Industry in the Economic War, [Elder], 225
Engineering Institutions' Volunteer Training Corps, 181
Engineering Standards Committee, 587
Engineering, State Recognition of, 274
Engineering Trades After the War, 509
Engineering Works, Utilisation of, After the War, 791
Engines, Oil and Steam, in Combination, [Porter], 524, 536
Engineers, Mobilise the, 341
Engineers, Royal (Wireless Section), 2
Entropy and Probability, 2
Epstein, I.: (C) Methods for Determining the Grading of Starting and Brake Resistances for Series-Motors, 57
Erichsen, H.: Electric Discharges in Substations, (C), 643
Ericsson, A New Celluloid Substitute, 655
Establishments, Controlled, 245
Examinations and Teaching, 418
Exports, Iron, 509
Exports, Prohibited, 366, 922
Exports, Restrictions upon, 95
Exposition Internationale de Lyon, 1914, 274

F

Factories and Workshops, 453
Faraday House Journal," 309
Farmers' Supply, 71
Fatal Accidents (Extension) Order, 1914, 453
Federated Home Guard, 553
Fellowship of Engineering Act, 773
Fessenden, C. V., and Magrath, C. M. J.: Arc to Ground between Non-Synchronous Electrodes, 284
Fiery Alloys, Elec. Furnace Melting of, [White], 156
Fire-Damage, Production of, in the Electric Furnace, 37
Fireproof Houses, Electrically Heated, [Smith], 177
Fire, Sprinkler Reinforcement, 725
Fisheries Technical Council, 418
Fish Hatcheries, Belgian, 668
Fish Preservation, 240
Flames, Radiation from, 89
Fleming, Hindley, J., Obituary of, Very High Insulation Resistance Cables, [De Fitzmaurice, R.: Metropolitan Elec. Supply Co., (C), 57
Fleming, A. P. M.:
On Industrial Research, 35
Training of Apprentices, 874
Fleming, F.R.S., Prof. J. A.:
Engineering and Scientific Research, 137, 176
Physical Science in Education, 486, 496
Radiography: A Retrospect of Twenty Years, 831
Flue Gases, Sampling and Analysing, 275
Flywheel Effect, 84
Flywheel Motor-Generator Sets, Calculation of, 591
Foreign Trading, Government Subsidy for, 611
Franklin, W. S.: Mechanical Analogies in Electricity and Magnetism, 556, 570
French Trade with the U.S.A., 197
Frequency Meter, A New, [Peukert], 350
Frequency, Standardisation of, 307
Fuel Economy, 906, 914
Fuel Economy on the North-East Coast as a Result of Electric Power Supply, [Sloan], 917
Furnace, Arsem Vacuum, 363
Furnace, Elec.-Arc, Service Requirements of, [Hollis], 243
Furnace, Electric, Production of Ferro-Silicon in the, 37
Furnace, Elec., Sheffield, 898
Furnace, Synder Electric, 308
Furnace, Wile Electric, 601
Furnaces, Electric, 452
Furnaces, Elec., as Applied to Non-Ferrous Metallurgy, 309
Furnaces, Steel, Electric, 275, 452

G

Galvanometer, Damping Factor in Moving Coil Ballistic, 655
Galvanometer Lamp and Scale, 569
Galvanometers, Sensitivity and Shielding, 689
Garnett, J. C. M.: Engineering Education and Research, (C), 575
Garrard, C. C.:
Instrument Transformers, 499, 537
Methods for Determining the Grading of Starting and Brake Resistances for Series-Motors, (C), 92
"Garrett" Superheated Steam Semi-Stationary Engine, 352
Gas Detector, Electric, 343
Gas Industry, Organisation of, 452
Gas and Electricity Supply, 679
Gelder, M. G. De: Shipyrd Cranes of the Rotterdam Dockyard Co., 178
General Electric Co.'s Report, 509
Generating Station, Automatic, 345, 358
Generating Station, Small, Problem of, [Wilkinson], 348, 358
Generation of Electricity on a Small Scale or Bulk Supply, [Ellis], 383, 398, (*Discussion*), 405
German Influence, Exclusion of, 331
German Plant, 755
German Scientific Men and the War, 308
German Trade and Copper, 452
Germany, Elec. Wiring Practice under War Conditions, 417, 426
Germany, The Rubber Trade in, 790
Gibbs, J. B.: Open Delta Connection for Transformers, 727
Glasgow, Depreciation Rates at, 418
Glasgow, Interesting Mains Laying Operation, 362
Glazebrook, R. T.: Limit Gauges, 898, 901
Goods Traffic on Tramways, 273
Grain Elevators, 173
Graphical Charts, 502
Gravitational Constant, 418
Gravity at Sea, Determination of, 37
Great Britain, Electricity Supply of, [Williams], 48, (*Discussion*), 80, 86, 175, 249, [Williams], (C), 438
Greater London, Electricity Supply in, 669
Griffiths, C. H.: New Method of Determining Ionic Velocities, 82
Grimsdell, W. H.: Earth Connections for Telephone Exchanges, 672

H

Hadfield, Sir Robert, F.R.S.
Training of our Captains of Industry, 467, 468
German Boasty-Fed Steel, 600, 602, [Wood], (C), 674
Hadfield, Sir R., and Technical Training, 377
Harmonics, Higher, Predetermination of, in the Alternating-current Transformer when the Impressed E.M.F. is a Simple Harmonic Function of the Time, [Dean], 325
Harmonics, Third, in the Phase Pressure of Three-Phase Alternators, with Critical Review, [Clapton], 216
Harrison, H. P.: Storage of Land Telegraphy, 708
Harrison, C., and Shaw, P. E.: Sensitive Manometer, 208
Heat Transmission through Boiler Tubes, 241
Heating Plant, Elec., Large Scale, 283
Hemmer, J.: Fischer Automatic Telephone Exchange, 668
High-potential Contact Protection of, with Moderate Power Capacity, [Hill], 220
Hill, A. W.: Protection of Circuits of High Potential with Moderate Power Capacity, 220
Hill, J. G., and Cable, B. S.: Long-distance and Cable Telegraphy, Underground and Submarine, 623, 660, 691, 721, 724
Hobart, H. M.: Three-Core Cables, 209
Holborn Electric Automatic, 621
Holland, C. W., and Cuming, D.: Utilisation of Tramways for Goods Traffic, 931, 943
Holidays, Municipal Employes' Annual, 163
Holland, Postponement of, 520
Holme, H.: Service Requirements of the Electric Arc Furnace, 243
Holmes, H. H.: Electric Hot Water Supplies, 401
Holmboe, C. F.: Tests on a Polyphase Continuous-current Converter of 3,000 kw. Capacity, 108
Hope-Jones, F.: Daylight Saving, (C), 226
Hot Water Supplies, Electric, [Holmes], 401
Howard, C.: Abacs for Electrical Calculations, (C), 574
Howe, Prof. G. W. O.:
Amplitude and Phase of the Higher Harmonics in Oscillograms, 149
Application of Telephone Transmission Formulæ to Skin-effect Problems, 739
Calculation of the Capacity of Radiotelegraph Antennæ, including the Effects of Masts and Buildings, 761, 880
Hunter, P. V.: Development of Elec. Power Stations, 838
Hydro-Electric Works, 196
Hydro-Electrics within the Empire, 475
Hydro-Extractors, 70
Hydrogen by Electrolysis, 343
Hysteresis and Hardness, 274
Hysteresis Loss, Graphic Determination of, [Castex], 488

I

Illuminating Engineering Society, 205, 207, 224
Illumination and Light, [Steinmetz], 40, 52
Illumination from a Radiating Disc, 343
Illumination in the Navy (U.S.A.), [McDowell], 653, 667
Imperial College of Science and Technology, 323
Imperial Institute, 378
Imperail Trade Bank, 931, 954
Import Duties in Russia, 442
Imports, Prohibition of, 331, 442
Income Tax, Double, 417
Incorporated Municipal Electrical Assoc., 4, [Convention], 375, 379, [Annual General Meeting], 430, [Elec. Vehicle Committee Report], 433
India, Aluminium Industry for, 688
Indian Industrial Commission, 921
Indian Industrial Development, 59
Inductance, Mutual and Self, 36
Inspecting and Viewing, 897
Institute of Chemistry, 139
Institute of Industry, 1, 15
Institute of Journalists, 208
Institute of Metals, 242, 757, [Autumn Meeting], 932
Institute of Radio Engineers, 208, 454
Institution of Civil Engineers, 105

INSTITUTION OF ELECTRICAL ENGINEERS—

Alien Enemies, Exclusion of, 292, 378
A.M.I.E.E.: Institution of Elec. Engineers, (C), 228
Annual General Meeting, 218
Benevolent Fund, 139, 207
Birmingham Section, 4
City and Guilds of London Inst. and the I.E.E. (Lundberg & Sons), (C), 951, 982
Continuous Current for Terminal and Trunk Line Electrification, [Storer], (*Discussion*)
Enemy Members, 174
Great Britain Electricity Supply, Present and Future Position, 454
Great Britain Elec. Supply, [Williams], 48, (*Discussion*), 80, 86, 175, 249
Insulating Oils, 73
"Journal" of the Institution of Elec. Engineers, 36
Manchester Section, 38
46
Motors, Continuous Current, Hire and Maintenance of, [Joseph], 185, 188, 205
Service Branches from Extra-High-Tension Circuits, [Macleod], 116
Trade Policy, 539
Wiring Rules, 554

Institution of Mining Engineers, 344, 378
Institutions, Engineering and Courteous Receptions, 240
Insulations, Air, Oil and Solid, Effect of High Continuous Voltages on, [Peek], 734
Insurance Extension, 679
Interconnection of Electric Supply Undertakings, 241
Interlinking of Elec. Supply Undertakings, 293
Invar and Related Nickel Steels, 206
Inventions, Useful, for Military Purposes, 921
Inventors, Education of, 453
Ionic Velocities, Determining, A New Method, [Griffiths], 82
Ionisation by Collision, 274
Ions, Migration of, [Smith], 498
Iron, Pure, 3
Iron, Pure, Crystal Size and the Electric and Magnetic Properties of, 2
Iron, Pure, Open-Hearth, Effect of Vacuum Fusion upon the Magnetic Properties of, [Yenson], 519, 533
Iron, Vacuum Fused, 145
Iron Wires, Variation of Resistance, with the Temperature on Alternate-current Circuits, [Peukert], 125

J

Japan, Elec. Undertakings in, 342, 535
Japan's Trade with China and the East, 510
Joseph, H.: Hire Maintenance of Continuous-current Motors, 185, 188, 205
Junior Institution of Engineers, 4

K

Kaye, Capt. G. W. C.: Recent Progress in X-Rays and Radiography, 861
Kelvin's, Lady, Gift to Glasgow University, 138
Kennelly, A. E.: (C) 2000th Issue, 950
Kerr, W. T.: Application of Electricity to Agricultural Purposes, 386, (*Discussion*) 406
Kingsbury, J. E.: Story of the Telephone, 812
Klingenberg, Prof. G.: Magnetic Hand, 327
Knight, G. L.: An Unusual Foundation for a Turbo-Alternator, 122, **104**
Knoll, Rudolf: Connection of Armature Coils to Commutator Segments, 770
Kyoto Imperial University Memoirs, 51

L

Laboratories, Chemical, at University College, 2, 16
Labour, Efficiency of, 677
Lackie, W. W.:
Boiler-house Design and Operation, 381, (*Discussion*) 404
Electricity Supply, 458
Lamme, B. G.: Iron Losses in Direct-current Machines, 634, 659
Lamp, Arc, Cadmium Vapour, Enclosed [Sand] 51
Lamp, Electric Evolution of, [Paterson] 822, [Willcox] (C), 950
Lamp Safety, 486
Lamps, Incandescent, Life Testing, 172
Lamps, Incandescent, Rating of, according to their Watts, [Naujokz] 710
Lamps, Pocket, Adjustable Elec., 898
Langmuir, I.: Characteristics of Tungsten Filaments as Functions of Temperature, 742
Lees, C. H.: On a General Bridge Method for Comparing the Mutual Inductance between Two Coils with the Self-Inductance of one of them, 123

LEGAL INTELLIGENCE—

American Radio Telegraph Patent Case, 94
American Tungsten Lamp Litigation, 408
American Wireless Patent Litigation, 94, 408, 955
Assessment of Electricity Works, 608
Baldry, Samuel Theo. *v.* Sun Electrical Co., 26, 127
Bates, Wm. Sons & Co. *v.* W. & R. R. Rea (Ltd.), 543
Browett, Lindley & Co., 295, 364
Cedes Elec. Traction (Ltd.), 94
Cia de Electricidad de la Provincia de Buenos Ayres, 61
Comins *v.* Weld-Blundell, 510
Commercial Cable Co. *v.* Government of Newfoundland, 609
Cook, Wm. *v.* Jennings, W. A., 746
Cumberland, L. H. *v.* Newport Corporation, 511
Daimler Co. *v.* Continental Tyre & Rubber Co., 477
Davis (D.) & Son *v.* Assessment Committee of Pontypridd Union Overseers of Rhondda and Rhondda Urban Council, 440
Electric Shock, Damages for, 544
Electro-Flex & Steel Co., 544
Falk, Stadelmann & Co. *v.* General Cable Mfg. Co., 295
Hands, A. C. *v.* Davis (J.) & Co. (Southampton), 196
James, J. C. *v.* Leatherhead Electricity Co., 294
Knowles, J. W. *v.* Electrolytic Plating Apparatus Co., 262
Krupp Magnetic Separator Patents, 93
Leiston Gas Co. *v.* Leiston-cum-Sizewell Urban Council, 364
Leitner Electrical Co., 127
Lion Spring Co. *v.* Carleon Electrical Co., 93
"Live Stud" Case at Lincoln, 576
Re Madras Elec. Supply Corporation, 609
Magneta Time Co., *Re* the, 440
Magnetic Separation of Wolfram, 60
Metropolitan Railway Co. *v.* H. M. Postmaster-General, 576
Metropolitan Water Board *v.* Dick, Kerr & Co., **585**, 609
Military Information, Publication of, 510
Mining Regulations, Breach of, 677
Monometer Mfg. Co. *v.* Elec. & Ordnance Accessories Co., 476
Motor, Second-hand, Warranty with, 60
Munitions Tribunal Cases and Appeals, 61, 511
North British Railway Co. *v.* Lord Advocate (Postmaster-General), 408
Patents, Alien Enemy, 60, 93, 230, 543, 576, 955
Prevention of Corruption Act Prosecution, 779
Pritchett & Gold & E.P.S. Co. *v.* Currie and the Hamble River Luke Co., 510
Prize Court Case, 745
Read *v.* Stella Conduit Corporation, 26, 93
Rickaby (A. E.) *v.* Plymouth Corporation, 439
Rowett, A. *v.* St. Austell Elec. Light & Power, 295
Scobie *v.* London County Council, 262
Storage Battery Contract, 162
Trading with the Enemy, 746
Tramcars and Lighting Regulations, 711
Tramcar Companies, Liabilities of, **654**, 677
Tramcar Drivers, Unlicensed, 128

Legal Intelligence—*continued.*

University of London Press and Others *v.* University Tutorial Press, **585**, 608
"Unsealed Patents" to be Licensed, 230
Valuation Appeal, 920
Weisenberg, A. *v.* Bodie, 330
Wireless Telegraphy Patents in U.S.A., 955
Workmen's Compensation, 26, 93, 127, 295, 646
Zinc Corporation *v.* A. S. Elmore and Others, 294

Leimer, E.: Radium Antennæ, 82
Liebowitz, B.: Electrical Oscillations from Mercury Vapour Tubes, 144
Lifting Magnets, **620**, 623, 654
Light and Illumination, [Steinmetz] 40, **52**
Light and Intensive Culture, 2
Light, Measuring the Pressure of, by means of Thin Metal Foil, [West] 741
Light, Mechanical Equivalent of, 2
Lighting Charges, Elec., **417**
Lighting, Elec., of Small Towns, [Munro] 353, **358**
Lighting, Public, Contracts for, **341**
Lighting of Factories, **1**
Linking-up, **239**
Local Government Guidance, **172**
Lock Machinery, Electrically-operated, 898
London County Council Tramways, **520**, 541
Longitude, Difference in, 688
Low-resistance Standards, New, [Drysdale] **619**, 629
Lowestoft Electricity Supply, 138
Lubrication in Practice, 104
Luckey, G. P.: Tungsten Arc Under Pressure, 947
Luft, E.: New Method of Braking Cranes, 949
Lundberg (A. P.) & Sons:
Electric Wiring Examinations, (C) 506
I.E.E. and the City and Guilds of London Institute (C), **932**, 951

M

Machine Tool and Engineering Assoc. (Ltd.), 4
Machine Tools as War Material, 781
Machinery, Breakdowns of Elec., 433
Mackay, C. M. J., and Ferguson, C. V.: Arcs in Gases between Non-Vapourising Electrodes, 254
MacLeod, D. M.: Service Branches from Extra-high-tension Circuits, 116
Magnetic Flux, Distribution of, in Commutating Zone of Direct-current Machines, [Shenfer] 10
Magnetic Hand, [Klingenberg] 327
Magnetic Survey, 172
Magnetic Testing, 104
Magnetic and Electric Properties of Pure Iron, Crystal Size, and the, 2
Magnetisation by Rotation, [Barnett] 76
Magnetism, Remanent, Reversible Change of, with Temperature, 37
Magneto Testing Apparatus, 791
Magnetometer, Sensitive, [Shaw and Hayes] 708
Mains Laying, Interesting Operation at Glasgow, 362
Manchester, One-Ton Electric Lorry, 952
Manchester Steam Users' Assoc., 276
Manufacturers and Organisation, 365
Manufacturing Interests, Organisation of, 229
Massachusetts Institute of Technology, 418
Materials, Handling of, **171**
Maycock, W. P.: City Guilds' Examinations, (C) 228
McDowell, Lieut. C. S.: Illumination in the Navy (U.S.A.), **653**, 667
McElroy, J. M.: Some Notes on Passenger Transportation in Large Cities, **931**, 939
McLachlan, N. W.: Characteristic Curves of a Poulsen-Arc Generator, 883, 900
Measuring Instruments, [Drysdale] 853
Merchant Shipping Convention Act (1914), 274
Mercury Pump, High Vacuum, 792
Merrick, E. G.: Approximate Solution of Short-circuit Problems, 694
Merz, C. H.: Electric Power Distribution, 915
Metal for Munitions, 509
Metal Trade After the War, 229
Metallurgy, Non-ferrous, Electric Furnaces as Applied, 309
Metallurgy in Relation to Elec. Engineering, 869
Metals, Coating with Zinc, 501
Metals, Corrosion of, 377
Metals, Grain Size in, 533
Metals, Investigation and Testing of, 633
Metals, Rarer, Metallurgy of, [Richards] 675
Meter Approved by Board of Trade, 377
Meters, Thomson, and their Maintenance, 703
Methane, Elec. Ignition of, Influence of Pressure, [Thornton] 775
Metropolitan Elec. Supply Co., 713, 889, [Fitzmorris] (C) 57
Mica in Intense Fields, 655
Middlesbrough Technical College, 452
Middlekauff, G. W., and Skogland, J. F.: Photometry of the Gas-filled Lamp, **240**, 252
Midland Railway (London, Tilbury & Southend Railway), 541
Milestones on the Path of Progress, [Cooper] 793
Mine Hoist Calculations, 418
Mining, Elec. Power in, 3
Mittag, A. H.: Higher Harmonics of Induction Motors due to Winding Distribution, 953
Models, Full Size, **70**
Monographs, The Electrician, **520**
Montana Power Co., Elec. Power Plants of, 947
Motor, Elevator, Two-speed Alternating Current, 486
Motor Generator Sets, Ball-bearings for, 677
Motor, Polyphase Induction, Air-gap Field of, [Chapman] 663, 705, 730, 904, 936
Motors, Alternating-current, 309
Motors, Continuous-current, Hire and Maintenance of, [Joseph] 185, **188**, **205**
Motors, Elec., Displace Gas Engines, 679
Motors, Induction, Higher Harmonics due to Winding Distribution, [Mittag] 953
Motors, Induction, Reconnecting, 419
Municipal "Electrics" to the Fore, 577
Municipal Extravagance, 197
Municipal Tramways Association, 587, 622, [Annual Conference], 939
Munition Worker, Skilled, Anomalous Position of, **704**
Munition Workers, Training, 289
Munitions, Skilled Labour for, Provision of, **274**
Munro, H. N.: Elec. Lighting of Small Towns, 353, **358**
Museums, Commercial, 441

N

National Physical Laboratory, 532, **553**, 565 593
Naujokz, R.: Rating of Incandescent Lamps According to their Watts, 710
Naval Engagement, **307**
Naval Preparedness and the Civilian Engineer, 898
New South Wales, Power Requirements and Resources of, [Corin] 491, 522
New Zealand, Our Trade with, 921
Newcastle Electric Supply Co., 274
Newquay, **138**, 165
Nitrogen, An Active Modification of, 309
Nixdorff, S. P., and Alexandersgn, E. F. W.: Magnetic Amplifier for Radiotelephony, 312
Nobel Prizes, 520
Nocturnal Transmission, Variations in, 275
North-East Coast Institution of Engineers and Shipbuilders, 622
Norway, Domestic Elec. Appliances, 645
Nottingham Society of Engineers, 757

O

OBITUARY—

Alexander, Pte. E., 933
Allen, Lieut. H. D., 587
Amey, Pte. W., 933
Arberry, H., 310
Ash, W. H., 487
Bain, 2nd-Lieut. J. M., 555
Baker, Capt. H. G., 757
Baker, Lieut. D. S., 621
Beales, A., 310
Beatty, 2nd-Lieut. E. E. F., 454
Bell, Lieut. S. W., 454
Betts, A., 933
Bille, Harold, 723
Blackburn, R. S., 173
Bodfish, H., 933
Boyd-Carpenter, Lieut. Victor C. D., 792
Brock, T. W., 723
Brockman, 2nd-Lieut. A. J., 689, 757
Burniston, Pte. H., 555
Callaway, Sapper J. H. L., 622
Carbonell, Lieut. W. C., 792
Cassels, Lieut. F. L., 621
Caton, R. E., 2nd-Lieut. F. W., 454
Challoner, Lieut. T., 622
Chamen, Lieut. H. A., 689
Chapman, Capt. J., 587
Chasseriand, Capt. René, 487
Chattock, Pte. C. A., 378
Clayton, Pte. Roland, 656
Collingwood, Capt. C., 656
Coombes, 2nd-Lieut. C. S., 487, 555
Cressall, Lance-Cpl. F., 899
Crookes, Lady, 207
Crowther, Lieut. D. H., 723
Curtis, Dr. C. W., 621
Davidson, Capt. J. S., 487
Davies, Lieut. I., 899
Davies, 2nd-Lieut. L. R., 555
Dennis, 2nd-Lieut., 656
Dobson, S. T., 487
Donaldson, Sir H. F., 310
Douglas, Capt. W. A., 757
Dyke, Lieut. G. B., 207
Dymott E., 310
Eason, Lieut. R. P., 521
Edinborough, 2nd-Lieut. N. D., 521
Eldridge, Lance-Cpl. P. J., 521
Ellis, 2nd-Lieut. C. W., 521
Esson, Prof. W., 723
Faithfull, 2nd-Lieut. S. L., 723
Fitch, Lieut. C. W., 521
Foukes, P. F., 933
Franklin, Sir Geo., 933
Freece, 2nd-Lieut. C. de, 656
Fyfe, Lieut. Gilbert, 555
Garnett, Flight-Lieut. W. H. S., 933
Gatt, L., 310
Gerard, Eric, 3
Gill, Company Sergt. Major H., 521
Goad, E. G., 310
Gow, Lieut. James L., 487
Gregory, Pte. J., 621
Griffiths, Capt. J., 487
Harris, Capt. L. A. P., 555
Harvey, 2nd-Lieut. O. C., 555
Hasler, 2nd-Lieut. G. B., 521
Hay, Admiral Lord John, 173
Henderson-Begg, Capt. J., 621
Hendry, Capt. J., 792, 899
Hill, 2nd-Lieut. M., 621
Hoggett, 2nd-Lieut. J. R., 555
Holden, 2nd-Lieut. J. R., 656
Horne, Capt. D., 521
Hughman, Captain C. M., 933
Ireland, J., 933
Jephcott, Pte. B., 757
Jessing, Capt. F. R., 621
Johnson, Capt. R. D., 521
Johnson, Capt. W. M., 521
Keith, G., 689, 722
Lardner, 2nd-Lieut. D. A., 933
Laughton, Company Sergt. Major E. C., 587
Liddiard, B., 933
Lloyd, Pte. C., 757
Lock, W. A., 933
Lomas, Lieut. H., 521
Lonsdale, Capt. Thos. Wilkes, 344
Lucey, C., 521
Lycett, 2nd-Lieut. W. B., 587
Mallech, 2nd-Lieut. D., 899
Martin, 2nd-Lieut. G. C., 656
Massey, Pte. R., 757
McLellan, Lieut. H. M., 521
M'Connell, Lieut. W. C., 521
Meeson, Pte. A., 521
Milburn, Lieut. W. H., 555
Mousley, E. A., 933
Murphy, 2nd-Lieut. P. F., 521
Noakes, Lieut. J. C., 933
Noble, Pte. H., 555
Nuttall, 2nd-Lieut. A. A., 689
Palmer, Lieut. J. H., 621
Parker, C., 933
Pickering-Clarke, 2nd-Lieut. J. N., 555
Poynting, Lieut. A., 621
Pringle, 2nd-Lieut. C. E., 587
Ramsay, Sir William, 554
Rawson, Lieut. S. M., 621
Reed, 2nd-Lieut. C. S., 621
Riding, Gunner J., 521
Robbins, S., 933
Robertson, L. S., 310
Robertson, 2nd-Lieut. R. S., 621
Rose, Corp. A., 933
Ross, Sergt. A., 621
Rutheriord, Capt. J. A., 723
Saw, Arthur C., 105
Scott, Lieut. E. B. R., 521
Shaddick, 2nd-Lieut. C. G., 723
Shorrocks, Sergt. E., 587
Sillars, Capt. H. F. L., 521
Simpson, Lieut. J. D., 757
Sissons, Lieut. N. L., 899
Sivewright, Sir James 792
Smith, Capt. R. J., 207
Smith, 2nd-Lieut. J. C., 71
Stanley, W., 310
Stewart, J. E. M., 276
Storey, Lieut. F. G. D., 757
Stott, J., 139
Swain, Pte. G. A., 656
Swarsbrick, D. H., 933
Talbot, Lieut. F. H., 622
Tanner, C. P., 344
Telby, L.-Corp. G., 933
Thompson, 2nd-Lieut. G., 899
Thompson, S. P., 359
Turner, Capt. H. K., 555
Turner, Lieut. F. W. R., 723
Tweedy-Smith, Lieut. Douglas, 71
Vaudrey, Capt. N., 521
Vigers, 2nd-Lieut. L. L., 587
Ward, 2nd-Lieut. C. R., 555
Watkins, Rflmn A. B., 933
Westonholme, Capt. C. S., 622
Wilkins, Lieut. T., 521
Wilkinson, Lieut. J. R., 344
Wilson, Lieut. E., 207
Withy, Lieut. B., 555
Woodall, Sir C., 207
Wood, Capt. A. Lee, 487, 521
Wood, Gunner R., 521
Wood, Lance-Cpl., 757
Wordingham, Madelire, 207
Worthington, A. C., 310
Wragg, Lieut. N. J., 555

Oil Switches, Tests on, [Wyssling] 38, [Bauer] 588
Oils, Insulating, 73
Omnibuses, Motor, and the Upkeep of the Roads, **103**, 131
Organisation, National, 331
Organisation of British Engineering Industry, 342
Oscillating Circuits, Elec. Coupling of, 722
Osmotic Pressure, 654
Output, Influence of Hours of Work, 932
Ovens, Electric, 452
Overhead Electric Lines, 791
Owen, D.: Laws of Variation of Resistance with Voltage at a Rectifying Contact of Two Solid Conductors, with Applications to the Elec. Wave Detector, 910
Oxford, New Chemical Laboratories, 377

P

Paints, Self-Luminous, 932
Palladium and Hydrogen, 689
Paris Trade Conference, 409

PARLIAMENTARY INTELLIGENCE—

Agents for the Purchase of Indian Mica, 646
Boiler Tubes, 711
Company with Alien Enemy Shareholders, 576
Daylight Saving, 196
Defence of the Realm (Acquisition of Land) Bill, 507
Electricity & Gas Supply, Proposed Limitation of, 94
Electricity Supply Charges, 440
Excess Profits Taxation, 440, 543
Gas Standard, New, 330
Gas (Standard of Calorific Power) Bill, 507
German Interest in British Companies, 576
Interconnection of Elec. Supply Undertakings, 609
Local Government (Emergency Provisions) Bill, 196
Nitrates & Welsh Water Power, 678
Post Office Services, 473
Registration of Firms Bill, 543
Royal Assent, 128, 295, 609, 646
Shropshire, Worcester & Staffordshire Elec. Power Bill, 408
Summer Time Act & Electricity Supply, 474
Technical Education, 542
Telegraph Breakdown, Report, 94
Telegraph (Construction) Bill, 543, 646, 711
Trade After the War, 329
Trading With the Enemy (Copyright) (No. 2) Bill, 646
Trading With the Enemy, 677
Unemployment Insurance, 474
Water Power Development, 408, 678
Women Munition Workers' Wages, 678

PARSHALL, H. F.: Electric Traction, 824
"Parturiunt Montes Nascetur Ridiculus Mus" ("Civis Romanus Sum") (C), 506
Passenger "Electrics," 611
Passenger Transportation in Large Cities, Some Notes on, [McElroy] 939
Patent Law Reform, 59, 575, **670**
Patents, Extension of, 611
Patents in 1915, **273**, 282
PATERSON, C. C.: Evolution of Electric Lamps, 822
PATON, C. K.: Elec. Power in Slate Quarries, 421
Peace, Prosperity, Preparedness and Probity, **241**
Peat, Utilisation of, 453
PEEK, Jun., F. W.: Effect of High Continuous Voltages on Air, Oil and Solid Insulation, **721**, 734
Pennsylvania, Rural Development of Transmission Lines, [Price] **418**, 424
PERKIN, F. M.: Electrochemistry, 867

PERSONAL—

Allen, W. H., 420
Angwin, R. E., Major A. S., 38
Atkinson, Pte. G. W., 521
Austin, Capt. F. C., 454
Barrow, Battery Scout C. F., 454
Bedford, Sir Charles H., 728
Bell, W., 555
Bisbee, R. M., 742
Bodey, Lieut. A. R., 555
Boraston, Lieut. C. A., 587
Bowen, T., 622, 699
Butter, J. H., 344
Carey-Thomas, R. E., Capt. H., 38
Challoner, 2nd-Lieut. T., 276
Clark, D., 420
Cridge, 2nd-Lieut. W. J., 419
Crookes, F.R.S., Sir William, 38
Davies, F. H., 555
Dickinson, H., 933
Dolman, Prof. J. H., 420
Donaldson, Capt. J. M., 699
Erskine, C. W., 933
Evans, R. E., Major L., 38
Fowler, H., 933
Fox, E. J., 737
Gillis, H. P., 132
Gilling, Lieut. A. E., 699
Goodman, C. W., 521
Goodman, R. G., 521
Gray, Capt., H., 933
Hadden, Pte. N., 521
Harris, Lance-Cpl. A., 521
Harris, Sergt. J. A., 737
Haynes, W. C., 622
Hatch, W. T., 587
Hawes, Capt. James, 454
Holmes, J. L., Cpl., 344
Horton-Lees, D., 622
Hunt, Lieut.-Col. Dent, W., 521
Jackson, Alfred E., 587
Johnson, Col. H. A., 467
Kilsby, Sir Alan B. W., 622
Lamont, H. W., 699
Lodge, 2nd-Lieut. R. N., 555
Lucas, Pte. C. H., 521
Mann, Pte. H. H. J., 521
Manton, J. F., 344
Maxwell & Williams, 170
Mellor, J. S. D., 344
Montagu, Right Hon. E. S., 467
Moore-Brabazon, Lieut. P. T., 699
Moorhouse, A. P., 454
Mullen, H., 420
Mullard, O. S., 555
Nelson, 2nd-Lieut. F. H., 699
Nevin, A., 699
Newton, Court Henry, 678
Nixon, T. H., 454
Page, G. W. F., 38

Personal—*continued.*

Parkinson, A. M., 207
Paterson, C. C., 105
Pearson, 2nd-Lieut. A. J., 689
Pringle, P. J., 173
Robertson, 2nd-Lieut. R. S., 521
Rodriguez, Senhor Don F., 38
Rosenbaum, M., 173
Royal Engineers (T.F.), 4, 105, 173, 207, 276, 310, 344, 420, 454, 487, 555, 723, 757, 792, 933
Sandbrook, A. H., 276
Shepherd, C. W., 521
Sparkes, R. E., Lieut. A. C., 38
Sparks, 2nd-Lieut. H. C., 723
Stephens, J. N., 757
Unbehaun, C. A., 105
Vignoles, Major W. A., 487, 555
War Casualties, 587, 933
Weymouth, G., 899
Williams, J. R., 521
Wortington, T., 899
Yarrow, Bart., Sir A. F., 310

Pencara River, Hydroelectric Station on, 758
PETERS, J. F.: Mechanical Stresses in Transformers, 5
Petrol-Electric Car, 554
Petrol, Ignition by Electric Spark, 554
Petrol Supplies, Control of, 331
PFLUKFERT, Prof. W.:
A New Frequency Meter, 351
Variation of the Resistance of Iron Wires with the Temperature on Alternate-current Circuits, 125
Photometer, Flicker, 36
Photometry of the Gas-filled Lamp, [Middlekauff and Skogland] **240**, 252
Physical Metallurgy and other Problems, **636**
Physical Society, [Griffiths, Smith] 92, [Owen, Barratt] 150, [Allen, Smith] 294, [Smith, Guild, Hatschek], 328, [Phillips, West, Humphrey, Griffiths] 437, [Shaw and Hayes, Allen, Darling] 643
Plant, Uneconomical *v.* Capital Expenditure, **485**
Platinum Positive Emission Currents from, 418
PLATTS, G.: Oil Engines and Steam Engines in Combination, 524, **536**
Post Office Electrical Engineers' "Journal," 173
Post Office Engineering Dept., New Headquarters, 420
Posters, Silly, and Silly Officials, **620**
Poulsen-Arc Generator, Characteristic Curves, [McLachlan] 883, 900
Power Distribution, Elec., [Merz] 915
Power Load, Effect of, **342**
Power Stations, Elec., Development, [Hunter] 838
Poynting's Theorem and Hysteresis, [Press] (C) 57
Preparedness, 898
PRESS, A.: Poynting's Theorem and Hysteresis, (C) 57
PRICE, J. W.: Rural Development of Transmission Lines in Eastern Pennsylvania, **418**, 424
Prime Movers, 754
Privy Council, for Scientific and Industrial Research, Report of Committee, 722, 768, **772**, 885
Problems, After-the-War, 229, 309
Profit-Sharing Scheme, American, 59
Proofs, Excess, **307**, 577
Projectors and Reflectors, Efficiency of, [Wheat] (C) 13
Provisional Orders, 932
Publicity and its Relation to Engineering Work, [Warrilow] 887
Pumps, Centrifugal, Ram, 70
Purdah, Station, Electrically-driven, 116

R

Radiator, Black Body, 38
Rankine, Dr. J. J. Thomson on, from Address to Royal Society, [Extract from Vol. LXXVI.], 14, 48, 118
Ratio Into Straight, 754
Railways, Chicago, Milwaukee & St. Paul, 308
Railways, Grand Trunk, 28
Railway Practice, High-voltage D.C. [Renshaw], 489

RAILWAYS, ELECTRIC.

Chattanooga Connecting Terminal and Track Elevation [Illus.], (Editorial), 48
Cornwall, Lancaster, Penn., Electric Railways, 36
North London Railway, 432
Power Generation for Elec. Railways, 766
Rail Joints and Bonds, Construction and Maintenance, in Elec. Railways, [Edward], 126
Railway Notes, Electrification, **239**, 248, 284, 318
Sydney Elec. Railways, 624
U.S.A. Elec. Railway Progress, 624

Railways, Nationalisation of, 442
Ramsay, Electric, 522
Rating, Re, "Speeding-up" in an Engineering Factory, 90, **103**, 110, [Cattell, Rankin, Stuart, Carney] (C) 161, [Carney, Brocklehurst, Stevens] (C) 193, 261, [Rankin, Stuart, Carney] (C) 326
RAWCLIFFE, J. F. S. P. Thompson, (C) 540
Rayleigh, Lord, Theory of Submarine Transmission, 442
RAYNER-SMITH, P.: Electrical Diagrams, 72
Reactor, Properties of, with Iron Core and Air-gap, [Sano] 567
Reforms after the War, 263
Registration of Business Names, 713
Regulators, Feeder Voltage, 757
RENSHAW, C.: High-voltage D.C. Railway Practice, 489
Research, Committee, Engineering, 377
Research, Engineering, 620
Research, Engineering and Scientific, [Fleming] **137**, 156
Research, Industrial, 206
Research, Industrial, Mr. A. P. M. Fleming on, **35**, 39
Research, Organised, and "Sweating," **1**
Research, Scientific and Industrial, Report of the Committee of the Privy Council, 768, **772**, 885
Research, Scientific, in United States and Japan, 898
Research, Technical, [Swinburne] 836
Resistance, Laws of Variation of, with Voltage at a Rectifying Contact of Two Solid Conductors with Applications to the Electric Wave Detector, [Owen] 910

REVIEWS OF BOOKS—

A.B.C. of Electricity, [Meadowcroft] 156
Aeroplanes and Airships, [Dommett] 504
Alternating Currents: Their Elements Explained and Their Calculation Effected Without the Use of Hyperbolic Functions, [Kempe] 739
British Destiny: Principles of Progress, [Dunlop] 156
Continuous-Current Engineering, [Hay] 671
Direct-Current Machines, Principles of [Langsdorf] 53
Dynamo-Elec. Machinery, Principles of, [Bailey] 87
Electrical Apparatus Making for Beginners [Ballhatchet] 223
Electricity, Treatise on, [Pidduck] 155
Engineers' Year Book of Formulæ, Rules Tables, Data and Memoranda for 1916, [Kempe], 671
Every Boys' Book of Electricity, 739
Heat-Power Engineering Elements, [Hirshfield & Barnard] 121
Machine Design, [Smith & Marx] 122
Magnetism & Electricity, Intermediate Text-Book of, [Woodhouse] 739
Material, Mechanical Handling and Storing of, [Zimmer] 503
Materials of Construction, Structure and Properties of the more Common, [Upton] 223
Mechanical Engineers' Pocket Book, [Kent] 672
Mechanics, Elementary Applied, [Alexander & Thomson] 705
Meteorological Treatise on the Circulation and Radiation in the Atmospheres of the Earth and of the Sun, [Bigelow] 603
Overhead Transmission Lines and Distributing Circuits: Their Design and Construction, [Kapper] 291
Physical Chemistry, Principles of, Introduction to, [Washburn] 53
Physics, Experimental, A Text-Book of Mechanics, Heat, Sound and Light, [Wilson] 470
Practical Physics, Text-Books of, [Allen & Moore] 223
Railway, Elec., [Buck] 87
Relativity and the Electron Theory, [Cunningham] 291
Universe and the Atom, [Erwin] 603
Wireless Stations, Experimental, Their Theory, Design, Construction and Operation, [Edelman] 121
Wireless Telegraphy and Telephony, [Eccles] 469

RICHARDS, J. W.: Metallurgy of Rarer Metals, 675
ROBERTSON, Prof. D.:
Mode of Studying Damped Oscillations by the Aid of Shrinking Vectors, 106
Mathematical Design of Transformers, 934
ROWAN, W. T.: Tramway Transit and Comfort, 464
ROWCLIFFE, M. and CARTER, F. A.: Automatic Protective Devices for Direct-current Systems, 189
Rotterdam Droogdok Co. Shipyard Crares, [Dr. Geller] 178
Royal Institution, 71, 139, 174
Royal Meteorological Society, 174, 242
Royal Society, 4, 208, 242, 276, 310, 400, 420
Royalties, A Question of, **554**
Rubleben, Camp School, 131, **154**
Rules de Guerre, **897**
RUSSELL, A.: W. Rawcliffe & S. P. Thompson, 435
Russia, Timber in, 679
Russian Imports, Duties, 442

S

SAGE, H. J. S.: An Enclosed Cadmium-Vapour Arc Lamp, 51
SAKO, S.: Properties of Reactor With Iron Core and Air-gap, 567
SALEE, J.: Electric Welding, **69**, 75
Save Us From Our Friends, **519**
SAYERS, T.: Excitation of Synchronous Machines, 140
SCHEUTTE, Dr. F.: Problem of Voltage Transformation, 142
Science, A Ministry of, [Dorman] 466, **468**
Science and Industry, Sir William Beardmore on, **171**, 195
Science and the State, **308**, 329
Science, Applied, 104
Science; Business Side of, Its Part in the Coming Economic Crisis, 50
Science in Education, Place of, [Fleming] **486**, 496
Science in Examinations, 173
Science in Industry, 263
Science, Neglect of, [Ackermann] (C) 575
Science Students, Selected, Exemption for, 453
Scientific Management, Factors in, **18**
Scotland, Elec. Winding in, 3
"Seek and Ye Shall Find," **69**
Series-motors, Determining the Grading of Starting and Brake Resistances for, [Erens] (C) 57, [Garrard] (C) 92
Servantless Flat, 163
Sewer Construction, Electricity in, 308
Shaft Speeds, Critical, 520
Shanghai Electricity Supply, 197
SHAW, P. E., and HAYES, C.: Sensitive Magnetometer, 708
Sheffield, Electric Steels at, 173
Sheffield, Obsolescence at, **485**
SHENFER, C.: Distribution of Magnetic Flux in Commutating Zone of Direct-current Machines, 10
SHEPARD, E. R.: Modern Practice in the Construction and Maintenance of Rail Joints and Bonds in Electric Railways, 126
Shielding, Magnetic, 554
Ships, British, Wireless Telegraphy on, 620
Short-circuit Current, Approximate Method of Calculating in an Alternating-current System, [Wilson] 696
Short-circuit Problems, Approximate Solution of, [Merrick] 694
Shot Firing, 36
Signalling, Elec., With Bare Wires, **619**, 638
SILSBEE, F. B.: Inductance of Conductors at Close Spacings, 945
Silver Furnace Fume, Treatment by Cottrell Process, [Aldrich] 559
Sinecure and a Suggestion, **452**
Skilled Labour for Munitions, Provision of, **274**
Skin Effect in Strap Conductors, 70
Skin-effect Problems, Application of Telephone Transmission Formulæ, [Howe] 739
SKOGLAND, J. F., and MIDDLEKAUFF, G. W.: Photometry of the Gas-filled Lamp, **240**, 252
Method of Exhibiting the Velocity of Iodine Ions in Solution, 255
Slate Quarries, Elec. Power in, [Paton] 421
SLOAN, R. P.: Fuel Economy on the North-East Coast as a Result of Electric Power Supply, 917
SMITH, H. L.: Adapting Direct-current Motors to Changed Conditions, 657
SMITH, P. H.: Precautionary Measures to Adopt to Prolong the Life of Diesel Engine Crankshafts, 642
SMITH, S. P.: Notes on Design of Electromagnetic Machines, 280, **290**, 320, 360, 427, 461, 493, 528
SMITH, S. W. J.:
Experiments With Filaments Heated Electrically in Volatile Liquids, 177
Migration of the Ions, 498
Smoke, Fume and Dust Problems, Solution of, by Electrical Precipitation, [Bradley] 152
Snyder Electric Furnace, 308
Society of Arts, 454
Sound, Absorption of, 2
South Africa, Electrical Prospects, **687**, 694
South Africa, Power Line Poles in, 654
South African Possibilities, 418
Spain, Elec. Manufactures, 781
Spanish Patent Law, 407
Specifications, American, and Foreign Trade, 2
"Speeding-up" in an Engineering Factory, [Rankin] 90, **103**, 110, [Rankin, Stuart, Carney] (C) 193, 261, [Carney, Brocklehurst, Stevens] (C) 161
Speeding-up in Factories, 586
Stalwart Cast-iron Columns, **376**
Standardisation of Electric Service, 899
Steel, Corrosion of, 275
Steel, German Bounty-fed, [Hadfield] 600, **602**, [Wood] (C) 674
Steel Industry, Elec., 452
Steel, Iron and Coke, Maximum Prices, 164
Steel Mills, Motor-drive for, [Crosby] **451**, 455
Steel Testing, 791
Steels, Electric, at Sheffield, 173
STEINMETZ, Dr. C. P.: Light and Illumination, 40, **52**
STEVENS, C. C.: (C) Speeding-up in an Engineering Factory, 162
Stock Transfers and Trading With the Enemy, 441
STONE, F. L.: Crown Mines Hoist Installation, 913
Storage Battery Car, 274
STOTT, H. G.: Power Generation for Elec. Railways, 766
Stresses, Mechanical in Transformers, [Peters] 5
STUART, H.: (C) Speeding-up in an Engineering Factory, 194
Submarine Cable, Story of, [Bright] 801
Submarine Telegraph Companies, **239**
Sub-station, Elec., Attendants, 486
Sub-stations, Elec. Discharges in, [Switchboard] (C) 605, [Erichsen] (C) 643
Sweden, Exports to, 713
SWINBURNE, J.: Technical Research, 836
SWITCHBOARD: (C) Elec. Discharges in Sub-Stations, 605
Switchgear for Central Stations and Isolated Plants, 394
Synchronous Machines, Excitation of, [Sciou] 140

T

Tapping Blast Furnaces Electrically, 241
Tars and Tar Oils as Fuel, 308
Tasmanian Government Undertakings, 520
Technical Education, 418
Technical Education and the "Daily Mail," **376**
Technical Education and the Lay Press, **738**
Technical Education, [Ashton] (C) 195, [Denton] (C) 227, 241
Technical Education for Apprentices, **553**
Technical Education, Higher, After War, **688**
Technical Teachers, **376**
Technical Training, Sir R. Hadfield and, 377

TELEGRAPHY—

American Submarine Cables, 892
Australian Telegraph Service, 28
Cheaper Telegraph Service, **138**, 166
Fanning Island Cable, Restoration, 173
Finance of Telegraph Service, **138**
Inland Telegraph Service, 166
Land Telegraphy, Story of, [Harrison] 798
New Zealand Telegraphs and Telephones, 783
P.O. Telegraph and Telephone Administration, 200
Submarine Telegraphy, Speed of, [Raymond-Barker] 808
Swiss Government Telegraphs and Telephones, 749
Telegraph & Telephone Breakdown, 28
Western Elec. Printing Telegraph System, 211
Western Union Cable System, 166

TELEPHONY—

Argentina, Telephony in, 131, 924
Automatic Telephony, Progress, 59
Dudley, 892
Earth Connections for Telephone Exchanges, [Grinsted] 672
Fortieth Anniversary of the Telephone, 36
Hull Municipal Telephone System, 547
Installation, Telephone, 444
London Telephone Service, Growth, 444
Long-Distance and Cable Telephony (Underground and Submarine) [Cohen & Hill] 627, 660, 691, 724
Long-Distance Telephony, 343, [Cohen] 814
New York-Havana Telephonic Communication, 892
Paisley Automatic Telephone Exchange, 547, [Hedley] 698
Portsmouth, 166
Revenue, Telephone, 366
Selective Telephones, 486
Story of the Telephone, [Kingsbury] 812
Telephone Charges 28
Telephonometry, [Cohen] 244, 276
Tientsin Telephone System, 28
Trunk Telephone Service, 334

Temperatures, High, Methods and Appliances for the Attainment of, in the Laboratory, 14
Termini, Railway Goods, 25
Thermo-Elements, Protected, 756
Thermopile, An Absolute, [Coblentz and Emerson] 606
THIEME, PAUL: Automatic Earthing Protective Device, 726
THOMPSON, M. DE KAY, and CROCKER, E. C.: Depolarisation in Leclanché Cells, 124
THOMSON, Sir J. J.: On Radiation from Atoms and Electrons, (*Continued from* Vol. LXXVI.) 13, 88, 118
Thompson, The Late Prof. S. P., 377, 435, [Bright] (C) 473, [Eborall] (C) 506, [Bright] [Raworth] (C) 540
THORNTON, W. M.: Influence of Pressure on the Electrical Ignition of Methane, 775
Timber, Elec. Treatment of, 343
TORCHIO, P.: Construction of High-tension Cable Joints, **376**, 391
Traction, Electric, [Parshall] 824
Trade, After-War, 25
Trade, After-War, and Key Industries, 921
Trade After the War, 129, 241, 297, 365, 441, 520, 781, 918, 958
Trade After the War, Financial Support for, 475
Trade After the War, Government Committee, 104
Trade After the War, The Allies and, **375**
Trade, American with Australia, 197
Trade and Traders, Reflections on, **434**
Trade, British in S. America, 781
Trade, Foreign and American, Specifications, 2
Trade of the Empire After the War, 59, 263
Trade Policy After the War, Imperial, 577
Trade Products of the Empire, 545
Trading With Firms in British Protectorates, 263
Trading With Firms in Neutral Countries, 509
Trading With the Enemy, 263, 957
Trading With the Enemy, Preventing, 713
Tramway Transit and Comfort [Robson], 464
Tramways and Light Railways Association, 276, 463
Tramways, Elec., Maintenance of, **721**
Tramways, Utilisation of for Goods Traffic, [Holford and Clough] **931**, 943
Transformation, Voltage, Problem [Schoter] 142
Transformer, Alternating-Current, Predetermination of High Harmonics when the Impressed E.M.F. is a Simple Harmonic Function of the Time [Dean] 325
Transformer Design, [Denton] 43, 78, 113, 147, 181
Transformer, Million-volt Experimental, Design of, [Bayley] **35**, 42
Transformers, Instrument [Garrard], 499, 537
Transformers, Mathematical Design of, [Robertson] 934
Transformers, Mechanical Stresses in, [Peters] 5
Transformers, Open Delta Connection for [Gibbs] 727
Transformers, Portable, in Film Productions, 655
Transporters, 2
TROTTER, A. P.:
Daylight Saving, (C) 226
Improvements in the Sensitiveness of Apparatus at the B.O.T. Electrical Standards Laboratory, 851
Truth is Stranger than Fiction, **653**
Tungsten Arc under Pressure, [Luckey] 947
Tungsten Filaments, Characteristics of as Functions of Temperature, [Langmuir] 742
Turbine-driven Alternators, 346
Turbine, Steam, 45,000 kw., 453
Turbo-Alternator Unit, 30,000 kw., 690
Turbo-Alternator, Unusual Foundation for [Knight] 122, **104**
Turbo-Generators, Steam, Performance of 30,000 kw., 311, **324**, 376
Two-Thousandth Issue, **789**, [Kennelly] (C) 950

U

Unemployment Insurance, 781
United Kingdom Trade with Australia, 95
United States, Exports to, 679
Units, Electrical, Dimensions of, [Ascoli] 17
University College, New Chemical Laboratories, **2**, 16, 208
"Unto Him that Hath Shall be Given," **755**
U.S.A. and S. American Market, 95
U.S.A. and S. American Trade, 297, 475, 545
U.S.A. Development of Electric Cooking, 25
U.S.A. Electrical Exports, 679
U.S.A., Electrical Manufacturers in, 163
U.S.A. Exports to S. America, 645
U.S.A., Foreign Trade of, 612
U.S. Anti-Dumping Legislation, 713

V

Vacuum Detectors [Cohen] (C) 951
Vacuum-Fusion, Effect of, upon Magnetic Properties of Pure Open Hearth Iron, [Yensen] **519**, 533
Vehicle, Elec., Committee, 139, 174, 454, 587, 622
Vehicle, Elec., Committee, Report of, I.M.E.A., 433
Vehicle, Elec., Future of, 409
Vehicle, Elec., Progress (April 28, May 26, June 23, July 28, Aug. 25, Sept. 29)
Vehicle, Railless Trolley Battery, at Bradford, 225
Vehicles, Edison Battery, in Municipal Service, [Watson] 399
Vehicles, Electric, Demountable Bodies for, 586, [Demountable] (C) 643
Vehicles, Elec., Import of American, 713
Vehicles, Elec., Refuse Collecting by, 17
Vehicles, Lights on, 206
Velocity of Iodine Ions in Solution, Method of Exhibiting, [Smith] 255
Ventilation, Forced, 342, 654
Verband Deutscher Elektrotechniker, 274, 723
Victoria Falls Power Scheme, 889
VOGELSANG, M.: Use of Carbon Tetrachloride (Benzinoform) with High-tension Switches, 540
Voltameter, Silver, Volume Effect in a, 655
Voltmeter, Electrostatic, Construction of, [Wolcott] 702

W

Walchensee Waterfall in Bavaria, Proposed Development of, 343
WALKER, MILES: Dynamo-electric Machinery, 1878-1916, 817
WALMSLEY, R. M.: The Nation, the Apprentice and the Polytechnic, 871
War Material Order, 577
War Work, 377
WARRILOW, W. E.: Publicity and its Relation to Engineering Work, 887
Water Heating, Elec., as Applied to Domestic Service, [Crosbie] 762
Water-Power Development, "Biggest Things" in, 569
Water Power, Modern Developments, 36
Water-powers of the World, 898
WATSON, W. H. L.: Edison Battery Vehicles in Municipal Service, 399
Watts *versus* Wallpaper, 688
Wave-lengths in the Iron Spectrum, 343
WEINBERGER, J.: Design of the Audio-Frequency Circuit of Quenched Spark Transmitters, 504
Welding, Electric, [Sauer] **69**, 75
WEST, G. D.: Method of Measuring the Pressure of Light by Means of Thin Metal Foil, 741
Westinghouse, American Works Strike, 206
WHEAT, H. C.: Efficiency of Projectors and Reflectors, (C) 23
Whitsun Holiday, **273**
Wile Electric Furnace, 601
WILE, R. S.: Elec. Furnace Melting of Ferro-Alloys, 356
WILKINSON, G.: Problem of the Small Generating Station, 348, **358**
Will, 620
WILLCOX, F. W.: (C) Evolution of the Elec. Lamp, 950
WILLIAMS, E. I.: Electricity Supply of Great Britain, 48, (*Discussion*) 80, **86**, 175, 249, [Williams] (C) 438
WILSON, D.: Boiler Development, 1882-1916, 840
WILSON, H. R.: Approximate Method of Calculating Short-circuit Current in an Alternating-current System, 696
Winding, Elec., in Scotland, 3
Wire, Zinc, 2

WIRELESS TELEGRAPHY AND TELEPHONY—

Aeroplanes, Wireless on, 654
Arc Oscillations in Coupled Circuits, 756
Atlantic Radiotelegraph Service, 200
Audio-Frequency Circuit of Quenched Spark Transmitters, Design of, [Weinberger] 504
Australian Government Radiotelegraph Service, 200
Australian Government Wireless Apparatus Factory, 924
Australian Radio Service, 166
Australian Wireless Service, 749
Bolivia, Radiotelegraphy in, 200
British Association Radiotelegraphic Investigations, 791
Canadian Radio Service, 654
Chaffee Gap, 688
Crystal Detectors, 655
Detector, Elec. Wave, Laws of Variation of Resistance with Voltage at a Rectifying Contact of Two Solid Conductors with Application to the, [Owen] 910
Detectors in Wireless Telegraphy, 756
Oscillations, Damped, A Mode of Studying by the Aid of Shrinking Vectors, [Robertson] 106
Oscillations, Electrical, from Mercury Vapour Tubes, [Liebowitz] 144
Oscillograms, Amplitude and Phase of the Higher Harmonics in, [Howe] 149
Patents, Recent, in Radiotelegraphy and Radiotelephony, [Eccles] 571, 595
Radiotelegraph Antennæ, Calculation of Capacity including Effects of Masts and Buildings, [Howe] 761, 880
Radiotelegraph Notes, 301, 648, 924
Radiotelegraphy, 63, 131, 334
Radiotelegraphy: A Retrospect of Twenty Years, [Fleming] 831
Radiotelephony, Magnetic Amplifier, [Alexanderson & Nixdorff] 104, 312
Radium Antennæ, [Leimer] 82
Research, Wireless Telegraph, 25
Ships, British, Wireless Telegraphy on, 620
Small Power Wireless Installation, 898
Transformers, Radiotelegraphic, 206
U.S.A. Wireless Telephony, 200
Waves, Elec., Transmission of, Around the Earth's Surface, 419
Wireless Communication of Speech, Methods Employed for the, [Coursey] 7
Wireless Telephony, Future of, **585**
Women Wireless Operators, 783

Wires, Silicon-Bronze, of 1,000 ft. Span, 172
Wiring Practice in Germany under War Conditions, **417**, 426
WOLCOTT, E. R.: Construction of an Electrostatic Voltmeter, 702
Women, Employment of, 619
Women in Elec. Supply Service, 487
WOOD, H. C.: German Bounty-fed Steel, (C) 674

WORKS, DESCRIPTION OF.

Metropolitan Elec. Supply Co.'s Accumulator Sub-Station, 54

WYSSLING, Dr.: Tests on Oil Switches, 8

X

X-Ray Spectrometer, Recording, 899
X-Rays and Radiography, Recent Progress [Kaye] 861
X-Rays, Maximum Frequencies of, 36

Y

YENSEN, T. D.: Effect of Vacuum-Fusion upon the Magnetic Properties of Pure Open-Hearth Iron, **519**, 533
Yorkshire Mining Elec. Engineers, 171

Z

Zinc, Coating Metals with, 501
Zinc Manufacture, 521
Zinc, Occurrence and Utilisation of, 703
Zinc Smelting, 365

Municipal, Foreign and General Notes.

ELEC. SUPPLY—

Extensions.

Aberdeen, 265
Accrington, 61, 96, 165
Aldershot, 959
Altrincham, 96
Ashton-under-Lyne, 681
Aylesbury, 479
Barnes, 96
Barrow, 647
Battersea, 198, 332, 715, 890
Belfast, 332
Bexley, 61
Birkenhead, 96
Bolton, 96
Bo'ness, 27, 198, 298
Bradford, 61, 333, 578, 922
Bristol, 511
Burton-on-Trent, 647, 681
Cardiff, 96
Carlisle, 231
Carnarvon, 61, 265, 410
Chesterfield, 714
Colwyn Bay, 298
Derby, 578, 647
East Ham, 27
Edinburgh, 578
Fulham (London), 198, 479, 612, 959
Glasgow, 366
Greenock, 165, 199, 410
Halifax, 199
Hammersmith (London), 199, 333
Haslingden, 511
Heston & Isleworth, 165
Ilford, 27, 298, 714
Islington (London), 265
Kingston-on-Thames, 298
Kirkcaldy, 511, 890
Leeds, 130, 298, 782
Leek, 681
London County Council, 130, 231, 612
Loughborough, 366
Luton, 130, 479, 578
Nelson, 130
Newcastle (Down), 366
Newport (Mon.), 714
Poplar, 579, 959
Rawtenstall, 891
Rochdale, 199
Rotherham, 61, 366
St. Pancras (London), 130
Salford, 27, 479, 782
Sheffield, 62, 199, 366, 511, 647, 782, 891
Shoreditch (London), 231
Stafford, 130, 681
Stalybridge, 442
Sunderland, 366
Swansea, 96, 410, 891
Wakefield, 366, 922
Walsall, 199, 511
Walthamstow, 298, 579, 782
Watford, 62
West Ham, 265, 442
Wigan, 199, 410, 511
Willesden, 265
Wimbledon, 612
Wolverhampton, 62, 96, 199, 333, 411
Woolwich, 479, 612
Worcester, 511
Yorkshire, 366

General.

Aberdeen, 62, 165, 333, 366, 891
Accrington, 265
Aldershot, 714, 959
Alnwick, 681
Amesbury, 748
Ardsley, 959
Aylesbury, 411, 546
Ballybay (Ireland), 782
Barnes, 231, 367, 546
Barnsley, 479
Battersea (London), 62, 511
Beckenham, 442
Bedford, 367, 715, 959
Bedworth (Warwickshire), 612
Belfast, 62, 546
Belturbet (Ireland), 579
Bermondsey (London), 647
Bethnal Green (London), 265, 612
Bingley, 479
Birkenhead, 367
Birmingham, 298, 333
Bolton, 367, 443
Bootle, 199
Bradford, 130, 546
Bradford-Shipley Linking-Up Scheme, 748
Bradninch, 959
Bray, 511
Bridlington, 27, 96
Brighton, 96
Bristol, 130, 959
Burnley, 199
Burton-on-Trent, 199
Callington, 681, 922
Carnarvon, 546
Charges, Increase of, for Electrical Energy, 511, 546, 579, 613, 647, 923, 959
Chatham, 959
Chepstow, 681
Chiswick, 782
City of London, 27, 298, 367
Coal Supplies, 62, 231, 367
Colwyn Bay, 443
Coniston, 891
Coventry, 443
Croydon, 265, 959
Cumberland, 298
Dartmouth, 62
Darwen, 367, 479
Derby, 511
Dewsbury, 923
Dublin, 231, 298, 748, 782
Dundalk, 782
Dundee, 681

Municipal, Foreign and General Notes.—*Continued.*

Ealing, 231, 367, 411
Eastbourne, 27
Edinburgh, 27, 165, 511, 681
Elec. Lighting Orders, 613
Electrical Energy, Revised Charges, 891
Electricity & Gas Supply, 299
Epsom, 891
Eton, 613
Exeter, 367
Finchley, 333, 546
Fuel Economy, 62
Fulham (London), 62, 333
Gas Fuel for Electricity Works, 923
Gillingham, 367, 411, 443
Glasgow, 681, 748, 923
Gloucester, 479
Gosport, 443
Grangemouth, 163
Grimsby, 130
Hackney (London), 579
Hamilton, 579
Hammersmith (London), 62, 479
Hampstead (London), 413
Heston & Isleworth, 479
Hinckley, 748
Holmfirth, 546
Hornsey, 265, 443
Hove, 231, 715
Huddersfield, 443, 715
Hull, 546
Ilkeston, 333
Ingleton, 165
Islington (London), 96
Ipswich, 199, 411
Keighley, 299
Kingston-on-Thames, 27, 479
Kingstown, 547
Knottingley, 231
Lanchester, 792
Leeds, 27
Leek, 479
Leicester, 165
Linking-Up or Bulk Supply, 923
Liverpool, 333
Llanfyllin, 299
London County Council, 479
London Elec Supply Scheme, 613
Loughborough, 681
Luton, 647
Maidstone, 333
Malton, 27
Malvern, 647
Manchester, 27, 130, 613
Mansfield, 165
Marylebone (London), 27, 165, 299, 579
Morecambe, 748
Municipal Contract with Austro-German Controlled Co., 647
Municipal Loans, 96
Nelson, 231
Newcastle (Staffs.), 199
Newport (Mon.), 923
Newquay, 138, 165
Newton Abbott, 959
Norwich, 959
Nottingham, 199
Oldham, 648
Ormskirk, 749
Pinner, 411
Plymouth, 231, 792
Poplar (London), 27, 97, 959
Provisional Elec. Lighting Order, Extension of, 681
Rathmines, 62
Rawtenstall, 265, 959
Redditch, 367, 411
Reigate, 27, 411, 749
Rhyl, 97
Ripon, 265, 443, 782
Rochdale, 749, 891
Rose, 165
St. Annes-on-the-Sea, 199
St. Pancras, 443
Salford, 165, 333, 511, 613
Scarborough, 443
Sheerness, 265
Sheffield, 62, 411, 512, 547, 648, 681, 923
Shipston-on-Stour, 959
Slaithwaite U.D.C. Elec. Lighting Order, 1914, 443
Southampton, 959
S. London Linking-Up Scheme, 579
Southend-on-Sea, 97, 411, 682, 959
S. Shields, 891
Stafford, 265
Stalybridge, 749
Surbiton, 27, 749
Stockport, 682
Stockton-on-Tees, 648
Stoke-on-Trent, 165, 273, 299
Street, 265
Stretford, 891
Sutton Coldfield, 367
Swansea, 232, 923
Swinton, 412
Teignmouth, 131
Torquay, 27, 62, 199, 648
Tottenham, 613
Tynemouth, 265
Walsall, 62, 412, 891, 959
Walthamstow, 443
Walton, 412
Walton-on-Thames, 579
Watford, 97, 131, 960
West Bromwich, 367
West Ham, 97
West Hartlepool, 367
Westminster, 62, 232
Weybridge, 367, 682, 960
Whitehaven, 232
Wigan, 62, 924, 960
Willesden, 579
Wimbledon, 62, 199, 512
Woolwich, 131
Worcester, 782, 960
Workmen's Dwellings, Lighting of, 62
Worksop, 62, 749
Worthing, 27
Wolverhampton, 512, 613
Yeovil, 512
Yorkshire Linking-Up Scheme, 479

LIGHTING.

Ballymoney (Ireland), 412
Burton, 547
Chelmsford, 613
Church Lighting, 682
Cranes, Elec., on the Clyde, 648
Dromore (Ireland), 547, 924
Hospital Lighting, 27, 367
Ilford, 97
Keynsham, 924
Leyton, 333
London Dock Improvement, 649
Luton, 924
Pateley Bridge, 715
Petroleum Oilfields, Electricity in, 648
Plymouth, 333
Sanatorium Lighting, 131
Scarborough, 131
Southend, 547
Stirling, 131
Vessels, Passenger, Emergency Lighting, 97
Wimbledon, 367

POWER.

Collieries, Elec. Power in, 613, 715, 924
Doncaster, 131
Huddersfield, 613
Ironworks, Electricity in, 682
Leigh (Lancs.), 28, 715
Mines, Electricity in, 27, 333, 367, 412, 547, 715
Oldham, 681
Petroleum Works, Electricity in, 683
Quarries, Electricity in, 97
Radstock, Elec., 412
Reigate, 333
Rolling Mills, Elec. Driving of, 682
Sheffield, 613
Zinc, Electrolytic Treatment of, 97

TRACTION.

Aberdeen, 333
Accrington, 333
Aldershot, 683
Ashton, 412
Astley (Lancs.), 299
Belfast, 333
Birmingham, 131, 232, 299, 891
Blackburn, 512
Blackpool, 232
Bolton, 265, 334
Bournemouth, 28
Bradford, 199, 334, 367, 960
Brentford, 443
Bristol Tramways, 782
Burnley, 63, 782
Cardiff, 579
Colwyn Bay, 36, 63
Coventry, 28
Croydon, 368, 443, 749, 715
Darwen, 480
Delivery Drays, Elec., 165
Doncaster, 891
Dover, 63, 648
Dublin & Blessington Steam Tramway, 782
East Ham, 265, 443, 580, 960
East London Rly., 232
Edgware & Hampstead Rly., 547
Edinburgh, 580
Erith, 299
Gateshead-on-Tyne, 199, 683, 891
Germany, Elec. Traction in, 412
Glasgow, 199, 334, 368, 412, 512, 683, 749, 782, 924, 960
Gloucester, 334
Goods Traffic by Tramcar, 131
Halifax, 165, 512
Heywood, 165
Huddersfield, 443
Hull, 299
Ilford, 28, 613
Ilkeston, 891
Ipswich, 63
Keighley, 232
Kirkcaldy, 512
Lambeth, 131
L. & S.W. Rly. Electrification, 368, 412
L.C.C. Tramway Power Station, 891
L.C.C. Tramways, 131, 299, 331, 368, 480, 613
Leeds, 28, 232, 368, 891
Leicester, 299
Leyton, 131
Liverpool, 783
London Underground Elec. Rlys., 960
Loughborough, 443
Luton, 299, 960
Manchester, 131, 412, 512, 648
Manchester-Bury Elec. Rly., 97, 334
Manchester District Elec. Rly. Service, 165
Middlesbrough, 648
Middlesex, 547
Middlesex Tramways, 63, 199, 443
Motor Omnibuses and Upkeep of Roads, 103, 131
Motor Omnibuses in Croydon, 265
Motor Omnibus Routes, New, 299
Motor Road Sweepers, 63
Neath, 580
Nelson, 63
Newcastle-upon-Tyne, 28, 919
Northampton, 28
North London Rly. Electrification, 334, 614, 891
Norway, 648
Nottinghamshire & Derbyshire Tramways Act, 1903, 131
Perth, 63
Plymouth, 97, 334
Portsmouth, 891
Rotherham, 63, 512, 648
Salford, 199, 783, 891
Sheffield, 892
Southampton, 131, 232, 443, 960
Swansea, 232
Southend-on-Sea, 232, 412, 924, 960
Torquay, 199
Tramcar v. Motor Omnibus, 480
Tramway & Transport Works, 299
Tramway Strike, 63, 97, 131
Tramway Track Maintenance, 614
Tramway Transfer, 63
Tramways, C.O.D. System, 924
Walthamstow, 166
West Ham, 131, 443
Wigan, 614
Woolwich, 480, 614
Women Tramcar Drivers, 97, 166, 265
York, 715, 960

EMPIRE.

Australasia, 28, 97, 132, 166, 232, 265, 300, 334, 368, 413, 444, 512, 547, 580, 614, 649, 715, 719, 783, 924, 960
British New Guinea, 715
Burma, 960
Canada, 749, 783
Canada, Elec. Smelting and Refining in, 233, 580, 649
Canadian Farming, Electricity in, 265
Canada, Patents in, 300
Canada, Water Power, 749, 925
Federated Malay State, 783
India, 98, 132, 233, 266, 300, 368, 413, 444, 513, 614, 649, 924
Newfoundland, Elec. Smelting in, 98, 513
New South Wales Mines, 925
Niagara Falls Power, 715
Ontario Hydro-Electric Commission, 166
S. Africa, 167, 749, 960
Straits Settlements, 300
Transvaal, 233

FOREIGN.

America, Elec. Furnace Development in, 683
Argentina, 29, 98, 132, 335, 444, 750, 925, 961
Argentina, Elec. Traction in, 750
Austria-Hungary Patents, 750
Bolivia, 683
Brazil, 29, 132, 513, 925
Buenos Ayres, Automat Telephones for, 335
Chili, 29, 335, 783, 925
Chili, Wireless Telegraph Charges, 444
China, 98, 444, 716
Chosen, 98
Colombia, 513, 548, 580, 750, 783, 961
Copenhagen, 335
Costa Rica, 925
Cuba, 784
Danish West Indies, 683
Finland, 513
Holland, 549
Iceland, 750
Italy, 368, 549
Italy, British Trade with, 444
Japan, 368, 580, 614
Lyons Municipal Contracts, 750
Melilla (N. Africa), 750
Morocco, 369, 548
Norway, 29, 548, 683, 925
Norway, Elec. Zinc Refining in, 98
Persia, 335
Peru, 335
Philippine Islands, 29
Porto Rico (W. Indies), 926
Portugal, 98, 335, 548
Portuguese India, 716
Portuguese Patents, 926
Russia, 369, 614, 649, 750, 784, 926
St. Thomas (Danish W. Indies), 444
Shanghai, 784
Spain, 63, 548, 961
Swedish Exports, 63
Swedish Water-Power Plants, 63
Switzerland, 751
Tunis, 29
United States, 649
Uruguay, 132, 335, 369
U.S.A. Coal Mines, Electricity in, 683
U.S.A. Hydro-Electric Works, 926
Venezuela, 63, 444, 784, 926

MISCELLANEOUS.

Alien Enemy Firms, 445
Australia, Radiotelegraphists in, 234
Bravery Rewarded, 132
British Engineering Industry, Council for Organisation, 413
British Firms in Germany, 751
British Industries Fair, 98
British Westinghouse War Relief Fund, 683
Cable Discounts, 300
City of London Fires, in 1915, 98
Clyde Labour Agreement, 369
Coal Supplies for Electricity Works, 444
Contraband of War Regulations, 29
Contracts with Alien Enemies, 63, 233
Controlled Establishments, 167, 266, 513
Conversion Table, &c., 167
Cuba-U.S.A. Telephone Communication, 683
Customs Decisions, 132, 413, 892
Customs Duties, 369, 614
Debts Owing by Enemy Firms, 369
Defence of Realm Regulations, 98, 335, 548
Derby Chamber of Commerce Year Book, 1916, 132
Directory of British Manufacturers for Russian Trade, 926
"Directory of Manufacturers," 548
Directory of Merchants and Manufacturers in India, 1915, 926
Elec. Light Switching, Supplementary Examination 63
Electrical Contractors and Labour Shortage, 266
Electricity Supply Undertakings and Munition Works, 63
Electrolytic Disinfecting Fluid at Poplar, 649
Enemy Firms to be Wound Up, 200, 233
Enemy Firms Wound Up, 29, 63, 99, 133, 167, 300, 335, 369, 413, 445, 513, 548, 580, 614, 649, 683, 716, 751, 892, 961
Engineering School for Boys, 751
Engineers' Wages, 649
Exports, 99, 234, 369, 514, 650, 893
Exports to China and Liberia, 961
Exports to China and Siam, 133, 167, 335, 513, 580, 751
Fatality, 369
Fires, 716
France and Algeria, Imports into, 784
G.E.C. Cadet Corps, 649
Hebburn, 926
Imports, 99, 234, 369, 514, 650, 893
Inquests, 98, 234, 335, 413, 716, 784, 892
Italy, Automatic Telephony in, 444
Kitchener Scholarships, 961
Legal Notice, 29
Liberia, Exports to, 200, 445, 784
Linking-Up Farm and Market, 892
Liverpool, Electricians' Demands at, 926
Loans, Local, 29
London Electricians' Wages, 580
"Manchester Guardian" Chinese Supplement, 99
Maschinenfabrik Oerlikon Shareholders, 133
Memorandum on the Electricity Regulations, 513
Military Tribunal Cases, 513, 548, 716, 751
Mine Electricians, 580
Miners' Safety Lamps, 335
Mongolia, Telegraphic Communication with, 413
Munitions Tribunal Cases, 29, 64, 99, 133, 167, 234, 266, 301, 336, 683, 716, 751, 892, 927
New Zealand Trade, 445
Pacific Radio Stations, 615
Patent, Application for Extension, 63
Patents, Alien Enemy, 29, 63, 751
Pig Iron, Maximum Prices, 927
Plant for Sale, 513
Porcelain, Hard Paste, 785
P.O. Servants and the War, 300
P.O. Servants' Wages, 300
Royal Assent, 751
Royal Flying Corps, 200
"Russian Press," 615
S. African Patent Law, 445
S. African Trade in 1915, 445
Secretaries' Association, 751
Ships, Lights on, 926
Siemens War Savings Association, 961
Sweden, Prohibition of Exports, 413
Swedish Chamber of Commerce Year Book, 892
Telegrams by Telephones, 513
Telephone in Canadian Farm Work, 445
Trade Union Congress, 785, 892
Trading with the Enemy, 64, 99, 167, 200, 335, 413, 580, 650, 716, 892
Tramcar Drivers, Employment of Disabled Men, 683
Walsall Chamber of Commerce Year Book, 892
Wills, 200, 716
Women as Travellers, 892
Wounded, Appliances for, 649

Companies' (Joint-Stock) Meetings, Reports, Dividends, Statutory Returns, &c.

Automatic Telephone Mfg., 373
Babcock & Wilcox, 169
Bahia Tramway Light & Power Co., 964
Barford Elec. Supply, 753
Barton-on-Humber Elec. Supply, 31
Bath Elec. Tramways, 134, 270
Baxendale Bros., 339
Bill, S. & Co., 719
Birmingham & District Power & Traction, 236
Brentford, Harlow & Epping Gas & Electricity, 929
Blackpool & Fleetwood Tramroad, 617
Bristol (R. W.) & Co., 272, 1753
Burton Elec. Supply & Tramways, 271, 482
Burtonwood & Poole Elec. Supply, 583
Burton-on-the-Water Elec. Light & Power, 450
Brazilian Traction, Light & Power, 101, 551, 787
Brilliant Arc Lamp & Engineering, 237, 450, 719, 753, 788
Brisbane Elec. Tramways Investment, 236
Bristol Tramways & Carriage, 617
British Aluminium, 31, 929
British Dyes, 33, 719
British Elec. Traction, 238, 372, 447
British Empire Trust, 754, 895
British Ever Ready, 236, 338
British Insulated & Helsby Cables, 929
British North Borneo, 551
British Thomson-Houston, 482
British Westinghouse Elec. & Mfg., 66
Brompton & Kensington Elec. Supply, 31, 754
Browett, Lindley & Co., 32, 896
Brown & Parsons, 753
Brunner Mond & Co., 338, 372
Brush Electrical Engineering, 66, 134
Bullers, Ltd., 416
Calcutta Elec. Supply Corpn., 67, 136, 169, 271, 374, 754, 929, 964
Calcutta Tramways, 169, 203
Calgary Power, 272
Callender's Cable & Construction, 236, 304
Calvo Box, 340
Cambridge Elec. Supply, 66

Companies' (Joint-Stock) Meetings, Reports, Dividends, Statutory Returns, &c.—*Continued.*

Canadian Elec. Power Combination, 374
Canadian General, 100
Canadian General Elec., 340, 896
Cape Town Consolidated Tramways & Land, 305
Castner-Kellner Alkali, 338
Cedars Rapid Mfg. & Power, 101
Central Elec. Supply, 238
Central London Rly., 583
Chadburn's (Ship) Telegraph, 450, 929, 963
Charing Cross, West End & City Elec. Supply, 618
Chatham & District Light Rly., 584
Chelsea Electricity Supply, 618
Chesham Elec. Light & Power, 305
Chili Telephone, 516, 550
Chiswick Elec. Supply Corpn., 236
Chloride Electrical Storage, 204
Cia de Electricidad de la Provincia de Buenos Aires, 651
Cie Francaise Pour l'Explcitation des Procedes Thomson-Houston, 448
City of Brisbane Elec. Light, 448
City of Buenos Ayres Tramways, 169, 618
City of London Elec. Lighting, 340, 618, 720, 964
City of Santos Improvements, 67, 134
City & S. London Rly., 584
Cleveland & Durham Elec. Power, 32
Cleveland, Portishead & District Elec. Supply, 67
Clyde Valley Electrical Power Co., , 754, 963
Clyde Valley Electrical Power Storage, 929
Colombo Elec. Tramways & Lighting, 134
Companies to be Struck off the Register, 551, 583, 788, 929
Consolidated Electrical, 450, 483
Consolidated Signal, 34
Cordoba Light, Power & Traction, 618
Cork Elec. Tramways & Lighting, 67
County of Dorset Elec. Supply, 582
County of London Elec. Supply, 584
Craigpark Elec. Cable, 204
Credenda Conduits, 582
Crompton & Co., 550, 582
Crossley Bros., 720
Cuban Telephone, 516, 720
Cuba Submarine Telegraph, 134, 168
Cunningham, 340

Davis & Timmins, 754
Dawlish Elec. Light & Power, 136
Delhi Elec. Tramways & Lighting, 305
Derby Lamp Works, 135 [272
Deutsche-Atlantische Telegraphengesellschaft, Dick, Kerr & Co., 930
Direct Spanish Telegraph, 930
Direct United States Cable, 67, 168, 518
Direct West Indian Cable, 963
Doulton & Co., 272, 338
Dublin United Tramways, 518
Dumbarton Burgh & County Tramways, 895
Dundee, Broughty Ferry & District Tramways, 895, 963
Duram, 450
Eastern Telegraph, 67, 101, 204, 267, 416, 930
Eastern Extension Australasia & China Telegraph, 67, 204, 236, 268, 484, 552, 895
Edison Accumulators, 583
Edmundsons' Electricity Corpn., 516, 583
Elec. Construction, 270, 305
Elec. & General Investment, 550, 582
Elec. Light & Power Supply Corpn., 651
Elec. Supply Corpn., 617
Elec. Supply Co. of Victoria, 929
Electro-Bleach & By-Products, 685
Electro-Flex Steel, 518
Electro-Galvanisers, 339, [652
Elmore's German & Austro-Hungarian Metal,
Falkirk & District Tramways, 34
Faringdon Elec. Light & Power, 788
Fife Tramway, Light & Power, 135
Folkestone Electricity, 32, 930
General Elec. 516, 551
General Elec. Co. (U.S.A.), 338
General Electric (of Sweden), 272
General Seating, 33
Giant's Causeway, Portrush & Bush Valley Railway & Tramway, 67
Globe Telegraph & Trust, 238, 448, 482
Glover (W. T.) & Co., 32, 67
Great Northern Telegraph, 101, 270
Gwynnes, Ltd., 238
Hadfields, 551
Halifax & Bermudas Cable Co., 963
Hampden Cloncurry Copper Mines, 929
Hart Accumulator, 484
Havana Elec. Rly., Light & Power, 372, 753
Henley's (W. T.) Telegraph Works, 686
Henson, Joseph R., 617
Highfield Co., 617
Hindhead & District Elec. Light, 169
Holsworthy Gas & Electricity, 100, 753
Hong Kong Tramway, 618, 895
Howlett (M.) & Co., 583
Huelva Gas & Electricity, 272

Ilford Dry Battery, 896
Imperial Tramways, 448
Indian Elec. Supply & Traction, 203
India Rubber, Gutta Percha & Telegraph Works, 484
Indo-European Telegraph, 101, 135, 168, 271, 302
Isle of Wight Elec. Light & Power, 32
Johnson & Phillips, 135, 169
Johnson (Richard), Clapham & Morris, 237
Kalgoorlie Elec. Power & Lighting Corpn., 101, 271, 305, 964
Kalgoorlie Elec. Tramways, 754, 787
Keith (Jas.) & Blackman, 448
Kensington & Knightsbridge Elec. Lighting, 652
Kent Elec. Power, 448
Kidderminster & District Elec. Lighting & Traction, 237
Lamplough & Son, 339, 583
Lanarkshire Tramways, 584
Lancashire Dynamo & Motor, 68, 305, 930
Lancashire Power Construction, 373, 448
La Plata Elec. Tramways, 101
Leamington & Warwick Elec., 68
Lima Light, Power & Tramways, 271
Lisbon Elec. Tramways, 203, 271
Liverpool District Lighting, 32, 930
Liverpool Overhead Rly., 551
Llandrindod Wells Elec. Light & Power, 237
London Elec. Rly., 584
London & Lancs. Fire Insurance, 237
Lymington Elec. Light & Power, 101
Mackay Companies, 306, 788
Madras Elec. Supply Corpn. (Ltd. & Reduced), 518
Madras Elec. Tramways, 32, 964
Malacca Elec. Lighting, 753
Manaos Tramways & Light, 895
Mander & Co., 652
Manila Elec. Railroad & Lighting Corpn., 895
Marconi International Marine Communication, 338, 415
Marconi's Wireless Telegraph, 34, 449, 483
Marconi's Wireless Telegraph of America, 34, 100
Marconi Wireless Telegraph Co. of Canada, 929
Mather & Platt, 584
Melbourne Elec. Supply, 238
Memoranda, 33, 67, 101, 136, 169, 204, 238, 271, 306, 340, 373, 416, 450, 484, 518, 551, 583, 617, 652, 685, 720, 754, 788, 896, 929, 964
Metallic Seamless Tube, 338
Metropolitan Elec. Supply, 170, 618, 719, 895
Metropolitan District Rly., 584
Metropolitan Rly., 618
Mirrlees, Bickerton & Day, 272
Montevideo Telephone, 68
Montreal Light, Heat & Power, 136, 516
Montreal Tramways, 720
Montreal Water & Power, 551
Nairobi Elec. Power & Lighting, 686
National Elec. Construction, 719
National Elec. Supply, 374
Newcastle-on-Tyne Elec. Supply, 584, 754
New Era Signs, 339
New General Traction, 338
New Peto & Radford Accumulator 753
New Transport, 686
Newton & Wright, 135
North Berwick & District Elec. Light & Power, 32
N. Melbourne Elec. Tramways & Lighting, 651
North of Scotland Elec. Light & Power, 170
Northern Counties Electricity Supply, 374
Oldham, Ashton & Hyde Elec. Tramway, 33, 652
Orford Elec. Light & Power, 33, 517
Oriental Telephone & Elec., 68, 101, 203
Oxford Elec., 754

Parsons & Hedges, 617
Peel-Connor Telephone Works, 305
Petter's Ventilating & Engineering, 720
Potteries Elec. Traction, 101
Pritchett & Gold & Electrical Power Storage, 271
Provincial Tramways, 374
Puebla Tramway, Light & Power, 237
Rangoon Elec. Tramways & Supply, 338, 373,
Reading Elec. Supply, 101
Record Electrical, 237
Resisto Elec. Mfg., 753
Reuter's Telegram, 271
Reyrolle (A.) & Co., 169
Richardsons, Westgarth & Co., 305, 373
Rio de Janeiro Tramway, Light & Power, 552
Rio Tramway, Light & Power, 68
River Plate Electricity, 135
Royce, 787
Runbaken Magneto, 33
Rural Electricity Supply, 450
Rushmore Lamps, 617
St. James & Pall Mall Elec. Light, 484, 552
St. John Del Rey Mining, 551
Sao Paulo Tramway, Light & Power, 68, 552
Shanghai Elec. Construction, 237, 305
Shawinigan Water & Power, 33, 374
Shropshire, Worcestershire & Staffs Elec. Power, 169
Singapore Elec. Tramways, 373
Slough & Datchet Elec. Supply, 33
Small Elec. Motors, 652
S. Metropolitan Elec. Light & Power, 136, 238
S. Wales Elec. Power Distribution, 101, 203
South Wales Transport, 237
Southern Brazil Elec., 516, 583
Spanish Telephone, 720
Stewarts & Lloyds, 720
Stone (J.) & Co., 518
Stratford-on-Avon Electricity Co., 964
Submarine Cables Trust, 34, 101, 136, 170, 237 269
Telegraph Construction & Maintenance, 484
Telephone Co. of Egypt, 102, 170
Trafford Power & Light Supply, 449
Tramways & General Works, 170,
Troup, Curtis & Co., 617
Trowbridge Elec. Supply, 482
Tubes, Ltd., 618
Turner (G. H.) & Co., 237
Tyneside Tramways & Tramroads, 686, 719
Underground Elec. Rlys. Co. of London, 584, 686
United Alkali, 33
United Elec. Car, 895, 963
United Elec. Tramways of Montevideo, 338, 415
United River Plate Telephone, 238, 271, 302
Urban Elec. Supply, 33
Vaughan Engineering Works, 617
Venner Time Switches, 720
Venture Trust, 517, 551
Veritys, Ltd., 416, 552
Vickers, 102, 552, 616
Victoria Falls & Transvaal Power, 306, 340, 895 963
Wakelin's, 237
Walters Electrical Mfg. Co., 963
Waste Heat & Gas Elec. Generating Station, 686
Waygood-Otis, 372, 449
Welsbach Light, 517
W. African Telegraph, 269
W. Coast of America Telegraph, 237, 269
W. India & Panama Telegraph, 203, 235
W. London & Provincial Elec. Supply, 237, 271
Western Canada Power, 517, 652
Western Telegraph, 68, 236, 340
Western Union Telegraph, 101, 339, 552
Westminster Elec. Supply Corpn., 618
White (J. G.) & Co., 449, 482
Whitstable Elec., 305
Willans & Robinson, 135, 169
Winnipeg Elec. Railway, 102, 305
Woking Elec. Supply, 33
Wolseley Motors, 101
Woodbridge & District Elec. Light, 135
Worcester Elec. Traction, 339
Wycombe (Borough) Elec. Light & Power, 67

Yorkshire Elec. Power, 583
Yorkshire (Woollen District) Elec. Tramway, 67
Yorkshire (W. Riding) Elec. Tramways, 374
Zinc Corpn., 449

Companies, Joint-Stock (New Electrical, &c.), Registered.

Alberta Engineering, 517
Allen (Marcus) & Sons, 33
Alexander (G. H.) Engineering, 373
Aluminium Solder, 895
Anchor Elec, 237
Ascog Metal Products (Glasgow), 685
Assoc. for the Protection of British Capital and Property in Enemy Countries, 685
Assoc. of British Motor & Aircraft Mnfrs., 67
Atkey (London), Ltd., 135
Automatic Loading, 517
Baxendale Bros., 135
B. I. Co. (of London and Birmingham), 449
Birmingham Elec. Accessories, 583
Borough Garage, 135
British Aero Magneto Mnfctrs. Assoc., 719
British Elec. Trading, 583
British Electro-Chemists, 517
British Electrolytic Zinc Co. (Isherwood Process), 339
British Graphite & Trading, 339
British Italian Corpn., 583
British Revival Mfg., 719
British Tungsten Mines, 517
British Utilities, 895
Butler Jones (Nameplates), 685
Carter (James) (Stalybridge), 617
Chase Bros., 517
Claes (Henri & Co., 617
Coleman & Appleby, 373
Conner & Magneto Ignition, 33
Cooper (H. G.) Ltd., 67
Cox (W.) (Mansfield), Ltd., 929
Cymograph (Ltd.), 33
Elec. Consulting & Supply, 517
Electrical Accessories Assoc., 339
Elliott Bros., 449
Ellis (A.) & Co., 583
Engineering Equipment Co. (Swansea), 339
Entente Engineering, 135
Faraday & Son, 787
Fellows Magneto, 753
Filbar Elec. Heater, 517
Fuller's Carbon & Elec., 449
Galloway Engineering, 339
General Instrument & Engineering, 237
Grinyer & Co., 651
Haddon & Co., 339
Hadon, Ltd., 753
Harlesden Lamp, 237
Headon & Marshall, 33
Hemel Hemstead Engineering, 737
Henson (Joseph R.), Ltd., 517
Higgins & Griffiths, 583
Hill Bros. Magneto, 753
Hill (Wm.) & Son & Norman & Beard, 339
Hook (C. S.) & Co., 929
Horsman (Victor), 135
Insulated Cap & Rivet, 895
International M.P. Superheater, 753
Julian & Grebert Engineering, 583
Jungo Mfg., 237
K. E. Syndicate, Ltd., 237
Kilmalloch Elec. Light & Power, 583
Lamplough Radiator & Engineering, 651
Latin America Chamber of Commerce in Great Britain, 929
Launa British Electrical, 33
Ling (Oliver) & Co., 373
Lock (Thos. J.) Ltd., 339
Lowcoyle Engine, 135,
Lyndin Partners, 339
Mander & Co., 373
McLeod & Sons, 963
Mitcham Rubber, 135
Moore & Avery (Blackburn), 373
National Wolfram Corpn., 237
N.E.C.T.A., 135
New Peto & Radford Accumulator, 617
New Union Elec., 895
Notable Elec., 929
Ogle (G. C.) & Sons, 617
Ormandy & Scott, Ltd., 929
Phillips' Magneto, 617
Phonophore Construction, 33
Powell (E.), Ltd., 67
Precision Screw, 135
Quead, Ltd., 339
Robb (Walter), Ltd., 33
Robin Hood Engineering Works, 517
S. Coast Kearney High-Speed Rly., 449
Selective Signal, 67
Selson Engineering Co., 963
Sheard (S. G.) & Co., 896
Shenton (F. J.) & Co., 339
Smith (James) Hoisting Machinery, 67
Steel's Elec. & Engineering, 896
Stevens Petrol-Electric Vehicles, 517
Storey Machine Tool, 339
Strand Elec. and Engineering, 373
Taylor (James) & Bates, 685
Telephone Motor Works, 373
Thornton (W. R.) & Son, Ltd., 929
Troup, Curtis & Co., 449
Volta Magneto, 517
Ward (Wm.) & Son (Sheffield), 517
Weekes (L.), Ltd., 517,
Wey Engineering, 517

"The Electrician"

COMMERCIAL & INDUSTRIAL SUPPLEMENT.

APRIL 7TH, 1916, TO SEPTEMBER 29TH, 1916.

INDEX TO CONTENTS.

A

Accessories, "L.P.S.," 74
Acme Three-Bar Fires, 154
Auto-Starters, Oil-Immersed, 61

B

Ballmer & Ellem, Elec. Lighting at, 2
Battery Zincs, 30
Benjamin Elec. Works, London, 54
Blue Print Washing, Drying and Ironing Machine, 120
Brake Solenoids, Single and Polyphase, 50
Brake Tank Bristle Motor Brush, 150
Bray, W. H.: Switches Up-to-Date Again, 58
British Industries, Organisation, 133
British Replacement Batteries for American Cars, 104
Bryan, The "Eco," 168

C

Cable Hangers and Clips, Elec., 111
Capstans & Windlass, Automatic Control for, 4
China, Engineering Works in, 80
Compact Luminous Chords, 4
Contactor, "Zenex" and "Hydrex," Electric, 47
Control Panels, Direct-Current Motor, 67
Cooling Apparatus, "Arctic," 128
Cookers, Elec., Economy of, 178
Coal Absorber, New, 17

D

Dynamo, London, 166
Drills, Elec., Hand and Bench, 42
Drummond Grinders, Elec., 28
Dynamo Gas and Oil, 78
Dynamos and Motors, Paddon "G" Type Continuous-Current, 96

E

Earth Switches, 121
Edison "H.O." Cells, 164
Electric Hospital Utensils, 180
Electric Light Plants, 167
Electrical Accessories, Miscellaneous, 48
Engines, Steam, Robey Semi-Portable, 8
Exhaust Accessories, 168
Extra, New Fighting Plant, 168

F

Fans, Edinburgh, 73
Fans and Portable Tools, "Sun," 124
Ferodo, Some Uses for, 148
Fire Catalogue, Carron, 192
Fires, "Quead," This Season's, 118
Flat, The Servantless, 30
Flour Mill, Modern, Electrification of, 92
Flow Meter, Electrically-Operated, 148
Furnace, Tilting Monometer, 68
Fuses, Ajax Gear and Fluvent, 74

G

Garage Lighting with Osram "Atmos" Lamps, 100
"Gasoline," Hand-Pulled, The Electric's Optimistic, 32
G.E.C. Cadet Corps, 51
Generators, Broadbent C.C., 88
German and Austrian Elec. Industries, 156
Glamox Elec. Heating and Cooking, 79

H

Hand-Worn Lanterns and Fittings, 170
Hammer Drill, Elec., Duntley Universal, 196
Helsby Elec. Supply at, 122
"Hotpoint" at Brighton, 40
House-Wiring Conductors, 146

I

Induction Motors, Alternating Current, Two and Three Phase, 24
Immersion Heaters, Belling, 94
Industrial Contractor Fuse Board, 104
Isolating Switches, B.T.-H., 70

J

"J. & P." Lamp, New, 142
Japanese Central Stations, 148
Japanese Ozone Electrically Heated, 190

L

Lamp Cables, Car Wanties, 166
Lamp Pioneer Bereaved, 172
Lamps, Half-Watt, New X-Ray Reflectors for, 43
Lamps, Osram, Inspection, 28
Lantern, Compton Hand Watt, 186
Lantern, "Electa," 14
Lantern, Industrial, 82
Lighting Set, Elec., with Overhead Valves, 126

M

Magnetic Clutches, Large, Use of, 168
Magnetic Couplings, Clutches and Brakes, 130
Manufacturing Operations, Interesting, 132
Motor, Second-Hand, 88
Motors, A.C. & D.C. Small Power, 17
Motors, Autosynchronous, 101

N

Night Light, Economical, 56
"New Maid," The, 128

O

Osram-Atmos Lamp not Affected by Atmosphere, 38
Ozone Generator, Laboratory, 190

P

Plant, Modern Electrical, 102
Portable Plant, Interesting, 14
Power "Multiplier," 154
Precision Grinder, Elec., 60
"Preparedness," 18
Propulsion, Turbo-Elec., 48
Pump, Panda, 46

Q

"Question of Origin," 102

R

Railways, Scientific Lighting for, 186
Rayburn Heating Elec., 66
"Reason" Manufactures, 11
Refectory, The Golders Green, 106
Re-Set Screw, 140
Rotor Starters, 70
Rustic Charging Electrical, 148

S

Sales, To Help, 158
Sandycroft Liquid Starting Switches, 182
Searchlights, High-Angle, 70
Shade Carrier, "Easy-Clip," 29
Shade, "Mazda," for Subdued Lighting, 22
Starting Compensators, B.T.-H. Hand-Operated, 116
Sterilisers, Simplex Elec., 59
Still, Plexsim Elec., 28
Street Lighting, Osram "Atmos" Type Lamps for, 59
Sweden's Large Ironworks, 46
Switch, New "Igranic" Two-Coil Magnetic Lock-Out, 34
Switch-Fuses, "Fluvent," for Heavy Duty, 32
Switch-Fuses, Horn Type, 44
Switch Fuses, Ironclad, 87
Switchboard, Continuous-Current, 37
Switching, Elec. Light, Exam. Results, 28
Switching Up-to-Date Again, [Bray] 58
Switchplug, A New Combined, 26

T

Table Utensils, "Universal," 86
Taylor Stoker, 82
Theatre Lighting, Artistic, 72
Three-Phase Motor, Peculiar Behaviour of, 126
Threshing by Central Station Power, 166
T.L.A. Discount Scheme, New, 90
Tumbler-Switch Controls for Small Continuous-Current Motors, 100
Tumbler-Switch Control, 194
Turbines, British-Westinghouse, Performance of, 62
Turbo-Generator of Continuous Current, 112

V

Vehicle, Elec. Self-Charger, 16
Ventilation Hygienics, Evolution in, 123
"Verilux," 48

W

"Westinghouse Supplies," 146
Winding Plant, Elec., in a Scottish Colliery, 22
Window Dressing, New Reflector, 64
Wire, Copper-Clad, 60
Wotan Monoplane Models, 144

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,977. [Vol. No. 1. LXXVII.] FRIDAY, APRIL 7, 1916. PRICE SIXPENCE (by post, 7d.). *Abroad 9d.. or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES	1
Arrangements for the Week	4
Mechanical Stresses in Transformers. By J. F. Peters. Illustrated	5
The Methods Employed for the Wireless Communication of Speech. By Philip R. Coursey, B.Sc.	7
Tests on Oil Switches. By Dr. Wyssling. Illustrated	8
Diesel Engine Users' Association	9
Distribution of Magnetic Flux in Commutating Zone of Direct-Current Machines. By Cl. Shenfer. Illustrated	10
Sir J. J. Thomson on Radiation from Atoms and Electrons. Illustrated.—*Continued*	13
Methods and Appliances for the Attainment of High Temperatures in the Laboratory.—*Discussion*	14
Institute of Industry	15
New Chemical Laboratories at University College	16
The Development of the Bureau of Standards	17
Dimensions of Electrical Units. By M. Ascoli	17
FACTORS IN SCIENTIFIC MANAGEMENT	18
Dry Cells. By W. R. Cooper, M.A., B.Sc. Illustrated.—*Concluded*	19
CORRESPONDENCE	23
Edge Effect of Plate Condensers (G. E. Bairsto).	
Efficiency of Projectors and Reflectors (H. C. Wheat).	
The "Electrician" Commercial and Industrial Section	25–34

NOTES.

Institute of Industry.

LAST week a meeting of the Institute of Industry was held to act upon a suggestion thrown out recently by Sir EDWARD CARSON, that the various bodies having at heart the future of British industry should work together instead of separately so as to benefit by the increased weight of combined action. Accordingly the Institute held a conference which a number of associations were invited to attend. As will be seen from another column, the Institute took the broad-minded line of inviting other associations to join in forming a new and representative body rather than join the Institute itself. In other words, the Institute is not aiming at continuing its own identity. We are very glad that this enlightened action has been taken. There is no question that if half-a-dozen different associations continue to handle these industrial problems, each from a particular standpoint, they must to some extent overlap one another's activities, whereas if they combine they can speak with much greater weight and be backed by far greater funds. This last point is really of the utmost importance, as no strong movement can be carried out without a large financial backing. It is far better to have one organisation with an income of, say, £100,000 per annum than five different organisations each with an income of £20,000 per-annum. At the meeting to which we have referred we were glad to find that the proposals were well received, and we hope that a further conference will take place without delay, at which the delegates of the various associations will take steps to form a single organisation. In our opinion, far too much time has so far been taken up by mere talking, and it is now time that we settled down to actions instead of words. The declaration of peace will only give us a rude awakening if we are not prepared for the changes that must follow.

Organised Research and "Sweating."

IN these columns a fortnight ago we set out in some detail the initial action taken by the Advisory Council which was appointed by the Privy Council for the organisation and development of scientific and industrial research. We return to the subject in order to suggest that the granting of the necessary time to those able and willing to undertake research in our universities and schools is as important as the granting of means. Under pre-war conditions it was customary for responsible members of the staffs of our colleges to be on duty, either in the lecture-room or laboratory, upwards of 30 hours per week. To this time must be added the time necessary for the preparation of lecture notes and the setting and marking of homework. Thus, in order to carry on the normal teaching work of our colleges, lecturers are expected to give 40 or more hours per week of their time. At some of the colleges, teachers are expected to give no less than four lectures per day in addition to a certain amount of laboratory work. Under conditions such as these it is virtually impossible for the staffs of our colleges to undertake further work. If, at the suggestion of the Advisory Council, the Board of Education threatened to withhold the grants from those colleges and schools where "sweating" is practised by the local education authorities, we venture to think that the evil would be quickly remedied. Had the Board to fix for each lecturer a maximum of four or six lectures per week, and a maximum of 12 to 15 hours teaching per week, it would be relatively easy for the Board to insist on men undertaking research or engaging in outside work As it is, the Board closes its official eye, and takes the line of least resistance.

Lighting of Factories.

A MEMORANDUM has been issued by the Health of Munition Workers Committee on the ventilation and lighting of munition factories and workshops, and forms one of a number of memoranda to which we refer in our Leading Article. The present memorandum deals more particularly with questions of ventilation and heating. In regard to lighting, very little is added to the rules which have been laid down on more than one occasion, and more particularly in the report of the Departmental Committee of Lighting in Factories and Workshops. A preference is expressed for natural lighting as against artificial lighting, on the ground of health as well as economy, and where possible roof lighting is advocated. Attention is also called to the desirability of light-coloured walls and white ceilings and to the necessity of the regular cleaning of windows. It is pointed out that bad illumination affects the output unfavourably, not only by making good and rapid work more difficult, but by causing headaches and other effects of eye-strain. All this is well recognised by those who deal with such matters, but these points will, no doubt, only become fully appreciated by the public at large through continual reiteration.

University College Chemical Laboratories.

Last week it was our privilege to inspect the new chemical laboratories at University College. To give the reader some idea of the magnitude of these laboratories we would ask him to imagine a great building larger than many of the technical colleges in our big industrial towns; a building upon which a sum of close upon £100,000 has already been expended. For the purchase of the necessary equipment a further £20,000 is required. Industrial chemistry is a subject about which a good deal has been said during the past 18 months, and, of late, our need of trained technical chemists has forcibly been brought home to us. That our scientists recognised the need before our statesmen is shown by the fact that in London to-day laboratories second to none in Europe are ready for occupation. For this reason we venture to think that those who attach importance to the doing of things, as distinct from the talking about them, will subscribe liberally to the fund. Donations may be sent to the treasurer of the Equipment and Endowment Fund, Capt. the Hon. Rupert Guinness, C.B., C.M.G., M.P., and should be addressed to the college. We understand that gifts of electrical machinery and apparatus for the laboratory of physical chemistry will be highly appreciated, and those of our manufacturers interested in higher education will do well to get into touch with Prof. Donnan. Highly creditable features of the work are that the Professor of Architecture has been responsible for the design of the buildings, and the whole of the electrical work has been carried out under the direction of Prof. Fleming.

Organisation of the British Engineering Industry.—At the Manchester meeting of the Council dealing with this question, on the 4th inst., Mr. Fleming (Westinghouse Company) said it would be an excellent investment if manufacturers would devote a percentage of the gross profits arising from their industrial processes to establish research laboratories.

Transporters.—To "Engineering Review" Mr. H. Hubert recently contributed an article entitled "Trolley Hoist Transporters." The author dealt with hoists and electric telpherage conveying systems, and described the chief features of the mono-rail telpher. These features are track, wheels, tractive effort, overhung axles, balance, curves, track-switch, direct lift, working load and speeds. Illustrations of typical installations were given.

Corps of Royal Engineers (Wireless Section).—This Section of the Corps of Royal Engineers is open to recruit first-class electrical instrument makers. Conditions as to pay, terms of service, &c., can be obtained by application to the Commanding Officer. Applicants should state fully their training and experience and say if they are eligible for service. Candidates should forward their application to Major A. Handley, C.O., Wireless Training Centre, St. Martin's Gate, Worcester.

Light and Intensive Culture.—Prof F. Keble, lecturing at the Royal Institution on April 4th, stated that Germany, Italy and California were great seed-growing countries on account of their high intensity of sunlight. Experiments which had been made showed that the yield of crops might be increased by artificial light. It might be possible to reinforce our obscure daylight by artificial means, and it would be curious if in the next century the finest results were obtained in the Black country by electric light.

Foreign Trade and American Specifications.—"Engineering Record" states that the Executive Committee of the American Society for testing materials has made the announcement to American industrial circles that it undertakes translation into foreign languages of such standard specifications which have an important bearing on American export trade. All numerical quantities are expressed in metric and English systems. It is intended to distribute these specifications among the United States Consular offices throughout the world. They are available to American manufacturers and others interested in foreign commerce at a moderate price.

Entropy and Probability.—In the kinetic definition of entropy it is necessary to define a function, S, which satisfies the equation $dS=dQ/T$ on transition from a state of equilibrium to a neighbouring one, and also increases in an isolated system which is not in equilibrium. Mr. O. Postma, in a Paper read before the Koninklijke Akademie van Wetenschappen te Amsterdam on this question, removes the difficulties, and under certain circumstances shows that Planck's and Tetrode's formulæ can be deduced from his results.

Mechanical Equivalent of Light.—Dr. Irving Langmuir, in the "Physical Review," has calculated this quantity, using Nutting's visibility data, and taking as constants of Planck's equation $C_1=3{\cdot}72\times10^{21}$ watts and $C_2=1{\cdot}4392$. He obtains 0·00121 watt per lumen, which compares well with Nutting's value of 0·00120. He considers the value 0·00162 as incorrect, since it would make the emissivity of tungsten 0·67 instead of 0·50, and the melting point would require to be at least 3,750°K., which seems inconsistent with his observations.

Absorption of Sound.—Mr. F. R. Watson, writing in the "Physical Review" on "An Investigation on the Transmission, Reflection and Absorption of Sound by Different Materials," has made experiments by means of a whistle emitting a given note placed in the focus of a parabolic reflector. The receiver of sound was a Rayleigh resonator placed in another room, the sound having to pass through a doorway, which could be closed by various materials. It was found that pressed-fibre $\frac{1}{4}$ in. thick practically stops all sound, and $\frac{1}{4}$ in. cork-board stops 80 per cent. of it, three layers stopping 92·6 per cent. It appears that the transmission of sound at constant pitch depends on the porosity, density and elasticity of the material. Porous bodies transmit sound much in the same proportion as they transmit air. The pressed-fibre stops more sound than cork, because it is heavier.

Zinc Wire.—In the "E.T.Z." there is an official announcement of the German Association of Electrical Engineers on the use of zinc wire. This is now being introduced in Germany on account of the scarcity of copper and because iron wires are not always satisfactory. The comparative figures for copper, aluminium, zinc and iron are as follows:—

——	Copper.	Aluminum.	Zinc.	Iron.
Specific resistance at 20°C. in ohms per metre and square millimetre.	0·0178	0·0306	0·0625	0·143
Conductance at 20°C. in Siemens per metre and square millimetre.	56·2	32·7	16·0	7·0
Conductivity in per cent. of copper	100·0	58·4	28·5	12·5
Temperature coefficient per deg. C.	0·004	0·004	0·0039	0·0057

Rules are given on the use of zinc wires in house installations and on the use of zinc cables and zinc bus bars.

Crystal Size and the Electric and Magnetic Properties of Pure Iron.—Mr. F. C. Thompson, B.Sc., gives the results of an investigation of this question in the "Philosophical Magazine." Regarding the electrical resistance of pure iron the formula for specific resistance $\rho_1=\rho_2+nR$, where ρ_1 is the observed specific resistance, ρ_2 is the specific resistance of the crystalline portion, n the number of crystals per centimetre, and R the boundary resistance for each grain. Various specimens were treated differently, so as to alter the crystalline structure, and in each case an increase in crystal size caused a decrease in the resistance. The formula $\rho=6{\cdot}83+1{\cdot}72n\times10^{-3}$ microhms per cubic centimetre was derived from the results. Regarding the magnetic properties, the results obtained indicate that the maximum induction, and remanent magnetisation for a field of 95 gauss were, to all intents and purposes, independent of the size of the crystals. The author considers that by suitable annealing processes iron for transformers might be obtained with far lower hysteresis than anything yet produced.

Pure Iron.—Entitled "Preparation of Pure Iron and Iron-Carbon Alloys," a Paper has recently been published in the "Bulletin" of the Bureau of Standards by Messrs. J. R. Caine, E. Schramma and H. E. Cleaves. Methods have been developed for producing laboratory samples of iron-carbon alloys of a very high degree of purity. Sources of contamination of melts and means of eliminating are described; a method for producing magnesia of a satisfactory degree of purity for making crucibles to be used in work of this kind has been developed; a procedure for making small ingots which are sound and free from blow-holes without the use of deoxidisers has been worked out. A series of iron-carbon alloys containing 99·96 per cent. of the two elements have been prepared to serve as a basis for the re-determination of the iron-carbon equilibrium diagram.

Electrolytic Corrosion.—Before the American Institute of Electrical Engineers on March 10 Messrs. Burton McCollum and G. H. Ahlborn read a Paper entitled "The Influence of Frequency of Alternating or Infrequently Reversed Current on Electrolytic Corrosion."

The authors describe experimental work that has been carried out to determine the coefficient of corrosion of iron and lead in soil with varying frequencies of alternating or reversed current with 60 cycles per second as the highest frequency and a two-week period as lowest, some continuous-current tests being made as a check on the methods. The results show: (*a*) that a decrease of corrosion occurs with an increase in frequency; (*b*) that the corrosion is practically negligible below a 5-minute period; (*c*) that there is a limiting frequency above which practically no corrosion occurs; (*d*) that certain chemicals affect the natural and electrolytic corrosion of the two metals quite differently; (*e*) that the loss of lead on continuous-current is about 25 per cent. of the thoretical loss; and (*f*) that alternating or reversed current with as long periods as a day or a week would in the case of iron materially reduce the damage to underground structures. The importance of these results follows from the fact that there are large areas in practically every city in which the polarity of the underground pipes reverses with periods ranging from a few seconds to an hour or more, due to the shifting of railway loads. The investigation shows that the corrosion under such conditions is much less than has generally been supposed.

Electric Winding in Scotland.—The "Colliery Guardian" has a description of an up-to-date electric winding plant installed at the Breich Pit of the Pumpherston Company, near Edinburgh. A feature of the system is a very complete remote control apparatus, which will bring the cages to rest in event of anything unforeseen happening. The winder combines the Ward-Leonard system of control, with a flywheel equaliser between the winding motor and supply mains. The advantage of the flywheel is shown when the peak load is 400 H.P., yet the maximum demand on the generator never exceeds 200 H.P. In event of power failure also the flywheel stores sufficient energy to give one or two winds. The winder itself is of the ordinary parallel drum type, and winds from a depth of 65 fathoms. The power is taken from a three-phase high-tension line at 3,000 volts, 50 cycles. This supplies a motor-generator set consisting of a three-phase motor, a variable-voltage direct-current generator and constant-voltage exciter. The normal speed of the motor-generator flywheel set is 750 revs. per min. The winding motor is separately excited, and has its armature permanently connected to that of the variable-voltage generator. The speed and direction of the winding motor are controlled by the position of the driver's control lever. Braking is effected by post brakes operating on machined brake paths cast on the drum cheeks, a compressed air cylinder operating the brake blocks, and which come into action when the air pressure is released. The emergency brake can also be operated by hand from the driver's platform.

Electric Power in Mining.—Mr. J. N. Bulkley, in a Paper read before the American Institute of Mining Engineers, refers to the fact that there are 143 electrically-driven hoisting engines on the Rand, exclusive of winches. The combined continuous rating of these is over 74,000 H.P.

With regard to winches, these are usually driven by a slip-ring motor, and double reduction gearing is used. The controller is of the tramway type. Owing to difficulties in control, which are not easily met by steam engines, electric motors controlling sinking plant are used, the first shaft to be sunk electrically being the central shaft of the Cinderella Consolidated Gold Mining Co. In this case the motor is of the synchronous type, fitted with starting motor, an exciter wound for double the normal voltage and a 8-ton 10 ft. flywheel running at 750 revs. per min. In case of power failure the reverse power rotary operates, leaving the motor driven by the flywheel operating as a generator, but so connected that the hoist bucket could be pulled up. Actually, however, the switch is tripped by hand, and the sinkers before each blast are hoisted by the flywheel. With regard to main hoists, the central stations on the Rand are so large that it is unnecessary to install any flywheel equalising sets. Rheostatic control is unsafe for speeds beyond those controlled by mechanical brakes, which the author places at about 1,500 ft. per minute. If eddy-current brakes are used the extra cost for motor-generator set makes the cost almost as high as for the Ward-Leonard system. The hoist control for rheostatic hoists was with liquid rheostat, and movable wire for torque control, and oil switch and air brake contactors for direction control, both of these being operated from one lever. On large machines compressed air has proved unsatisfactory. When the Ward-Leonard system is used the hoist motors are of fairly large size, so that commutator troubles are avoided, and a good motor for direct coupling to the drum shaft can be obtained. These sets are usually provided with interpoles and compensating windings on the generator. In some cases the Deri distributed winding is used with marked success. The control in such cases is by regulation of the generator field, other systems of control using rotary converters, and others again using "bucking motors," which are not used on the Rand. In the Ward-Leonard system every position of the control lever is equivalent to fixed generator excitation; this makes the control very easy for the driver.

OBITUARY.

ERIC GERARD.—We regret to record the death of Prof. Eric Gerard, in Paris, on the 28th ult. Born at Liége in 1856, he left the University of Liége in 1878 with the honorary degrees of Ingénieur des Mines and Ingénieur des Arts et Manufactures, and completed his electrical studies at the Ecole Supérieure de Télégraphie. He then



THE LATE PROF. ERIC GERARD.

became engineer in the Belgian State Telegraph Service, was secretary with M. Mascart of the first Congress of Electricity in Paris, 1881, and in 1883 was called to be principal of the Montefiore Electro-technical Institute, founded in connection with the Liége University. Prof. Eric Gerard was the author of "Eléments d'Electrotechnique," and of "Lecons sur l'Electricité," many editions of which have been issued. He also published "Mesures Electriques" and "Traction Electrique," and collaborated with M. de Bast in writing "Exercices et projets d'Electrotechnique." Prof. Gerard had several flattering offers to manage industrial concerns, but he preferred to continue in his educational career. He was president of the Belgian Official Board of Electricity, member for Belgium of the International Committee of Electrical Units, president of the Belgian section of the International Electrotechnical Commission, and an Officer of the Ordre Léopold and other valued orders. So far as the International Electrotechnical Commission was concerned, Prof. Gerard was always of the greatest assistance, because of his open-mindedness and kindly disposition whenever he attended any of the large meetings or the smaller Committee meetings. He presided at one of the early meetings of the Commission in 1910 in Brussels, when he made a

most interesting speech on the aims and objects of the Commission. Under his personal direction the delegates went through the Brussels Exhibition, and also visited Liége and were received at the Institut Montefiore, so well known to a very large number of Prof. Gerard's students now scattered all over the world. He was also secretary of the first section of the Paris Congress dealing with units in 1881. He took a keen interest in nomenclature, and was present both in Paris and Cologne when the International Committee had a nomenclature meeting. He will be mourned by a very wide circle of friends, students and admirers.

PERSONAL.

ROYAL ENGINEERS (T.F.)—The following promotions have been made :—

London Electrical Engineers : Sapper A. M. Jenkins, Sapper F. S. Aldred and Private R. G. Burton (from Artists' Rifles, O.T.C.), to be Second Lieutenants (on probation).

Tyne Electrical Engineers : Second Lieutenant Herbert G. White to be temporary Captain and to be seconded.

APPOINTMENTS VACANT.

A station engineer is required by the War Department, conversant with internal combustion engines and maintenance of wiring and motors. Applications to Chief Engineer, Southern Command, Radnor House, Salisbury.

A first-class foreman armature winder, used to a.c. and d.c. winding, is advertised for.

An electrician is required for the Gold Coast Government waterworks. Salary £300, rising to £350, with free quarters. Candidates must be capable of taking charge of 500-volt suction gas generating plant and electric motors. Applications to the Crown Agents for the Colonies, 4, Millbank, London, S.W. *See an advertisement.*

INSTITUTIONS AND SOCIETIES.

Institution of Electrical Engineers : Birmingham Section.—In accordance with the rules relating to local sections, the Committee have prepared the following list of officers to act during the session 1916-17 : *Past Chairmen*, M. Railing (1910-11-12), A. M. Taylor (1912-13-14), A. H. Railing, D.Eng. (1914-15). *Chairman*, Col. J. F. Lister, R.E. *Vice-Chairmen*, S. T. Allen, N. B. Rosher. *Present ordinary Members of Committee (remaining in office)*, H. Foulds, C. C. Garrard, Ph.D., S. H. Holden, W. A. Jackson, Prof. G. Kapp, D.Eng., W. Marden, A. Pearson, B.A., W. E. Sumpner, D.Sc., F. Thursfield, J. M. Walshe. *Ordinary Members of Committee (new nominations)*, *F. H. Clough, T. Plummer, E. O. Turner. Hon. Secretary*, J. D. Morgan. The Committee's nominations are given in italics. They herewith invite other nominations, and it is suggested that the members in each important centre should send in a nomination for that particular centre. In compliance with Rule 7 of these General Rules, Messrs. F. W. Carter, C. M. Shaw and A. Willmott, who are members of the present Committee, are not eligible for re-election this session, having served for three years consecutively. Nominations must reach the Hon. Secretary at 13, Temple-street, not later than Wednesday morning, the 12th April, and in the event of any being received a ballot list will be prepared and circulated. The list of officers for 1916-17 will be declared at the annual general meeting of the section on May 3, 1916.

The following letter has been forwarded to members : "Your Committee have had under very careful consideration the question of alien enemy membership which is at present before the Institution. After a full discussion of the matter at two meetings, your Committee unanimously passed the following resolutions for transmission to the Council of the Institution, and I was instructed to send you a copy of the same : (1) That the Council be requested to obtain powers to amend the articles of association to exclude from membership of the Institution any undesirable aliens or undesirable members of alien origin. (2) That in view of the foregoing resolution it is not considered necessary to proceed with the resolutions at present before the Institution."

Incorporated Municipal Electrical Association.—The programme has been issued of the Convention of this Association, which will be held on June 22nd and 23rd. The arrangements are similar to those of last year, the proceedings being limited to two days, the first being technical and the second restricted to business matters. The meetings will be held at the Institution of Electrical Engineers. On Thursday, June 22nd, Mr. A. C. Cramb will deliver his presidential address, and Papers will be read by Mr. W. W. Lackie on "Boiler House Design," by Mr. H. S. Ellis on the "Area of Supply from an Economic Standpoint," and by Mr. W. T. Kerr on "The Application of Electric Power to Agriculture."

Junior Institution of Engineers.—The meeting arranged for the 10th inst. has been postponed till the 18th inst., when a Paper on "Speeding-up in an Engineering Factory," by Mr. R. Rankin, B.Sc., will be read.

Royal Society.—Amongst the Papers read at last Thursday's meeting we notice the following : "On the Instability of the Pear-shaped Figure of Equilibrium of a Rotating Mass of Liquid," by J. H. Jeans, F.R.S. ; "A Hypothesis of Molecular Configuration in Three Dimensions of Space," by Sir William Ramsay, K.C.B., F.R.S.

Machine Tool & Engineering Association (Ltd.)—The fifth annual report (for 1915) states that six firms joined the Association and three resigned during the year, making the membership 134. Three applications for membership were refused.

The next exhibition had been arranged to be held from Sept. 28 to Oct. 18 next, but owing to the war this will have to be postponed.

Four exhibitions were considered by the board during the past year, and in two cases no support or approval was given, in one individual members were allowed to exhibit, and in the fourth general permission to exhibit subject to certain restrictions.

The ordinary activities of the Association have been largely suspended since the formation of the machine tool department of the Ministry of Munitions, and more especially since all machine tool works became controlled establishments. The Association has rendered some assistance to the Ministry of Munitions, and the Secretary of the Association is the secretary of the machine tool department.

In view of the fact that the existing classification of machine tools for Customs purposes is very imperfect in consequence of which the Board of Trade returns are very misleading, representations have been made to the Board of Trade, and a promise has been given that the matter shall receive attention after the war, during which no alterations are being made to the classifications.

Negotiations have been opened with the British Electrical & Allied Manufacturers' Association with a view to the re-adjustment of certain trading practices as between machine tool makers and electrical manufacturers. While it is not possible to continue usefully the negotiations at present it is proposed to resume them after the war.

A recommendation was made to the members as to the attitude to be adopted to firms having connections, direct or indirect, with alien enemies.

Dynamicables' Anniversary Meeting and Dinner.—We are informed that this will take place at the Trocadero Restaurant at 7.30 p.m., Wednesday, the 12th inst. Mr. C. P. Sparks will be in the chair.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, April 7th (to-day).

N.E. COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

7:30 p.m. At the Lecture Theatre, Literary and Philosophical Society, Westgate-road, Newcastle-on-Tyne. Address by Mr. T. C. Elder, "The Business Side of Science : Its Part in the Coming Economic Crisis."

SATURDAY, April 8th.

THE ROYAL INSTITUTION.

3 p.m. At Albemarle-street, W. Lecture by Prof. Sir J. J. Thomson, F.R.S., on "Radiations from Atoms and Electrons." (Lecture V.).

BIRMINGHAM AND DISTRICT ELECTRIC CLUB.

7 p.m. Meeting at the Swan Hotel, New-street. Paper by Mr. W. H. Whitehouse on "Standard Time and Its Distribution by Telegraph."

THURSDAY, April 13th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. At Victoria Embankment, W.C. Discussion on "The Present Position of Electricity Supply in the United Kingdom, and the Steps to be taken to Improve and Strengthen it."

ENGINEERING INSTITUTIONS VOLUNTEER TRAINING CORPS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

The following orders have been issued for the week commencing April 10, 1916.

Drills, 6:25 to 7:25 ; 7:25 to 8:25.

Monday, April 10th.—Sections 1 and 2, Technical ; Sections 3 and 4, Squad and Platoon. Signalling Class and Recruits.

Tuesday, April 11th.—School of Arms, 6 to 7 p.m.

Thursday, April 13th.—Shooting for Sections 3 and 4.

Friday, April 14th.—Sections 3 and 4, Technical ; Sections 1 and 2 Squad and Platoon. Signalling Class and Recruits.

Saturday, April 15th.—Adjutant's Instruction Class at 2:30 p.m.

Sections for Technical Parade at Headquarters, London Electrical Engineers, 46, Regency-street, S.W.

Sections for Shooting Parade at Miniature Ranges.

Unless otherwise stated, all parades at Chester House.

Members who have not yet been measured for uniforms must call on Samuel Bros., Ludgate-hill, as soon as possible.

MECHANICAL STRESSES IN TRANSFORMERS.*

BY J. F. PETERS.

Summary.—The distribution of the leakage field and the stress due to the groups of coils in certain cases is considered. Formulæ are then derived for the magnetic forces between coils and the radial forces operative when coils are out of centre, as well as the forces acting on the leads, is dealt with. Finally, the attraction of rectangular leads placed close together is discussed.

The mechanical stresses in transformers are caused by the stray magnetic fields that pass through the windings. These fields are caused by the load currents and are proportional to the product of these currents into the number of turns in the windings. The magnitude and distribution of these leakage fields depend, in addition to the number of turns and the current, upon the groupings or interspacing of the primary and secondary windings and upon the dimensions of the core and coils.

As a preliminary step toward arriving at the value of the mechanical stresses, it is well to consider the distribution of the leakage field. A cross-section of one-half of a shell-type transformer having four primary and four secondary coils is shown in Fig. 1. There are

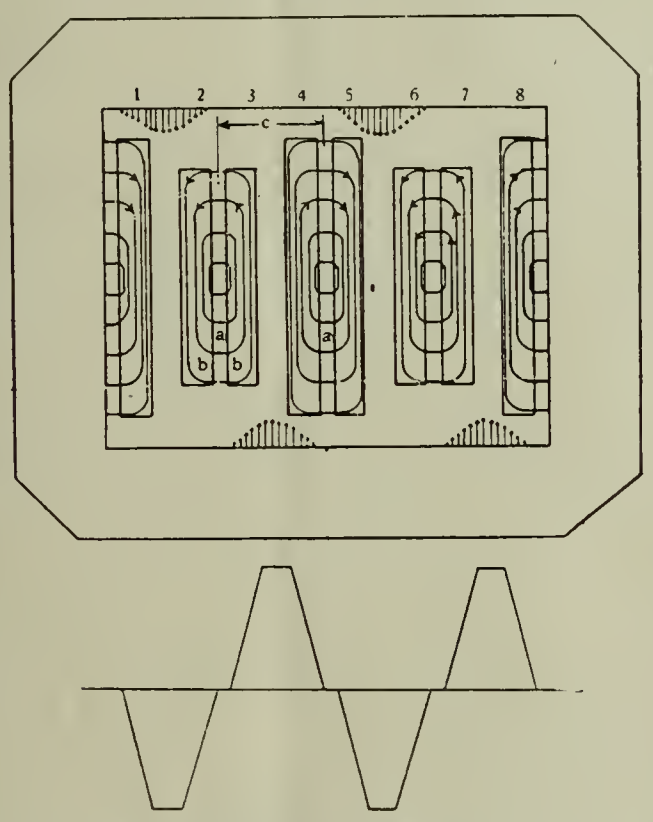


Fig. 1.—Diagram Representing the Magnetic Conditions in a Shell-type Transformer.

two distinct leakage fields superimposed. One is due to the individual groups of coils and the other is due to the combined primary and secondary groups.

An element of M.M.F. has a magnetic field surrounding it. The lines of this field, if magnetic material is absent, will be circles with the element M.M.F. as a centre. If a second element of M.M.F. is near, it, too, will be surrounded by circular lines of force, but the two fields will combine and the resultant will be an elliptically-shaped field, as shown by Fig. 2. If magnetic material such as iron is in the

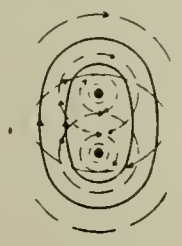


Fig. 2.—Magnetic Field Surrounding Two Elements of M.M.F.

neighbourhood, the lines of force will tend to crowd into the iron and further distort the field. Referring to Fig. 1, the contour lines of force indicated at *a* have approximately a circular shape in the centre of each group, while as they advance outwardly they become more distorted, tending toward the shape of the coils.

Considering the instantaneous direction of current in the primary coils 1, 4, 5, 8 as being down through the paper, and that of the secondary coils 2, 3, 6, 7 as being up through the paper, the fields due to the M.M.F.s would be in the direction indicated by the arrows. The mechanical force, due to the local field in a group of coils, on a conductor located at *b* in coil 2 would tend to draw this conductor toward the centre of the group of coils 2 and 3.

The stress due to the field in any group of coils, due to its own M.M.F. tends to draw the conductors closer together. In addition to the field in the individual groups of coils, there are magnetic fields directly across the opening. These fields are caused by the combined M.M.F.s of the primary and secondary groups. Consider the space between coils 1 and 2. Coil 1 has a M.M.F. producing a field in a clockwise direction, while the M.M.F. of coil 2 produces a field in a counter-clockwise direction. With a symmetrical grouping which is assumed in this case, so far as the space between coils 1 and 2 is concerned, the M.M.F. of coil 3 is cancelled by coil 4, that of coil 5 is cancelled by 6, and that of coil 7 by coil 8. This leaves the M.M.F. of coil 1 or coil 2 (they being of equal values, but in opposite direction) to produce a field down across the opening between coils 1 and 2. This M.M.F., and also the magnetic field, gradually decrease as the outer surface of coil 1 is approached, becoming zero in the space between this surface and the iron. The magnitude of this field is plotted in the lower part of the figure.

With the current in coil 1 flowing down through the paper and with the magnetic field in the direction indicated by the arrows, the conductors in coil 1 would be forced toward the left of the figure. Since there is no magnetic force in the opposite direction on coil 1, this force must be balanced by a brace against the side of coil 1. Considering the force on the other coils, that between 1 and 2 tends

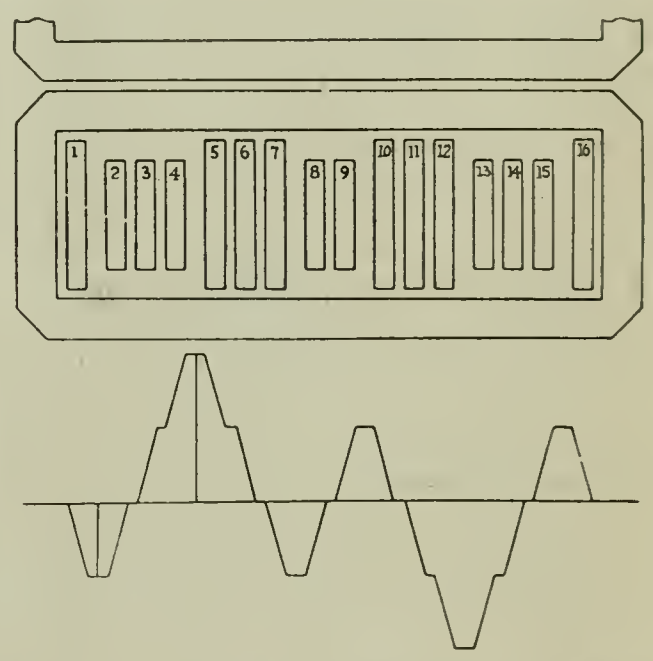


Fig. 3.—Magnetic Conditions in a Shell-type Transformer with Unsymmetrical Grouping of Coils.

to move coil 2 to the right, but there is an equal force between 3 and 4, tending to move 3 to the left. Therefore, these two forces balance each other. In like manner the force between 5 and 6 balances the force tending to move 4 to the right, and the force between 7 and 8 balances the force tending to move 6 to the right. Therefore, all of the forces are balanced except those tending to move coil 1 to the left and coil 8 to the right. When the coil arrangement is not symmetrical—that is, when the groups do not all have the same number of ampere-turns—the repulsion between some of the inner groups will not be balanced by equal and opposite forces between other groups. Referring to Fig. 3, which represents an unsymmetrical grouping, all coils having the same number of ampere-turns, the force between 4 and 5 is greater than that between 1 and 2, since the group 5, 6, 7, 8 has more ampere-turns than 2, 3, 4. The extra force between 4 and 5 is transmitted through the group 2, 3, 4, and is added to the force between coils 1 and 2, which produces an extra force tending to move coil 1 to the left.

The M.M.F. producing the field down across the space between coils 1 and 2 is equal to the ampere-turns in coil 1. If I is the effective current, N is the number of turns in coil 1, and a=the effective length of the leakage path in centimetres, the maximum density of this field in gausses at the right-hand edge of coil 1 is $B=\frac{4\pi\sqrt{2}IN}{10a}$.

The flux density of the field varies from a maximum at the right-hand surface to zero at the left-hand surface of coil 1. The average density then is :—

$$B_{av.}=\frac{2\pi\sqrt{2}IN}{10a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

* From the "Electric Journal," slightly abbreviated.

The force in dynes acting on a conductor carrying current when in a magnetic field, is :—

$$F=\frac{B\sqrt{2}INl}{10}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where I and N are the same as in the foregoing and l is the length of the turns in centimetres. Combining (1) and (2) :—

$$F=\frac{4\pi I^2N^2l}{100\,a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Assuming I to be of a sine-wave form, then F is a sine^2 function, and the average force over one-half cycle is :—

$$F_{av.}=\frac{2\pi I^2N^2l}{100\,a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

for (1) and (2), a and l are in centimetres, but in (4) one is in the numerator and the other in the denominator, and, therefore, they can be expressed in inches without altering the value of F. Expressing the force in pounds (4) becomes :—

$$P_{av.}=\frac{1{\cdot}41I^2N^2l}{a\times10^7} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

In the above expression l is the average length of that part of the coil onr which the foce is desired, and a, the effective length of the leakage path, is the per cent. average width of the primary and secondary coils plus a small amount due to the ends of the leakage path$=\frac{2h_1h_2}{h_1+h_2}+\frac{C}{3}$ approximately, where h_1 and h_2 are the widths of the primary and secondary coils and C is the distance from centre to centre of adjacent coil groups, as indicated in Fig. 1. The force against the outer group of coils is that due to the largest group. For instance, referring to Fig. 3, each coil contains 16·7 per cent. of the total turns of either the primary or secondary. Starting from the left-hand side, coil 1=16·7 per cent. and coils 2, 3, 4=50 per cent.

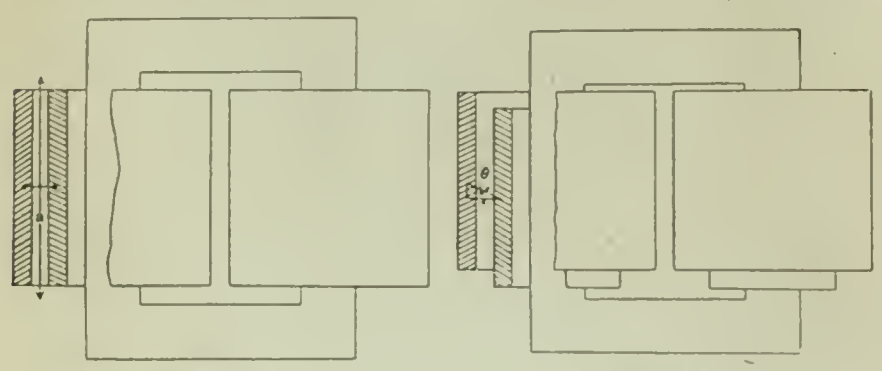


Fig. 4. Fig. 5.

Diagram of mechanical stresses between primary and secondary coils in a core-type transformer, when the electrical centres coincide (Fig. 4) and when they do not coincide (Fig. 5).

Subtracting 1 from 2, 3, 4=50−16·7=33·3 ; therefore, the stress between groups 2, 3, 4 and 5, 6, 7 is that due to 33·3 per cent. of the total number of turns. This should be used for N in (5) to get the force against the support on the left of coil 1, or that against the right of coil 12.

Usually the force on that part of the coils within the iron of shell-type transformers is not of great importance, as the compression of the coils and spacing strips between coils is well within a safe limit, and the iron punchings forming the ends of the opening will resist the tendency of that part of the coils to move outwardly. That part of the coils which extends beyond the iron, however, must be supported by some method of clamping or bracing. An effective method of bracing consists of heavy wooden blocks backed with boiler plate placed against the outer face of the coils. Structural iron channels or angles extend across the block, and tie rods extend from the ends of one structural iron brace to the ends of the other. With this method of bracing, the frames supporting the core receive no stresses from the winding. Also, there is no tendency to distort the coils, since there is always an equal and opposite force against the outer coils on each side of the transformer.

In the core type of transformer with cylindrical concentric coils, the force between primary and secondary is radial. The force on the inner coils is toward the core (one of compression), and on the outer coils is away from the core (one of tension). If the electrical centres of the primary and secondary windings coincide there is no force tending to move the coils in a direction parallel to their axis, and, therefore, no necessity for bracing against end thrusts. The compressive and tensile strength of the coils are in general, ample to resist the radial forces. If the coils are rectangular, the force between coils tends to force the outer coil into cylindrical shape. In large units this force may be large enough to injure the coils. Small units, however, can be built of rectangular coils and safely withstand the short-circuit stresses.

It is a very difficult matter to have the electrical centres coincide under all conditions, especially when the windings have taps provided for changes in voltage. When the centres do not coincide, the mechanical force tending to separate the primary and secondary windings can be resolved into two components, one radial and the other parallel with the axis of the coils. It requires only a slight shifting of these centres to produce an enormous force tending to move the coils in a direction parallel with their axes.

The radial force in pounds between coils, Fig. 4, is approximately $P_{av.}=\frac{1{\cdot}41I^2N^2l}{a\times10^7}$, where l is the average length of turns in both coils and a is the effective length of the leakage path, both dimensions being in the same units. With the electrical centres shifted, as indicated in Fig. 5, the total force will be approximately the same as above, but the radial force now is $P_{av.}\cos\theta$, and there will be an end thrust on the coils of $P_{av.}\sin\theta$. It is sometimes a difficult matter to brace the coils against this end thrust without materially interfering with the ventilating ducts for the windings.

Another phase of mechanical stress that should be taken into consideration in the design of transformers is the force on the leads extending from the coils to the outlet connections. This is of importance only where large currents are involved. Since under short-circuit conditions the current may reach 20 times normal value or more in large transformers of low voltage, the mechanical force on the leads may be of sufficient magnitude to wreck the supports, unless they are liberally designed. This force can be calculated in the following manner :—

Let l be the length of the leads and a their separation centre to centre, I_1 the current in one lead and I_2 the current in the other in amperes. Then with no iron around the leads, which is generally the case, the flux density at lead 2 due to lead 1$=B=\frac{4\pi\sqrt{2}\times I_1}{2\pi a\times10}$, where a is in centimetres. The force in dynes on lead 2, either attraction or repulsion, is

$$F=\frac{\sqrt{2}I_2Bl}{10}=\frac{4I_1I_2l}{a\times100}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

in which l and a are both to be expressed in the same units. This gives the maximum force. The average for a cycle is one-half of this. The average force in pounds is :—

$$P_{av.}=\frac{2I_1I_2l}{445a\times10^5}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

If I_1 and I_2 are the currents in the leads at opposite ends of the same winding the force will be one of repulsion. In this case $I_1=I_2$ or the force varies with I_2. If I_1 and I_2 are in the leads of the same polarity the force will be one of attraction. If I_1 and I_2 are in different phases of a three-phase transformer, then the force is one of attraction if the currents are 60 deg. apart, and one of repulsion if 120 deg. apart. When the leads under consideration are in different phases of a polyphase transformer, then the force, whether attractive or repulsive, is proportional to the product of the currents multiplied by the cosine of the time angle between the currents. The force can, therefore, be expressed as one of attraction, as it is attraction for all angles less than 90 deg. and for angles greater than 90 deg. the cosine is of a minus value, and a minus attraction is a repulsion. The expression then for the force of attraction between two conductors carrying currents of the same frequency is :—

$$P_{av.}=\frac{2I_1I_2l\cos\theta}{445a\times10^5}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Equation (8) is applicable when the leads are circular or if of rectangular shape when they are separated several times their width (when a in Fig. 6 is several times b). When the leads are rectangular

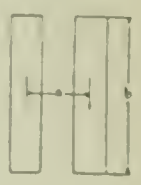


Fig. 6.—Cross-section of Rectangular Transformer Leads.

and close together, as shown in Fig. 6, the force of attraction can be calculated by the following expression :—

$$P_{av.}=\frac{2I_1I_2\cos\theta\,a\,l}{445b^2\times10^5}\left[\frac{b}{a}\tan^{-1}\frac{b}{a}-\tfrac{1}{2}\log_e\left(1+\frac{b^2}{a^2}\right)\right] \quad . \quad . \quad (9)$$

where the angle $\tan^{-1}b/a$ is in radians. When a is considerably larger than b, $\log_e(1+b^2/a^2)$ is approximately zero, and $\tan^{-1}b/a$ is approximately equal to b/a. Under these conditions (9) takes the same form as (8). The derivation of equation (9) is not given.

THE METHODS EMPLOYED FOR THE WIRELESS COMMUNICATION OF SPEECH.*

BY PHILIP R. COURSEY, B.SC.

Summary.—Conduction and induction methods; also photophones and thermophones are considered, and their limitations discussed. The essentials for success follow, and in conclusion the author deals with arcs, gaps and high-frequency generators and transformers.

After a discussion of the earlier methods of attacking the problem of wireless telephony, the author considers the different ways in which suitable waves are produced. This leads to the more recent arc methods.

Arc Methods of Generating Oscillations.

If we take an ordinary continuous-current arc, and, while maintaining the arc length constant, we vary the current passing through it, and at the same time measure the P.D. between its terminals, we obtain what is called the characteristic of the arc. In the case of all ordinary arc discharges this characteristic is what is called a "falling" or "negative" one, that is to say, when the current is increased the voltage falls, and *vice versa*. Hence, if we connect across such an arc an oscillation circuit containing a condenser, there will be a sudden rush of current into the condenser tending to charge it; this current rush will momentarily cause a decrease in the arc current, with, as a result, a corresponding rise of the P.D. across the arc terminals. This voltage rise tends to further charge the condenser to a voltage *above* the normal running voltage of the arc. It then begins to discharge, and this discharge current is in the same direction through the arc as the supply current, and hence causes a fall in the arc P.D. by reason of the increased current. This further facilitates the condenser discharge. As the condenser completes its discharge, the arc current falls and the P.D. rises again to its normal value, when the cycle is repeated over again and continues indefinitely as long as the supply is maintained, and the arc retained of a constant length.

Hence the condenser will be continuously charged and discharged, at regular intervals depending on the inductance in the circuit, the capacity of the condenser, and the length and other conditions of the arc; in other words, continuous oscillations will be set up in the circuit by virtue of this action of the arc.

It follows from considerations of the arc characteristics that we require an arc which has a very steep characteristic in order to produce oscillations of wireless frequencies with any degree of readiness. By inspection of the characteristics, we see that they become much steeper for small arc currents, while at the same time for a given current a longer arc at higher voltage has a steeper characteristic, and hence in general low-current arcs oscillate better than heavy current arcs.

As a rough guide for experimental purposes it will generally be found necessary to limit the supply current value to not more than about 2 or 3 amperes when employing arcs in air between ordinary solid arc lamp carbons, if it is desired to generate oscillations approaching wireless frequencies. With lower frequencies the supply currents may be increased. The arc length must also be kept very short. On the other hand, if very high frequencies are desired for experimental purposes it will be generally found advantageous to employ special carbons for the arcs. Some grades of graphite rods are very suitable for this purpose; while the employment of compressed air or other gases round the arc often leads to considerable advantages from the point of view of the steadiness of the oscillations that are produced, as well as their intensity. The ratio of the capacity to the inductance in the oscillation circuit is also very important; a rough guide to begin with may be taken as ratio of inductance to capacity=about 100, when both are measured in absolute units (centimetres). This figure is, however, liable to very considerable variations to obtain the best effects, depending on the arc employed, on the supply voltage, and current, and more especially on the gas surrounding the arc. The use of a suitable choking inductance in the supply circuit to the arc is also important to secure more vigorous oscillations by confining them to the oscillation circuit and preventing them going back on to the supply mains.

It has been suggested that the use of the powerful magnetic fields customary in the Poulsen apparatus, has a greater utility than that of causing a mere steadying of the arc; and that the strong field really causes vibrations or oscillations to be set up in the arc, after the manner of arc interrupters, the arc being actually blown out by the magnetic field in some cases, and then automatically restruck again by reason of the applied voltage being sufficient to jump the small ionised space between the electrodes. Some such action as this may possibly take place in the Poulsen apparatus. F. Mercer, in a Paper recently read before the Physical Society of London* on this subject, came to the following conclusions:—

1. There is a definite value of inductance for any given capacity which gives a maximum current in the shunt circuit. 2. The effect of increasing the gas pressure becomes more marked as the electric pressure is increased, but as the gas pressure rises the steadiness of the arc diminishes. The effect is somewhat similar to that obtained by increasing the arc length. 3. Any effort made to increase the output by the use of a magnetic field, or by altering the arc length, or the resistance in series with the arc, is detrimental to the steadiness of operation. These conclusions were of necessity obtained from experiments on copper carbon arcs, and they do not apply to any and every type of arc oscillation generator without modification.'

Dr. Fleming's "Oil-Arc."—In the oil-arc a number of arcs between carbon and copper electrodes (copper positive) are struck just over the surface of a heavy oil. The heat generated by the arcs causes vaporisation of the oil, and consequently an atmosphere of hydro-carbon vapour is created round the arcs. No magnetic field is employed, and the oil generally provides sufficient cooling, without having to resort to water cooling, but a water circulation through the oil may be provided if desired. The arrangement has been constructed for powers up to a maximum of about 2 kw.; but it is probable that modifications would have to be introduced to enable it to be available for much high powers. In connection with the operation of arcs of this type, *i.e.*, copper carbon arcs, it is interesting to note that it is not essential that the copper electrode should be positive and the carbon negative, as is usually supposed, and as is customarily the case, for example, with the Poulsen arcs, as advantage are often found in using the reverse connection. This is often more especially the case when difficulty has been experienced in starting up the arc and obtaining stable oscillations. Under these conditions a reversal of polarity will frequently cause strong oscillations to be set up, which persist when the polarity is again reversed back to the normal direction.

When an arc is running in air there is always a burning away of the carbons; if, however, the arc is placed in an atmosphere which is rich in carbon (hydro-carbon gases), the gas will be decomposed by the heat of the discharge, and carbon deposited on the arc electrodes. It is thus possible to have an arc in which the carbons "grow" instead of wearing away when in use.

The Colin-Jeance Arc Generator.—This is, in the main, very similar to the Poulsen apparatus, consisting of three copper-carbon arcs connected in series, and burning in an atmosphere composed of a mixture of acetylene and hydrogen in such proportion that the normal wear of the carbon electrode is compensated for by the deposition of carbon from the gaseous atmosphere. The mixture of gases may be conveniently generated from a mixture of calcium carbide and calcium hydride, and the usual voltage necessary varies between 500 and 750 volts.

The author refers to the use in this case of an intermediate circuit tuned to the oscillation frequency. He points out that the frequency in the shunt circuit does not depend merely on the values of capacity or inductance in that circuit but also on arc length. This is on account of the resistance of the arcs not being negligible.

To meet this case a formula has been devised by G. Nasmyth† and is as follows:—

$$n=\frac{1}{2\pi}\sqrt{\left\{\frac{1}{LC}-\frac{\{R-(C+ld)/A\}^2}{4L^2}\right\}}$$

where n is the frequency, L is the inductance in henrys, C is the capacity in farads, R is the resistance in the oscillation circuit in ohms, A is the current through the arc, l is the length of the arc, and c and d are constants depending on the nature of the arc electrodes, and on the nature of the gas surrounding the arc.

Hence it is evident that quite small changes in the arc length, supply current, &c., will produce changes in the frequency of the oscillations. This variable frequency is a great drawback to most arc transmitters.

The author then deals with the Dubilier and the T.Y.K. arc.

Short Spark Methods of Generating Oscillations.—He points out that the action of the so-called "quenched" spark-gaps depend on ionisation, and if very rapidly worked they would be suitable for telephony.

Spark-gaps of this kind form the basis of the Lepel, Telefunken, Peukert and other patents, and are based on the results of experiments of M. Wien on the quenching effect of short spark-gaps.

The Lepel Gap.—This consists essentially of two metallic discs,

* Abstract of Paper read before the Students' Section of the Institution of Electrical Engineers.

* "Proc.," Phys. Soc. Lond., 26, p. 372, June, 1914.

† Physical Review, 27, p. 117, 1908.

separated by a paper ring which, placed with their faces very close together form the electrodes of the spark, and which are often made to form the ends of shallow boxes to enable water cooling to be employed to remove the heat of the discharge.

When in operation the gap should be connected in series with suitable choking inductances and resistances to limit the flow of current from the supply mains, and also to determine and regulate the spark frequency.

A spark frequency of the order of 10,000 per second or more can usually be obtained, and the discharge that takes place in the gap is often described as an arc.

The Telefunken and Peukert systems, and the methods of examining oscillations, by means of the Braun cathode ray tube are considered in the Paper.

The Marconi Disc Discharger for Generating Undamped Waves.—The arrangement of apparatus is very much that of the usual Marconi studded disc discharger fed from direct current. In this instance, however, the spark frequency is arranged to be much higher than the usual, and at the same time a number of such discs are arranged on the same shaft, with their studs or contacts so displaced relatively to one another that the sparks will occur on successive discs at regular intervals during the spaces on the first disc. Each disc is preferably arranged to discharge through its own condenser and oscillation circuit, independent of the others, the effects of them all being summed up in a secondary circuit connected to the aerial in the usual manner. If, now, we so arrange the oscillation frequency of each circuit that one complete wave (or at the most two) of current takes place in the interval between the spark on one disc and the next spark on the next disc, the effect of the second spark will reinforce that due to the first, and the oscillations will be maintained. If the sparks take place every complete wave, the oscillations will be to all intents and purposes undamped, but if every second wave, there will be a slight diminution of amplitude every alternate wave—much as may probably be the case with some of the short spark dischargers described above. Such an arrangement should be capable of dealing with considerable power if properly designed, while the oscillations produced would be eminently suited for wireless telephony. The system, in fact, amounts to an attempt to accomplish in a regular mechanical manner what happens in effect in some of the short quenched spark dischargers—*i.e.*, to ensure that each fresh impulse due to the passage of a spark shall exactly synchronise with the existing oscillations in the circuit. To a considerable extent this occurs automatically in the short-spark methods by reason of the reactions which take place between the currents in the various circuits; but, nevertheless, some irregularities will generally occur. The great objection to the mechanical method apart from the difficulties of the high speeds required for the discs is the difficulty of maintaining the discs running at a perfectly definite and constant speed. This is essential if the method is to work properly in order that the successive impulses shall synchronise properly with one another. It renders imperative some very sensitive form of speed governor that will maintain the discs running at a constant speed.

The author next deals with vacuum oscillation generators. The work of Dr. Fleming is referred to, and the employment of many vacuum bulbs in the Arlington Honolulu transmission of 5,000 miles is mentioned.

Referring to the fact that high frequencies are obtained either by adding or multiplying processes, the induction motor field is cited as an example of double frequency production, and the Goldschmidt alternator is also dealt with.

Frequency Multipliers.—The most important representatives of this class are the transformer frequency raisers, in which use is made of the fact that the magnetising current of a transformer working on a sine wave E.M.F. is generally very far from being a sine curve.

The exact shape of this current curve depends on the state of magnetic saturation of the magnet core, and may be varied, within limits to suit the requirements. The Fourier analysis of the above current curve shows that there is a prominent third harmonic present in the current wave. This will generally be found to be the case.

It is possible by suitably designed tuned oscillation circuits to strengthen this third harmonic by resonance, and therefore to obtain from a given alternating current E.M.F. of approximately sinusoidal wave form a current of three times the frequency of the original supply. This current may be utilised in a similar manner to produce another of three times its own frequency—*i.e.*, nine times the initial frequency, and so on.

Comparing this method with the frequency adders previously described, it is seen at once that a very much more rapid multiplication of the frequency is obtained; thus, three stages would raise the frequency 27 times. The great limitation to this method is that it is not very easily adaptable to handling large powers, since the magnetising current of a transformer is quite small.

The author then deals with methods of modulating the transmitted wave.

Receiving Apparatus.—This generally differs but little from the apparatus used in wireless telegraphy. The detector, however, should be such that its indications are proportional to the energy received, as otherwise distortion of speech results. The various detectors—Marconi's magnetic, Perikon zincite-bornite and carborundum—are then described. Amplifiers are then referred to as of the microphonic and vacuum types. S. G. Brown's relay is typical of the former type, and to the second class belong the "Audion" and "Pliotron."

In conclusion, the author summarises the results achieved.

TESTS ON OIL SWITCHES.*

BY DR. WYSSLING.

Danger of fire arises from excessive current densities in parts of an installation or in the production of arcs or sparks in the neighbourhood of inflammable materials. The former causes can easily be eliminated by the use of fuses or circuit-breakers as far as concerns the external circuits, but there is no protection against overheating in the generators. Such overheating may cause the generators to catch fire, but the fire would usually be localised by the methods adopted for installing the generators. The main danger lies in the possible spread of fire through the insulating covering of the cables connected to the machines. Where bare wires cannot be used it is therefore essential to lay cables in such a manner that they cannot act as carriers of fire; this may be effected by embedding

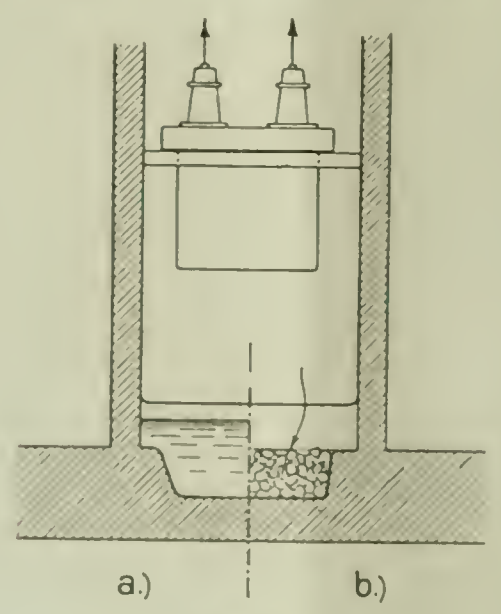


FIG. 1.

them in sand or running them in fireproof partitions. The main originators of fire are the instruments in which sparks and arcs are produced in their normal operation, and it is found that most fires originate in oil-switches in which arcs are formed in immediate contact with inflammable oil. The programme of the Commission divides the scope of its investigations into three headings. The provision of means of extinguishing fires, the improvement of the general arrangement of installations and the study of the action of oil-switches with the object of improving their construction. The last heading has been fully dealt with in the first report and the second report is concerned with the other two headings.

Regarding the means of extinguishing fires a separate report has been published,† and further tests are in progress which will form the subject of a later report by the Commission. The information at present available shows that solid materials, such as sand or bicarbonate of soda, are most effective, where they can rest on horizontal surfaces. For vertical surfaces and free conductors, liquids must be used, and in many cases the employment of water in large quantities is the best, if the electrical supply can be shut off. Some chemical extinguishing fluids have the drawback of producing dense smoke. It is possible that gases, such as carbonic acid, stored in readiness, may prove to be the most effective means of fighting fire. The improvement of the methods of mounting all apparatus and partic-

* Being an abstract of the Second Report of the Commission on High-Tension Apparatus and Fire Protection, appointed by the Schweizer. Elektrotechn. Verein and Verband Schweizer. Elektrizitätswerke. The report appears in the "Bulletin" (No. 8 of 1915) of the Schweizer. Elektrotechn. Verein, known also as the Association Suisse des Electriciens.

† "Bulletin" Schweiz. Elektrot. Verein II., p. 393, 1913.

larly oil-switches and of the general arrangement of buildings used for electrical installations forms the main subject of the second report.

It has been found necessary to leave openings in the oil-containers of oil-switches to prevent the containers from bursting when internal explosions take place. It is, therefore, necessary to take precautions to prevent the oil issuing from such openings from spreading. Cellular sub-division by solid walls and the provision of oil wells on the

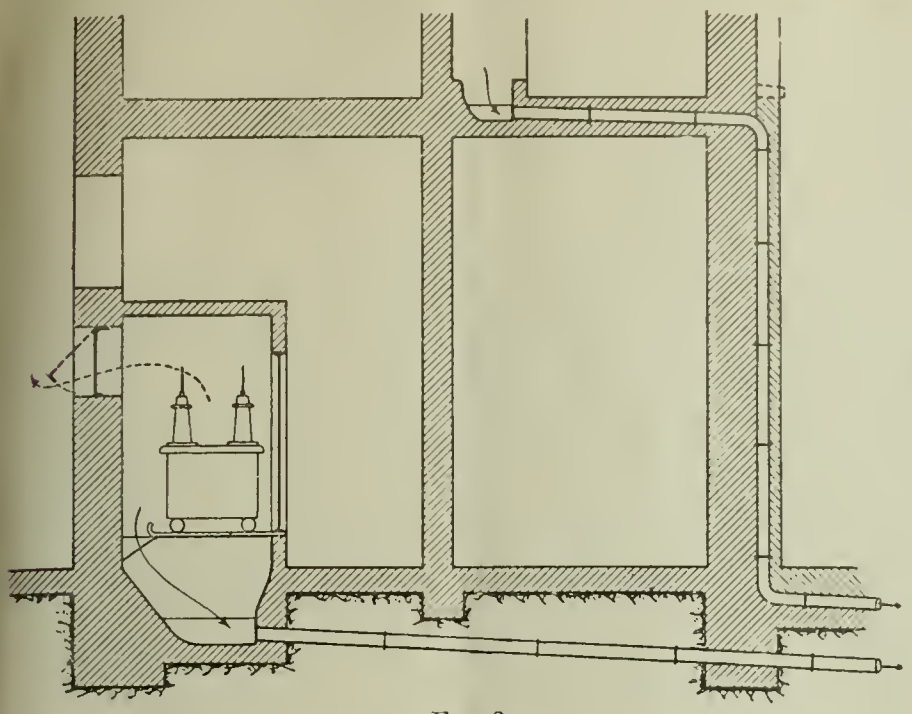


Fig. 2.

ground form the best protection. Fig. 1 shows an oil-switch in a cellular compartment with an oil-well, and Fig. 1*b* shows the well partly filled with sand or gravel to cool the heated oil. The cooling of the oil and extinguishing of flame may also be effected by placing perforated metal covers over the well. A further method is shown in Fig. 2, in which pipes are provided to carry off burning oil. The same figure shows a flap-opening for giving a relief to the pres-

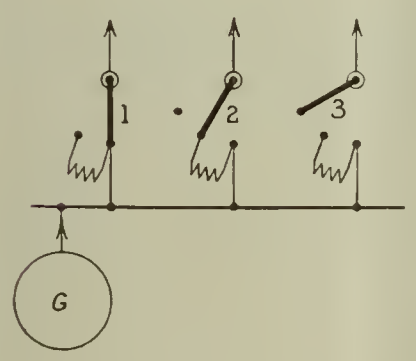


Fig. 3.

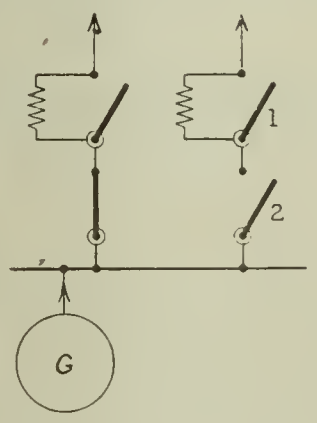


Fig. 4.

sure produced by explosions in the chamber, the flap being arranged so as to close itself to stifle a conflagration within the chamber. A number of other illustrations are given in the report showing possible methods of carrying out the ideas referred to above.

The admission of volumes of dense smoke into the switch gallery may hinder the attendants in their efforts to extinguish a fire and damage the gear to such an extent that the supply has to be inter-

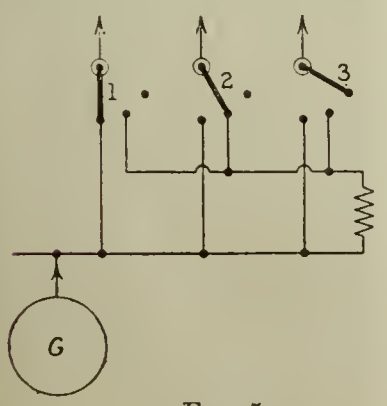


Fig. 5.

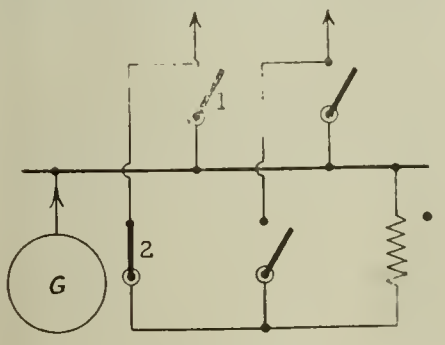


Fig. 6.

rupted for considerable periods. To prevent this the switch-cells may be provided with chimneys, and the room occupied by the switch-board attendants should be shut off from the rest of the building. In new installations it is desirable to arrange for a possible air-tight sub-division of the switch-rooms into sections, and the cells in which the switches are contained should be shut off from the switch gallery both at the front and at the back. Wired glass fronts may be used to enable the switches to be seen by the attendants. Cables should enter and leave each air-tight compartment through porcelain stuffing boxes.

The greatest switch troubles arise on the switching off of short-circuits, and it is, therefore, desirable to reduce the short-circuit power before breaking the circuit. This may be done by the introduction of reactance or preferably ohmic resistance, as shown in Fig. 3, the reactance or resistance being contained within the switch. Existing switches may be adapted by the connections of Fig. 4 by the addition of auxiliary switches successively operated by relays with suitably adjusted time-lags. The methods of Figs. 3 and 4 may be modified, as shown in Figs. 5 and 6, so as to use common resistances for a group of switches. It is also possible to connect a single oil-switch with enclosed resistance so as to control a group of switches. In order to prevent the full short-circuit power of all the generators in a station from feeding into a short-circuit the 'bus bars may be sub-divided between the different generators by automatic switches, resistances or reactances. These methods will be discussed in a subsequent report.

DIESEL ENGINE USERS' ASSOCIATION.

The March meeting of this Association was held at the Institution of Electrical Engineers, and a further list of engineers having control of Diesel engine plants in this country and in other places were elected members.

Attention was drawn to the forms which had been circulated among the members of the Association in connection with the annual return of costs of maintenance and costs due to mechanical breakdown.

Tar Oils and Paraffin as Fuel.—This subject was further discussed, and the president, Mr. Geoffrey Porter, gave some particulars concerning the unfavourable results which had been obtained in mixing tar or tar oils with ordinary crude oil for use in Diesel engines.

Mr. W. Fennell introduced the subject of the use of paraffin oil as fuel. In the discussion which ensued the opinion was expressed that paraffin could be quite suitably used as fuel at times when its price showed any advantage as compared with the price of other fuels. It was necessary to run at a lower blast pressure when using paraffin.

Accident at Smithfield Markets Electric Supply Co. (Ltd.)—The following particulars are extracted from Mr. P. H. Smith's report to Lloyd's underwriters :—

An accident occurred on the plant of the Smithfield Markets Electric Supply Co.'s power station very shortly after midnight on February 6, 1916, and, unfortunately, one of the drivers was killed. The coroner's jury returned a verdict of "Accidental death," no blame being attached to anyone concerned. They added a rider recommending the adoption of certain precautionary measures which are embodied in Mr. Smith's report.

The compressor attached to the engine is of Messrs. Reavell & Co.'s standard quadruplex type, comprising four cylinders—viz., two low-pressure cylinders, one intermediate and one high-pressure. The air is drawn into the low-pressure cylinders through slots in the piston pin, and is then compressed, passing into the low-pressure receiver or purge-pot through copper pipes immersed in the water jacket of the compressor. This purge-pot contains a drain and regulating valve, and a relief valve set at about 100 lb. per square inch. The air from the low-pressure purge-pot is drawn into the intermediate-pressure cylinder past a valve through another cooling coil. Then it is compressed and delivered past another valve into the intermediate-pressure purge-pot, which is almost identical with the low-pressure pot, except that its relief valve is set to blow freely at 300 lb. to 400 lb. pressure. From the intermediate-pressure pot it passes into the high-pressure stage, from which it is delivered to the small bottle, being cooled immediately after passing the high-pressure delivery valve.

The compressor is so designed that, under normal conditions and when pumping its full capacity, the absolute terminal pressures of the various stages are approximately : Low pressure, 60 lb. ; intermediate pressure, 240 lb. ; high pressure, blast pressure.

A feature of the design to which we call particular attention is the construction and location of the intermediate-pressure plunger. This, being, so to speak, inverted, receives an excess of lubricating oil, which when the engine is standing collects in the inverted piston, and can, in actual practice, get past the rings into the cylinder itself. The rings are forced tight against the cylinder walls, not merely by their own springs, but by air pressure passing behind the rings, the air being conducted thereto by four small holes communicating from the inside of the cylinder to the ring grooves.

It appears that this construction greatly facilitates the ingress of the oil to the intermediate-pressure cylinder when the engine is allowed to stand, and as seeming to corroborate that the oil actually takes this

path it is worthy of note that in most cases these holes soon choke up. In the case of the compressor under examination, two out of the four holes were choked. Further evidence of the ingress of the oil in this manner is supplied by the extraordinary condition of the high-pressure valves, which were both very heavily carbonised in 30 hours' running.

Under normal conditions, the machine is a three-stage compressor developing terminal pressures approximately as follows: Low pressure, 60 lb. abs.; intermediate pressure, 240 lb. abs.; high pressure, blast pressure.

Assume that either or both the high-pressure valves are not properly tight, then there is a leakage tending to increase the intermediate-pressure terminal pressure. If either or both valves become wholly inoperative, then the machine becomes two stage, the intermediate pressure showing the blast pressure (if the relief valve is inoperative) and the low-pressure showing normal pressure.

Assume next that the intermediate-pressure valves become defective and leak, then the low-pressure terminal pressure increases. If either or both intermediate-pressure valves become quite inoperative, the machine becomes two-stage, showing approximately 240 lb. in the low-pressure and intermediate-pressure pots (again assuming that the relief valves do not operate). Now let us investigate the possibilities of the machine becoming a single-stage machine. Assume both high-pressure valves inoperative. Under these conditions we have shown that the low-pressure terminal pressure may reach a maximum of 60 lb. absolute, and the intermediate-pressure terminal pressure is that of the blast; but the low-pressure terminal pressure is approximately the intermediate-pressure suction pressure. Now, suppose the compressor is running slowly with the low-pressure drain valve fully open. Then the pressure in the low-pressure purge-pot will not greatly exceed atmospheric pressure. Hence, on the assumption that the high-pressure valves are both inoperative, the pressure in the intermediate-pressure cylinder would be raised from slightly above atmospheric pressure to the blast pressure in a single stage.

These conditions apparently prevailed to an indefinite degree at the time of the accident, for at the inquest driver Baker remarked that he had started the engine in the usual way, the drain valves on the compressor being open. Then, when the engine commenced to fire, he closed them and immediately turned to the blast bottle. He had just commenced to throttle the blast to re-charge the bottles when the explosion occurred. His estimate of the number of revolutions of the engine to the time of the explosion is only 20. To this I advert later.

The Cause of the Accident.—What happened was that the intermediate-pressure purge-pot burst. The pot was of good average quality iron, and was of even thickness. Assuming its tensile strength at 7 tons per square inch, its bursting pressure would be about 2,400 lb. per square inch. Hence, no pressures ordinarily prevailing in the compressor would be likely to cause its fracture.

I therefore submit that the pressure originated from a spontaneous ignition of oil vapour in the intermediate-pressure purge-pot. To avoid confusion of thought, I define this particular example of spontaneous ignition as "the inflammation of oil vapour and air by internal or self-contained means, the temperature necessary to produce the ignition arising from the heat resulting from the compression of the air in the intermediate-pressure stage."

Provided that the oil is very finely divided it may combine with oxygen with sufficient rapidity to cause it to ignite, notwithstanding that the surrounding temperature is well below the ignition point of oil vapour. For example, a pile of oily waste in an engine room is liable to ignite spontaneously. This digression is introduced merely to show that one need not necessarily have to account for an explosion by purely mathematical calculations, though on certain warranted hypotheses it will be shown that the compression temperature far exceeded the flash point of the oil.

Assuming that the flash point of the oil were as high as 450 F., the inlet temperature to the immediate pressure only 80 F., and that the compression follows the law

$$PT^{1.5} = K,$$

then the intermediate-pressure stage has to compress the air to one-fourteenth of its original volume to attain 450 F. as the terminal temperature. If the compressor had been working at its full capacity, this is the equivalent of raising the pressure in the intermediate-pressure stage from roughly 60 lb. absolute to 800 lb. This of itself is quite feasible provided that the intermediate-pressure relief valve was inoperative.

The evidence is that the intermediate pressure relief valve did not blow, so that it is very probable that the terminal intermediate pressure was well below 800 lb., as, on testing the intermediate-pressure valve it commenced to lift at 350 lb. Probably the valve would not have lifted under 400 lb. pressure at the time of the accident; but assuming, now, that the terminal intermediate pressure was 330 lb. when the explosion occurred, or well below the pressure at which the valve was nominally set, we find that the initial pressure would have been 10 lb. gauge pressure to have resulted in the attainment of 450 F. terminal temperature under the assumptions specified above.

From a study of different drivers I am strongly of opinion that in the time elapsing between Baker's closing the low pressure drain valve and turning to the bottles the low pressure pressure had not attained even this figure. Hence, on this hypothesis, we find a very possible explanation of spontaneous ignition arising. The only other analytical method I see of accounting for the phenomenon is to assume that the relief valve was entirely inoperative, and there are inadequate grounds for making an hypothesis so sweeping.

Certainly the relief valves on the other compressors had lifted at different times, and there is no record of their having ever lifted on this particular compressor; but, on the other hand, one cannot prove a point by employing negative evidence.

As to the positive proof of an ignition explosion, it should be mentioned that the fractured purge-pot showed a black deposit on an otherwise clean fracture, some soot or similarly finely divided black deposit on the fingers when inserted in the pipes communicating with the purge-pot, and also a similar dir from the inside of the purge-pot. It should be noted in this latter connection that the inside of the Chelsea purge-pot recently examined did not dirty the fingers at all.

Hence I conclude that an ignition explosion occurred, and base my recommendations accordingly: (*a*) Fit pressure gauges on both low and intermediate-pressure purge-pots. It has never been my experience that valves fail without giving ample warning by causing the pressure to rise unduly. The warning generally extends over several days, and in the worst cases I have met with the warning has well exceeded an hour. The gauges should read fairly high to minimise the chances of their bursting in the event of being subjected to abnormal pressure. For this reason the dials must be large, say 6 in. or 7 in.: the low-pressure gauge should record 600 lb. or more, and the intermediate-pressure 1,200 lb. As a further precaution, I would recommend that they be fitted with long pipes and have a throttle valve fixed immediately below them. (*b*) The holes leading behind the intermediate-pressure rings to be plugged. This will probably prevent the oil gaining easy ingress to the intermediate-pressure cylinder, and so reduce the heavy carbonisation of the high-pressure valves. (*c*) Fit on a large relief valve to the intermediate and low-pressure pots. The present valves are only 10 mm. diameter, and the greater part of this area is choked with the wings of the valve. The type of valve, which Messrs. Banks, Warner & Co. are recommending lifts at a predetermined pressure, and should remain well off its seat until the pressure has dropped to a lower figure predetermined by its design. Whatever form of valve is fitted, it should be designed so that it can be readily tested for sticking. (*d*) Relief valves should be tested periodically for lifting pressure. (*e*) There may be some advantage in fitting a non-return valve between the high-pressure delivery and the bottle. This valve should be fitted as close to the high-pressure outlet as is convenient. (*f*) Drivers in charge should make a habit of feeling the temperature of the purge-pots. The low-pressure is always the hotter when the machine is in good order, but when the high-pressure valves become defective the intermediate-pressure becomes warmer. (*g*) To safeguard the water jacket it is advised to work with an open top to the compressor, or where this is difficult to fit, then in place of the diaphragm or relief valve usually fitted it is advised to place a stand pipe 4 in. to 6 in. diameter, of sufficient height to obviate "head" difficulties.

DISTRIBUTION OF MAGNETIC FLUX IN COMMUTATING ZONE OF DIRECT-CURRENT MACHINES.

BY CL. SHENFER.

(Electrical Laboratory of the Imperial Technical School, Moscow.)

Summary.—The author, on the basis of a series of oscillograms, arrives at the conclusion that the magnetic lines of force of a commutating pole pass through the iron of the armature core and not across the teeth and slots, avoiding the iron of the armature core, which latter theory is the one accepted by several authors.

Latterly there have been different hypotheses as to the manner in which the magnetic lines of force arising from the commutating poles of a direct-current machine travel; thus, in contradistinction to the old theory, according to which the lines of magnetic force of the commutating poles pass through the armature core, Worrall, L. Binder, R. Richter and others* have advanced the theory that the magnetic lines of force with sparkless commutation do not enter the armature core at all, but pass across the teeth and armature slots. In Fig. 1 is given the magnetic figure, according to Worrall, of a commutating pole; from this figure it is seen that in the upper part of a tooth situated under the commutating pole, magnetic lines of force, arising from the winding of the commutating pole, run from below in an upward direction, while in the upper part of the tooth magnetic lines arising from the armature winding run from above in a downward direction. In this way the lines of force arising from the commutating pole and those arising from the core meet in some neutral plane, and then travel approximately parallel to one another, passing across the teeth and slots.

The effect of the commutating poles is as if to squeeze out the lines of force of the armature reaction flux, which are, therefore, compelled to pass across the teeth and slots, and do not reach the air-gap at all.

*"The Physical Theory of Commutation," by G. W. Worral, M.Sc., M.Eng., THE ELECTRICIAN, 1913, p. 715. THE ELECTRICIAN, 1913, p. 975. "Elektroteknik und Maschinenbau," 1913. No. 9, 16, 17, 26, 30.

The compensation of the reactance voltage induced in a short-circuited coil at the moment of commutation according to this representation is described as follows :—

As the core revolves, the conductors situated in the lower part of a slot (nearer to the armature core) intersect the lines of force of the armature reaction flux, and in these conductors reactance voltage is set up. The conductors in the upper part of the slots intersect the lines of force of the commutating pole, and in these conductors is set up an E.M.F. in opposition to the reactance voltage.

Each coil of a two-layer armature winding (which we have to do with in most cases in actual practice) consists of an equal number of conductors situated in the upper and lower parts of the slot : in all the lower conductors of a short-circuited coil reactance voltage is induced, and in all the upper conductors an E.M.F., which compensates this voltage.

In accordance with this theory there should be some cylindrical " neutral " surface not intersected by either the lines of force of the commutating pole or the lines of force of the armature core, which would form, as it were, the boundary of these two magnetic fields.

No E.M.F. at all will be induced in any conductor coinciding with this surface on entering the commutating zone. The position of this " neutral " surface depends on the excitation of the commutating poles. As the excitation increases, the " neutral " surface approaches the base of the teeth, and vice versa ; with decrease in the excitation it approaches the heads of the teeth.

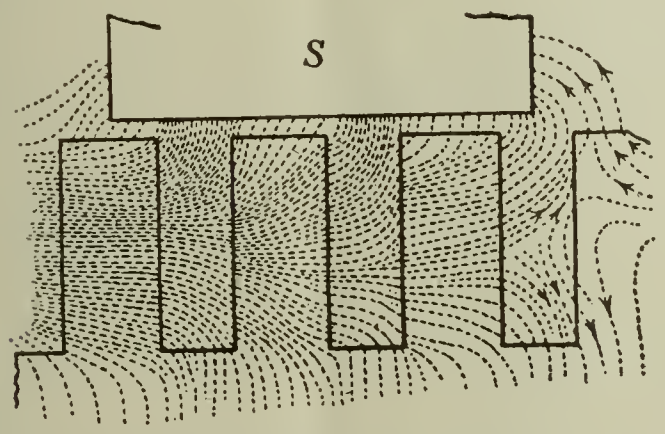


Fig. 1.—Diagram showing Distribution of Flux in Commutating Zone (according to Worrall).

Such, in brief, is the hypothesis stated by Worrall and Binder. These authors, however, bring forward no experimental data directly supporting their theory, and it is very desirable that such data should be given, for if it turned out that the magnetic field were really such as it is represented in Fig. 1 it would be necessary to change completely the usually accepted computations for commutating poles. Therefore the author of the present article has made an attempt to solve this question experimentally.

The experiments were made with a " Lahmeyer " shunt-wound motor with commutating poles, of which the following is the specification :—

Horse-power	5
Terminal voltage	110
Normal strength of current	5 Amp.
Speed, revs. per min., R	200/1,200
Number of poles	4
Armature :	
Diameter, D	312 mm.
Length	150 mm.
Air-gap	2 mm.
Commutator :	
Diameter ;	245 mm.
Number of segments	207
Number of brush spindles	4
Number of brushes per spindles	2 (10 × 20 mm.)
Armature Winding :	
Series drum winding in	69 slots
Number of conductors per slot	12
Number of armature conductors, N	828
Commutating Poles :	
Width of pole	22 mm.
Length of pole, *l*	110 mm.
Winding	68 turns per pole

In one of the armature slots of the machine were placed three conductors (Nos. 1, 2, 3, Fig. 2), in the upper, middle and lower part of the slot respectively.

The terminals of these exploring conductors were connected to slip rings, one fixed at the back end and one at the commutator end of the armature. When the armature revolved, E.M.F.s were induced in these conductors, and the curves were photographed by means of an oscillograph.

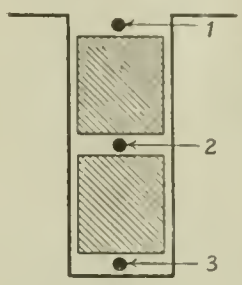


Fig. 2.

Fig. 3 gives a diagram of connections. Here S=shunt winding, D=commutating pole winding, A=armature, R=starting rheostat for the motor, g=changing switch for switching off winding of commutating poles ; R_s, R_d, R_a are rheostats for regulating current in shunt winding, winding of commutating poles and of armature respectively.

Exploring conductors 1–3 are connected by means of rings a, b, c, and brushes d, e, f with the loops of the oscillograph.

A testing battery, B, regulating rheostat r, voltmeter V, and change-over switch F are employed for calibrating the oscillograph. After each photograph of a curve the loop of the oscillograph was brought into contact with the battery, the tension of which was measured by the voltmeter V, and a deflection in millimetres of the spot of light was observable on the drum of the oscillograph. In this way it was possible to determine the scale of curves on the oscillograph.

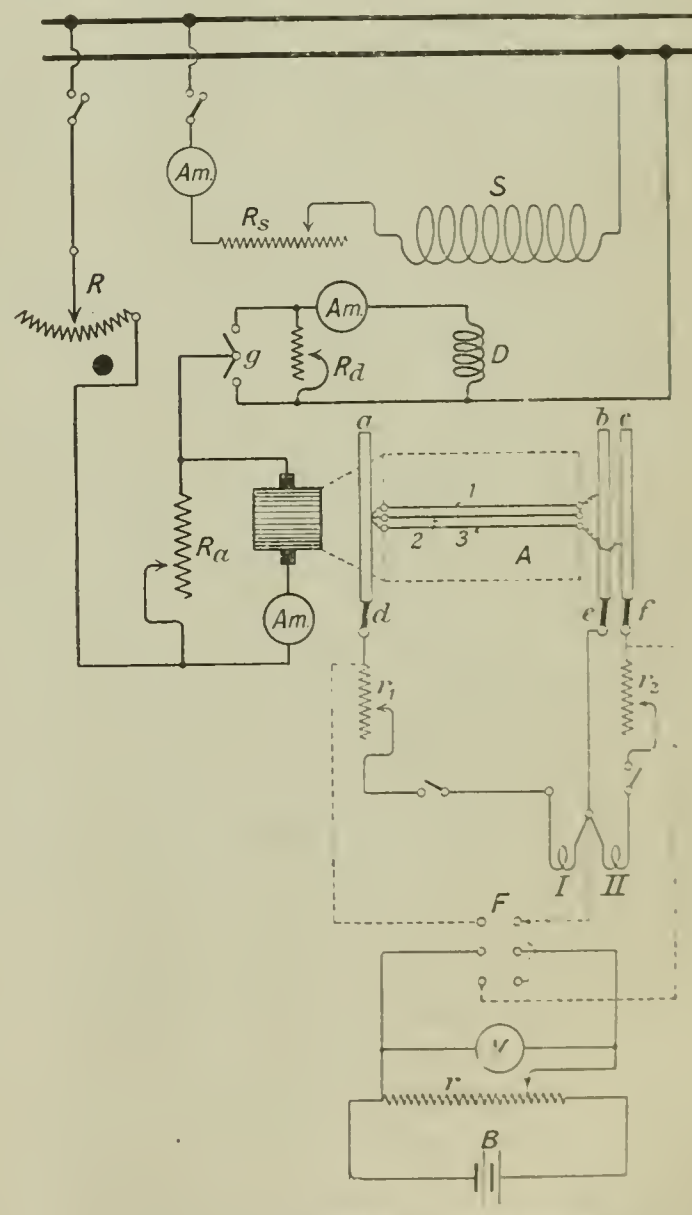


Fig. 3.—Diagram of Connections.

The oscillograms thus obtained are shown in Figs. 4–8.

In the oscillogram, Fig. 4, two curves appear, photographed at one and the same time, namely, the curve of E.M.F. induced in the conductor (No. 1, Fig. 2) placed in the upper part of the slot, and the curve of E.M.F. induced in the lower conductor (No. 3, Fig. 2). Before taking the oscillogram the loops of the oscillograph were brought, by means of rheostats (r_1, r_2, Fig. 3), to the same sensibility. In Fig. 4 we see that the curves of E.M.F. induced in the upper (No. 1) and lower

(No. 3) conductors differ *very slightly* (in some parts these curves even coincide), which shows that the magnetic figure under the commutating pole, assumed by Worrall and Binder, is not in accordance with the facts. If the assumptions of these authors were right the curve of E.M.F. (No. 3) in the region of the commutating poles would not coincide with curve No. 1, but would follow the dotted line in Fig. 4. This and the other oscillograms, Figs. 5–9, prove that the lines of force of a commutating pole, after traversing the air-gap, enter the core of the armature in accordance with the old theory of Arnold and others.

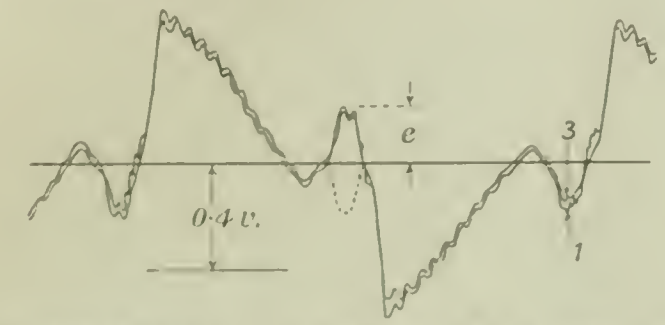


Fig. 4.—Curve of E.M.F. (1) in Upper and (3) in Lower Conductor.

Current in armature I_a = 38 amperes, current in commutating pole I_c = 47 amperes, exciting current I_e = 0·85 ampere, speed in revs. per min. R = 390.

In the oscillogram, Fig. 4, the attention is struck by a slight divergence of the curves 1 and 3 in the region of the commutating pole. This may result from the magnetic lines of force of the slot field passing for the most part through the upper part of the slots and from top to top of the teeth, so that the number of magnetic lines of force surrounding conductors 1 and 3 are almost equal. In order to protect the exploring

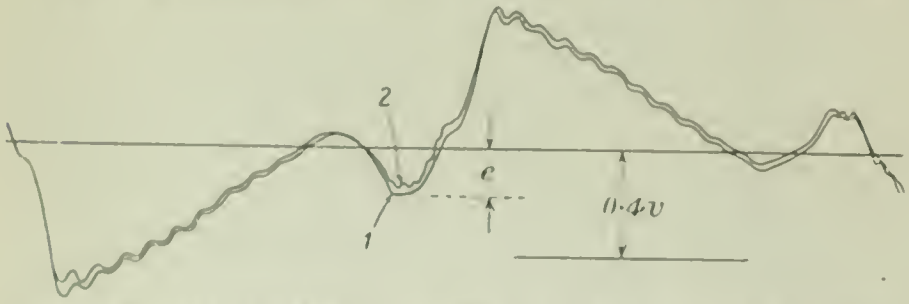


Fig. 5.—Curve of E.M.F. (1) in Upper and (2) in Middle Exploring Conductor.

Current in armature = 40 amperes, current in commutating pole = 50 amperes, exciting current = 0·85 ampere, speed in revs. per min. = 390.

conductor from the action of the slot field it would have been necessary to place it above the tops of the teeth, which, from the smallness of the air-gap, was difficult to effect.

The oscillogram, Fig. 4, was photographed while the machine experimented on was worked as a motor, the armature current I being 38A, commutating poles winding current I_c = 47A, exciting current I_e = 0·85A, and the speed in revolutions per minute R = 390. The current in the commutating poles winding

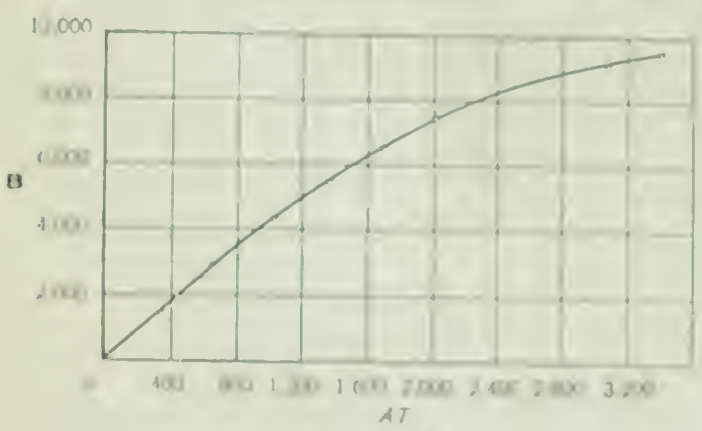


Fig. 6.

was fixed at this strength, so that the mean voltage between the edges of the brushes, measured by means of two exploring copper brushes and a voltmeter, was zero. The line traced in the oscillogram at a distance 0·4 U from the zero line gives the scale. In the oscillogram No. 4 the E.M.F. e set up in the exploring conductor as it passes under the commutating pole does not give any idea of the magnitude of the magnetic field in the commutating zone, as the E.M.F. e is the difference between two E.M.F.s—the E.M.F. induced by the magnetic field of the commutating poles and the reaction voltage induced by the slot field. If the ohmic resistance of the short-circuited coil is zero, and the magnetic flux arising from the back end of the armature is also zero, then with sparkless commutation e should also be zero.

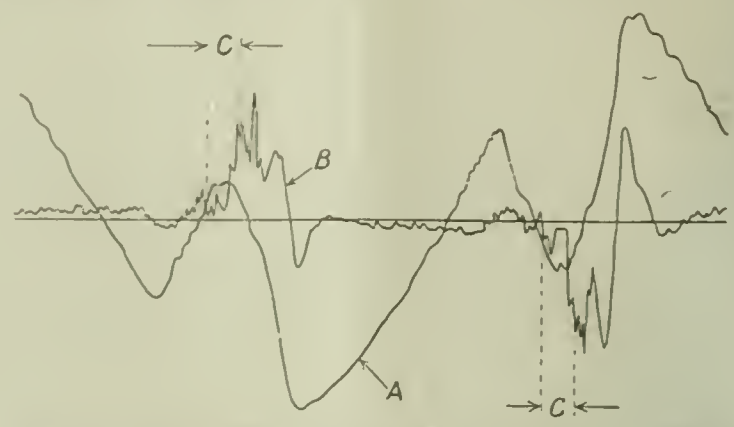


Fig. 7.—(*A*) Curve of E.M.F. in Upper Conductor and (*B*) Curve of Resultant (Difference) E.M.F. in Upper and Lower.

I_a = 54 amperes, I_c = 57 amperes, I_e = 0·5 ampere, R = 470.

To determine how much greater is the actual influence of the magnetic induction under the commutating poles than that which is obtained on the basis of the oscillogram, the magnetic characteristic of the commutating poles of the machine was taken separately (*see* Fig. 6). We will endeavour, on the basis of this curve, to determine the actual magnitude of the magnetic induction B in the neutral zone of the motor to arrive at

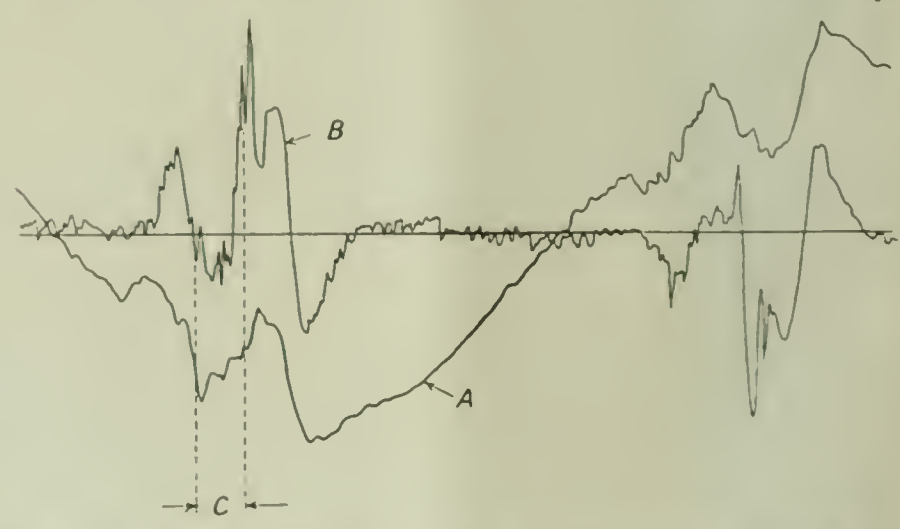


Fig. 8.—(*A*) Curve of E.M.F. in Upper Conductor and (*B*) Curve of Resultant (Difference) E.M.F. in Upper and Lower.

I_a = 60 amperes, I_c = 0, I_e = 0·8 ampere, R = 310. Strong sparking at the trailing edge of brush.

the conditions under which the oscillogram, Fig. 4, was obtained. The number of ampere-turns of one commutating pole under these conditions will be $n_c . I_c = 68 \times 47 = 3{,}200$; the number of ampere-turns of the armature winding per pole will be $\frac{1}{2}\tau . A$, where τ is the pole-pitch of the machine = 24·5 cm., and A is the number of ampere conductors per centimetre of circumference; as

$$A = N.I/\pi D,$$

where I, the current per armature path = $\frac{1}{2}I_a$: therefore

$$\tfrac{1}{2}\tau A = \frac{24{\cdot}5}{2} \times \frac{828}{\pi \times 31{\cdot}2} \cdot \frac{I_a}{2} = 51 I_a = 51 \times 38 = 1{,}940.$$

Bearing in mind that the magnetic flux in the neutral zone arises from the difference between the ampere-turns

$$n_c\ I_c - \tfrac{1}{2}\tau\ .\ A\ \tfrac{1}{2} = 3{,}200 - 1{,}940 = 1260,$$

on the basis of the magnetic characteristic of the commutating poles, we find the magnetic induction B, corresponding to the number found for the ampere-turns, is 5,200.

If we wished to calculate the magnitude of the magnetic induction in the neutral plane on the basis of oscillogram, Fig. 4, we should arrive at a figure considerably smaller than that just obtained. As a matter of fact, the E.M.F. induced

in the exploring conductor when passing through the neutral zone may be expressed as follows:

$$e=B\,.\,l\,.\,s\,.\,10^{-8} \qquad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where l=length of commutating pole in centimetres and s=peripheral speed in cm./sec. (in the present instance $s=\frac{\pi.D.R}{n}=\frac{\pi\,.\,31{\cdot}2\times390}{60}=635$); from equation (1) we have

$$B=\frac{e}{l\,.\,s}\,.\,10^{8}=\frac{e}{11\times635}\,.\,10^{8},$$

or, taking the value of e derived from the oscillogram as 0·196 volt, we get

$$B=\frac{0{\cdot}196}{11{\cdot}635}\,.\,10^{8}=2{,}810,$$

i.e., nearly one-half less than the value obtained above on the basis of the magnetic characteristic of the commutating poles.

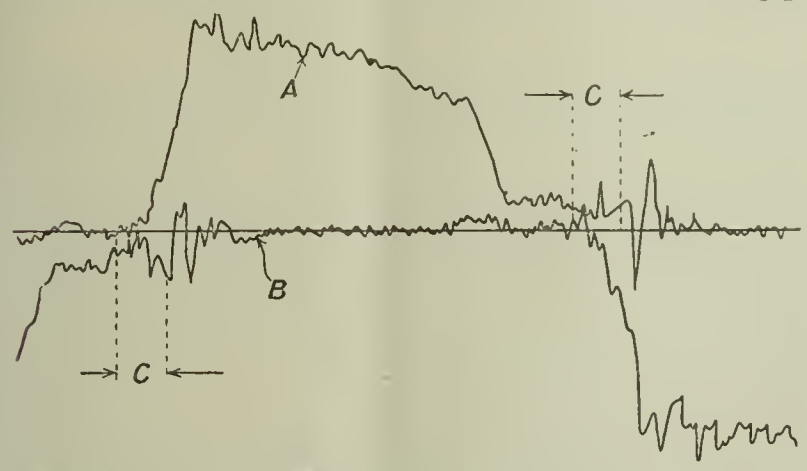


Fig. 9.—(*A*) Curve of E.M.F. in Upper Conductor and (*B*) Curve of Resultant (Difference) E.M.F. in Upper and Lower.

Ia=13 amperes, Ic=13 amperes, Ie=1·7 amperes, R=370. Brushes displaced 5·5 commutator segments in direction of revolution. Slight sparking.

In Figs. 7–9, at the same time as curve *A* of the E.M.F. in one upper conductor was photographed (giving in a certain degree a magnetic figure of the induction in the air-gap), there was photographed also the curve *B* of the difference of E.M.F.s induced in the upper and lower conductors (giving some indication of the change of magnitude of the slot field in different parts of the armature). For that purpose the back ends of conductors 1 and 3, Fig. 2, were connected together, and the free ends connected up with the loop of the oscillograph.

In order to judge of the form of those parts of the curves *B* described during the period of commutation, in Figs. 7–9 is marked the duration *C* of the short-circuit.

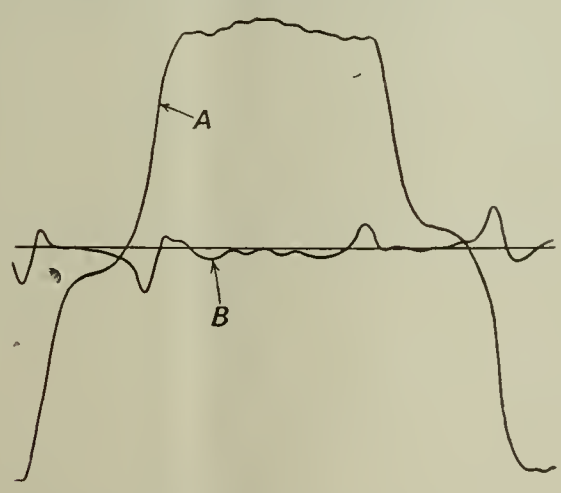


Fig. 10.—(*A*) Curve of E.M.F. in Upper Conductor and (*B*) Curve of Resultant (Difference) E.M.F. in Upper and Lower. Brushes Raised.

In each of the oscillograms, Figs. 7–9, the scale of curve *B* is approximately five times greater than the scale of curve *A*.

The oscillograms Nos. 7 and 8 were taken with brushes in normal positions, and No. 9 with brushes displaced 5·5 commutator segments in the direction of rotation of the motor. The fact that the teeth appear in this oscillogram may be explained, firstly, by the reaction of the current in the short-circuited coil, and, secondly, by fluctuation in the resistance of the magnetic circuit arising from the teeth of the armature. This latter fact is shown by the oscillogram in Fig. 10, taken with the brushes raised, where the teeth are also observable.

SIR J. J. THOMSON ON RADIATION FROM ATOMS AND ELECTRONS.

(*Continued from page* 911, *Vol.* LXXVI.)

The iodine vapour experiment of Wood suggested another way of looking at the problem. When the light falling upon the vapour was of one particular wave-length the line spectrum of iodine was seen, but when the incident light was of any other wave-length quite different series of lines were observed. These might be resonance effects, like those heard when a piano was being played in a room containing apparatus tuned to different notes. There might be an irregularity in the vibrations of the atoms of the iodine vapour. As long as the incident light and the iodine vibrations kept in phase without interruption, there was no disturbance and no absorption of energy with vapour; if there were interruptions, light energy brought up would be converted into something and be absorbed by the iodine.

If the irregularities repeated at regular intervals, series of equidistant lines (satellites) would appear on both sides of the original lines; they would be related to the original lines, diminishing in intensity with greater distance, and the distance itself would increase with the frequencies of the internal irregularity. These irregularities might be ascribed to the collisions of the iodine molecules; but that explanation had proved insufficient. The phenomenon could more probably be likened to those presented by a spiral spring, weighted below by a cross-bar. When the bar was pulled down the spring vibrated, but the vibration was of two kinds, up and down and torsional; as the up-and-down motion quieted down the torsional rotation became more pronounced, to give way again to the former up-and-down motion, and so on. Thus there was a periodical flow of energy, backward and forward, of vertical vibration into torsional vibration and *vice versa*, in the spring. The original up-and-down motion corresponded to the ordinary iodine lines; the superimposed absorbed energy gave rise to the satellites. This suggestion, Sir Joseph added, was not necessarily the correct explanation of Wood's complicated spectra, which, it should not be forgotten, were only observed in the neighbourhood of absorption lines; but irregularities in the medium might give rise to complicated spectra.

Text-books. Sir Joseph remarked finally, said little about absorption, and the usual reference to the absorption of acoustic waves by tuning forks did not explain anything as to light. A tuning fork absorbed sound waves of the same frequency as it emitted. But the case of light, like that of the forced spring vibrations, was not merely one of resonance; in their case a transformation of energy was required, and absorption occurred only when there was interruption or irregularity in the medium. Opacity of a substance indicated that interruptions occurred at short intervals; in transparent bodies the interruptions were separated by long intervals.

In the third lecture Prof. Thomson considered the comparatively simple case of light emission by substances at ordinary temperature and not exposed to electric or other disturbances—phosphorescence. The phenomena of luminous paints had not escaped the notice of the alchemists, whose writings were interesting. The lecturer exposed a series of test tubes filled with whitish powders to the arc lamp for a minute; the tubes then shone in the different colours of the spectrum, from red to violet. By holding the tubes in front of a projected spectrum the colour of each tube could be determined: the chief phosphorescence would become apparent in the ultra-violet region. The powders were all solid solutions of sulphides, and seemed to contain at least three substances: the colours were very sensitive to traces of other metals, and the tubes probably showed different colours mainly owing to their impurities; but zinc sulphide seemed to phosphoresce by itself. To prepare the sulphides, mixtures of salts were dissolved and precipitated together so that sensitive complex compounds were formed: mixing the already formed sulphides would not answer. Lenard and Klatt (since 1904) had thrown much light on the problem. Their active complex compound was of the type $A_xC_zB_y$, which formed molecular groups; these were also the centres of the absorption of the exciting light rays, the latter being active only at certain parts of the spectrum, so that only certain wave-lengths stimulated absorption and phosphorescence; copper had two absorption bands in the ultra-violet, the region between them being inactive; every metal had its own bands, which shifted slightly in the presence of other metals. The best metals were the heavy metals of high valency, magnesium being the lightest of the active metals. To produce phosphorescence, absorption of light energy by the substance had to be secured in the first instance; that energy caused some change in the complex substance, which was converted into an unstable compound, the latter reverting quickly or slowly to the original complex; the phosphorescence took place during this return. Under the excitation by light the complex probably shot out an electron which settled on

an electro-negative substance like sulphur, giving rise to a new arrangement; the electron then returned like a thrown up stone, the stored energy being that of the incident existing light.

If that explanation were correct it might be possible to stop phosphorescence by cold, *e.g.*, Phosphorescent tubes, dipped into liquid air, lost their brightness, but slowly became bright again as the substance warmed up once more; thus phosphorescence admitted of cold storage, so to say. Substances like a paraffin candle and a piece of egg shell were not phosphorescent under ordinary conditions, but became so if cooled in liquid air after exposure to light; the glow vanished soon, whilst in the sulphide tube it remained visible for many minutes. In these cases (paraffin) the return was too quick to mark phosphorescence, unless it was arrested by cooling. There were other ways of producing phosphorescence, for instance, by kathode bombardment, *i.e.*, by driving negative particles into the substance. Under this bombardment Iceland spar gave a reddish phosphorescence, fluorspar a bluish light. The interesting case of fluorspar had been studied by Morse; by stimulating this mineral with the light from sparks between electrodes of aluminium, zinc, &c., he obtained spectra of sharp bright lines bearing no relation to any known spectra, one of the few cases where solids gave bright lines. Didymium was another case, the didymium glass of Crookes giving lines where the solutions of the pink and of the green salts showed absorption (in those regions). If these observations were confirmed, the case of fluorspar would be similar to that of Wood's vapours of iodine and sodium.

Thermo-luminescence, Sir Joseph proceeded, was a kind of phosphorescence in which the complex substance formed by the light was so stable that the return was very slow unless stimulated by heat. A solid solution of manganese sulphide in calcium sulphide (a yellowish powder) was first bombarded by kathode rays; it phosphoresced green for a few minutes. When it had turned dark again it was gently heated over a Bunsen burner, when it became luminous once more, for a longer period. The case was the opposite to liquid air cooling; if heat were not applied, the return would spread over days.

Gases were also phosphorescent. To demonstrate this Sir Joseph made use of a glass cylinder wound with a few turns of a primary coil, and placed the glass bulb containing the gas at low pressure inside the cylinder, so that the gas itself formed the secondary. Oxygen glowed the discharge of an induction coil, and the glow continued after the discharge had been stopped, but vanished when the bulb was heated over a burner. This experiment will again be referred to. To show the phenomenon in nitrogen a bulb was used whose neck widened out above into a cylindrical chamber for two spark-electrodes (Fig. 3); this chamber was encased to stop the glare. When the discharge passed, a cone of greenish-yellow light was seen to issue through the neck. The explanation of the phenomena for gases was probably the same as for solids, complex compounds or modifications being formed.

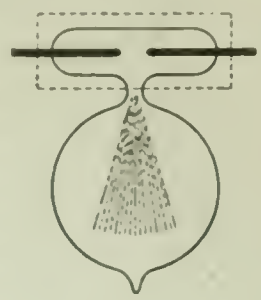


Fig. 3.

In the case of liquids the phenomenon was generally called fluorescence, but there was no real difference between phosphorescence and fluorescence, except that the fluorescence of liquids lasted only as long as the excitation. Thus, when red eosin powder was dropped into water, long streams of beautiful green light, following the single falling particles, and a green cloud surrounding the mass of powder, were observed; but that stopped at once when the lantern above the water was shut off. According to the law of Stokes, the fluorescent light was of greater wave length than the exciting light; that law held generally, but exceptions to it were known (Wood). The connection between fluorescence and chemical constitution was important for the creation of artificial dyes. There we wanted first of all something to absorb light (with absorption bands); the substance should be complex to yield an unstable modification; and we wanted a visible luminescence, not in the ultra violet. In this connection Sir Joseph referred to his suggestion of dividing substances into two classes: (1) Uncharged bodies containing atoms and molecules not showing free charges, because the positive and negative charges balanced one another; (2) charged bodies, whose atoms held free charges, some negative, some positive. Some organic radicles were charged, others uncharged. Ultra-violet rays falling upon an uncharged compound would discharge negative particles and convert it into a charged body, which would return to its uncharged condition. That would help to explain the relations between fluorescence and constitution.

There was a great deal of evidence now, Sir Joseph further said, that the greater the amount of energy which the negative particles acquired, the shorter would be the wave-length, and the more blue, therefore, the light emitted. In the above-mentioned experiment with oxygen, the oxygen molecules inside the bulb close to the wall were in a strong electric field (being close to the primary outside), and the gas nearer the centre was in a weaker field. Watching the glow in the bulb carefully one could see that the colour was not uniform; an outer blue ring and an inner red ring could be distinguished. There was thus a connection between the energy put into the system and the kind of light it emitted. This was in accordance with Planck's relation that the frequency was proportional to the actual energy, red radiations requiring less energy than blue radiations.

(*To be continued.*)

Erratum.—The words "System I." and "System II." in Fig. 2 in our account of these lectures in our last issue should be interchanged.

METHODS AND APPLIANCES FOR THE ATTAINMENT OF HIGH TEMPERATURES IN THE LABORATORY.

At the last meeting of the Faraday Society, held on Wednesday, March 15, at the Institution of Electrical Engineers, an interesting informal discussion took place on this subject. The chair was taken by the President, Sir Robert Hadfield, F.R.S., and Dr. J. A. Harker, F.R.S., of the National Physical Laboratory, opened the discussion.

The President, in introducing the subject under discussion, referred to the difficulties experimenters used to labour under in trying to melt small quantities of metals like steel or copper in the laboratory before modern appliances, such as would be described by Dr. Harker, were devised. He then went on to emphasise the importance of laboratory high-temperature furnaces in connection with the standardisation of pyrometric determinations, and he gave a short historical sketch of developments in pyrometry, beginning with Wedgwood's work in 1782, and referring particularly to the work of le Chatelier and Osmond in France, and W. Siemens, Roberts-Austen and Callendar in this country, coming down to the more recent work carried out by some who would take part in the present discussion.

Dr. J. A. Harker, in opening the discussion, said his object was to draw attention to some of the more difficult points in this subject. He dealt almost exclusively with the carbon resistance furnace. The difficulty with this type of furnace was to obtain carbon of the proper qualities, and it was satisfactory to know that in this country the General Electric Co. had a stock of carbon tubes for this purpose. Carbon for electric furnaces had a very variable specific resistance from one sample to another. Graphite had, roughly, one-fifth the specific resistance of carbon. It was much more uniform and contained very much less inorganic impurities. It differed chiefly in that its hardness was of quite a different order, and it could be cut on a machine like hard wood. With carbon, on the other hand, the lathe tool lost its edge directly, and it was impossible to cut rings or patterns, unless the specimen was particularly tractable. The temperature coefficient of carbon was practically nil for the first part of its running up, and then became strongly negative. Provision had to be made for the fact that the voltage had a tendency to fall rather than rise, and the current consequently to go up. For certain purposes when using graphite it was better not to make a plain, straight conductor, but to make it into a spiral or zig-zag. One of the difficulties was that at high temperature a neck was likely to form just inside the clamps, and irregularities of heating took place, which resulted in a poor life, and there was a great tendency for the whole thing to break in cooling off. Provision had also to be made for the carbon monoxide formed in the furnace to be quickly burnt. The material of which most tubes were made contained inorganic matter up to about 2½ per cent., whilst a thoroughly good specimen contained about ½ per cent. This could nearly all be burnt out by heating quickly to 1,800 deg. or 1,900 deg. The need for completely enclosing the carbon furnace was very great, and at the National Physical Laboratory some years ago Mr. Eden built the walls of such a furnace of reinforced concrete, which was considerably better than bricks for preventing the carbon monoxide from getting into the atmosphere. At the same time for laboratory purposes it was essential to have an apparatus of not quite so permanent a character, and in this connection he exhibited a new form of furnace which Mr. Eden had made. The difference between a good and bad type of furnace was all in the small details. In the carbon tube furnace, for instance, it was not at all easy to keep the thing working properly unless the ends were water-cooled. No conductor having a large current density with a big temperature gradient could go on working very long and maintain steady conditions. Sooner or later it caused a big increase in the voltage drop where the copper conductor joined on to the ends, and trouble followed, such as great local heating at the contact. In this new furnace, water cooling had been applied not only to the electrodes but also to the ends, because the furnace was enclosed in an aluminium bomb arrangement, and the ends which were bolted on to the bomb were fas-

tened by a packing ring which had to be kept cool. The maintenance of the insulation of the carbon tube was also important. One way was to have another tube round the carbon tube with an air space between, but for high-tension work this was thoroughly bad. He had found the simplest and best thing was to use the grade of lampblack used by paint makers, filling up all the space around the carbon tube for a radial distance of 3 in. This had been found to be by far the most satisfactory material for ranges of temperature above 1,500 or 1,600. Another point in connection with the new furnace was the important one of economy. It was necessary to obtain high temperatures with small power, and in order to get over this satisfactorily a small portable transformer had been made which could be used in the laboratory. There were 80 turns of primary made up in the simplest way and three secondary turns capable of being coupled in series or parallel. The primary was split so as to be used at 300 volts and downwards, and currents could be obtained up to about 1,000 amperes. With the insulating soot which he had mentioned the 1 kw. which was necessary to maintain the temperature of 2,000°C. in the furnace only heated the outside wall to something over 100°C., so that there was no need for elaborate precautions.

The PRESIDENT pointed out that one of the furnaces exhibited was to be sent to his works at Sheffield.

Dr. HARKER added that Messrs. Hadfields were going to do with that furnace just what had been done with it at the National Physical Laboratory, namely, standardise optical pyrometers. At the National Physical Laboratory there was a furnace like the one shown mounted beside a bench on which all pyrometers for verification were put and slid along, the indications being compared with those of the standard.

Mr. R. S. WHIPPLE dwelt on the difficulties he had experienced with optical pyrometers owing to the fact that many optical materials came from Germany and that it was difficult to get truly monochromatic glass. With regard to Dr. Harker's furnace, what struck him was the way the temperature could be maintained constant. He described some electric furnaces he had seen in America used for gear-hardening. Thermocouples passed through the furnace on to the work, which was simply brought up to the recalescent point, as indicated in a Northrup recording pyrometer, and then taken out and quenched. It was a beautiful technical application of scientific phenomena.

Dr. W. ROSENHAIN, F.R.S., said the problems mentioned by Dr. Harker became more difficult when one dealt with a larger space in which it was desired to melt things. The application of electrical heating for making optical glass was at present under investigation, but he would refer to some general difficulties in the use of high-temperature furnaces. One was the presence of carbon compounds; he wanted a furnace as tractable as Dr. Harker's which would be free from carbon. On a small scale a tungsten wire vacuum furnace was effective, and he had melted pure iron (1,525±5°C.) in such a furnace. But the tungsten became brittle and a fresh winding was necessary for each run. Granular tungsten resisters might be used, and so might a carbon resistance furnace with an inner tube, an indifferent gas between the two and a slightly oxidising gas in the inner space. The drop of volts between metal clamps and electrodes in electric furnaces became serious with large currents. He suggested coating the carbon with copper, aluminium or iron, as the case might be, by the Schoop spray process, burnishing the coating to give a good metallic contact. The possibilities of gas furnaces were often overlooked. He described two types which he had found useful—the Ségar furnace, and one they had evolved at the National Physical Laboratory. The former, which required a 30 ft. chimney, worked quietly and steadily; but for high temperatures he used a special type of injector burner for use with compressed air at 100 lb. per square inch, and with this temperatures up to 1,800°C. were obtained.

Mr. C. R. DARLING remarked that the furnace first described would be very useful for laboratory purposes for melting small quantities of metals. He pointed out some of the drawbacks of platinum-wound furnaces. In the furnaces of Dr. Harker's type he had found magnesia bricks satisfactory for outside lagging. Up to 1,000°C., furnaces wound with nickel-chrome wire gave good results. A furnace 1 ft. long, using a 1 in. tube, consumed only ½ kw.

Mr. H. G. LACELL agreed as to the value of nickel-chrome winding. A kieselguhr tube wound with ribbon of this material could be rigged up in a few minutes. He had given up gas-heating for any temperature below 1,000°C.

Mr. H. A. KENT had been using a lime furnace for melting platinum and iridium working beyond 3,000°C.; but he had recently obtained excellent results with a crucible of pure zirconia, using an oxy-hydrogen cyclone burner. He hoped it would be possible to make here pure zirconia in granular form; if so, almost any temperature could be obtained with surface combustion.

Mr. A. J. WEBB said he had obtained good results with the Brayshaw burner, with which he had accidentally melted a large piece of platinum with an air pressure of only 20 lb. and the ordinary gas supply. Mr. Kent had introduced a good burner similar to Dr. Rosenhain's, in which gas was blown in at the side.

Mr. S. N. BRAYSHAW said it was possible with his burner to melt small quantities of platinum with 3 lb. air pressure. Noise was of the essence of a good burner; the gas and air had to be sent into the furnace not only mixed, but in a state of violent agitation. The turbulence of the explosive mixture in gas-engine cylinders was a parallel phenomenon. He gave a descriptive sketch of the burner which bore his name.

Dr. H. C. GREENWOOD thought there was nothing better than charcoal for insulating carbon tube furnaces, and he held a brief—for many purposes—for the rougher type of furnace built of bricks and charcoal. He described a simple device for the calibration of pyrometers. With regard to large furnaces, something was wanted between the arc-furnace and the steel-melting furnace, and where a completely reducing atmosphere was not required the gas furnace had great possibilities. He had melted 100 lb. of German silver at 1,200°C. in a resistance furnace with a number of resistors in series.

Mr. F. TWYMAN suggested the use of gelatine screens as a substitute for red glass in optical pyrometers.

Dr. W. ROSENHAIN remarked here that at the National Physical Laboratory they were experimenting with zirconia, and he hoped something would emerge that would be generally available.

The PRESIDENT believed that very high pressure blasts would have a great future. Bessemer had worked on them at one time, and he was glad the idea was being taken up again.

Dr. J. A. HARKER, in reply, said that until they had zirconia tubes alundum could be used as a substitute for carbon where that was unsuitable; but it was more expensive than carbon, and at present it was not gastight. He hoped that lampmakers would make squirted tungsten tubes, as they would be extremely useful. In his carbon-tube furnace, to prevent the soot from falling into the spiral groove it was only necessary to wrap filter paper round the tube. Its ash kept the soot from falling. The present uncertain quality of coal-gas was a difficulty in gas furnaces.

INSTITUTE OF INDUSTRY.

On Thursday, March 30, a meeting convened by the Institute of Industry took place at the Savoy Hotel, London, to discuss a project for forming a central body to co-ordinate all national movements for protecting and furthering the interests of British industry and commerce.

Mr. F. J. NETTLEFOLD (Messrs. Courtaulds, Ltd.), who occupied the chair, said the Right Hon. Sir Edward Carson, at a luncheon given by the Institute on Jan. 12, appealed to the business men to co-ordinate and consolidate all national movements such as theirs into one powerful national organisation, and so avoid waste of effort and energy. The court of directors had that object in view, and believed the organisation would readily lend itself to that purpose. There was sitting daily in Berlin an organisation representative of all trades, and composed of the cleverest brains of industrial Germany, ready to complete a programme for the conduct of the economic struggle which would commence directly the war came to an end, and we should be ready with a similar organisation, so that the leaders of industry in this country might have had time to consider the best commercial policy suited to all trades. There were already throughout the country organisations representative of each trade. Individually, although extremely valuable, they could achieve very little towards advancing our general commercial policy. Collectively, they would form such a body of expert opinion as is required and would be invaluable to any Government. The meeting that day was convened in order that they might consolidate their forces, and provide a central representative organisation promptly to start the work which Berlin was already doing. The committee was authorised to state that the sole object of the directors was to bring into existence the necessary organisation to deal with our economic future after the war. They wished to see the board composed of the most able business men of the country, and desired it to be distinctly understood that everyone of them was willing at any time to stand aside to give place to men who might be better able to advance the programme which had been outlined. Mr. Peddie, the founder of the Institute, and who was mainly responsible for the excellent progress made up to now, had placed his resignation in the hands of the directors, in order that, in inviting the co-operation of those present and of other similar organisations, they might be offered the advantages of a central association whose machinery was free and unfettered by any existing agreement as to management and conduct. The Institute had no politics, and its policy, which had received considerable publicity, had been generally approved. The first question was naturally one of finance. It would be necessary at the outset to have an assured minimum income of £5,000 a year. It was proposed that it should be raised by inviting donations of £1,000 each, and that the capital should remain intact and invested, the interest only to be used as income for the purposes of that association. They might also invite annual subscriptions of large amounts for a period of years, and there would also be smaller amounts subscribed by the members themselves. It was suggested that associations, and groups of associations, should send their deputies to take counsel together, and through the various ramifications they might at last come to a committee of manageable size, each member of which might voice the opinions of the trade he represented. They had heard much during the last few years of a business Parliament. The way now proposed was the only way this could materialise. It was useless to expect such a thing in the

House of Commons. (Hear, hear.) It was not only so-called key industries that deserved special attention, but every industry that was capable of giving employment. The strength of a country largely depended upon the number of people who could be employed at a wage which enabled them to maintain a decent standard of living. That created a large home market from which all industries benefited. He recommended that no permanent appointments should be made until they had arrived at the best form of board to adopt. They should put aside all personal ambitions and petty jealousies and have one object in view—the general good of their native land. (Applause.)

Mr. Godfrey Isaacs (Marconi's Wireless Telegraph Co.) said in Berlin, as the result of the conference of the ablest business men of Germany, there were contracts now being made in several neutral countries with the object of securing as nearly as possible a monopoly of certain products from the date when peace shall be declared, and also endeavours were being made by numerous groups to charter all neutral tonnage for three years from the declaration of peace, and other matters were being organised in Germany to meet the position which would arise from the moment peace was declared. We ought to be doing the same thing without delay. If we merely continued to talk about the organisation of our economic interests we might be too late, as we had been before. He asked those present not to wait to see whether the Institute of Industry was going to be a success, but to put their shoulders to the wheel to make it a success. As the representatives of the industry and commerce of the country they could wield whatever power they pleased in the country, and in that way they could be assured that they would not have to face a condition of things such as they had had to face in the past. The whole of the industry and commerce of this country would be at stake after the war. If they acted together they would find a satisfactory solution. If they left these matters to the tender mercies of Government departments and conflicting political parties in the House of Commons he need not tell them what would be the result. The Institute of Industry invited every trade organisation in the country to join and send its representatives to one central organisation. He hoped thay would be able to find 500 who would each put up £500. There were several there ready to start that list.

Mr. Frank Warner (President of Silk Association of Great Britain and Ireland) moved: "That this meeting of manufacturers and other representative men closely connected with all phases of industrial activity in the United Kingdom fully endorses and approves of the statement of policy outlined by the chairman at this meeting to-day, and they cordially approve and welcome the proposal that all national movements of a similar nature should amalgamate their forces with a view to creating a strong central organisation": and, "That this meeting recommends all persons or companies interested in the industrial life of the British Empire to support the Institute by becoming members, in order to stimulate action in the direction desired."

Mr. Warner, continuing, said he represented one of the trade organisations which, as the chairman said, existed throughout the country. During the few years he had held the presidency of that association he had had the greatest difficulty in getting any Government department to recognise any policy the association deemed necessary. He went, on the previous day, to a department with a very reasonable requirement, but came away without anything satisfying. That must go on in connection with their national policy unless they combined. Just as a trade association was a rallying point for a particular trade they wanted that Institute to become the rallying point for the associations. If the business men of the country did not combine and decide what the business policy of the country should be it would be decided upon by those who had proved in the past to be quite incapable of guiding or constructing such a policy. (Hear, hear.) They not only wanted such a central body for dealing with the policy that must follow the war, but also to continue such policy. He thought the broad principles upon which the Institute of Industry was based made it a good rallying point for a central body to construct the business policy which was vital to the country.

The Chairman said he wished it to be distinctly understood that the Institute of Industry did not wish to pose as the institution into which all the others would come. It was open to those who came in to make their own arrangements afterwards.

Col. Cassell (President of Institute of Chemical Technology) said he felt that it was very proper that the resolution proposed should be passed. It was important that there should be a rallying point where every industry could turn for advice and assistance. The chemical industry was in a state of disorganisation. He did not blame the manufacturers for this, but it was essential that manufacturers should appreciate that without organised scientific effort it would be impossible to compete against so highly organised a country as Germany. With regard to the Government Departments he did not know which was the worst. It was due to the evil system under which they had grown. From the time a civil servant received his appointment practically no mental effort was necessary and the result was that they were incapable of working effectually for the national interests. Anything more inept, more worthless than the system of the Government Departments with which he had had dealings could not be conceived even in Gilbert's opera. He would plank down his small subscription with pleasure and endeavour to get his colleagues to support the objects of the Institute.

Mr. W. Howard Lancaster (National Federation of Furniture Manufacturers) said he noticed there was no proposal made so far that the various federations should subscribe as institutions. It might be possible to get 50 or 60 federations to put up 100 guineas a year each. Perhaps a sliding scale corresponding with the financial condition of the federation could be devised.

Mr. Dudley Docker (Midland Carriage & Wagon Co.) said he was interested in an association whose objects were almost identical with those of the Institute of Industry. He understood the idea was to form one large association which would have sufficient power to enable business men to exercise the influence they ought to have in the affairs of the country. The movement would have his support and that of the association with which he was connected, and, he felt sure, that of all other trade associations in this country. His association had already between 30 and 40 members who had all undertaken to subscribe £1,000 each. That nucleus ought to bear fruit and carry weight. He suggested that a conference should take place between the Institute of Industry and his association—which belonged to the Manchester group—and out of that might come one big association which even the Government would have to recognise. The politicians must be kept out of it. He thought it would be possible for capital and labour to work together after the war as they had done in the trenches.

Mr. Cassels suggested that a few gentlemen, including Mr. Docker and Mr. A. W. Tait, should be appointed to draw up a scheme. On April 14 Mr. Hughes was to address a large meeting at Glasgow and he was anxious that the joint organisation should be officially represented there.

Mr. A. W. Tait (Ferranti Ltd.) said he was associated with Mr. Dudley Docker in connection with the association which Mr. Docker had mentioned. He agreed that men representing the industries of the country and the capital invested in those industries should come together as a central body to look after the vital interests of capital and labour. Various associations had been started with excellent ideals but they did not go very far. That was why Mr. Docker had started his association and got together men who could give questions vital to industry their time and attention and back it up with money. Nothing would be done for industry unless industry did it for itself. They must have brains and money of the best quality and in the largest quantity. To talk about living on the interest of £100,000 was puerile. A thousand men putting down £50 a year each would give a revenue of £50,000, and if it was not worth £50 to anyone having anything to do with industry he ought not to be there. He supported Mr. Docker's proposal that there should be a conference of the parties responsible for the three movements to see whether a strong central organisation could not be evolved.

Sir Alexander Stenning, on behalf of the Surveyors' Institution, said the Institution would be pleased to do what it could to assist the movement.

The Chairman said one direction in which the Institution would be of great value was in regard to education. The £5,000 a year income to which he had referred was merely the minimum with which they could make a start. They would require very much more.

Mr. Summers said he represented organisations connected with the steel industry. He would like to know whether it was intended to invite the co-operation of labour or to be a body, which, although not antagonistic to labour, would resist what were considered unjust claims by labour. If that were made one of their principles, labour would be antagonistic. A paragraph in Mr. Docker's pamphlet might be interpreted to mean that the organisation would be antagonistic to labour.

The Chairman and Mr. Docker both said there was no such intention, but the former said before inviting the co-operation of labour they must have a body properly organised. Labour already had a very large and powerful body. When they had a powerful body also the two combined would be an irresistible force.

Mr. Allcock (Manchester) said the ideals of the Institute were approved by all. They should link up the present successful sectional organisations. When a man was asked to join an association he wanted to know the subscription and what he would get out of it. If it were shown that as the result of the Association's work he would get a more ready market for, say, his steam engines, he would be ready to subscribe. He suggested that the central association should derive its funds by tapping the resources which the sectional organisations had no difficulty in obtaining. It might be suggested to the existing organisations that they should set aside 10 per cent. or some such proportion of their income for the central organisation.

The resolution was put and carried unanimously and the vote of thanks to the Chairman concluded the proceedings.

NEW CHEMICAL LABORATORIES AT UNIVERSITY COLLEGE.

The facilities for carrying out research work and for training men in the higher branches of chemistry at University College have recently been considerably extended by the raising, on a site immediately to the north of the main college buildings, of laboratories which are said to be without equal in Europe. Largely owing to the energy of the provost, Dr. T. Gregory Foster, a sum of close upon £100,000 was collected for the purpose by members and friends of the College.

Much still remains to be done before the buildings can be fully utilised. The largest defects yet to be supplied are the laboratory equipment and apparatus, the provision of the necessary electrical machinery and circuits, and the equipment of the department of

physical chemistry. In order to remedy these defects it is estimated that a sum of £14,000 is required at once, and for the development of research work during the next three years a sum estimated at £6,000 will be required, making the total still required £20,000. It was to further the raising of this amount that Captain the Hon. Rupert Guinness, M.P., the treasurer of the equipment and endowment fund, invited friends of the college to inspect the buildings on the 31st ult., after luncheon. Before the inspection was over the provost was able to announce that towards the £20,000, Sir Ralph C. Forster, Bt., who had already been a munificent donor, had contributed £5,000.

The new laboratories have been erected from designs prepared by Prof. F. M. Simpson, F.R.I.B.A. The site fronts upon Gower-place and has a frontage of 315 ft. The area covered by the buildings is about 17,500 sq. ft.

The building comprises a half-basement, ground, first and second floors. The western portion of the half basement is occupied by the laboratories and research rooms for physical chemistry. At the eastern end is a room about 50 ft. square, specially designed for large-scale operations, such as the examination of a new process with a view to its utilisation for manufacturing purposes. Adjoining this room is a well-fitted workshop for the construction of apparatus for the departments of chemistry and physics and for the use of students. On the same floor are rooms for the production of liquid air and hydrogen for low-temperature research, and for the main chemical stores. The cellarage of the houses that previously stood on the site has been adapted for the storage of corrosive and inflammable chemicals.

The entrance hall and main staircase are in the middle of the ground floor. To the east are two lecture theatres and preparation rooms, the library, the private room and laboratory of the Professor of Inorganic and Physical Chemistry. The large lecture theatre occupies the whole width of the building and is fitted with tip-up seats accommodating 240 persons. It is well lighted, having windows on both sides, and possesses excellent acoustic properties. The small theatre accommodates 110 persons.

Immediately to the west of the entrance hall is the museum for the exhibition of important chemical products, and next to that is the main inorganic laboratory for second-year students, with rooms adjoining for operations involving noise or fumes, for balances, and a store for the chemicals needed on this floor. The laboratory and the balconies have special fan ventilation. The tops of the benches are of unglazed, highly compressed tiles, which are fire-proof; they are easily kept clean and do not increase the breakages, as was feared. Beyond this laboratory is a group of research rooms for the assistant members of the staff and for research students.

On the first floor, westwards, are the private room and laboratory of the Professor of Organic Chemistry. Adjoining these are the organic laboratory, combustion room and balance room at one end, and a group of research rooms at the other. To the east of the main staircase are the organic theatre, the organic chemical stores, an apparatus store, a dark room, a spectroscope room, a service room and lavatories.

At the east end of the second floor is the laboratory for first-year students, providing bench accommodation for 100 to work at a time. Balance and store rooms immediately adjoin it. West of the main staircase is the department of pathological chemistry. This department is devoted entirely to post-graduate and research work; it comprises a general laboratory, a research room, operation and post-mortem rooms. To the west are six research rooms for general chemical research.

The general ventilation of the building is controlled by four separate fans, the flues from each room running to a main duct in the roof. The laboratories and research rooms have glazed brick walls; they are amply supplied with fume cupboards, which are ventilated by separate flues in which the draught is created by gas flames.

THE DEVELOPMENT OF THE BUREAU OF STANDARDS.

The "Electrical World" recently published an instructive article by Dr. Stratton on the growth of the Bureau of Standards since its enlargement about 1900. In a prefatory statement he mentions that the Bureau is in constant touch with every branch of American industry, and is having the sincere co-operation of technical societies, industrial concerns and scientific laboratories. The work being done is grouped under a scheme of organisation, and includes absolute physical measurements, weights and measures, pyrometry and fire-resisting properties, chemistry, engineering instruments and investigations, structural engineering and metallurgical work.

One of the main activities of the Bureau is the testing of materials for the Government. For instance, the materials used for the Panama Canal work were tested here. In addition, 1,501,491 incandescent lamps at various Government factories were inspected. The testing for the public is confined to standards, as the Bureau does not compete with private laboratories. Qualities of goods are also certificated, and, since America is dependent on Europe for optical glass at present, glass furnaces have been installed.

The Bureau is also in close touch with the clay and pottery industries, and there is a decided tendency on the part of the cement, paper, textile, rubber, paint and other industries to co-operate with the Bureau in fixing standards of quality. In this respect the Bureau appears to be much further ahead than the similar institutions in this and other countries.

The younger people employed in the Bureau receive a minimum salary of £95 a year, and are encouraged to attend the evening schools, and after five or six years of this training they rank as graduates as regards promotion.

DIMENSIONS OF ELECTRICAL UNITS.*

BY M. ASCOLI.

The present memoir was written in April, 1914, but publication was postponed on account of the European war. The author emphasises the necessity of retaining what Rücker used to call the "suppressed" dimensions, such as those of dielectric constant and magnetic permeability, more especially when units have to be defined and names assigned to them. This is especially to be borne in mind in view of the proposal to use the same unit for such heterogeneous quantities as magnetic field and magnetic induction. Prof. Ascoli protests against the long prevalent view, originated by the Paris Congress of 1881, that there is any specially fundamental character in the units of length, mass and time. Any of these can be replaced by others, and systems can be devised in which mass, for instance, is replaced by density or elasticity. The very fact that the dimensions of electromagnetic quantities, expressed in terms of L, M and T, are different in the electrostatic and electromagnetic systems respectively shows that a fourth quantity has been tacitly omitted. But this fourth quantity may be any one of those that enter into the electromagnetic list of quantities. The author characterises as "extravagant" the assertion that an essentially electromagnetic quantity like inductance should be homogeneous with a length, or that resistance should be measurable in metres per second. It is like "measuring the height of a mountain in henries or the speed of a train in ohms!"

The author gives examples of a number of other systems in which the units may be arranged. For instance, magnetic pole strength may be assumed as the fourth fundamental quantity, and fractional indices thus made to disappear. The same result follows the adoption of current as a fundamental unit as proposed by Giorgi. It is sometimes of advantage to introduce the "constant" of Biot and Savart's magneto-electric force as the fourth quantity.

When any quantity is expressed by its full dimensions, these are identical in whichever system they are expressed.

Refuse Collecting by Electric Vehicles.— Mr. J. A. Priestley, in a report presented to a sub-committee of the Sheffield Corporation, refers to the results obtained with electric vehicles fitted with Edison batteries in comparison with horse-drawn vehicles. These were used for collecting dustbin refuse, and he finds that when the total mileage does not exceed three per journey the horse-drawn vehicle is the most economical, but above that distance the electrically-propelled vehicles show a decided superiority. The following are some of his figures:—

District.	No. I.	No. II.	No. III.
Cost per ton, electric ...	5s. 0·8d.	2s. 3·4d.	1s. 10·3d.
" " horse	7s. 0·4d.	3s. 3·2d.	2s. 6·2d.

He states that in Sheffield, where the system of day and night work is in vogue, the electric vehicle is a pronounced success, and he recommends the extension of the method where opportunity offers, more especially as it renders possible the centralisation of the work, and the use of one destructor capable of dealing with all the refuse of the city.

*Abstract of an article in "L'Elettrotecnica" for Nov. 25th, 1915.

The Electrician.

The Oldest Weekly Electrical Journal (established weekly 1861—1878).

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone : City 4698 & 4699. *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITOR. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed. Advertisement Rates, &c., forwarded on application to the Publisher.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by Wednesday. Renewals of expiring Advertisements, alterations to standing Advertisements and Wrapper Advertisements by Tuesday evening.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **12.30 P.M. THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXV. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRICAL MEASURING INSTRUMENTS : THEIR DESIGN, CONSTRUCTION AND APPLICATION. By C. V. Drysdale, D.Sc., and A. C. Jolley *In preparation.*

ELECTRIC LIFTS AND HOISTS. By Gilbert Rowe, M.I.E.E., &c. *In preparation.*

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation*

THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone. 9s. nett, post free 9s. 4d.

STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett

ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S. Heather, M.I.E.E. 9s. nett.

AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.

WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.

ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.

LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.

ELECTRIC BLASTING APPARATUS AND EXPLOSIVES : With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.

THE SHOT-FIRER'S GUIDE : A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.

THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.

THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*

BOILER FEED WATER. By F. A. Anderson. Price 6s. nett

LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.

SECONDARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.

THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.

INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903). Full Report of Proceedings at, 8s. 6d. ; post free, 8s. 9d. : abroad, 9s.

INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.

BRAKES FOR TRAMWAY CARS. By H. M. Sayers. Price 2s. 6d. nett.

ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.

ELECTRICITY IN HORTICULTURE. By Prof. S. Lemstrom. Illustrated. 3s. 6d. nett.

Further portions of this list of "THE ELECTRICIAN" SERIES OF BOOKS appear each week.

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM) : A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d each, post free. Hanging Cards : 8d. each post free. Pocket Books, complete in envelope, 2s. 6d., post free

"THE ELECTRICIAN" TABLES OF ELECTRICITY SUPPLY.

These important Tables and Data relating to Electricity Supply in the United Kingdom in 1916 (which have been published annually since 1887) are now obtainable, price 3s. net, post free 3s. 3d.

The Tables of Colonial (and certain Foreign) Electricity Supply, Power and Traction Stations are also obtainable, price 2s. 6d. net., post free 2s. 9d.

The two sets of Tables are supplied, price 5s. net., post free 5s. 4d.

SPECIAL NOTICE.

Last week's number of "THE ELECTRICIAN" completed Vol. LXXVI. With next week's number will be issued (Gratis) the Index to the Volume.

NEARLY READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

SPECIAL NOTICE.

In order that we may be able to supply the newspaper trade effectively and meet the requirements of the Post Office, we are sending THE ELECTRICIAN to press a few hours earlier every week. All editorial and news matter for the next current issue of THE ELECTRICIAN must reach us as much earlier as possible, but not later than WEDNESDAY MORNING, and advertisement text and blocks must reach the offices as much earlier as possible, but not later than TUESDAY EVENING, during the continuance of the War. Displayed Advertisements not for proof before first insertion can be taken until NOON ON WEDNESDAY, and Official Announcements, Auctions and "Smalls" of all kinds of which no proofs are required before insertion can be accepted up to FIRST POST THURSDAY MORNING.

FACTORS IN SCIENTIFIC MANAGEMENT.

One effect of the war is that public attention has been directed to the science of production—a science to which, prior to the war, little attention had been given in this country. Without fear of contradiction it may even be stated that with few exceptions many of our industries were carried on without reference to the science of production. The manufacture of munitions during the past year by firms unaccustomed either to the use of gauges, or to repetition work and rigid inspection, will materially strengthen our engineering. By some it is argued that severe restrictions are imposed as regards accuracy of dimensions and, to a certain extent, this may be so ; but those competent to form an opinion assure us that on repetition work accuracy is easily attained provided that the method of production be correct. The enormous sums of money expended by private firms in the manufacture of gauges and tools, which at first sight appears to be largely a dead loss, may, in reality, be regarded as being devoted to a big educational campaign. A direct result of this campaign has been the enforcing of a discipline which, of its kind, is as severe as that demanded of a soldier or sailor.

Little more than six months ago a strong committee, known as the Health of Munitions Workers Committee, was appointed, with the concurrence of the HOME SECRETARY, "to consider and advise on questions of industrial fatigue, hours of labour, and other matters affecting the personal health and physical efficiency of workers in munitions factories and workshops." All matters affecting the personal health and physical efficiency of workers properly belong to the science of production. Attention to these matters not only lessens the cost of production, but also increases the wage-earning capacity of the worker. Both are highly important factors in promoting the welfare of the working classes. We take it that no one will deny either man or woman the right to live comfortably by exercising his or her ability, and, with thrift, to provide for old age and sickness. If it be so, lessening cost of production should give rise to greater employment, and, in the long run, increasing the wage-earning capacity of the worker

should undoubtedly promote thrift. The decrease of pauperism may be taken as evidence of the importance of these matters.

Of the 10 memoranda already published by the Health of Munitions Workers Committee for the Minister of Munitions, amongst the most interesting are the four recently prepared dealing respectively with "Industrial Fatigue and its Causes," "Special Industrial Diseases," "Ventilation and Lighting Munition Factories and Workshops" and "Sickness and Injury." In connection with the first-named the Committee express the hope that the study of industrial fatigue and the science of management based upon it, which is now being forced into notice by immediate need, may leave lasting results to benefit the industries of the country during succeeding years of peace. We also hope and believe that the deliberations of the Committee will yield lasting results to benefit our industries.

At the moment, one of the most important problems awaiting solution is that of industrial fatigue. In an able article in the "Daily Mail," of the 31st ult., Mr. B. TILLETT discussed the position on the Clyde, and went to the root of the matter by stating: "In the first place, these men . . . have for 20 months been working at full pitch day in and day out. Long hours and overtime have been the rule and not the exception. Body and brain alike have been fatigued. Weariness due to physical strain, temper due to the greyness of their lives, have made them fit subjects for the promptings of revolt." In dealing with the best remedy for the present discontent, Mr. TILLETT urged: "First let the hordes of moralising busybodies who so sedulously preach to labour cease their activities, and do something of benefit to the country. Calm down the men somewhat by ceasing to nag them. . . . Then overtime and Sunday labour should be ruthlessly cut down. Both mental and physical recuperation is necessary for the men. Flesh and blood cannot go on as many men have had to go on for the past 20 months without breakdowns and possibilities of disaster."

That such is the case is evident from a perusal of the memorandum dealing with "Industrial Fatigue and its Causes," and the memorandum appears at an opportune time. Excellent illustrations of signs and symptoms of fatigue are given. Thus: "Two officers . . . recently . . . competed in making equal lengths of a certain trench, each with an equal squad of men. One let his men work as they pleased, but as hard as possible. The other divided his men into three sets, to work in rotation, each set digging their hardest for five minutes and then resting ten, till their spell of labour came again. The latter team won easily." Equally convincing are the following figures which serve as illustrations in the section devoted to tests of industrial fatigue.

"In a specific instance before the Committee a group of five male volunteer Sunday workers . . . were able in eight hours (or seven hours free of meals) to exceed the average day's output of eight week-day men who work 14 hours (or 12½ hours free of meals). These five men worked, no doubt, at a 'sprint,' which could not perhaps have been maintained daily. But there can be little doubt that they could repeat their eight hours' effort on, say, four days in a week; and if so, the startling result follows that they could do in those four days rather more than the whole week's work of an equal set of men adopting the other system of hours. . . . Would these five volunteers be 'slackers' if they did a full week's work judged by the 14-hour standard or more, but had three holidays per week . . . and slept longer at night?"

At another large factory the manager . . . is proposing to aim at "sprint," and hopes to get the same output from 7½ hours' work as from the present 10½ hours' work. He instituted a competition as to which shift and which group of men could do most as an experiment. He found that a small bonus "increased the output of a group of boys 120 per cent."

A further illustration is given of a shop built and staffed so as to produce 5,000 of a particular stock article of warfare per week from which, notwithstanding the inexperience of the new hands, 13,000 of these particular articles are now produced weekly. The workers need have no fear that the solution of these problems will have any effect other than a beneficial one on themselves. It may be that they, themselves, will, consciously and unconsciously, solve many of the problems connected with the science of production. Improvements resulting from a proper application of such science will add to the dignity of labour, and will ultimately make toil into a kind of Heaven, as assuredly it should be, to be worth while. Many of our readers will agree that the world stands in urgent need of such toil.

DRY CELLS.*

BY W. R. COOPER, M.A., B.SC.

(*Concluded from p.* 909, *Vol. LXXVI.*)

Summary.—The author gives an account of recent investigations on dry cells and the materials that are used. He then refers to various methods of testing.

The Reliable Cell.—This cell is made by the Associated Battery Co., and has some unusual features. The container is of galvanised iron instead of zinc, and is covered

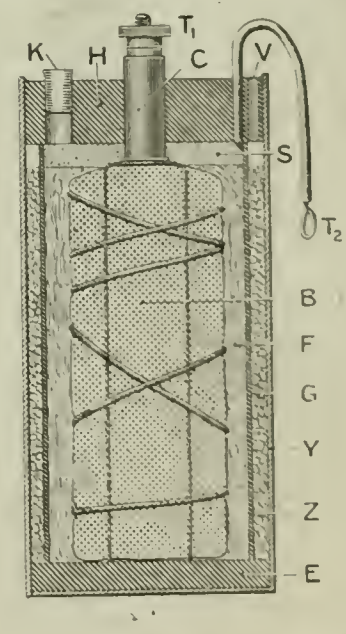


FIG. 9.—SECTION OF THE RELIABLE CELL.

B = Sack element.
C = Carbon.
E = Insulating layer.
F = Turkish towelling.
G = Excitant crystals.
H = Bituminous seal.
S = Sawdust.
K = Cork stopper.
V = Vent tube.
Y = Galvanised-iron container.
Z = Zinc.
T_1 = Positive terminal.
T_2 = Negative terminal.

on the outside with a paper wrapper. It is protected internally at the bottom by a thick bituminous layer and the walls are also protected by a bituminous coating. This container is rectangular in section. The carbon element is in the form of a sack, and surrounding this is a cylindrical sheet of zinc. Between the sack and the zinc is a layer of Turkish towelling, and the space between the zinc and the container is packed with excitant crystals. The cell is finished off with a layer of sawdust, then some

* From a forthcoming edition of "Primary Batteries." (Copyright.)

thin canvas and finally a bituminous seal, through which there is a corked aperture on the one side and a vent on the other, as seen in Fig. 9.

The W.O. Cell.—The W.O. cell, which is made by the Atlas Carbon & Battery Co., differs from the cell last described in that an earthenware jar is used as the container. The sack element is surrounded by a cylindrical sheet of zinc, and between the two is a sheet of paper. This space also contains exciting salts. The cell is finished off with a layer of sawdust and a bituminous seal, there being a layer of cardboard both above and below the sawdust. No vent is provided. A section of the cell is given in Fig. 10.

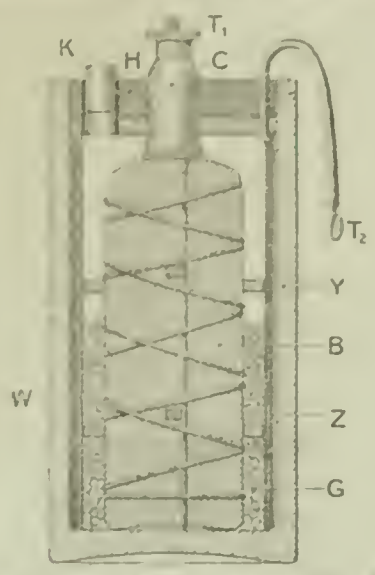


Fig. 10.—Section of the W.O. Cell.

B—Sack element.
C—Carbon.
G—Exciting crystals.
H—Bituminous seal.
K—Cork stopper.
W—Sheet of paper.
Y—Earthenware jar.
Z—Zinc.
T_1—Positive terminal.
T_2—Negative terminal.

Comparison of Wet and Dry Cells.—A comparison of the performance of wet and dry Leclanché cells reveals the fact that dry cells are superior from the point of view of capacity for a given weight. In order to obtain such a comparison it is, perhaps, best to rely upon the data given in any one maker's list (rather than on a variety of tests) so as to compare cells which are presumably of the same standard of manufacture for all types and are, therefore, fairly comparable. The following table has been prepared on this basis, cells of the General Electric Co., being selected for the purpose. The weight of wet cells can only be stated very approximately, as this varies with the amount of, and strength of, the electrolyte. By "useful life" is meant the number of days taken for the voltage of the cell to fall to 0·75 volt when run continuously on a 10 ohm circuit. The last column gives the figure obtained by dividing the useful life by the weight of the cell, or, in other words, the life per pound.

Comparison of Wet and Dry Cells.

Wet Cells.

Type of Cell.	Weight (Approx.)	Size (Overall.)	Useful life in days.	Useful life per lb.
Porous Pot Leclanché (pint)	2¼ lb.	3½" × 3½" × 6¾"	3½	1·3
Carporous (pint)	4 lb.	4" × 4" × 7½"	4	0·95
Carsak (pint)	4 lb.	4" × 4" × 7½"	15	3·5
Porous Pot Leclanché (quart)	4½ lb.	3½" × 3½" × 7½"	7½	1·6
Agglomerate Block (quart)	4 lb.	3½" × 3½" × 7½"	4½	1·1
Carporous (quart)	6 lb.	4½" × 4½" × 8½"	11	1·8
Carsak (quart)	6½ lb.	4½" × 4½" × 7½"	39	6·2
Porous Pot Leclanché (3 pint)	7 lb.	4½" × 4½" × 8½"	17½	2·6
Agglomerate Block (3 pint)	6½ lb.	4½" × 4½" × 8½"	10½	1·7
6 Block Agglomerate (3 pint)	11½ lb.	6" diam. × 9"	17½	1·6
Carporous (3 pint)	8 lb.	4½" × 4½" × 9½"	16	2·0
Carsak (3 pint)	8½ lb.	4½" × 4½" × 8½"	81	9·4
Dry Cells.				
No. 3 G.E.C. square	11b. 11oz.	2¼" sq. × 5½" high	74	4·4
No. 2 G.E.C. square	2lb. 12oz.	2¾" sq. × 6¾" high	154	5·6
No. 1 G.E.C. square	5 lb.	3½" sq. × 7½" high	32	6·4

From these figures can be seen the great advantage of the sack form of cell over the other types of wet cell. Agglomerate cells do not show up so well as the ordinary porous pot cells on this basis. It is noticeable that the dry cells are much superior to the wet cells, and that this superiority is obtained with a smaller weight. Thus, the No. 1 dry cell weighs only 5 lb., whereas the average 3-pint wet cell weighs 8 lb. and gives a considerably less efficient result. The No. 1 dry cell has about the same weight as the average quart-size wet cell. It is seen that the efficiency in all types generally increases with the size of cell.

In the matter of first cost, wet cells generally have an advantage. For example, the list price of a No. 1 G.E.C. cell is 3s., whereas the prices of the 3-pint wet cells are 1s. 10½d., 2s. 3d. and 3s. 9d. for a porous pot cell, an agglomerate block, and a carporous respectively. The price of a 6-block agglomerate is 5s. 6d., but that of a 3-pint Carsak cell is only 3s.

A dry cell has the disadvantage that when it is exhausted it is of no further use and must be thrown away, unless the manufacturing company makes an allowance for old cells, which is sometimes the case. Wet cells can, of course, be re-charged. But fresh electrolyte does very little to put new life into an exhausted cell. It is necessary to renew the depolarising material as well, and not infrequently the zinc also. Consequently the supposed advantage of being able to re-charge a cell is not a very great one, and, on the other hand, the dry cell is greatly superior in that it is always ready for use and is exceedingly easy to handle.

Testing Dry Cells.

The testing of dry cells has assumed some importance as a distinct branch of cell testing owing to the fact that these cells are used in enormous quantities and for very different classes of service. For this reason a good deal of attention has been given to the subject.

The object of tests is generally to obtain *comparative* results, so that one kind of cell may be compared with another, or, so that different batches of the same kind of cell may be compared so as to ensure a certain standard of manufacture. Unfortunately, different kinds of tests do not always lead to the same comparative results, and therefore a test should be selected having some relation to the character of the work for which the cell is required. Thus for some purposes an intermittent test may be preferable to a continuous test. It need scarcely be remarked that the precise service conditions under which a cell is to be used can rarely if ever be reproduced as test conditions, and even if they could the test would be too prolonged to be useful. But it is desirable to be able to deduce the life in service from the life on test with some show of probability.

Apart from comparative life tests, other tests are used to determine whether a cell is in good condition and whether it deteriorates on open circuit.

Tests to Determine the Condition of a Cell before Use.—These tests include the measurement of E.M.F. (which should vary from 1·5 to 1·6 volts) and internal resistance. Such information is not of any great value.

A third test is what is known as the *Short Circuit Test.* It is in common use in the United States, but it has been subjected to a great deal of criticism on the ground that it may be harmful to the cell and gives information of only doubtful value. Taking the average American cell, which is 6 in. high by 2½ in. diameter, it is found that the current on short-circuit, when the cell is new and good, varies from 18 to 25 amperes. Inferior cells give currents as low as 10 amperes. This remark, however, does not apply to English

cells. American practice and English practice differ so much that the product of these countries cannot well be compared. In the former everything seems to be sacrificed to high initial current, whereas in this country the best qualities and preparations of materials are selected with a view to producing a cell with the longest useful life. A current ranging from 5 amperes in the middle sizes to 12 amperes in the large sizes is undoubtedly sufficiently high for ordinary requirements, and dry cells can be made which give such currents on the short-circuit test, and will give also a maximum output and possess the useful characteristic of maintaining their condition when kept in store for a very long time.

This test gives an easy means of determining if a cell is in good condition, provided the behaviour of the particular brand of cell is known. It also forms the basis of what is called the *Shelf Test.* The longer a cell is kept in stock the smaller is the short-circuit current. In the United States it is considered that the short-circuit current should not fall below 10 amperes after storing ("on the shelf") for about 12 months. The curves in Fig. 11 have been given by C. Hambuechen* as showing the variation of the short-circuit current as a cell is stored.

For the short-circuit test to have any true meaning it is necessary that the ammeter should have a definite resist-

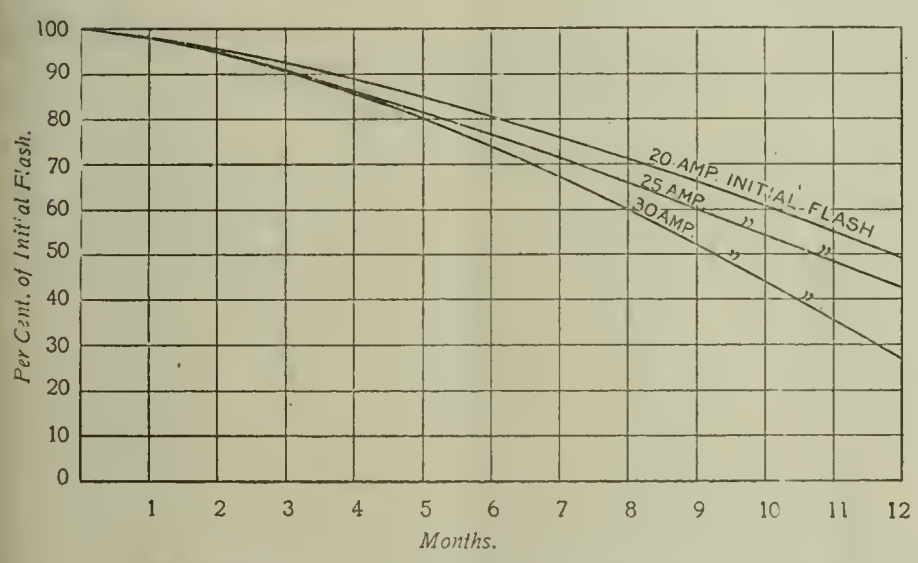


FIG. 11.—VARIATION OF SHORT-CIRCUIT CURRENT WITH AGE OF CELL. (Hambuechen.)

ance; otherwise the results might vary with the ammeter selected. A committee of the American Electrochemical Society have recommended that the resistance, including the leads, should be 0·01 ohm, correct to within 0·002 ohm. Connection must be made by the cell terminals, and it is suggested that the maximum swing of the needle should be taken as the short-circuit current. This direction should scarcely be necessary, as a very dead beat instrument should be used and the circuit should be closed only just long enough to secure a reading. It is stated to be an advantage if the leads terminate in a strip of lead, as this improves the contact with the terminals.

The value of the short-circuit current depends appreciably upon the temperature. It is found that the current rises (for the size of cell above mentioned) by about 1 ampere for each 10°C. rise in temperature between 10°C. and 80°C. Cells are particularly sensitive in this way at low temperatures.

Shelf life is affected considerably by temperature. This fact is illustrated by the figures in Table I., which are given by D. L. Ordway.† They refer to cells tested after keeping for five months at the temperatures indicated.

* "Trans.," American Electrochemical Society, Vol. XXI., p. 297.
† "Trans.," American Electrochemical Society, Vol. XVII., p. 341.

Table I.—*Effect of Temperature on Shelf Life of Cells* (6 in. × 2½ in. diameter).

Temperature at which cells were stored.	Short-circuit current at 25° C. after 5 months.
0°	18·1
25°	17·4
50°	0·5
75°	0·4

There is, therefore, good reason for storing cells in a cool place.

The short-circuit test, although it gives an indication of age or defective condition, gives no measure of the service capacity. The figures in Table II., due to D. L. Ordway,* illustrate this point. Here the "old" cells were nine months old, and the capacity was found by discharging continuously on a 2-ohm circuit down to 0·25 volt.

Table II.—*Short-circuit Current and Service Capacity of New and Old Cells.*

	New Cells.	Old Cells.
Short-circuit current	22·4 amperes	3·6 amperes.
Service capacity	24·9 ampere-hours.....	20·2 ampere-hrs.

On the other hand, the short-circuit current obviously gives an indication of the internal resistance, and for this reason some conclusions may be drawn as to the ingredients in the case of a new cell. For example, if the current is unduly high we may conclude that an excessive amount of low resistance carbon or graphite has been included, thus reducing the manganese peroxide below the proportion which is desirable for good depolarisation. But if the current is unduly low it is probable that cheap materials have been used.

The short-circuit test, although commonly used in the United States, has not found much favour among English manufacturers or users. Dry cells are not intended to give large currents, and it is felt that indiscriminate testing by short-circuits can do no good to a cell and may do harm. Moreover, such a test is not a measure of the life obtainable; in fact, if the current is above a certain figure the output in service will probably be low.

Life Tests.—There is much to be said for simplicity in tests, and for this reason a continuous test, by running on, say, 10 ohms, has been popular. Results are sometimes stated in ampere-hours or in watt-hours, but generally the user is more concerned simply with time. In other words, cells are generally used on constant resistance circuits, and so long as the current is maintained above a certain value the result is satisfactory; but current above this value, and the voltage necessary for this excess, are merely so much waste from the user's point of view. Hence time, rather than ampere-hours or watt-hours, is important.

For some purposes, such as ignition, cells may be tested in series, but generally speaking it is preferable to test cells singly, rather than in series, because the average obtained by the series arrangement is not necessarily the same as the average obtained by testing the cells separately and averaging the results.

Reliance should not be placed on a small number of tests. If the comparison is important it is better to run a series of tests over six months or a year. The following results (due to W. B. Pritz) of 10 monthly tests on two brands of cell illustrate this point †:—

No. of Tests	1	2	3	4	5	6	7	8	9	10	Average
Brand A	42	35	38	32	60	45	48	35	66	48	45·0
Brand B	30	37	24	25	27	40	48	42	40	40	35·3

On a continuous test the character of the curve depends upon the value of the resistance that is used for the circuit.

* *Loc. cit.*
† Report of Committee of American Electrochemical Society. Also W. B. Pritz, "Trans.," American Electrochemical Society, Vol. XIX., p. 31, 1911.

If the resistance is low, say, 2 ohms for an ordinary size cell, the voltage falls rapidly because the depolarisation is insufficient to meet the needs of the case. With a high resistance the fall is much less rapid. A low resistance test would not be used for testing a cell intended to be used for only small currents.

The effect of an intermittent test is to give a cell time to recover and consequently the result obtained is materially different from that obtained by a continuous test. This is emphasised by the curves in Fig. 12, which are due to D. L. Ordway.* These tests refer to a circuit of 10 ohms, the results being obtained with three cells in series on each test. Curve A shows a continuous test, whereas curve B refers to a test in which the cells were on circuit for five minutes in each hour. Only the times the cells were on circuit are taken into account in plotting the results, and consequently the hours shown are not unduly long. In the case of curve C the conditions are the same as for curve B except that the test was only run for eight hours per day and for six (or even fewer) days per week, or in other words the time for recuperation was increased and the total time for the test (including the intervals of rest) was longer. It is noticeable that cells on intermittent service are able to stand up better than on continuous use for a considerable time, but eventually the position of affairs is reversed. Curiously enough, when the intervals are increased, as in

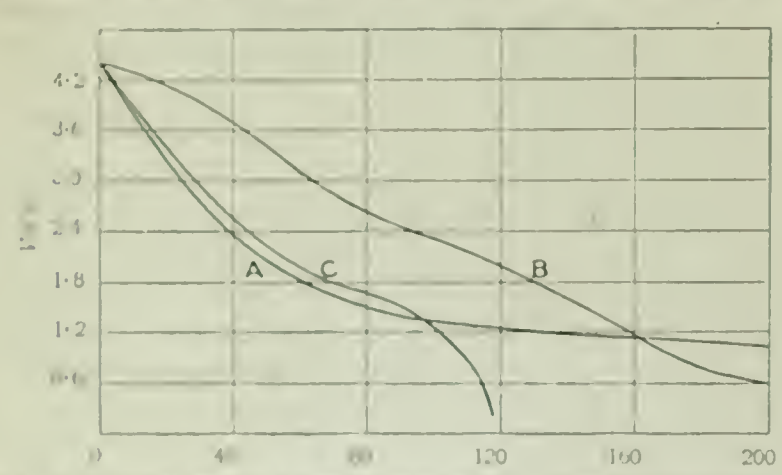


Fig. 12.—Comparison of Intermittent and Continuous Tests. Three Cells, through 5 ohms External Resistance. (Ordway.)

A. Continuous Discharge.
B. Discharge 5 minutes in each hour.
C. Discharge 8 hours per day and 6 days per week.

curve C, the result is not so good. This is apparently due to the fact that the time of the test is then so far extended that deterioration of the cell sets in through ageing, and this view is supported by the fact that both curves B and C fall more quickly below curve A as the resistance of the circuit is increased (*e.g.*, if a circuit of 20 ohms is used instead of 10 ohms), the duration of the test being thereby extended. It must be borne in mind that water is formed in the action of a cell and thus a discharge up to a certain value may be beneficial in keeping a cell in condition. Whereas if only small discharges are taken at long intervals a cell tends to suffer from ageing to a greater extent.

Similarly, it will be understood that the service capacity of a cell depends upon the temperature at which it is used. The life is increased by raising the temperature if the service is heavy. But if the service is light a low temperature is preferable so as to reduce the effect of ageing. This is shown by the results in Table IV., due to D. L. Ordway.* In these tests the cells were discharged down to 0·5 volt, and it will be noticed that the temperature at which the maximum life is obtained varies with the current taken from the cell.

* *Loc. cit.*

Table III.—*Effect of Temperature on Life of Cells* (6 *in.* × 2½ *in. diam.*)

Temperature at which cells were tested.	Life on 2 ohm circuit.	Life on 32 ohm circuit.
0°C.	40 hours	1,800 hours.
25°C.	60 ,, ...	1,550 ,,
50°C.	70 ,, ...	1,250 ,,
75°C.	65 ,, ...	1,390 ,,

Table IV.—*Relative Capacity of Cells at Various Rates of Discharge* (S. W. Melsom). (The values are in watt-hours, except where otherwise stated. V.B. means P.D. at beginning of daily discharge, and V.E. means P.D. at end of daily discharge.)

Test No.		Cells. A.	B.	C.	D.
1	5 mins. per hour on 50 ohms to 0·9 volt	100	93	83	28
2	5 mins. per hour on 1 ohm. Cells new.	100	59	43	7
	Ditto after 6 months' storage	100	58	50	...
	Ditto after 12 months' storage	100	53	42	...
3	Six hours per day on 5 ohms—				
	By V.E.	100	71	68	47
	By mean of V.B. and V.E. curves ...	100	50	50	35
4	Continuous at 20 milliamperes—				
	By ampere-hours. Cells new	100	43	36	30
	By watt-hours. Cells new	100	45	40	29
	By watt-hours after 8 months' storage	100	50	45	5
5	Continuous on 10 ohms—				
	To 0·7 volt	100	75	53	60
	To 0·5 volt	100	76	55	60
	To 0·7 volt after 6 months' storage ...	100	59	44	28
	To 0·7 volt after 12 months' storage	100	67	50	2
6	Continuous on 100 ohms to 0·9 volt...	100	68	51	35
7	Continuous on 500 ohms to 1·3 volts	100	102	87	10

Table V.—*Showing the Effect of the Different Tests given in Table* IV. *on the Capacity Expressed in watt-hours.*

Test No.	Cells. A.	B.	C.	D.
1	43	40	36	12
2	44	26	19	3
3	126	63	63	46
4	105	47	42	31
5	64	49	35	38
6	107	73	55	38
7	70	66	...	...

That the comparative results may vary considerably according to the test adopted is shown by the results in Table IV. These were obtained by S. W. Melsom* at the National Physical Laboratory. Four types of cell were selected, the size being 7 in. by 2½ in. by 2½ in. Four cells of each make were submitted to each test. In the Table, the type A is regarded as giving 100 per cent. value and the other types are expressed in terms of this. It will be noticed that generally, though not always, the order of merit is the same in all the tests, but the extent to which one type is better or worse than another varies a great deal. For example, type D was consistently low except in test 5. It is evident that some cells show up better on a continuous than on an intermittent test, and *vice versa*. This point is emphasised by Table V., in which the watt-hours are given for the different types. It should be noted that the voltage limits are not the same for all the tests, and this in itself will cause some differences, but the variations are in many cases much greater than can be accounted for in this way. Cells A, C and D all give the maximum output on the intermittent test of six hours per day, but cell B gives its maximum on a continuous test on 100 ohms.

As to what test should be employed depends on the nature of the work for which the cell is required. A Committee of the American Electrochemical Society has considered the whole question carefully and has recommended a number of tests which we give briefly below :—

1. Telephone Service.—Discharge three cells, connected in series, through 20 ohms resistance for a period of two minutes, each hour,

* "Trans.," Faraday Society, Vol. VIII., p. 1, 1912.

during 24 hours per day and seven days per week, until the closed circuit voltage of the battery at the end of a period of contact falls to 2·8 volts.

The following readings are taken :—

1. Initial open circuit voltage of the battery.
2. Initial closed circuit voltage of the battery.
3. Closed circuit voltage at the end of the first discharged period.
4. Closed circuit voltage at the end of a discharged period after three days, and weekly thereafter.

Report the results as the number of days during which the closed circuit voltage remains above the limiting value of 2·8 volts.

Fig. 13 shows a representative discharge curve obtained from a battery of three 2½ in.×6 in. (6 cm.×15 cm.) cells of a well known brand. The curve passes through the values of the closed circuit voltage at the ends of the contact periods.

The test should be conducted in a dry place, and normal room temperature should be maintained as closely as possible.

II. Ignition Service.—Discharge six cells connected in series through 16 ohms resistance for two periods of one hour each per day, seven days per week. The periods should be 11 hours apart, but in cases where the circuits are not automatically controlled, the first and the last hour in the working day may be chosen for the discharge periods and the discharge omitted on Sunday, without materially affecting the results.

The following readings are taken :—

1. The initial open circuit voltage and short-circuit current of the battery.
2. The initial closed circuit or working voltage, and the initial impulse of current which the battery is capable of forcing through a 0·5 ohm coil connected in series with an ammeter, and in parallel with the 16 ohm coil.
3. Closed circuit voltage and impulse current through the 0·5 ohm coil at the end of the first period of closure, at the end of the sixth period, at the end of the 12th period, and after every 12th period thereafter.

The test is considered completed when the impulse current at the end of a period falls below four amperes. Report the results as the number of hours of actual discharge to the limiting value of impulse current.

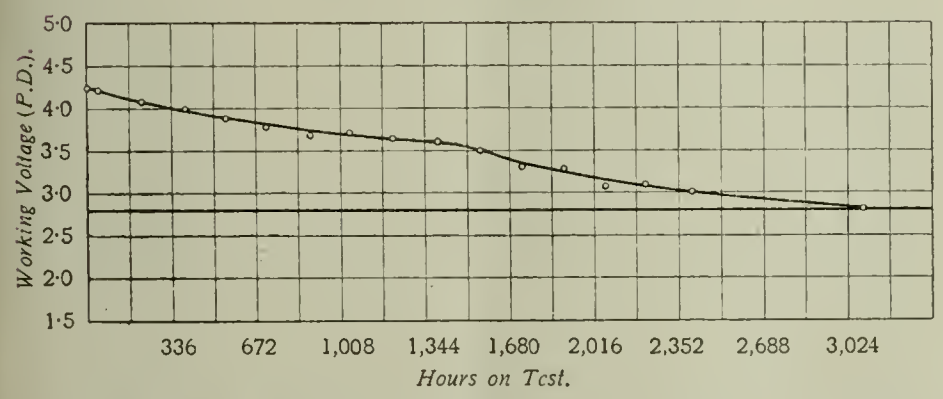


Fig. 13.—Representative Discharge Curve of Cells on Telephone Test.

III. Flashlight Batteries.—Discharge the battery to be tested through a resistance of four ohms for every cell in series, viz., eight ohms for a two-cell battery and 12 ohms for a three-cell battery, for a period of five minutes once each day until the closed circuit voltage at the end of a discharge period falls to 0·75 volt per cell, viz., 1·5 volts for a two-cell and 2·25 volts for a three-cell battery.

The following readings are taken :—

1. Initial open-circuit voltage and short-circuit current.
2. Initial closed circuit, or working voltage.
3. Closed-circuit voltage at the end of the first, third and seventh periods of closure, and after each seventh period thereafter.

Report the results as the number of minutes during which the battery was discharged through the resistance to the given end point.

Miscellaneous Services.—In addition to the telephone and ignition services, which are by far the most important services in which dry cells are used, there are numerous other services, among which may be mentioned the operation of automobile horns, sewing machine motors, small fans, toys, massage vibrators, cigar lighters, bells, buzzers, &c. In the aggregate these miscellaneous services consume enormous numbers of cells, but they are so numerous, and there are such variable conditions prevailing in each kind of service, that it would be useless to attempt to develop standard tests covering them.

It is not difficult for anyone particularly interested in any special service to arrange a suitable test for himself. Care should be taken to make the conditions of test, viz., number of cells, resistance in circuit, period of drain, &c., approximate those of the service in question.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from The Electrician Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Electric Bells and Telephones." Edited by Bernard E. Jones. (London : Cassell & Co.) Pp. 156. 1s. net.

"British Destiny. The Principles of Progress." By D. N. Dunlop. (London : The Path Publishing Co.) Pp. xi.+113. 3s. 6d. net.

"A Treatise on Electricity." By F. B. Pidduck. (Cambridge : The University Press.) Pp. xiv.+646. 14s. net.

CORRESPONDENCE.

EDGE EFFECT OF PLATE CONDENSERS.

TO THE EDITORS OF THE ELECTRICIAN.

Mr. C. J. Watson in The Electrician, March 24th, has raised doubts as to the agreement between the measured capacity of a plate condenser and that calculated from the formula $C=A/4\pi d$. I would point out that the correction for the spreading out of the lines of force at the edges of the plates may be very appreciable indeed in cases where the radius of the plate is only *moderately* large compared with the distance between them. G. Kirchhoff ("Gesammelte Abhandlungen," p. 112) gives a formula by which this correction may be calculated for circular plates of given area, thickness and distance apart. In the case of very thin plates his formula reduces to

$$C=\frac{\pi r^2}{4\pi d}\left(1+\frac{d}{\pi r}\log_\epsilon\frac{16\pi r}{\epsilon d}\right),$$

where r is the radius of the plates, d is the distance between them and ϵ is the base of the Naperian logarithms. Using this expression and Mr. Watson's figures of plates, 1 ft. square and ⅛ in. apart, the increase in capacity amounts to 4·8 per cent. It must also be remembered that square plates will give a still further spreading effect at the corners, and also no account has been taken of the correction to be applied for the capacity of each of the two plates to surrounding bodies. This may be considerable and will have a greater proportional effect the greater the distance between the plates.

Taking these three factors into consideration, errors amounting to the figure mentioned by Mr. Watson, viz., 20 per cent., may easily arise.

Liverpool, March 28. G. E. Bairsto.

EFFICIENCY OF PROJECTORS AND REFLECTORS.

TO THE EDITORS OF THE ELECTRICIAN.

My attention has been drawn to the report in your issue of March 17th of a Paper on the above subject, read before the Liverpool Engineering Society, by Mr. Hayden Harrison. As this contains some extraordinary statements, perhaps you will be good enough to spare me space in your columns to criticise some of them.

Mr. Harrison states that the cause of the increased intrinsic brilliancy of the half-watt type *lamp* is due to the reduced area of the light source. I venture to think that it is more probably due to the increased temperature of the filament. If an ordinary incandescent lamp is taken and half the filament is removed, the intrinsic brilliancy of the balance (when carrying the same current) is not affected. It would appear that Mr. Harrison is confusing the efficiency of reflectors with their ability to concentrate the light in any particular direction. The reduction of the divergence of the *beam* of a searchlight does not necessarily imply any increase in efficiency of the reflector, but generally, that the light source is more wholly contained within the focus of the reflector, assuming, of course, that the latter is properly designed. The efficiency of reflection is obviously entirely dependent on the surface that is employed.

Contrary to what Mr. Harrison states, it is generally agreed that strong local lighting without general illumination is a great mistake, because the eye does not work well under such conditions.

I am naturally more concerned with Mr. Harrison's remarks regarding indirect lighting since his reference to the "best known system" undoubtedly refers to the "Eye-Rest" system, for which my company is responsible. It will probably be of interest to your readers to learn that the efficiency of the "X-ray" reflectors which we employ is in the region of 86 per cent. instead of Mr. Harrison's assumed figure of 70 per cent., and further, that various competent authorities return the reflection efficiency of a good whitewashed ceiling as over 80 per cent. instead of 70 per cent., thereby showing a total

overall efficiency of reflection of practically 70 per cent. instead of 50 per cent., as stated in the article.

The value of a mathematical proof is practically destroyed when the more important factors are assumed, and even if we ignore the question of efficiency of reflectors and ceilings for the time being, the fact that the author has assumed that the light from the ceiling is equally distributed in all directions is quite sufficient to render his arguments valueless.

Coming down for a moment from theory to practice, I will just quote particulars of one "Eye-Rest" installation made under conditions by no means ideal, of which detailed particulars are available, as follows:—

Floor area, 2,184 sq. ft. Average intensity (mean of 71 independent tests) 1·71 ft. candles; therefore, lumens on working plane equals 4,322.

10, 100-watt lamps at 827 lumens = 8,270
8, 40-watt lamps at 294 lumens = 2,352

Total overall efficiency, therefore, equals $\frac{4,322}{10,622} = \frac{10,622}{4,322} = 40$ per cent., which compares quite favourably with Mr. Harrison's theoretical figure of 14·6 per cent.

Judging by this, and other public utterances of the author of the Paper, it is evident that he is prejudiced against indirect lighting, and it is therefore unnecessary to discuss his general comments thereon in detail. Suffice it to say, that thousands of users of the "Eye-rest" system in both this and other countries appreciate that it has advantages which cannot be obtained by any other means.

Mr. Harrison appears to be under the impression that the employment of a reflector and lamp which will give an approximately parallel beam, is the best manner of dealing with, at any rate, the great majority of lighting problems. Without entering into any discussion as to the suitability of such an arrangement for the majority of cases, it will probably be sufficient to draw attention to the fact that such a combination is, as a rule, far from efficient, since the reflector only subtends a very small angle of the light source, and therefore only a small proportion of the total light is reflected. The multiplying power of the reflector is, in itself, no index of the efficiency of the whole as a lighting unit. From experiments which I have made with reflectors of this nature it would appear rather that the means necessary to prevent divergence of the beam of light, and therefore to secure a high beam candlepower, tend to reduce the efficiency of the unit.

Rugby, April 3. H. C. Wheat.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by Messrs. Markham, Eaton & Peyton, Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.

Wherever the date applied for differs from the time on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914

15,580 Alan. Control [illegible]

21,992 Hochstadter. Means [illegible] electric [illegible]. ([illegible])

24,074 Meyer. Telephony [illegible]

1915

2,004 Chell. [illegible]

3,329 Jenkins. Secondary [illegible]

3,410 British Thomson-Houston Co. (General Electric Co.) Arrangement for [illegible] the lamp [illegible]

Relates to that type of [illegible] each of [illegible] parts. According to [illegible] final [illegible] the final [illegible] heating the bulbs during [illegible] means to [illegible]

3,420 Stern. [illegible]

3,523 International Electric Co., Kemp & Le Noir. [illegible] particularly adaptable to telephony.

3,575 Quain. Electric [illegible]

3,706 Roberts & [illegible]

3,733 Wynne. Electrical [illegible]

3,953 Scott & Hughes. Electric [illegible]

3,954 Naamlooze Vennootschap tot Nederlandsche Thomas-Houston Maatschappij. Winding [illegible]

Consists in the combination, [illegible] with an aerial [illegible] earth as a detector [illegible] the value of which [illegible]

4,172 Wireless Motive Life & Research Apparatus. [illegible]

4,000 Hearn. Electric heating element for kindling.

5,928 Montagnie. Ignition magnetic driving couplings.

7,638 Brimley. Control of electric motors.

8,421 British Thomson-Houston Co. (General Electric Co.) Electric incandescent lamps.

8,660 Railing, Gaffard & Greenhalgh. Electrical resistances.

9,346 British Thomson-Houston Co. (General Electric Co.) X-ray devices.

An electric discharge device comprising the combination of a sealed envelope evacuated to a pressure so low that a substantially pure electron discharge may be passed therein, a cathode adapted to be independently heated, an anode deprived of ionizable gas, a charge-receiving member located adjacent said cathode, an electrical conductor surrounding the space intermediate between said electrodes, and an electrical connection between said conductor and one of said electrodes.

10,350 Filmes. Electric light fittings.

11,457 Hochstadter. Electric distributing systems.

11,511 Fahy & Otway. Leclanche cells and methods of and means for resuscitating the same when apparently exhausted.

14,746 Automatic Telephone Manufacturing Co. & Archer. Electric-heating apparatus.

17,116 Heiberg. Electric table lamp. (1·9·15.)

17,413 Smith. Electrical apparatus for heating liquids.

APPLICATIONS FOR PATENTS

*Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

February 14, 1916.

2,164 Burge. Telephone transmitter.

2,176 Phillips. Electric switches or couplings.

2,179 King. Electric torches or pocket lamps.

2,201 Wordingham. Systems for distributing electric energy.

February 15, 1916.

2,212 Pearse. Automatically effecting release of electrically-operated mine signals, &c.

2,242 Williams & Williams. Telephonic receiver.

2,253 Knight. Automatic electric driving engine.

2,256 Baxter. Electric batteries.

2,261 B.T.-H. Co. & Shuttleworth. Regulation of induction motors.

2,266 O'Donnell. Electrically-operated indicating apparatus for signalling apparatus on railways.

2,283 M-L Magneto Synd. & Watson. Dynamo-electric machines.

February 16, 1916.

2,293 Julian. Electrical fire and burglar alarm.

2,328 Dunham. Electrical discharge devices. (20·2·15, U.S.)

2,329 B.T.-H. Co. (G.E. Co.) Producing alternating currents.

2,339 Fuller. Telegraphy and apparatus therefor.

2,312 Gell. Heavy current relay key.

2,345 Berry. Electric heat radiators.

2,347 Berry. Oil-cooled transformers.

2,350 Kuhn-Frei & Weinmann. Electric pocket lamps.

February 17, 1916.

2,375 Hote. Combined plug, socket and switch devices for electric circuits.

2,384 Russell. Accumulator-charging systems for vehicles.

2,388 Pullak. (Soc. Anon. des Etablissements L. Blériot.) Electro-magnetic apparatus.

2,400 Gamage & Horan. Electric buzzers, &c.

2,402 [illegible]. Signalling by electromagnetic waves.

2,405 Gray. Electric switches.

February 18, 1916.

2,443 Baker. Fluid-operated electrical switches.

2,444 Tierney. Electromagnetic overload circuit-breakers.

2,464 Morris, Watson & Morris & Lister. Electrostatic machines.

2,468 Brown. Telephony.

February 19, 1916.

2,478 Filmes. Electric-conductor strips.

2,491 Cox. Electrical fuses or cut-outs.

2,524 Dixon. Transforming motor into electrical waves or impulses. (19·7·15, U.S.)

February 21, 1916.

2,530 Levy. Carbon electrodes.

2,541 Pirie. Carbons and method of manufacturing same.

2,546 St John. Electrically-operated valves.

2,547 Lancashire Dynamo & Motor Co. & Whitmore. Dynamo-electric machinery.

2,552 Angell & Railing. Miners' electric hand lamps.

2,556 Quasi Arc Co. & Stansfield. Electrode holders for electric welding.

2,569 B.T.-H. Co. (G.E. Co.) Dynamo-electric machines.

2,576 Beckie. Relay control [illegible] lamps and ordnance.

2,580 Hewlett & Relay Automatic Telephone Co. Telephone systems.

2,582 Milne. Dynamo-electric machines.

2,594 Wright. Electric [illegible]. (19·2·15, U.S.)

2,595 Bellini. Devices for [illegible], in an aerial for wireless telegraphy and telephony, electric [illegible] having a strictly [illegible] frequency.

2,600 Landys & Gyr, Soc. Anon. Ampere-hour meter with friction-compensating device. (22·2·15, Germany.)

February 22, 1916.

2,615 Fleetwood & Railing. Electric heating apparatus.

2,616 Crossley. Electrical ignition apparatus for starting internal-combustion engines.

2,617 Cox. Completing the connection of tubular electrical conductor conduits to [illegible] boxes, &c.

2,629 B.T.-H. Co. (G.E. Co.) Amplifying electrical variations.

2,641 Brooks. [illegible]

2,642 Richardson & Spratley, Soc. Limited. [illegible]

2,646 Hutchinson. Automatic [illegible] exchange systems. (23·2·15, Sweden.)

February 23, 1916.

2,665 Ambrose, Shelbourne & [illegible]

2,681 Johnson. Terminal [illegible] & [illegible]

2,687 Hewlett & Snowden. Automatic electric [illegible]

2,700 Marconi International Marine Co. (1·3·15, U.S.)

2,704 Electrical Gas Lighting Apparatus. (Assignee.) Manufacture of electric [illegible] (4·5·15, Germany.)

2,728 Higgins & Bailey. Automatic Telephone Co. Electrical [illegible] responder or [illegible]

2,732 Electric Boat Co. [illegible] (23·4·15, U.S.)

2,743 Kemp. [illegible]

February 24, 1916.

2,756 Buchanan & Wilson. [illegible] for electric lighting.

2,758 Dunne. Automatic [illegible] electrical apparatus.

2,787 Galbraith. [illegible] apparatus.

February 25, 1916.

2,804 Thompson. Automatic [illegible] and communicating with trains.

2,807 Thomas. Electric [illegible] internal-combustion engines.

2,811 Marconi's Wireless Telegraph Co. & Sharp. Receivers for wireless signals.

February 26, 1916.

2,831 Nicholson. Telephone [illegible]

2,841 Partridge. Telephone [illegible]

2,848 Lacoste. Electrical [illegible], &c., for telephones.

2,861 Nutt. Protection for X-ray workers.

2,871 B.T.-H. Co. (G.E. Co.) Measuring instruments.

2,884 Cossor. [illegible] Fleetwood Co. Construction of [illegible]

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	25	The Round Table	1
Imports and Exports of Electrical Manufactures	26	Electric Lighting at Ballater and Ellon. Illustrated	2
Legal Intelligence	26	Automatic Control for Capstans and Winches. Illus.	4
Business Notices	26	Concealed Lighting in a Church. Illustrated	6
Bankruptcies, Liquidations, &c.	27		
Electricity Supply	27	Tenders Invited	30
Lighting and Power Notes	27	Tenders Received & Accepted	30
Traction Notes	28	Companies' Meetings and Reports	31
Telegraph and Telephone Notes	28	New Companies, &c.	33
Empire Notes	28	City Notes	33
Foreign Notes	29	Electrical Companies' Share List	34
Miscellaneous Notes	29		

COMMERCIAL TOPICS.

British Banks and Trading Facilities. Sir J. S. Harmood Banner, M.P., chairman of the General Investors & Trustees (Ltd.), made an interesting speech on our banking system at the recent meeting of the company. He said he was thoroughly in accord with those who had pointed out that the work of financing on fixed and not liquid capital was not one that appertained to the banks of this country, which were receiving deposits of necessity bound to be available at any moment for return to the customers who had placed them with their bankers. When it was suggested to create some wonderful new financial institution, controlled by bankers and assisted by the Government, as the proper method of dealing with finance development on the termination of the war, he ventured to point out that both the Government and bankers were ignoring the magnificent work which the trust companies of the City and the country had been most successfully performing, so far as safety and their resources permitted, in giving their services for the provision of capital which it was not within the provinces of banks to find, and, in fact, acting as buffers to the banks. He believed that the combined capital resources of the trust companies of this country exceeded one hundred millions, and they had been of enormous assistance in the development of trade and commerce, not only in this country, but in all parts of the globe. It was quite true there were some things which trust companies could not do, as it was true, also, there were matters of the same description which banks could not entertain, but which were both encouraged and assisted by the German system of banking and finance; but to his mind it was a question whether it was not due more to the want of Government assistance, protection and support, such as Germany had given to her commerce, than to any other cause which had prevented the trust companies and banks entertaining the financial proposals which the German bankers were ready to take up. For instance, the Allegemeine Electricitäts Gesellschaft before the war offered to supply electrical installations for towns and for manufacturing firms on terms of 10 years' credit and payment by instalments. That work was financed by German bankers, but he ventured to say that neither the bankers of this country nor the trust companies would have entertained financial proposals of that description. Again, as they all knew, smelting, the manufacture of aniline dyes and other industries were lost to this country entirely by the encouragement which was given by the Government and the bankers of Germany, as against our own laissez-faire policy.

* * * *

After-War Trade. At a meeting of the Council of Leeds Chamber of Commerce last week Mr. John McLaren, the representative of the Chamber on the Executive of the Associated Chambers, stated that two of the most important questions discussed at the recent meetings were those relating to the establishment of a Minister of Commerce and to the Consular service. He approved of the establishment of a Minister of Commerce, but we must be rather careful how we multiply Ministerial offices. As to the Consular question they were all in absolute agreement. One of the best things that could happen to the commerce of this country would be a radical change in the Consular service. He admitted frankly and gladly that all our Consuls were sound, but they did not have the experience. He hoped that by the time the war was over we should have our Statesmen agreed upon a policy. Many people were prophesying that at the end of the war we should have an industrial upheaval. He agreed that, unless the matter was carefully handled, there might be. After we have got rid of our foreign foes we might have some industrial warfare among ourselves. But he did not see any need for that, and capital and labour ought seriously to consider the question, and try if possible, to get a good start after the war in producing commodities for sale. Supposing Germany, after the war, were wiped off the slate, would the present factories in England, Belgium, France, and even the United States, be capable of dealing with the excess of business that should come to them? He did not think so. We had to look about to see how we could extend our existing workshops and prepare for the starting of new ones. There were a large number of industries foreign to us upon which we were dependent on Germany for supplies. Without those supplies we were not prepared to-day to say that we could supply those goods which we had been purchasing so largely from Germany, because our factories were either not built or not equipped. He mentioned that because the Americans had a fund of £10,000,000 raised by business men ready for the end of the war to promote the establishment of new industries and the extension of existing ones. We should want twice that sum. We had talked enough, and it was time our talk was crystallised into something like action.

* * * *

Development of Electric Cooking in the U.S.A. It is reported that the demand for electric cooking and heating apparatus in the U.S.A. is developing very rapidly. In the first six weeks of the current financial year it is stated that the appliance department of the General Electric Co. has sold more than 1,700 electrical ranges.

* * * *

Wireless Telegraph Research. In an announcement made by Marconi's Wireless Telegraph Co. (Ltd.) it is stated that Senator Marconi has been engaged in important research work in Italy and that the results obtained are far reaching and will have an important bearing on the future of wireless telegraphy and telephony. Senator Marconi is applying for patents which will probably be applied at once in Italy to military purposes.

* * * *

Railway Goods Termini. General progress in the province of mechanical transport is tending to bring to light the many discrepancies which exist at the goods termini of the principal railway companies. Could the charges made by the railways in the handling of goods, say, from a given factory in the north of the country to a warehouse, say, in London be separately analysed they would show that the terminal charges were in excess of the on-rail charges. Some difference is naturally to be looked for, but not such as to indicate an exceedingly high proportion in favour of the rail. The entire problem of terminal handling of goods has been made the subject of considerable study, but, strangely enough, by individuals outside rather than inside the employ of the railway undertakings. Not a few of the schemes which have been put forward are either too costly or too drastic to admit of their adoption. Such was held to be the opinion before the war. It would be reasonable to suppose that under war conditions the state of affairs would be exaggerated, yet such is not proving to be the case. The railway undertakings have not, probably, cared to admit that (we are presuming pre-war conditions for the moment) while mechanisms can displace labour on locomotives, in signal boxes and in the manufacture of rolling stock, obstructions of every kind have been placed in the way of their use to supplement practically unskilled labour in the handling of goods. Now that the war has put labour at a premium the railway companies are compelled to turn to mechanical transport devices, and their use of battery vehicles and small industrial battery-driven trucks and tractors is a noteworthy step which will have far-reaching consequences in the future. In the United States, where the "electric stevedore," as the electric

baggage truck is designated, is coming into extensive use, the railway companies are obtaining operating data regarding the handling of goods at their termini in a form in which it could not previously be presented. The unit by which computations can be arrived at as to cost of handling is a simple and only slightly variable one. For the handling of an electric, unskilled labour, not excluding female labour, can be employed, and every machine will do the work of many hands. Some of the data which are becoming available are proving conclusively that no science and little or no organisation have been applied to the terminal handling of goods. The entire technical effort has been exerted upon the rolling stock and track, a fact which explains the high handling charges for all rail-borne goods. It is still early to prophesy that an immediate change is likely to come over the lack of method of the railway companies in the handling and re-handling of goods, but in the battery-driven truck and tractor they have a ready means of increasing the efficiency of depots, and thereby of reducing the charges on goods. Such economies as are effected must go to the reduction of the charges, and not to the swelling of shareholders' profits. The introduction of equitable goods charges by the railways is just as important a part in the capture of German trade as the general organisation of manufacturers for a similar purpose.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From March 27, 1916, *to* March 31, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

LONDON.—*U.S.A.:* Elec. machinery, £1,892; elec. lamps, £63; elec. motors, £846; wire and cable, £882; carbon candles, £668; unenumerated, £9,182. *Holland:* Elec. lamps, £4 209 401 pkgs. *France:* Unenumerated, £160 49 pkgs. *Switzerland:* Elec. machinery, £68; unenumerated, £40. *Italy:* Wire and cable, £865. *Japan:* Elec. lamps, £423; unenumerated, £513.

MANCHESTER.—*U.S.A.:* Elec. light carbons, 35 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Unenumerated, £118. *Melbourne:* Elec. machinery, £56; unenumerated, £94. *Sydney:* Wire and cable, £1,037; elec. machinery, £54; unenumerated, £207. *Perth:* Elec. lamps, £183; unenumerated, £23. *Christchurch:* Unenumerated, £18. *Dunedin:* Wire and cable, £1,358; unenumerated, £102. *Lyttelton:* Unenumerated, £180. *Brisbane:* Unenumerated, £122. *Nelson:* Unenumerated, £54. *Adelaide:* Unenumerated, £24. *Napier:* Unenumerated, £101.

AFRICA.—*Durban:* Wire and cable, £628; unenumerated, £56. *Zanzibar:* Unenumerated, £59.

SOUTH AND CENTRAL AMERICA.—*Buenos Ayres:* Wire and cable, £6,322; unenumerated, £499. *Valparaiso:* Unenumerated, £55. *Rio de Janeiro:* Wire and cable, £428; unenumerated, £408. *Rosario:* Unenumerated, £1,103. *Santos:* Unenumerated, £47.

U.S.A.—*New York:* Unenumerated, £132.

GIBRALTAR.—Wire and cable, £138.

WEST INDIES.—*Barbados:* Unenumerated, £26.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Wire and cable, £1,550; elec. machinery, £300; unenumerated, £131. *Calcutta:* Elec. machinery, £201; unenumerated, £248. *Ceylon:* Unenumerated, £136. *Rangoon:* Unenumerated, £122.

CHINA.—*Shanghai:* Unenumerated, £44

HOLLAND.—*Amsterdam:* Wire and cable, £266; unenumerated, £145. *Rotterdam:* Unenumerated, £307

FRANCE.—*Paris:* Elec. machinery, £966; unenumerated, £73. *Dieppe:* Unenumerated, £174. *Marseilles:* Unenumerated, £236.

DENMARK.—*Copenhagen:* Wire and cable, £175

RUSSIA.—*Vladivostock:* Unenumerated, £47.

PORTUGAL.—*Lisbon:* Wire and cable, £497; unenumerated, £30.

SPAIN.—*Malaga:* Unenumerated, £29

SWEDEN.—*Gothenburg:* Unenumerated, £187. *Stockholm:* Wire and cable, £572.

CANADA.—*Montreal* Unenumerated, £84. *St. John's:* Telegraph material, £95.

FOREIGN GOODS (duty paid and free).

Bombay: Unenumerated, £71 *Buenos Ayres:* Unenumerated, £72. *Cape Town:* Unenumerated, £31. *Marseilles:* Unenumerated, £671. *Paris:* Unenumerated, £36. *Rotterdam:* Unenumerated, £627

IN TRANSIT.

Cape Town: Elec. lamps, £1,200 *Melbourne:* Elec. lamps, £680. *Sydney:* Elec lamps, £420. *Shanghai:* Elec. glow lamps £147

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

LEGAL INTELLIGENCE.

Read v. Stella Conduit Corpn.

Last week this case came before the Court of Appeal (the Master of the Rolls, Lord Justice Phillimore and Mr. Justice Sargant) an appeal by plaintiffs from a judgment of Mr. Justice Joyce dismissing the action.

Plaintiffs brought the action against defendants for an injunction, damages and ancillary relief for the alleged infringement of letters patent No. 18,375 of 1905 granted to Jas. Wm. Brooks and Albert Edward Read for "an improved means for connecting tubular electrical conduits together and for connecting the said electrical conduits to the fittings, such as elbows, tees, junction boxes, switches, inspection boxes and the like, the invention enabling the said parts to be effectually secured together without screwing." The claim was for an appliance for connecting the ends of two electrical conduits or fittings consisting of two longitudinally divided socket-like clips formed together with a cross slot between them, the clips being made with lugs and tightening screws or bolts and of the proper internal diameter to suit the respective tubular conduits or fittings on to which they were to be clamped.

Plaintiffs alleged that defendants, by making, supplying and offering for sale of fittings for electrical conduits described by the defendants as "Stella Grip Fittings" were an infringement of their letters patent. Defendants did not deny the allegation of infringement, but pleaded that there was no subject matter in plaintiffs' invention, the alleged invention being simply to make a connection, and was simply using the old method of fastening at two ends. It was a tight fastening, and the same as that used in a bicycle head. Mr. Justice Joyce held that the gripping arrangement was a well-known and common one, and as there was no invention in the use of the patented appliance, the patent was invalid.

Mr. A. J. Walter, K.C., Mr. Colefax, K.C., and Sir Denham Warmington appeared in support of the appeal; and Mr. T. Terrill, K.C., and Mr. Arthur Gray for respondent company.

Mr. WALTER contended that there was subject matter in the plaintiffs' invention, there being disadvantages in using screws which plaintiffs' invention obviated. He admitted that there were many anticipations, but they were for all kinds of different things. He submitted that the plaintiffs were entitled to the relief they claimed.

Mr. TERRELL (for respondent) contended that, having regard to the bicycle head attachment and Whitehead's specification there was no subject matter in duplicating that, and that was really all that plaintiffs had done. The method of clamping used in the bicycle head attachment was common knowledge and known to every engineer.

At the conclusion of the arguments their lordships reserved judgment.

Samuel Theo. Baldry v. Sun Electrical Co. (Ltd.).

At Lambeth (London) County Court on Monday plaintiff (aged 14 years) sought (through his father, Joseph Wm. Baldry) to recover compensation for injuries.

Applicant was employed by respondents as a learner in November, 1915, his average weekly wages being 9s. 10d. He was waxing vulcanite blocks at their works on Jan. 21 when he was called by another boy, named Harris. He left his bench to speak to him, when there was a dispute about a small piece of metal as to whether it was a steel shaving or solder. He was returning to his bench when he was struck in the ball of the right eye with a piece of steel shaving. He could not see where it came from. He was taken to the Royal Eye Hospital, St. George's-circus, where his eye was removed, and he remained as a patient until Feb. 1. In cross-examination, plaintiff admitted it was not part of his work to touch the steel shavings.

Another boy (Hector Robb) said they brought the article to him for his opinion. He replied that anyone could see it was a piece of steel shaving and threw it away over his shoulder. He heard applicant cry out, and then found the shaving had struck him in the eye.

Mr. SHAKESPEARE (for respondents) said the boys had nothing to do with the metals with the exception of brass, as they were working on the waxing of vulcanite blocks. If boys were larking, and an accident occurred, the Court of Appeal had decided that such accident did not arise out of or in the course of their employment, and therefore did not come within the scope of the Act.

Judge PARRY said if that was so, they might as well shut out boys from the operation of the Act, as they were always larking. If applicant had not been employed there he would not have met with the accident, and that to his mind meant arising out of and in the course of their employment. In view of the importance of the case and the likelihood of an appeal, he reserved his judgment.

BUSINESS NOTICES.

A firm of engineering merchants in Western Australia advertise that they are desirous of adding a first-class electrical agency to their business. Applications to Messrs. Hoperaft & Broadwater, 4, Fenchurch-avenue, London, E.C. *See an advertisement.*

Sale by Auction.—Messrs. Box, Capp & Co. will sell by auction on April 12 at 1 p.m., machinery, electrically driven lathes, furniture, &c., on the premises of the Light Electric Motor Co. (Ltd.), Farnham-road, Meads-lane, Seven Kings, Ilford. On view morning of sale. Catalogues of the auctioneers, 218, Lower Clapton-road, London, N.E. *See also an advertisement.*

Plant for Sale.—In an advertisement particulars are given of second-hand Parsons' steam turbo sets which are offered for sale.

An advertiser offers a 5 kw. Berry transformer for sale.

Plant Wanted.—An advertiser wants motor-generators, 15-50 kw., 440 to 550 volts d.c. motors, 90-110 volt compound-wound generators.

Messrs. Arrol-Johnston (Ltd.), Dumfries, advertise for two second-hand steam dynamos (one of 75 kw. or 100 kw. and one of 500 kw.).

BANKRUPTCIES, LIQUIDATIONS, &c.

A first and final dividend of 20s. is payable at the O.R.'s, 33, Carey-street, London, W.C., in the liquidation of Electro-Steel Foundries (Ltd.), Booth-street, Darlaston.

Claims against the New York Hamburg India Rubber Co. (Ltd.) are to be sent to the Controller, Mr. Harry E. Clark, 7, St. Mildred-court, E.C., by April 30.

Deed of Arrangement.—A deed of arrangement executed by Israel E. Poyser (trading as the Liverpool Electrical Co.), 55, Renshaw-street, Liverpool, was filed on March 21. Unsecured liabilities £43. Assets £158. Mr. P. S. Booth, 2, Bixteth-street, Liverpool, is trustee.

ELECTRICITY SUPPLY.

EXTENSIONS.

Bo'ness.—The Council recently applied to the Secretary for Scotland for sanction to borrow £14,500 for the proposed extension of the electricity works.

Since making the application the Deputy Town Clerk submitted a proposal for a loan for the required amount to various banks and insurance companies, but as the replies had been so unfavourable the Council resolved to apply to the Public Works Loan Board for a loan for 30 years, or alternatively for 20 years for carrying out the work. The Board have now intimated that they cannot comply with the application.

East Ham.—The mains are to be extended in order to give a supply of current for power to premises in Manor Park-road.

The question of increasing the price of current for public lighting has been deferred for the present.

Ilford.—The electrical engineer (Mr. A. H. Shaw) has been authorised to proceed with the extension of mains to supply a number of houses in course of erection.

Salford.—The Electricity Committee recommends the Council to authorise the cost of the proposed sub-station in the Greengate district to be defrayed out of moneys to be obtained from the sale of l.t. cables which will fall into disuse, the balance to be credited to capital account.

The Committee proposes to enter into agreements with six persons for the supply of current at tariff rates, and it is also proposed to enter into an agreement with the Peel-Connor Telephone Co. for the supply of energy for a period of 10 years.

GENERAL.

Bridlington.—After the June quarter the charges for electrical energy will be :—

For general lighting : Up to 500 units per quarter, 5½d. per unit ; up to 1,000 units, 5d. ; up to 1,500 units, 4½d. ; and exceeding 1,500 units per quarter, 4d. per unit. For heating and cooking : Up to 100 units per quarter, 2d. ; exceeding 100 units per quarter, 1½d. per unit.

City of London.—At the meeting of the Court of Common Council last week Mr. C. H. Collett moved that the Streets Committee be instructed to take the necessary steps to oppose the application of the Charing Cross, West End & City Electricity Supply Co. to the Board of Trade for sanction to increase the maximum lighting rate in the City from 5d. to 5½d. per unit during the period of the war and for 12 months afterwards.

Mr. COLLETT argued that the charges of the company to-day varied so much, as there were preferential rates which ranged from 1½d. to 3d. per unit. The result of this was that the small consumer had to pay considerably more for his light than the large consumer. The balance-sheet of the company for 1915 showed that it suffered a reduction of only about £2,000 in its earnings compared with 1914.

Mr. SAMUEL, chairman of the Streets Committee, said that the company's position was that it was paying 60 per cent. more for its coal, and the cost of labour had considerably increased.

After discussion, the resolution was carried.

Eastbourne.—The Council has decided to pay, without prejudice, and as an act of grace, £20 to the widow of one of the men killed in the recent collision of a motor cab with a street box in Seaside, and £10 to the parents of a soldier who was killed on the same occasion.

Edinburgh.—At last week's meeting of the Electric Lighting Committee it was reported that the applications for a supply of electricity for the previous three weeks were equal to 11,801 8 c.p. lamps, against 6,202 for the corresponding period of 1915.

The total applications for the year to date were equal to 96,508 8-c.p. lamps, which showed the increasing demands for current notwithstanding the war. There were intimations of a large number of applications for electric power in connection with public works, present and prospective.

Kingston-on-Thames.—The Lighting Committee reports having further considered the mode of charging for the supply of electric current, and states that it has adopted the following scale :—

Lighting.—First 3,000 units a year, 6½d. per unit ; second 3,000, 6d. ; third 3,000, 5½d. ; fourth 3,000, 5d. ; all over 12,000, 4½d.

Basement Lighting.—First 3,000 units, 3d. ; second 3,000, 2¾d. ; all over 6,000, 2½d.

Power, Heating and Cooking.—First 10,000, 1¾d. ; second 10,000, 1½d. ; next 50,000, 1¼d. ; second 50,000 1¼d. ; all over 120,000, 1d.

Leeds.—The Council has reduced the rates from 10s. 1d. to 9s. in the £ by taking £90,000 from the tramway earnings and by saving £17,000 on street lighting and £13,000 on street repairs.

Malton. The Northern Counties Electricity Supply Co. propose to increase the charge for electric current by 20 per cent. from April 10.

Manchester.—Mr. Ross Clyne has given notice of motion for the next meeting of the Council expressing regret that "a request made to the Electricity Committee for large supplies of current by a firm intending to contract with the Government for a product of great importance, to be supplied from a contemplated new works in Manchester, was not brought before the Committee as a whole for consideration as to possible ways and means to meet the demand in question," and directing that in future all proposals, offers, or requests of like importance shall be properly submitted to the discretion of the Committee before acceptance or refusal.

Marylebone (London).—The estimates of the Electric Supply Committee of their income and expenditure for the year ending March, 1917, were submitted to the Council yesterday (Thursday).

The revenue is estimated at £218,795 and the total expenditure £215,862, leaving a credit of £2,933, after providing for a reduction of £47,440 in capital indebtedness. The sales of current are estimated at 15·9 million units. The net result of the working of the sales, &c., department is expected to be a net balance of £320, instead of a debit of between £2,000 and £3,000 as hitherto.

Poplar (London).—The Council recently authorised an increase of 10 per cent. in the charges for electrical energy.

Reigate.—The Council has rescinded a previous resolution increasing the price of electric current for heating from 1d. to 1¼d. per unit as from April 1, and has adopted a report of the Electricity Committee recommending increases of 15 per cent. for energy for lighting and power, and the raising of the charge for heating from 1d. to 1½d. per unit, plus a 15 per cent. increase.

Stirling.—Last week the Council authorised an increase of 12½ per cent. in the scale of charges for electric current.

Torquay.—Last week the Council decided not to light the town during the months of May, June, July and August. It is anticipated that during this period a saving of £725 on public lighting will be effected.

Worthing.—On Tuesday the Council considered a report of the Electricity Committee on the Diesel engines at the electricity works.

The committee reported that the Electrical Engineer had had under consideration the question of equipping one of the Diesel engines with an additional fuel pump, at a cost of £160, to enable the engine to be worked with tar oil as well as residual petroleum, which would not only effect a considerable saving by the consumption of a cheaper fuel oil, but would allow a choice in future between two oil markets. The Council were recommended to authorise the committee to have the pump installed.

The report and recommendation were adopted.

LIGHTING & POWER NOTES.

Electricity in Mining.—At the recent meeting of the San Salvador Spanish Iron Ore Co. (Ltd.) the chairman, Mr. C. S. Quartermaine said that the conversion from steam to electric power had proved very satisfactory indeed, and it was very fortunate that the change was effected, otherwise the present prices for coal, plus freight, would have rendered the working of the mines practically prohibitive ; whereas electric current was costing them no more than in normal times. The production of washed ore for the year showed a falling off, but when one considered that they had been working only one of their lines, and that for a period of only eight months, the output was really very satisfactory. That was due partly to an improvement in the quality of the earths treated, partly to the electric installation and partly to the energy displayed by their manager and staff.

At the meeting last week Mr. Edgar Taylor gave particulars of the progress and discoveries made during the year.

They had heard in February that the new high lift pump was delivering water satisfactorily from the 2,000 ft. level to surface, and that all the pumping machinery was then being operated by electric power. At Oriental shaft the new electrical winding engine at surface was erected, and the shaft itself had been adapted for quick hoisting. A much larger quantity of tailings was dealt with in the new plant, and there was an increase in the cost of the Cauvery power during the last half-year.

Hospital Lighting.—The Children's Committee of the Metropolitan Asylums Board has reported upon the defective condition of the electric lighting installation at the Children's Infirmary, and certain alterations, &c., are to be carried out at a total cost of £215.

Leigh (Lancs.).—The Rural Council has entered into an arrangement with the Pilkington Colliery Co. for the supply of electrical energy for pumping at the Lower Green sewerage works.

TRACTION NOTES.

Bournemouth.—It is reported that the municipal tramways department carried nearly 18,000,000 passengers during the year ended March 31.

Coventry.—The Council have increased the salary of the engineer and manager of the tramways (Mr. T. R. Whitehead) from £500 to £600 per annum.

Ilford.—In view of increased running expenses and the present prosperity of the district, the tramways manager has advised his committee to consider the question of adopting the penny universal fare, and suggests that the scheme should be put into operation for the period of the war.

Leeds.—The total receipts of the tramways department during the year ended March 31 were £41,150 in excess of those for 1914-15, equal to an increase of 9½ per cent.

The decrease in the car-miles run was 117,616 miles, or 1·23 per cent., but, in spite of the decline in mileage, the number of passengers carried exceeds all records, the total being 103,153,801. The receipts per car-mile went up by 1·187d., or 10·84 per cent.

Newcastle-upon-Tyne.—At the meeting of the Corporation on Wednesday the Tramways Committee reported that £15,142 had been expended in excess of the sum of £81,700 authorised by the Corporation Act of 1911, and recommended that application be made to the Board of Trade for sanction to borrow that amount.

The expenditure on construction of tramways had been £4,094, and street works £11,048. The committee also reported that expenditure under the Tramways Order of 1913, amounting to £10,789, had been incurred in the construction and equipment of tramways, and recommended that application be made to the Board of Trade for sanction to borrow this sum also.

The report was adopted.

Northampton.—The Council has been recommended to have the curved tram-tracks in Mercers' Row and Abington street relaid.

TELEGRAPH & TELEPHONE NOTES.

Australian Telegraph Service.—The Eastern & Associated Telegraph Companies announce that they will shortly open their own public office in Melbourne, Australia, which will be connected by special wire with their direct cable system, thus "speeding up" the transmission of cablegrams exchanged with Melbourne "via Eastern." Further information of the service can be obtained by applying to any of the company's stations.

Telephone Charges.—At last week's meeting of the Corporation the Special Committee on Telephones reported that they had before them the resolutions passed at the public meeting held on Feb. 9 protesting against the increase in charges for the unlimited telephone service, and the letter of the Postmaster-General declining to receive a deputation on the subject.

The Committee recommended the Corporation to record their protest against the manner in which the increased charges had been imposed, and without subscribers having been afforded an opportunity of making representations against them, in accordance with previous assurances from the Postmaster General, and to intimate to him that the Corporation reserved their right to take, after the termination of the war, such steps as they might deem advisable, with the view of having the charges modified and the other conditions of the service altered and amended.

Telegraph and Telephone Breakdown.—The recent snowstorm seems to have played havoc with the telegraph and telephone lines throughout the country.

Communication with all districts, more particularly the industrial towns in the north, especially Manchester, Liverpool, Bradford, Leeds, Newcastle, Glasgow and Edinburgh, was greatly interfered with. The work of restoring communication is proceeding slowly, and many towns in the north are still without adequate means of communication. Manchester commercial circles are demanding underground cables between London and Manchester for telegraph and telephone purposes.

The case of Leicester is typical of the damage done. The town is still entirely cut off from telegraphic and telephonic communication. Royal Engineers and the Leicester Pioneers are at work restoring the lines, but progress is slow on account of the complete wreckage of wires and posts. It is hoped that a single telegraph wire from Leicester to Birmingham will be completed before the end of the week. The telephone exchanges will take at least a month before they can be restored to normal condition.

Tientsin Telephone System.—A description of the new telephone system at Tientsin (China) appeared in a recent issue of the "Far Eastern Review."

The new central battery telephone system for Tientsin, ordered from the Western Electric Co. by the Chinese Government in 1913, was put into operation in June, 1914. The old magneto system consisted of three central offices located in Tientsin City, the British Concession and Hopei, but for the new system only one central office is used—viz., on the Tientsin City land near the boundary line of the Foreign Concessions. The main switchboard consists of 13 three-position eight-panel sections and one three-panel section, and is of the company's No. 2,001 central-battery multiple type with lamp signals. The switchboard has a capacity of 10,000 lines, and is at present equipped for 4,000. The first position of the subscriber switchboard is equipped with 15 toll-switching trunks for connecting city subscriber lines to toll lines. The second position has a partial equipment of regular subscriber cord circuits and also some special cord circuits for handling the rural lines. The remaining positions, except the last, are equipped each with 17 pairs of regular cord circuits for completing connections between city subscriber lines. The last position is equipped with cords for testing. Each section has a capacity of 10,000 multiple jacks, 160 trunk jacks and 480 answering jacks with lamps. At present there are equipped in each section 4,000 multiple jacks, 40 trunk jacks and 300 answering jacks with lamps. Each operator takes care of 100 incoming lines, and can reach any one of the 10,000 multiple jacks for calling purposes. There is also a two-position toll or long-distance switchboard equipped for 20 toll lines.

The distributing frames and apparatus racks are in the terminal room on the first floor directly beneath the switchboard. All the wires from the subscribers' telephones are terminated on protectors, consisting of carbon block arresters and heat coils. All switchboard circuits are fused. Current for operating the switchboard and subscribers' telephones is obtained from storage batteries located in the basement. There are two main 24-volt batteries, each consisting of 11 Chloride type cells. Also, there are two smaller auxiliary batteries of 11 cells each to obtain 48-volt current for long-distance transmission. There are two separate generating sets for charging the batteries, one a motor generator taking current from the city mains and the other a generator belted to a producer gas engine. All wiring for the power apparatus and batteries is carried in steel conduit laid in the floors of the building. All local wiring in the switchboard sections is formed into cables, and all wiring between the switchboards and the distributing frames and racks is carried in cables protected by a fire resisting covering. The wires to subscribers' telephones are carried in 300-pair steel armoured underground lead-covered cable, to junction boxes mounted on steel poles in the various districts. The Tientsin system is under the management of Mr. Tsai Chee, managing director, and Mr. K. Rothe, superintendent and engineer, the assistant engineer being Mr. K. T. Long.

EMPIRE NOTES.

Australasia.—Melbourne Council recently decided to install electrical recording meters in connection with the chilling chambers at the city abattoirs at a cost of £300.

The Postmaster-General of the Commonwealth (Mr. W. Webster), in a recent communication to the Hobart "Daily Post," said, in justification of the proposed telephone charges in the Commonwealth, the average wage paid to the telephonists was 13·87d. per hour, whereas in America the average was 9·09d. and in England 6·25d. The cost of the mechanical section was 21·519d. in Australia, 10·071d. in England, and 16·20d. in the U.S.A. It had been stated that if the rates were reduced the number of subscribers would probably increase, but the larger the number of people connected to the exchanges the less was the profit on the undertaking. In Sweden, Switzerland and Denmark the rates were low, but labour cost only about one-third of what it cost in Australia, so that the rates were relatively higher. In America (where the conditions more nearly approximated to Australian conditions) the rates were from 200 to 300 per cent. higher. A deputation had asked him to consider the question of turning over the system to private enterprise, but in America the telephone systems were run by private enterprise, with the result he had mentioned.

It is stated that, owing to the carbons recently purchased by Sydney Council in England not proving satisfactory, the engineer proposes to substitute Nitro lamps for the arc lamps, in which it was proposed to use those carbons in certain localities where the failure of a circuit of lamps will not have a serious effect.

The Australian Electric Steel Co. (Ltd.), which has been formed in South Australia for the purpose of installing electric furnaces in the principal States of the Commonwealth for the manufacture of steel from cast scrap, has at its head Mr. Teesdale Smith. It is hoped to erect the first plant in Sydney in May, the next in Melbourne in June or July, and the third in Western Australia in October.

Several years ago Mr. J. H. Gillies undertook to produce marketable spelter direct from the complex ores of Western Tasmania, and Complex Ores (Ltd.) was formed. A long interval supervened owing to the necessity of obtaining electric power at a cheap rate, and as the Tasmanian Government of that time declined to undertake this task the Hydro-Electric Power & Metallurgical Co. tackled the question. However, the company was unfortunate in its finances, and its hydro-electric scheme has now been acquired by the Government. Confidence in the Gillies process never waned, and it was decided to erect a demonstrating unit of

the plant, of such capacity that the commercial practicability of the process would be adequately tested at East Camberwell, near Melbourne. It is stated that a few weeks ago the directors of the company were able to make a fine exhibit of their product in a Melbourne shop. Broken Hill ore had been previously dealt with satisfactorily, but on the present occasion the very refractory ore of the Rosebery district of Tasmania was handled. The ore contained zinc 39 per cent., lead 12·6 per cent., iron 8·06 per cent., copper 0·46 per cent., sulphur 28 per cent., arsenic 0·14 per cent., silica 9 per cent., gold 4 dwt. per ton, silver 13 oz. per ton. After a month's run the directors stated that sufficient data had been obtained to indicate that the process is capable of economically treating these refractory ores, the product being a spelter 99·91 per cent. pure, which is superior to the standard fixed by the British Government for munition purposes.

The Wollongong (N.S.W.) correspondent of the "Australian Mining Standard," writing in February, says the electric safety lamps which were to arrive for South Bulli colliery before the war, have now been received. At the Excelsior colliery, in the Bulli seam, the ventilation is accomplished by a fan, which is to be operated electrically, and which has a capacity of 50,000 cubic ft. of air per minute. A Bellis & Morcom engine, coupled to a 100 kw. generator, does all the pumping and ventilating work. A new electrically-driven fan to put in 80,000 to 100,000 cubic ft. of air per minute is also to be installed.

Barcaldine (Queensland) Council has decided to borrow £5,000 to complete its electric lighting and water schemes.

The question of adopting electric lighting in Mirboo North (Victoria) is being considered by the Council and also the Mirboo North Dairy Co.

The Government of New South Wales has decided to proceed at an early date with the development of a State coal mine at Lithgow, where there is an extensive local demand on account of the proximity of the steel and iron works.

FOREIGN NOTES.

Argentina.—The National Census Commission has asked all electric supply undertakers in the Republic for particulars of the systems of generation, motive power, uses for which current is supplied, capital invested in the undertakings, and output in first year of working and in 1914 respectively.

The Ministry of Marine have approved regulations formulated by the electrical section of the Ministry's Direccion General de Material. The object of the regulations is to unify types of electrical materials employed in the navy and to ensure a careful technical selection of same. The regulations are sub-divided into sections relating to incandescent lamps, lamp fittings, conductors, fuses, circuit breakers and commutators, switches, cells and accumulators, ventilators and arc lamps. Each section occupies a leaflet containing the exact specifications as to the conditions with which the material must comply. Three of the pamphlets have appeared, dealing with incandescent lamps, lamp fittings and conductors and fuses, and six more are ready for the press.

Of these ranges, 600 were for Salt Lake City and other points served by the Utah Power & Light Co., and 400 went to Texas towns served by the Texas Power & Light Co. Many of the others also went to various western and southern points. The electric light and power companies in the West are offering special rates for electric current for cooking, with the result that there has been a large increase in electric cooking in many of the western towns.

Brazil.—A consular report for 1914 states that the electrification of the tramways at Parahyba was completed in February, 1914.

The Alagvas electric tramways were inaugurated in June, 1914, but were not completed by the end of the year. Imports into Pernambuoo included 442 metric tons (against 233 in 1913) of accessories for electricity and lighting, valued at £62,133 (against £33,671).

Chili.—A Decree has been issued granting permission to the Chile Exploration Co. (a United States syndicate) to instal an overhead 5,000-volt electric power transmission line from Chuquicamata to El Banco and to the San Salvador station of the Antofagasta-Bolivia railway (about 5½ miles).

A decree has been issued conceding to Don H. U. Gundian permission to establish a telephone system connecting Combarbala with Illapel, Los Vilos, Salamanca and Petorca.

Norway.—"The Financier" says many new companies and authorities are being started for the utilisation of the waterfalls in Norway in order to generate electric energy for industrial requirements.

Hangersund municipality has recently bought a waterfall for half-a-million kroner capable of supplying 30,000 H.P. The current will have to be transmitted 42 miles.

The A/S Hoyangfaldene Norsk Aluminium Co. has been formed at Christiania with an authorised capital of 10 million kroner. Work on the construction of the power stations has already commenced and the first 20,000 H.P. will be developed as quickly as possible, to provide for the production of 4,000 tons of aluminium per year.

At the recent annual meeting of the Fredriksstad Elektrokemiske Fabriker it was resolved to increase the capital from 350,000 to 700,000 kroner, and to pay a dividend of 15 per cent. for 1915.

Philippine Islands.—It is stated that a large sugar refined is to be built at Isabela, Occidental Negros, by the Government Sugar Central Board. Tenders have been invited for the erection of a 1,000-ton mill which will be driven electrically.

Tunis.—An exhibition has been organised at the Tunisian Government Office in Paris of catalogues of German and Austrian goods imported into Tunis prior to the war.

A handbook issued in connection with the exhibition contains a preface by the President of the French Chamber of Commerce at Tunis, in which the reasons for the successful development of German and Austrian trade in Tunis are discussed. It is stated that owing to the efficiency of their commercial representation German and Austrian firms established a predominancy in all branches of commerce and industry in Tunis. During the last few years German and Austrian travellers became more and more numerous; they quickly learned the customs of the country: then, amply supplied with samples and catalogues, they called frequently upon consumers. The German traveller endeavoured to meet the exact requirements of customers, and did his best to induce his principals to take up the manufacture of new lines according to patterns be submitted, and to turn out at prices cheaper than those of competing firms. Catalogue prices, in francs, were subject to discounts of from 45 to 80 per cent. Prices were always free of all charges such as freight, insurance and packing, and same included delivery at customers' premises and customs duty. Periods agreed for payment varied from 1 to 10 months and sometimes longer. Amongst the goods catalogued were electric lamps and accessories, ironmongery, colours, varnishes, machinery and steel goods.

MISCELLANEOUS NOTES.

Alien Enemy Patents.—Messrs. Reavell & Co. have applied for the suspension of patent No. 3,525 of 1912 for turbine compressors or pumps granted to Lawaezeck & Aerzener Maschinenfabrik Ges.

The Rapid Magnetting Machine Co. has applied for the suspension of three patents (Nos. 14,082, of 1908, 29,230 of 1911, and 4,595 of 1913) relating to the magnetic separation of ores and apparatus therefor.

Contraband of War Regulations.—On March 30 His Majesty in Council ordered:—

(1) That the provisions of the Declaration of London Order in Council No. 3, 1914, shall not be deemed to limit the right of His Majesty to capture goods upon the ground that they are conditional contraband, nor to affect the liability of the additional contraband to capture, whether the carriage of the goods to their destination be direct or entailing trans-shipment or subsequent transport by land; (2) that the provisions of Art. I. (ii.) and (iii.) of the said Order in Council shall apply to absolute as well as conditional contraband; (3) that the destination referred to in Arts. 30 and 33 of the said Declaration, in addition to any presumption laid down in the Order shall be deemed to exist if the goods are sent to or for a person who, during the present hostilities, has forwarded imported contraband goods to territory belonging to or occupied by the enemy; (4) that in the cases covered by Arts. (2) and (3) of this Order it shall lie upon the owner to prove that their destination was innocent; (5) that art. 19 of the Declaration of London shall cease to be put into force. Neither a vessel nor her cargo shall be immune from capture for breach of blockade upon the sole ground that she is on her way to a non-blockaded port.

Legal Notice.—Claims against the estate of Montague H. Bythway (deceased), formerly electrical engineer, of Claremont, Hale-road, Hale, but serving in H.M. Naval Air Service at the time of his death, are to be sent by May 20 to Messrs. Tatham, Worthington & Co., 1, St. James-square, Manchester.

Local Loans.—On March 31 the Treasury decided upon revised rates of interest on loans granted out of the Local Loans Fund.

Rates varying from 5 per cent. to 5¾ per cent. have been fixed for housing, small holdings and harbour works, and the rates for other loans on local rates are: Not exceeding 30 years, 5 per cent; not exceeding 50 years, 5¼ per cent.

More Enemy Firms Wound Up.—Up to date the Board of Trade have ordered the winding up of 87 companies or firms controlled by alien enemies:—

The latest list includes: Veithardt & Hall (Ltd.), iron and steel importers, 41, Eastcheap, London, E.C.; Hadenfeldt & Co., general merchants, 4, Cullum-street, London, E.C.; Gustav Rosenmann, hardware merchant, 194-200, Bishopsgate, London, E.C.; Eugen Rudenburg, shipping and forwarding agent, 14-20, St. Mary Axe, London, E.C.; C. F. H. Müller, X-ray tube maker, 47, Red Lion-street, London, W.C.; London Electron Works Co. (Ltd.), Regent's Dock, Limehouse, London, E.

Tribunal Cases.—At Blackpool Appeal Tribunal, on March 30, the general manager of the Tower supported the application for exemption of the chief assistant to the electrical engineer and the electrical engineer.

It was stated that 70 of the company's men were serving and they had not appealed for a single man. Temporary exemption was granted until the end of October.

At Erpingham last week Lord Suffield through his agent applied for exemption for his electrician, aged 28, single, who had charge of a valuable electricity and gas plant at Gunton Hall. The claim was made on the ground that the man could not be replaced. The appeal was refused.

TENDERS INVITED.

Switchgear.

SALFORD Corporation require tenders by noon April 17 for the supply, delivery and erection of Three-phase Extra-high-pressure and low-pressure Switchgear for three 5,000 kw. sub-station equipment. Specifications, &c., from the burgh electrical engineer, Mr. J. A. Robertson, Frederick-road, Salford. *See an advertisement.*

Electricity Meters and M.D. Indicators.

The Council of the City of MELBOURNE (Australia) invite tenders for the supply of Electricity Recording Meters and Maximum Demand Indicators. Specifications, conditions of contract and form of tender from the Agents for the City Council, Messrs. McIlwraith, McEacharn & Co. Ppy. (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders are to be sent by noon of Monday, May 1. *See also an advertisement.*

Motors and Transformers.

WARRINGTON Electricity and Tramways Committee require tenders by noon April 11 for supply of Motors and Transformers. Specifications from Borough Electrical and Tramways Engineer.

The CHIEF COMMISSIONER FOR N.S.W. RAILWAYS AND TRAMWAYS, Sydney, requires tenders by noon May 24 for supply, erection and maintenance of 16 (600 v.) d.c. Motors, with Field Rheostats, &c., or (alternatively) Motors with interpole windings. Specifications, &c., from the Electrical Engineer, 61, Hunter-street, Sydney, N.S.W.

Arc Lamp Carbons.

Tenders are invited for the supply of 533,000 Arc Lamp Carbons to the City of MELBOURNE (Australia). Tender form copy of specification, conditions of contract, &c., from the Agents for the City Council, Messrs. McIlwraith, McEacharn & Co. Ppy. (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders are to be sent by noon April 11.

Turbo-Alternator, Gas Producer Plant, &c.

The NEW SOUTH WALES GOVERNMENT Railways and Tramways Department invite tenders for the supply and erection of a 2,500 kw. Turbo-Alternator for the Zarra-street (Newcastle, N.S.W.) power house. Specification (No. 470) from the Electrical Engineer, N.S.W. Government Railways and Tramways, 61, Hunter-street, Sydney. Tenders to Chief Commissioner for Railways and Tramways, Phillip-street, Sydney, by noon May 3.

WANGANUI (N.Z.) Borough Council require tenders by noon May 9 for the supply and erection of Additional Plant at their tramway power house, including Pressure-type Gas Producer Plant, Gas Engine, Electric Generator and Switchgear. Specification, &c., from the Town Clerk.

Street Lighting.

SAN FELIN DE GUIXOLA (Province of Gerona) Municipality require tenders by April 10 for a concession for lighting the town by electricity or gas.

Tramway Construction, &c.

The Dirección General de Obras Publicas, Ministerio de Fomento, Madrid, requiire tenders by May 19 for the construction and working, for 60 years, of an electric Tramway in BILBAO, connecting the existing system with the Irala-Barri district. Minimum rolling stock required to commence is one motor and one trailer coach for passengers, and one motor goods coach and two trailer goods wagons. An option on the concession is held by the Sociedad Tranvia Urbano de Bilbao.

JOHANNESBURG (Transvaal) Council require tenders by noon June 6 for supply of two Manganese Steel Crossings. Specification, &c., from the Municipal Offices, Johannesburg.

Tramcars and Electrical Equipment.

DUNEDIN (N.Z.) City Council require tenders by 5 p.m. May 17 for six Electric Tramcars and sections of Cars (Bodies, Electrical Equipments and Trucks). Specifications, &c., from the Town Hall, Dunedin.

Sub-Station Equipment.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. April 26, for the supply of Electrical Equipment and Accessories for sub-station for the Sandringham-Black Rock tramway (contract No. 29,762). Specifications and forms of tender from the Victorian Railway Commissioners, Melbourne.

Telegraph and Telephone Material, &c.

Tenders are invited up to April 15, 1916, for the supply, delivery and erection at Rockhampton Telephone Exchange (State of Queensland) of a Common Battery Multiple Switchboard (Schedule 362), or an Automatic or Semi-automatic Switchboard and Associated Apparatus (Schedule 361), for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. April 18 for supply of 8,500 Fuses (schedule 1,299) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification from Deputy Postmaster-General, Melbourne.

Tenders will be received until 3 p.m. April 26 by the Deputy Postmaster-General, Brisbane, for supply at Toowoomba Exchange (Queensland) of five Sections of Trunk Line Switchboard (Schedule 342) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specifications, &c., from the Deputy Postmaster-General.

Car Lighting Material, &c.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. April 26 for Car Lighting material, including i.r. Cable, Switches, Lamp Cartridge Fuses, Plugs, Sockets, &c. (contract No. 29,784); and by 11 a.m. May 10 for Motor Generator and Accessories for Battery Charging of Baggage Trucks, also Switchboard and Connections (contract No. 29,796). Specifications from the Commissioners' Offices, Spencer-street, Melbourne, Victoria.

Varnish Impregnating Apparatus and Storage Battery.

The Victorian Railway Commissioners, Spencer-street, Melbourne, require tenders by 11 a.m. April 19 for the supply and erection of a Complete Plant for Impregnating Electrical Apparatus with Insulating Varnishes and Solid Compounds (Contract No. 29,678.); also a 1,000 Ampere-hour Storage Battery (Contract No. 29,743). Specifications, forms of tender, &c., from the offices of the Commissioners.

TENDERS RECEIVED AND ACCEPTED.

SALFORD.—The following tenders have been accepted by the Tramways Committee for annual supplies:—

Car Accessories (Electrical), Insulating Materials, &c.—W. McGeoch & Co. (approx. value of contract, £49), W. T. Henley's Telegraph Works Co. (£8), General Electric Co. (£367), L. Andrew & Co. (£40), British Westinghouse Co. (£1,200), Micanite & Insulators (Ltd.) (£80), North British Rubber Co. (£73), Griffiths Bros. (insulating varnishes) (£29), C. Macintosh & Co. (£6), British Insulated & Helsby Cables (1 in. P. & B. tape, £56), Siemens Bros. Dynamo Works (£89), Le Carbone (Ltd.) (£16), H. Norbury & Co. (£114), Gabriel & Co. (£10), W. Boydell & Sons (£16).

Car Accessories (Mechanical).—W. J. Ritchie & Co. (£294), National Rail & Tramway Appliances Co. (£667), Anti-Attrition Metal Co. (Babbit metal, £340. 10s.), Brown-Bayley's Steel Works (steel tyres, six months, £932. 10s.).

Ears, Frogs, Pull-offs, &c.—British Insulated & Helsby Cables (£212), Watlington & Co. (£100), J. Hall (£8), British Westinghouse Co. (lightning arresters, £5. 5s.).

Iron and Steel.—J. Kidd & Sons (£258) and Vickers Limited (£67).

Special Car Accessories.—British Westinghouse Co. (list prices), Westinghouse special accessories (£766).

Wire, Solder, Lead and Tin.—British Insulated & Helsby Cables (64), L. Andrew & Co. (£137), R. Johnson, Clapham & Morris (£72).

Special Paints and Varnishes.—Nobles & Hoare (£292).

Trolley Cord.—L. Andrew & Co. (£45. 10s.).

The Tramways Committee has also accepted the tender of Scholey & Co. (at £1,055) for a supply of steel tram tyres.

The following tenders have been accepted by the Electricity Committee: British Westinghouse Co., two 1,000 kw. rotary converters, £5,590; General Electric Co., one 500 kw. rotary converter, £1,579. 15s.; Babcock & Wilcox, two water-tube boilers, £11,544.

LONDON COUNTY COUNCIL.—The Asylums Committee have accepted the tender (at £83. 17s. 8d.) of A. F. Goodwin & Co. for

electrical sundries; and of Pope's Electric Lamp Co. (£70) for electric lamps.

LEYTON.—The quotation of Siemens Bros. & Co. (at £172) has been accepted by the Council for the supply of 2½ miles of service line cable (several sizes).

BATTERY MAINTENANCE.—The Metropolitan Asylums Board proposes to renew the contract with the Pritchett & Gold & Electrical Power Storage Co. for the maintenance of the battery at theGrove Hospital for five years at £75 per annum.

DUNDALK.—The Council have accepted the following tenders for 12 months' supply of electrical supplies:—

General Electric Co., incandescent lamps, switches, pole brackets and insulators, and lighting accessories; Siemens Bros. & Co., service joint boxes and accessories; W. T. Henley's Telegraph Works Co., house service fuses; Ferranti Ltd., house service meters. For cables and wires no contract has been let.

GLOUCESTER.—The Council has accepted the tender of Edgar Allen & Co. for the supply and supervising the fixing of points and crossings for the light railways department.

BOLTON.—The following tenders have been accepted by the Electricity Committee:—

Wareing Bros., oils, &c.; Jas. Orrell, paints, &c.; T. Moscrop & Co., asphalte oil; G. Reason, waste; E. Higson, sundries; Bolton Brick Co., trough covers; J. & F. Webster, casings, &c.

MELBOURNE (VICTORIA).—The Council has accepted the offer of Machin & Co. for testing set at £25. 10s., and has ordered two sets of spare parts for 4,400 turbines from Willans & Robinson at £207.

SYDNEY (N.S.W.)—As the supply of consumers' meters (240 volts s. phase) under existing contract is still delayed, the Council have authorised the purchase of the following meters from stock in Sydney:—

From Standard Waygood Hercules (Ltd.), 76 2½-ampere, 31 5-ampere, 10 10-ampere, two 20-ampere; and from Australian General Electric Co., 299 5-ampere meters.

Foreign Contracts Secured by British Company.—Messrs. Ferranti Limited, Kingsway, W.C, and Hollinwood, Lancs., write as follows:

You have frequently emphasised in the columns of your paper the necessity for the expansion of foreign trade, and therefore we think you will be interested in the following list of orders received by this firm from abroad during the last few weeks:—

France, switchgear and transformers, value of order £15,000; Denmark, transformers and meters, £7,000; Holland, transformers and switchgear (including two 4,000 k.v.a.), £3,500; China, meters, £8,000; Russia, instruments and meters, £2,500; Spain, meters, £1,500; Australia, meters, £4,000; S. America, meters, £1,900; India, meters, £1,500; other countries, meters, £2,000; a total of £46,000.

Lamp Contract.—In our issue for Feb. 23 we announced that the Midland Railway Co. had accepted the tender of the General Electric Co. (Ltd.) for the supply of Osram drawn-wire lamps for the ensuing six months. We are asked to state that this was for a portion only of their requirements, and not for the exclusive supply of metal filament lamps to the Midland Company.

Commonwealth Contracts.—The following tenders have been accepted by the Australian Government Deaprtments:—

Victorian Railways.—Stothert & Pitt, electric cranes for Ballarat and Bendigo workshops, at rates; British Westinghouse Elec. & Mfg. Co., frequency changers and rotary converters for Spencer-street and Elwood sub-stations, at rates; R. W. Cameron & Co., battery signal machines, £36. 18s. and £35. 18s. each, and Ackley brakes, at rates; McKenzie & Holland, electric point and lock detectors for five years, £18. 2s. 6d. each; Austral Otis Eng. Co., yellow flame arc carbons, £12 per 1,000; Noyes Bros., toggle insulators for St. Kilda-Brighton electric railway, 5s. 3d. each; Gibson, Battle & Co., 15-ton electric crane, &c., at £1,596; Forman & Co., railway and electric tramway crossing, £229, and steel anchor bolts for overhead equipment, at rates.

Department of Defence.—W. G. Watson & Co., two electric motors, £214; and Crompton & Co., two electric motors, £164, for the small arms factory, Lithgow, N.S.W.

FINANCIAL MATTERS.

COMPANIES' MEETINGS AND REPORTS.

BARTON-ON-HUMBER ELECTRIC SUPPLY CO. (LTD.)—At the recent meeting the Chairman (Mr. F. Hopper, J.P.), in moving the adoption of the report, said that in common with all lighting companies they had suffered from the lighting order. The number of consumers was steadily increasing, and when the war was over the success of the company was assured.

BRITISH ALUMINIUM CO. (LTD.)—Mr. A. W. Tait, who presided at the meeting on Friday last, said that their works were controlled establishments. The year's trading profit, after making provision for excess profit duty and adding interest and dividends, revenue from estates and transfer fees, was £312,546, compared with £272,255, an increase of £40,291 over 1914. Those results were the best which the company had shown since it was originally incorporated in 1894. The conditions were, however, absolutely abnormal, and were entirely due to the exceptional demand for war purposes. Owing to this abnormal demand the whole of the company's output had, since August last, been under the absolute control of the Ministry of Munitions, and the supply had been reserved for the use of the Government and its contractors for munition purposes. The ordinary domestic demand for general commercial purposes and the requirements of the export trade, on the development of which considerable time and money had been spent by the company, had necessarily been closed down meantime, and at the conclusion of the war they would have energetically to endeavour to get back to their ordinary business, which had meantime been stopped. His opinion was that the recent uses and developments would go a long way to make up for any falling-off there might be in the ordinary demand, due to the unavoidable and necessary period of recuperation required by all the countries which had been involved in the war. Further, there was no doubt that the experience gained during this war would open up a demand in certain directions in the future which would considerably broaden the uses and applications of the metal. The sales had been approximately the same as those of the previous year, and that was accounted for not by any slackening in the demand but owing to a shortage in the anticipated production, due to abnormal weather conditions in the West of Scotland and in Norway during the summer of last year. Prices for the metal showed substantial advances during the year, but those advances occurred particularly during the last six months, and, as it had always been the practice to cover the requirements of our regular customers at fixed prices for the whole year, the average which was obtained was considerably below current prices at the end of the year. Costs of production had been very materially affected owing to heavy increases in labour charges, the cost of raw materials, freights, insurances and other expenses. The importance to the company of the freight question was shown in the fact that he mentioned last year that they dealt with over 200,000 tons of seaborne freight per annum, apart from railway freights. With regard to labour, they were suffering, in common with all other businesses, from the shortage of the available supply and the increasing needs of the country. Their various works had been fully employed during the year, and the additional plant for the manufacture of carbon electrodes at Kinlochleven works was completed and put into operation before the close of the year. The erection of the new alumina works at Burntisland, which should have been completed by this time, had made slow progress, entirely due to the shortage of labour and materials, and it would be some months yet before those works could be put in operation. By the application of the sinking fund, the prior lien debentures had been reduced by £9,400 during the year, reducing the amount outstanding to £772,600, and the debenture stock had been reduced to £660,690. The depreciation reserve account had been increased to £250,000, and the reserve account had also been brought up to £250,000 by the appropriation of £70,000 from the profits of the year. The necessity for making ample provision for reserves had been accentuated by the abnormal conditions now ruling. The directors had recommended an increase in the dividend on the ordinary shares to 7 per cent., against 5 per cent. in 1914, and the board would take into favourable consideration the question of the institution of the declaration of interim dividends on the ordinary share capital. The results were undoubtedly satisfactory, and amply justified the policy of the gradual building up of reserves which had been one of the main principles adopted by the present board.

BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)—Mr. H. R. Beeton, who presided at the meeting on Monday, said that although their output had more than doubled in the past 13 years, their profits for last year were the lowest for any year in that period, and it had only been after considerable discussion and some difference of opinion that the board had recommended the payment of their usual dividend of 10 per cent. The justification for such a course was that they had husbanded their resources in more prosperous years, so that they found themselves to-day with more than half of their capital represented by mains, with

reserves of profits amounting to upwards of 60 per cent. of their capital invested in their business, with no debenture debt, and with 15 years of their tenure still to run. But although they had restricted themselves to 10 per cent. dividend when it would sometimes have been possible to pay more, they could not, of course, maintain the rate if their scale of profits were to remain permanently at its present level. The present condition of things was due to a concurrence of adverse influences, and mainly to public restriction and private economy in lighting and to increased cost of production consequent upon the war. They continued to be able to provide for their capital expenditure without increasing their capital. Although a profitable return on the capital invested in the Accessories Company with a view to encouraging the use of electricity for heating and cooking had been further postponed owing to the war, it was largely due to such expenditure that, in a purely residential area like theirs they had succeeded in virtually maintaining their output in spite of restriction in lighting. When their new turbo-generator the delivery of which had been delayed by the priority demanded by Government from the engineering shops, was installed they looked for considerable economy in working to compensate them in some measure for the increased cost of coal. They were carrying on both in their offices and at their works with smaller and less experienced staffs than ever before, while their allowances to those who had gone to the war and their bonuses to those who remained continued in operation. Although the progress of the Accessories Company had been retarded by the war, its capital account had not been extended and its results showed an improvement which was likely to grow. The restaurant, which continued to serve as an excellent advertisement as well as an experimental laboratory, now enjoyed a custom which, in spite of the increased price of food, made it self-supporting. The showroom sales had been prejudiced by the prevailing shallowness of the public purse; and the stove department, whilst furnishing some important cooking installations, had been largely diverted to the production of munitions. The experience of the first three months led him to conclude that the results of the present year would not be substantially worse than those of the past year, and if the coal position, which was undoubtedly precarious, was not aggravated, they might be rather better.

BROWETT, LINDLEY & CO. (LTD.)—After deducting £907 for interest, writing off £6,316 for depreciation and making provision for tax and duty, the net profit for 1915 is £14,010, leaving the outstanding debit £7,696. The directors submit a scheme for readjustment of capital.

CLEVELAND & DURHAM ELECTRIC POWER (LTD.)—Mr. Jas. Falconer, M.P., who presided at the meeting last week, said that the gross profit for the year amounted to £31,157, compared with £36,838 in 1914. The diminution of £5,681 was due to the exceptional way in which the company had been affected by the war. The revenue of the three combined companies in which the company was interested, had been £131,933 in 1913, £141,482 in 1914, and £151,512 in 1915, indicating increases of £10,000 in each of the two years. In their case, however, there had been a diminution in the volume of business done without any corresponding diminution in the amount of plant required to meet the demand. The company had been seriously hit in the cost of production. In 1913 the figures were £91,639, in 1914 £95,914, and in 1915 £110,368. Those increases were due to two causes. In the first place, the amount of current which they had developed at the waste-heat stations had been seriously reduced by the fact that hematite iron had been largely substituted for Cleveland iron, and thus gases which had been available for the waste-heat stations had been largely reduced. In the absence of the required amount of waste heat, energy had to be supplied through coal fires at Grangetown. Thus the coal bill had gone up from £845 in 1913 to £16,404 in 1915, an increase of over £15,000. Those figures showed the extraordinary value of waste heat to the company. Notwithstanding the apparent adverse result on the year, it was testimony to the stability of the company that it had maintained its supplies to consumers. After paying debenture interest £10,972 was available for allocation, and it was proposed to pay a dividend of 2 per cent. on the preference shares, and to carry forward £8,571.

FOLKESTONE ELECTRICITY CO. (LTD.)—The chairman (Mr. G. Spurgen) stated at the meeting last week that, considering the abnormal circumstances under which the company had been working during the past year, the financial results were in every way satisfactory. The lighting restrictions, &c., had restricted the revenue and their expenses had increased. The most important factor of the latter was coal, and apart from the extra outlay incurred during 1915 under that heading, they were faced with a still heavier increased cost on supplies for the immediate future.

W. T. GLOVER & CO. (LTD.)—The result of the trading for 1915 is a credit balance of £54,138. 1s. 1d., and with £7,970. 0s. 10d. brought forward the total is £62,388. 1s. 11d. Deducting directors' remuneration and expenses, interest on 4½ per cent. first mortgage debenture and on 5 per cent. second mortgage debenture stocks, writing £5,949. 10s. 10d. off investments, and appropriating £4,000 for payment to trustees of second mortgage debenture stock, the balance is £43,511. 7s. 3d. After paying the year's dividend on the 5 per cent. cumulative preference shares, transferring £2,500 to first mortgage debenture redemption fund, paying a dividend on the ordinary shares at rate of 5 per cent. (less tax) and transferring £20,000 to reserve fund, the balance to be carried forward is £11,701. 3s. 11d. During the past year the works have been, and are still, largely engaged on the manufacture of cables, wires, &c., directly or indirectly for the prosecution of the war. A plot of land of rather more than 9 acres opposite the company's premises has been purchased for the general development of the business, which of late years has suffered by the works being greatly congested. A portion of this land is thought to be in excess of the company's probable requirements, and it is proposed to sell such portion to the Trafford Power & Light Supply (1902), Ltd., in whose welfare the company is largely interested.

ISLE OF WIGHT ELECTRIC LIGHT & POWER CO. (LTD.)—At the end of 1915 the equivalent of 154,547 33-watt lamps was connected, an increase of 8,729 33-watt lamps over 1914. The result of the year's trading, including £2,374 brought forward, is a profit of £12,867. After providing for interest and sinking fund on debentures (£5,500) and 5 per cent. dividend on preference shares (£2,500) the balance is £4,867. Of this sum £3,500 was placed to renewal fund and £1,367 carried forward.

At the meeting the chairman stated that visitors seemed to have forsaken the island for the time being, though why they should have done so was very difficult to explain. Most of the South Coast watering places had had almost record seasons last year, but the fact of having to cross the Solent seemed to keep people away from the Isle of Wight, although it was in the opinion of many one of the safest places in the Kingdom. In addition to the absence of visitors, the severe lighting restrictions had affected them very adversely. Although they had added a large number of additional lamps the consumption of electricity had fallen from 1,279,000 units sold in 1914 to 1,160,000 units in 1915. The decrease (154,000 units) being entirely in the lighting units, as they sold more units for power than in 1914, owing to the demand for power from the Newport and Cowes station by consumers. Their receipts were £21,012, against £23,006, and the costs were £12,024, against £11,102, the profit being £8,988, compared with £11,904. Coal and oil had cost £531 more, wages £236 more and repairs to plant and machinery £246 more. On the wiring account they had made a profit of £820, or £424 more than last year. They have done a good deal of wiring work, and that was the only bright item in the year's accounts. There was small chance of seeing much improvement during the war, and their expenses would certainly be much heavier during the current year, as now they had to pay more than 80 per cent. increase on pre-war prices for coal. They increased the price to power users by 10 per cent. a year ago, but deferred making any increase in the charges for lighting as long as possible. They had had to give notice that the price to lighting consumers would be increased by 15 per cent. and that a further 10 per cent. increase would be made to power users as from April 1.

LIVERPOOL DISTRICT LIGHTING CO. (LTD.)—The annual meeting was held last week, and in moving the adoption of the report and accounts, the chairman (Mr. Chas. McLaren) said that the company had done better than they expected. Owing to the lighting restrictions they estimated that they sold 40,000 units less than they would have done, or a loss in revenue of £850. As a set off they had been successful in obtaining power contracts resulting in the sale of 108,000 units, so that there was a net increase of 68,000 in the number of units sold during the year. That was the largest increase the company had ever made. It was obvious that they could not obtain the same price from the power consumers for large contracts as from other consumers—the price agreed was the cost at which the consumers might reasonably have expected to manufacture for themselves had they installed their own plant, making due allowance for capital expenditure. The result was a net increase in income of £168. Owing to the increased cost of fuel, wages, &c., there was a total increase of costs of £560, and the net result was a reduction of profit of £302. Unfortunately fuel had again risen, so that they must be prepared for a further increase in costs in 1916. To counteract that they had followed the lead of Liverpool Corporation, and had increased their charges by 12½ per cent. all round. Their working costs had been kept down to £852, which included laying cables and service lines, meters, &c., while no serious capital expenditure was anticipated for 1916. The directors were now considering the question of coal storage, with a view to providing further reserves of fuel. They were paying a dividend of 4 per cent. for the year.

MADRAS ELECTRIC TRAMWAYS (1904) (LTD.) At the annual meeting last week the chairman (Mr. A. M. Quill) said the accounts showed a moderate improvement upon those of the preceding year. For the first seven months of the year the traffic receipts were 6 per cent. less than for the corresponding period of 1914. However, during the last five months of the year there was such a marked improvement that for the whole year they had an increase, both in traffic and net receipts. The passengers carried were 18,509,877, against 17,622,219. The total amount at credit of profit and loss was £22,198, compared with £21,522 for 1914, an increase of £976. The net profit was £11,030. 19s. 4d., and with £3,258 brought from last year, the amount available was £14,289. The directors recommend dividends of 6 per cent. per annum on the preference and ordinary shares. The board were glad to be able to recommend an increase in the rate of dividend on the ordinary shares. The majority of the Madras Corporation recently passed a resolution praying Government to increase the track rent paid by the company. If the petition were granted it would be a breach of faith, as the rents now exigible were agreed with the Corporation when the lines were laid, and were confirmed in the various Government orders. The fares in Madras were as low as, if not lower, than on any tramway in the world, and much lower than they were entitled to charge under Government orders. If further burdens were imposed upon their desire to maintain an efficient service the existing low fares might be defeated. Besides, it would become difficult to obtain capital for the contemplated extensions.

NORTH BERWICK & DISTRICT ELECTRIC LIGHT & POWER CO. (LTD.) At the recent annual meeting the chairman, Prof. Sir E. Schafer, moved

the adoption of the report and accounts. For the past year it was stated that there had been a considerable increase in the number of consumers' and further additions were anticipated during the current year.

OLDHAM, ASHTON & HYDE ELECTRIC TRAMWAY (LTD.)—The revenue for 1915 amounted to £34,823 (compared with £33,398 in 1914) and the expenditure (including £1,600 for debenture interest and £1,500 placed to provision for renewals), £25,062. 4s. 2d. (against £26,024 in 1914) leaving a net profit of £9,761 (against £7,374 for 1914), which, added to £1,021 brought forward, makes an available balance of £10,782. The directors propose to place £3,000 to reserve fund, to pay a dividend at rate of 5 per cent. per annum on the cumulative preference shares (£2,500) and a dividend at rate of 6 per cent. per annum on the ordinary shares (£3,000), leaving to be carried forward £2,282. 0s. 9d.

SHAWINIGAN WATER & POWER CO.—The gross earnings for 1915 were $1,920,143, and after meeting all fixed charges the net revenue (including $39,472 brought forward) was $1,208,505. Three quarterly dividends of 1½ per cent. each and one of 1¾ per cent. have been paid, $279,683 placed to reserve, $100,000 set aside for depreciation and $15,000 appropriated for insuarances, &c., leaving $26,690 to be carried forward.

SLOUGH & DACHET ELECTRIC SUPPLY CO. (LTD.)—In moving the adoption of the annual report at the recent meeting the chairman (Mr. H. L. Prior) said that they had actually sold 239,000 more units than in 1914, although the revenue increased by £669, there was a reduction in the profit, as coal and oil fuel cost £1,100 more, wages £93 (including war bonus to staff), repairs £137, and rates and taxes £267 more. Those four items made an addition to the costs of £1,597, and as the revenue increased only by £669, the profit had suffered to the extent of £900. The additional units, unfortunately, were not sold for lighting but for power, chiefly supplied to Messrs. Peters under a contract made before the war. The cost of production when they made that contract was far below what it was to-day. At that time oil was 42s. per ton. During last year the average cost was 90s., and at present it was up to 170s. per ton. If the average price for the whole supply for power and lighting had been maintained at 2d. per unit on their output of over 1,000,000 units they would have received an additional £2,000, and in that case they would have been in the happy position of recommending an increased dividend. The balance available for distribution was £3,949. On the reserve fund there was a credit balance of £8,588, and out of the profits for 1915 they were adding £1,250, which would bring the reserve fund up to nearly £10,000. They were again increasing the price of current for light by another ½d. per unit. At the same time the people using the current were actually getting their light far cheaper now than when electricity first came in, because metal filament lamps had reduced the price of the current at least 70 per cent. or more. They had added a good many new customers, but they would only reap the full benefit of these when they resumed their former conditions of lighting, and the cost of production came down to its normal level. They recommended a dividend of 4 per cent., which was a drop of 1 per cent.

UNITED ALKALI CO. (LTD.)—The report for 1915 shows that, after transferring £15,000 to debenture redemption fund, the profit is £326,986, an increase of £124,904 over 1914, and £32,462 was brought forward. The directors transfer £75,000 to reserve, and, after bringing preference dividend to date, recommend a dividend of 5 per cent. on the ordinary shares, carrying forward £50,379.

URBAN ELECTRIC SUPPLY CO. (LTD.)—The gross profits for 1915 amount to £68,513. 5s. 7d., compared with £68,961. 17s. in 1914, and after deducting expenses the balance is £65,311. 18s. 1d. The amounts required for interest and debenture stock redemption absorb £43,423.5s.2d., leaving an available balance of £21,888. 12s. 11d., which the directors recommend should be applied in paying a dividend of 5 per cent. for the year on the preference shares, and in placing the balance (£9,389) to reserve for depreciation. The 13 electric supply undertakings controlled by the company had at the end of the year the equivalent of 920,505 33-watt lamps connected, against 836,519 in 1914 and 760,319 in 1913.

WOKING ELECTRIC SUPPLY CO. (LTD.)—The total revenue for 1915 was £20,331 and the balance on the year's working was £9,681. The expenditure on capital account is £139,635 and depreciation and renewals fund is £14,469. Mr. John Ashby, in proposing the adoption of the report and balance-sheet, said that the year's revenue was the highest on record. With balance brought forward (£653) and income tax accumulations (£124), the available total was £10,458. After paying interest on debenture stock, &c., and the dividend on the 6 per cent. cumulative preference shares, the balance was £4,656. 8s. 7d., and it was decided to place £1,750 (against £1,500) to depreciation and renewals fund and £900 to reserve, and after allowing for certain smaller items payment of a 5 per cent. dividend on the ordinary shares was recommended, leaving to be carried forward £693. The number of consumers was 2,101, and 8 c.p. lamps connected 106,360, an increase of about 10,000 lamps for the year, the largest increase they had ever had. Their expenses had been more, partly owing to the war. The cost of coal had increased £205 for the year, but they had sold 31,841 more units of electricity than in 1914. That had only been brought about by careful management, and they had to thank Mr. Bowden for the time and attention he had given to the works department. The increase in sales was due to a large extent to the extra number of cookers, &c., sold during the year, there having been a great demand for cookers and heating apparatus exclusive of the lighting. As to the question of the electric lighting supply for Chobham, he said that although for a time the company had had the right of supplying the current to Mimbridge and other parts of Chobham, the area belonged to the Ascot Electric Lighting Co., who had now connected to the Woking Company continuing the supply on their behalf.

NEW COMPANIES, MORTGAGES AND CHARGES, &c.

NEW COMPANIES.

CONNER & MAGNETO IGNITION (LTD. (143,436)—Reg. March 30, capital £52,600 in 50,000 preference shares of £1 each and 40,000 ordinary shares of 1s. each, to adopt agreements with the Peel-Conner Telephone Works and with M. S. Conner to carry on the business of proprietors and manufacturers of and dealers in aeroplanes, motors, vans and other vehicles, magnetos and other ignition apparatus, and electric lighting and starting appliances, &c. Private company. First directors are H. Hirst, J. Fraser and M. S. Conner (managing director). Reg. office: Midland Bank Chambers, 71A, Queen Victoria-street, E.C.

CYMOGRAPH (LTD.) (143,323)—Reg. March 18, capital £1,000 in £1 shares, to carry on the business of mechanical and electrical engineers, manufacturers of implements and other machinery metallurgists, &c. Private company. Reg: office: Bush-lane House, Cannon-street, E.C.

HEADON & MARSHALL (LTD.) (143,410).—Reg. March 27, capital £2,000 in £1 shares, to adopt certain agreements, to carry on the business of mechanical engineers, manufacturers of and dealers in apparatus used in connection with steam, electrical or petrol motive power, manufacturers of and dealers in motors, motor cars, &c. Private company. First directors are W. F. Headon, A. J. Marshall and A. Headon.

LAUNA BRITISH ELECTRICAL CO. (LTD.) (143,140.)—Reg. Feb. 28, capital £1,000 in £1 shares, to carry on the business of electrical and general manufacturers and contractors, designers, makers and producers of electrical glow lamps, appliances, fittings, cables, flexible wires, &c. Private company. First directors are F. Dove (permanent governing) and D. Schofield. Sec., M. J. Dove, and reg. office, 61, Call-lane, Leeds.

MARCUS ALLEN & SONS (LTD.) (143,444)—Reg. March 29, capital £10,000 in £1 shares, to carry on the business of mechanical, chemical and electrical manufacturing engineers, brass and iron founders, &c., as formerly carried on by M. Allen at Old Trafford, near Manchester. Private company. First directors are M. Allen (gov. director, with £500 per annum as remuneration), V. M. B. Allen and T. W. Allen (all permanent subject to each holding 100 ordinary shares).

PHONOPORE CONSTRUCTION CO. (LTD.) (143,445)—Reg. March 29, capital £4,175 in 4,000 ordinary shares of £1 each and 3,500 founders' shares of 1s. each, to carry on the business of manufacturers of military telephonic and phonoperic instruments, munitions and all articles used in the manufacture thereof or used in connection with warfare on land or sea, engineers, &c., and to adopt an agreement with Justus Eck. Private company. Justus Eck shall be one of the first directors, and shall hold office permanently subject to holding 1,500 founders' shares. The New Phonopore Telephone Co. (Ltd.) shall be entitled during the continuance of a lease referred to in an agreement dated Jan. 7, 1916, to be represented on the board by two directors. Justus Eck is chairman. Reg office: 53-57, Park-street, Southwark, S.E.

WALTER ROBB (LTD.) (143,493)—Reg. March 31, capital £10,000 in £1 shares (9,000 A and 1,000 B), to take over the business of an electrical engineer carried on by Walter Robb at Wakefield. Private company. First directors are W. Robb (permanent) and H. F. Buttenshaw.

MORTGAGES AND CHARGES.

GENERAL SEATING CO. (LTD.)—Two charges on company's property, (present and future), both dated March 2, 1916, to secure not more than £1,650 and £1,550 respectively. Holders: H. Brittain and A. J. Smith.

ORFORD ELECTRIC LIGHT & POWER CO. (LTD.)—Issue on Dec. 10, 1912, of £20, and on March 17, 1916, of £130, debentures, parts of a series of which particulars have already been filed.

RUNBAKEN MAGNETO CO (LTD.)—Particulars of £1,000 debentures created Feb. 11, 1916, have been filed, whole amount being now issued. Property charged: Company's undertaking and property, present and future. No trustees.

CITY NOTES.

MEMORANDA (April 5).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 57 1/16. Stocks and Shares Ticket Days, April 12 and 27. Pay Days, April 13 and 28. Price of silver, 29⅜d.

BRITISH DYES (LTD.)—Dr. M. O. Forster, F.R.S., chairman of the Technical committee, and Mr. Joseph Turner, manager of the company's

works, have accepted seats on the board, and Dr. J. C. Cain has been appointed chief chemist of the new works at present under construction.

CONSOLIDATED SIGNAL CO. (LTD.)—An interim dividend for the half-year to Feb. 16 on the preference shares at rate of 6 per cent. per annum has been declared.

FALKIRK & DISTRICT TRAMWAYS CO. (LTD.)—The net revenue for year ended Oct. 16 last (including £674 brought forward) was £5,813. A dividend of 5 per cent. has been declared and £726 carried forward.

MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)—The company announce that Senatore Marconi has been engaged in research work in Italy, where he has been able to carry out some important experiments and tests. He advises that the results obtained are far reaching and directly concern the future practice of the entire science of wireless telegraphy and telephony, over both long or short distances, no matter whether conducted by means of ordinary spark, quenched sparks or continuous waves. He is now engaged in making applications for the patents, which will probably be applied at once in Italy to military purposes. By these means results heretofore impossible will be obtained.

MARCONI WIRELESS TELEGRAPH CO. OF AMERICA (LTD.) The gross earnings for 1915 were £141,000, against £150,600 in 1914; other income £21,000, against £20,000. The sum of £22,400 is placed to reserve, compared with £24,400, carrying £35,400 forward, against £29,800.

SUBMARINE CABLES TRUST.—Notice is given that the coupon due on April 15 will be paid by Messrs. Glyn, Mills & Co., 67, Lombard-street, E.C., between 10 a.m. and noon, and after that date between 10 a.m and 2 p.m.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date, April 4, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17d.
Solid Drawn Copper Tubes	18½d.
Brazed Copper Tubes	18½d.
Brazed Brass Tubes	19d.
Brass Wire	16½d.
Copper Wire	18d.
Rolled Brass	16½d.
Brass Sheets	16½d.

	per ton.
Copper Sheets	£148 0 0
Spelter	£93 0 0

	per ton.
English Lead	£35 10 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£102 0 0
Clean Brass Scrap	£63 10 0
Braziery Copper Scrap	£92 0 0
Old Lead	£28 0 0
Old Zinc	£60 0 0
Hollow Pewter	£120 0 0
Black Pewter	£85 0 0
Gun Metal	£84 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date April 4, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£112 0 0
Clean Mixed Brass	£67 0 0
Clean Copper	£100 0 0
Braziery Copper	£90 0 0
Gun Metal	£78 0 0

	per ton
Old Lead	£29 10 0
Tea Lead	£27 10 0
Old Zinc	£64 0 0
Hollow Pewter	£120 0 0
Shaped Black Pewter	£85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £115; Blowpipe Solder, £120.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, April 4. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., April 4.	Rate per cent. Yielded. £ s. d.	Dividend Due.
		Electricity Supply.			
10	6%	Bournemouth & Poole E.L. Ord.	9⅞ †	6 16 2	Mar, Sept
10	4½%	†Do. 4½% Cum. Pref.	9½	4 15 8	Feb, Aug
10	6%	†Do. 6% Cum 2nd Pref.	10⅞	5 16 4	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅜	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	5 0 0	Mar, Aug
St.	4%	Central Elec. Supp. C. Deb. St	80	5 0 0	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 11	Jan, July
5	2/3	Do. 4½% Pref.	3	7 2 7	..
5	5%	Do. Ord.	3⅛	8 0 0	Aug, Feb
5	4½%	Do. City Pref.	2⅜	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	4⅛	4 6 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	11⅝ †	6 18 0	Feb, Aug
10	6/0	Do. 6% Pref.	10⅜ †	5 19 8	Mar, July
St.	5%	Do. 5% Deb. St.	97½	5 2 6	Jun, Dec
St	4½%	Do. 4½% Debs.	80	5 12 6	Jan, Dec
10	7%	County of London Ord.	13⅜ †	6 19 6	Mar, Sept
10	6%	Do. 6% Pref.	12⅜ †	5 18 7	Feb, Aug
St.	4½%	Do. 1st Deb.	86⅛	5 4 7	Jan, July
St.	4½%	Do. 2nd Deb.	97	4 12 9	May, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	78	6 0 0	July
5	7%	Kensington and Knightsbridge Ord.	4⅜	7 7 4	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 3	Jan, July
5	6%	London Elec. Supp. 6% Pref.	4⅛	7 5 5	..
St.	4%	Do. 4% Mort Debs.	80	5 0 0	Jan, July
	3%	Metropolitan E. Supp Ord.	2⅝ †	6 2 2	Mar, Aug
St.	4½%	Do 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St	99½ †	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St	5%	Newcastle-on-Tyne E.S 5% 2d Mt. Db St.	91½	5 9 3	Mar, Sept
	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord.	3⅞	6 10 7	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Dividend	Name.	Price, Tues., April 4.	Rate per cent. Yielded. £ s. d.	Dividend Due.
		Electricity Supply—*cont.*			
5	8%	St. James' & Pall Mall Ord.	5⅞	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅞	6 0 3	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp 4½% Db. St.	83	5 8 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅛	7 2 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5½	6 7 3	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4	5 12 6	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	80½	6 4 3	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	71⅛	8 8 5	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	67	5 19 5	..
St.	4%	Do. do. Assented Def. Ord.	67½	5 18 0	..
St.	4½%	Do. 4½% Pref.	99½	4 10 3	Jan, July
St	4%	Do 4% Deb. St.	93½	4 5 9	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	62½	8 0 0	Feb, Aug
10	11%	London Electric Ry. Ord.	1 1⅛	6 9 1	Jan, July
St.	4%	Do. 4% Pref.	64½	6 4 6	Mar, Sept.
St.	4%	Do. 4% Debs.	85	4 14 4	Jan, July
St	1%	Metropolitan Ry. Con. Ord.	23⅝	5 5 7	Feb, Aug
St	3½%	Do. 3½% Pref.	77½	4 10 4	Feb, Aug
St	3½%	Do. 3½% Convertible Pref.	74½	4 13 9	Feb, Aug
St	3½%	Do. 3½% A Debs.	82½	4 4 6	Jan, July
St	3½%	Do. 3½% Debs.	83½	4 4 1	Jan, July
St	..	Metropolitan Dist. Ry. Ord.	17½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	92	4 7 0	May, Nov
St.	4½%	Do. 4½% First Pref.	70½	6 7 8	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 7	Jan, July
St.	4%	Do. 4% Debs.	71½	5 12 1	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	68	5 17 7	Mar, Sept
		Electric Manufacturing, &c.			
1	14%	Babcock & Wilcox Ord.	2⅝	5 3 0	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	5%	Brit. Aluminium Ord.	1⅜	4 6 6	Mar
10	5%	Do. Prior Lien Debs.	90	5 11 1	Jan, July
1	6%	Do. 6% Pref.	⅝	6 8 0	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	11	6 16 4	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref.	⅞	6 17 2	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	7 7 8	April
100	6%	Do. 6% Prior Lien Debs.	102½ †	5 17 4	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	64	6 5 0	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	11½	6 10 5	Jan, July
5	2/6	Do. 5% Pref.	4⅝	6 10 9	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅝	1 17 2	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	⅛	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	¾	8 0 0	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs	72	5 11 1	Jan, July
.5	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9⅜	6 3 6	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14⅛	6 15 7	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4⅛	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	9⅛	10 7 10	Feb, Aug
10	5%	Do. Pref.	7⅞	6 16 9	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	34½	6 18 2	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1⅛	4 5 9	May, Aug
1	6d.	Do. 5% Pref.	⅝ †	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	80	5 0 0	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jan, Dec
St.	4%	Willans & Robinson B. Cum. Pref.	41½	9 12 9	..
St.	4%	Do. 1st Mt. Deb. St.	50½	7 18 5	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	98½	6 1 9	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	21½	6 18 9	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69†	5 15 11	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7⅞	6 1 8	May, Nov
10	10%	Do. 10% Pref.	12	8 6 8	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	5⅛	7 0 8	Ja,Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	12⅛	5 8 9	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	63	5 9 8	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	7⅛	5 1 11	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77	5 3 11	Feb, Aug
10	7%	Do. Ord.	12⅜	5 9 6	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co.	31½	6 8 6	Ja, My, Jly
25	13%	Indo-European	4⅜	6 10 4	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2⅞	4 6 6	April
1	7%	Do. 7% Pref.	2⅛	3 8 11	July
10	1%	West India & Panama Ord.	1⅛	8 18 10	May, Nov
10	6%	Do. 1st Pref.	7⅛	7 12 11	May, Nov
10	7%	Western Telegh. Co.	12½ †	5 9 10	Mr, Jly, O, Dec
St.	4%	Do 4% Deb. St.	77½	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½	4 10 3	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	1⅝	6 12 5	Nov.
1	10%	*Oriental Telephone Ord.	1⅛	5 14 3	Apl, Oct
St	4%	Do. Db. St	79	5 1 3	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	5⅞	6 15 5	Apl, Oct
.5	5%	Do. 5% Cum. Pref	4½	5 10 4	Jan, July
St	4½%	Do. Deb. Stk.	84½	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	10½ †	5 14 3	Sp,De,Mr,Jn
10	6%	Do. 6% Pf.	11 †	6 4 8	Sp,De,Mr,Jn
100	5%	Mackay Companies' Common	80½	6 4 7	Ja, Apl, Jly,O
..	4%	Do $100 Pref	64½	5 14 9	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	124	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅛	6 10 8	Mar, Sept
St.	5%	Do. 5% Debs.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10⅞	5 16 4	..
St.	4½%	Do. 4½% Debs.	87½	5 2 10	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6⅞	7 5 5	May, Nov
5	5%	Do. 5% Pref	4⅛	5 1 3	Mar, Sept

* And 13½% bonus. † Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. LROUGHTON.

No. 1,978. [Vol. LXXVII. No. 2.] FRIDAY, APRIL 14, 1916. PRICE SIXPENCE (by post. 7d.) *Abroad 9d., or 20 cents. or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 35
Arrangements for the Week .. 38
Mr. A. P. M. Fleming on Industrial Research 39
Light and Illumination. By Dr. C. P. Steinmetz 40
Design of Million-Volt Experimental Transformer. By G. L. Bayley. Illustrated 42
Transformer Design. By F. M. Denton, A.C.G.I. 43
The Use of Continuous Current for Terminal and Trunk Line Electrification.—*Discussion* 46
The Electricity Supply of Great Britain. By Ernest T. Williams 48
The Business Side of Science: Its Part in the Coming Economic Crisis 50
An Enclosed Cadmium-Vapour Arc Lamp. By Henry J. S. Sand, Ph.D., D.Sc. Illus. .. 51
THE PRODUCTION OF LIGHT .. 52
REVIEWS 53
Principles of Direct Current Machines [Langsdorf].
An Introduction to the Principles of Physical Chemistry [Washburn].
Large Accumulator Sub-Station of the Metropolitan Electric Supply Co. Illustrated 54
CORRESPONDENCE 57
Metropolitan Electric Supply Co. (R. Fitzmorris).
Methods for Determining the Grading of Starting and Brake Resistances for Series-Motors (F. Erens).
Poynting's Theorem and Hysteresis (A. Press).
The "Electrician" Commercial and Industrial Section 59-68

NOTICE.—GOOD FRIDAY WEEK.

"THE ELECTRICIAN" will be published on THURSDAY next instead of on Friday. Communications intended for that issue must reach the Offices not later than WEDNESDAY MORNING'S POST.

Alterations to existing Advertisements and Copy for new Advertisements must reach the Publisher as much earlier as possible, but not later than TUESDAY MORNING. Official Announcements and "Small" Advertisements must be sent in not later than noon on WEDNESDAY.

NOTES.

A Million-Volt Experimental Transformer.

THE thousand kilovolt-ampere, million-volt transformer installed at the Panama Pacific Exposition, described elsewhere in this issue by Mr. G. L. BAYLEY, is of interest to engineers on account of the originality shown in its design and its performance under abuse. The author describes in detail the construction and arrangement of the windings and the oil insulation arrangements, and describes a number of tests which show that very severe conditions were imposed on the unit. It is to be regretted that there was not sufficient time to carry out the experimental work that had been planned, but no doubt this will be possible when the transformer is re-erected in Chicago. In the meantime, from the experiments which were conducted it is evident that the simple construction adopted is a suitable one for extra-high-tension transformers. Engineers will find it difficult to improve upon the open-type concrete pit in which the transformer was installed, and the ease with which the transformer was repaired, after many of the insulating spacers had broken down, is noteworthy. Although the generally accepted view is that oil in the open air absorbs water, with this transformer it was found that the dielectric strength, which originally was 18,000 to 20,000 volts with an air-gap of 0·2 in. between 0·5 in. diameter spheres, rapidly increased under the electrostatic stress accompanying operation to 40,000 volts, at which value it remained constant.

Organised Industrial Research.

INTEREST in industrial research continues to be shown by an ever-increasing circle of people, but, as yet, those most concerned are, with few exceptions, silent. Up to the present the majority of our manufacturers have taken no active part in the discussion. We give elsewhere an account of Mr. A. P. M. FLEMING'S recent lecture on the subject at Manchester, under the auspices of the Council for the Organisation of British Engineering Industry. Although on many points we are in entire agreement with Mr. FLEMING, there are, nevertheless, certain matters to which we take exception. It must be tacitly assumed that American firms invest money in research in order to profit thereby. Everything in the American character serves to indicate that the assumption is a correct one, and the investing of money in order to profit thereby is to the credit of the American people. Now, if certain American firms find it profitable to spend £100,000 per year on research connected with their share of a particular industry, we ask what expenditure will be needed on centralised laboratories for the requisite research in all the industries of this country? At the risk of some overlapping we should prefer to see centralised research laboratories for each industry, each laboratory being situated in the centre of the district in which the particular industry is pursued. Nearly 12 months ago we urged the formation of technological museums and libraries in every industrial town in the country, and we are firmly convinced that these would be of inestimable value to our industries. Under existing conditions we fill our museums with dead things and fossils. Instead of our museums being packed, almost to bursting, with the dead, we ought surely to endeavour to pack them with the living.

WE have libraries in our cities and towns, and in practically all our villages; but if any student desires information on a particular industry it is necessary for him to search in London at one or other of the great libraries. To us it seems incredible that special information of this kind can only be obtained in London—in a city in which industrial activity should be limited by Act of Parliament. But we make it easy for our people to read light literature. If the question of economy arises, library committees economise by refusing to buy books costing more than a few shillings each, and this rules out all serious works on technology. These matters are not dealt with by Mr. FLEMING, but the thoughts crowd in on us on reading his Paper. The most questionable part of the latter, in our opinion, is the suggestion that patents should be taken

out on behalf of the Government. Surely Mr. FLEMING cannot be serious in suggesting that patents should be taken out on behalf of those who, irrespective of party, both by precept and example, have gulled our people into the belief that an Empire can be founded and conducted by the adoption of a "wait-and-see" policy. Working under every conceivable disadvantage our traders have built up industries of unparalleled magnitude, and our scientists working under similar conditions have made most of the fundamental discoveries that have been made. All we ask of the State is a sum annually equal to the cost of three Dreadnoughts. As a return for this our scientists and engineers will promise to make war impossible, and will undertake to put our industries on a sure foundation. By trusting the State, the people of Britain are to-day paying close upon five millions sterling per day. By the time our people extricate themselves from the danger zone into which they have been led by their politicians, we hope and believe they will be able to rely on themselves, so far as industry is concerned at least. And we urge them, both capital and labour, to organise and to co-operate in order to demand from the State a sum equal to the cost of three Dreadnoughts annually, so as to enable them to live decently and to reap the fruits of their labour.

Colwyn Bay and the Board of Trade.

THOSE who are of the opinion that people ride on the tops of tramcars for the purpose of looking into the bedrooms of houses *en route* will be shocked to learn that this will shortly be possible at Colwyn Bay—of all places on earth. Judging by the evidence that was given at the Board of Trade inquiry, it appears that certain of those whose privilege it is to live on the car route strongly resent the proposal made by the tramway company to run double-deck cars. We are exceedingly glad to note that silly and frivolous evidence has had no effect on the Board, and we understand that after making minor alterations it will be possible for double-deck cars to be used at Colwyn Bay. We compliment the Company on its success, and we believe the decision of the Board of Trade to be a sound one. To those who desire more privacy in their bedrooms than that afforded by opaque blinds we would recommend another asylum.

Mutual and Self Inductance.—Mr. S. Butterworth, writing in the current issue of the "Philosophical Magazine," discusses a "Method for Deriving Mutual and Self Inductance Series." In the article will be found various expressions in the form of series for the self-induction coefficients of both long and short coils.

Crystal Palace School of Practical Engineering. Last week the 130th award of certificates was held at this school, the presentation being made by Mr. J. P. Barber. The occasion is of more than usual interest owing to the fact that it is the last of the series in the old South Tower over a period of 13 years. The school is about to move to more convenient premises close at hand.

"Journal" of the Institution of Electrical Engineers. In view of the Government restrictions in regard to the supply of paper, and also owing to the great increase in its cost, the Council have decided to reduce the amount of matter in the "Journal," and to publish it monthly, instead of fortnightly, until conditions are again normal. The last fortnightly Part (No. 257) was dated March 1, 1916.

Modern Developments of Water Power. We have received a copy of Mr. A. Steiger's Paper on this important subject. As many of our readers will remember, the Author was awarded the Bessemer prize by the Society of Engineers. The Paper, which as an analysis and compilation of general hydraulic turbine engineering is unique for the conditions of hydraulics to be met with in this country and in the colonies, may be obtained from the Author at 32, Victoria-street, London, S.W. The cost is 2s. post free.

Maximum Frequencies of X-Rays.—Mr. A. W. Hull, writing in the "Physical Review," states that measurements from curves of energy distribution in X-ray spectra at constant potentials show that the maximum frequencies up to 100,000 are given accurately by the quantum relation—*i.e.*, they are proportional to the voltage. There is no tendency for the frequency to fall off at the higher voltages, such as Rutherford reported from work with absorption methods. The highest frequency observed was $22{\cdot}8 \times 10^8$, with a voltage of 95,000.

Shot Firing. An informative technical Paper, entitled "Shot Firing in Coal Mines by Electricity Controlled form Outside," by Messrs. H. H. Clark, N. V. Breth and C. M. Means, has recently been issued by the Bureau of Mines (U.S.A.). Details are given for operating and constructing nine different kinds of systems. A general discussion then follows, bringing out the more preferable and reasons for selecting the same. Suggestions for outside shot-firing systems are then given, with a correct description of the ways in which they should be operated. Costs of installation and essential features are then given as a final section.

Leakage of Current From Electric Railways.—In a Paper recently published by the Bureau of Standards the theory of the leakage of current from electric railway tracks is developed mathematically. Assuming, first, a single track of uniform construction, and, later, a track whose sections vary in conductivity, leakage resistance and loading, the effects of rail and leakage resistance and of the length of the line on the distribution and amount of leakage current are calculated for systems with both grounded and ungrounded negative buses. Curves are plotted showing the effects of the principal variables in the formulæ developed. The conclusions with respect to electrolysis to be drawn from the formulas and curves are discussed and tabulated. The Paper contains 14 figures.

Flicker Photometer.—Messrs. H. E. Ives and E. F. Kingsbury have an article in the "Philosophical Magazine" on "The Theory of the Flicker Photometer." Among the experimental results referred to there are the following: (*a*) Different ratios of light to dark exposures require varying critical speeds. At high illuminations a maximum occurs for approximately equal light and dark intervals, but the curves connecting relative period of light and dark intervals, but the curves connecting relative period of light exposure and critical speed are not symmetrical. (*b*) The relationship between illumination and critical speed is represented by critical speed $= a \log \text{illumination} - b$, where a and b are constants, a being closely the same whatever the relative light and dark exposures, and b varying with the relative exposure. (*c*) When a flickering illumination is superimposed on a steady one the critical frequency is connected with the mean illumination by the same logarithmic relation, but the constant a varies with the ratio of flickering to steady illumination.

Fortieth Anniversary of the Telephone.—On March 7, 1876, the first telephone patent was signed by the United States patent authorities. Forty years after, on the 7th ult., the 40th anniversary of this "official" birthday was celebrated by a banquet at Washington of the National Geographical Society, at which Dr. A. Graham Bell, the inventor and one of the board of managers of the society, was present, along with several secretaries of the U.S. Government. All the speakers devoted themselves to the subject of the telephone, and many long-distance communications were received in the banqueting room. Among others, the General in command at El Paso, on the Mexican border, spoke to General Scott, Interim Secretary of War, sitting at the dinner table, stating that all was quiet on the border. Sir R. Borden, the Canadian Premier, speaking from Ottawa, sent a message to the meeting. In his own speech, Dr. Bell said he was overwhelmed by some of the examples of long-distance telephony demonstrated at the meeting, modestly declaring that he did not see what he had

to do with the results achieved, inasmuch as many minds had contributed to the development of the telephone of to-day. He foretold, however, the possibility that, some day, the time might arrive when the people of the United States would be able to sing the "Star Spangled Banner" in unison.

Regeneration of Sulphated Storage Cells.—A Paper on this subject was contributed recently to the "Journal of Physical Chemistry," by Messrs. G. A. Perley and C. W. Davis. The authors have previously shown that sulphated storage cells can be regenerated satisfactorily if the battery acid is replaced by a solution of sodium sulphate. Upon the passage of a normal charging current, the lead sulphate is reduced within 60 hours, even in badly-sulphated grids. This method has since been tried by others with uniformly good results. It was conceivable that some other salt might give deposits that were good enough to justify its use, and, accordingly, some experiments have been made with other sodium salts. The experiments point to the following general conclusions: (1) Sodium sulphate is the best salt to use in regenerating positive and negative storage-battery grids. (2) Dummy positive grids on the outside of the negative plates diminish the time of reduction. (3) Hydrolysis of the lead salts formed in sodium hydroxide solution yields large and troublesome quantities of lead monoxide. The active material of the grids is removed to a considerable extent. (4) With sodium sulphite solutions, a hard crystalline material is deposited at the cathode which causes buckling of the grids. (5) Reduction in whole or in part of a sulphated grid results by the use of a solution of sodium sulphate, carbonate, phosphate or sulphite. (6) Good anode deposits from sulphated grids can be obtained only with sulphate, carbonate and hydroxide solutions. Relatively high anode corrosion with sodium hydroxide solutions makes these useless.

Reversible Change of Remanent Magnetism with Temperature.—Dr. G. Elias has a Paper on the above in the "Proceedings" of the Koninklijke Academie van Wetenschappen te Amsterdam. When a magnet is heated it loses magnetism, and when cooled again to its initial temperature the magnetism increases, but not quite to its original value. With repeated operations of this type these differences become smaller until a cyclic state is reached, and the changes become reversible. This reversible change is the one investigated. If M_1 and M_2 are the magnetisations at temperatures t_1 and t_2, then

$$M_2 = M_1\{1-a(t_2-t_1)\},$$

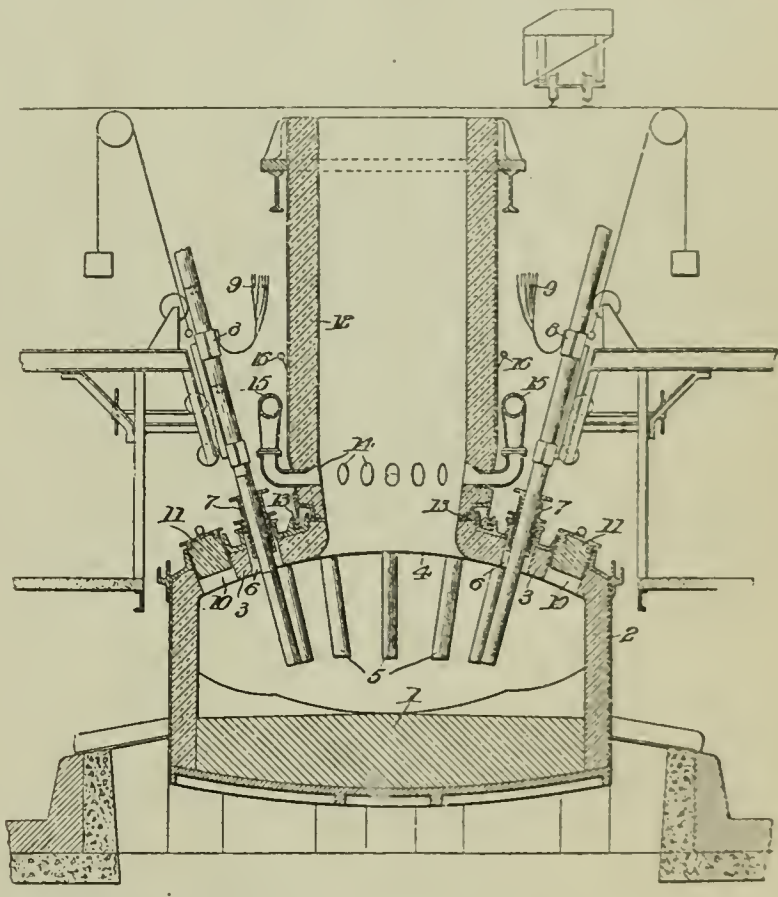
and the coefficient a was positive, as found in the experiments of Ashworth and Durward. For steel the highest value found for a was 0·0014, and cast iron 0·0029. Negative values for piano wire had been found by Ashworth. The spontaneous magnetisation of the "elementary crystals," which Weiss regards as the building stones of the iron, decreases with the rise of the temperature according to the formula

$$M/M_0 = \coth a - 1/a,$$

where $a = 3\theta M/TM_0$, M_0 is magnetisation at absolute zero, M that at temperature T, and θ the Curie point. If by means of this formula we calculate the change between 10 deg. and 100 deg., taking the Curie point as 757 deg., we obtain 4·2 per cent., which agrees very well with the experimentally found value of 3·9 per cent. The results Ashworth found for steel were confirmed experimentally, the highest value for a being 0·0015. The author determined a for different parts of the same magnet, and found that a near the ends is less than in the middle, since the demagnetising force at the ends is greater.

Determination of Gravity at Sea.—Prof. W. G. Duffield, in a recent Paper read before the Royal Society on this matter, discusses a method which depends upon balancing a column of mercury against the pressure of a constant volume of air contained in a bulb. The whole apparatus is maintained at as constant a temperature as possible. The height of the column varies inversely as the value of gravity. In an early form of the apparatus the adjustment of the air volume was made by raising or lowering, by means of a magnet, an iron needle immersed in the mercury in the upper part of the apparatus. This lowered or raised the level of the mercury in the vertical tube and produced the change in pressure necessary to restore the lower surface of the mercury to its normal level. The value of gravity was measured by the length of the needle immersed. A practical difficulty in regulating the position of the needle led to the adoption of a different method of adjustment. In this case the level of the mercury in the lower line was regulated by introducing or extracting mercury through two side tubes, one of which was of coarse bore for making the initial adjustment and the other of fine bore for purposes of delicate measurement. A high sensitivity could be attained by making the diameter of this tube small and that of the vertical tube large. A small pump was used for extracting the mercury. The constancy of volume was indicated by electrical contact between the mercury and a pointer, a trembling coil and telephone completing the circuit. The apparatus was tested on a voyage to Australia and modified in Adelaide in accordance with experience gained. It was further tested during part of a return voyage under very unfavourable conditions, nevertheless the results indicate the suitability of this type of instrument for future observations of gravity at sea.

Production of Ferro-Silicon in the Electric Furnace.—According to "Metallurgical and Chemical Engineering," a furnace for the production of ferro-silicon, which is designed for the utilisation of lower-grade raw materials than generally used, has recently been patented by Mr. H. C. Harrison. It is a combined combustion and electrical furnace, a cross-section of which is shown in the accompanying figure. The furnace



has 12 electrodes extending down into the hearth (1), as shown, the connections and adjustments needing no explanation. The roof (3) has manholes (10) with gas-tight closures (11); supported directly above the roof opening (4) is a stack combustion chamber (12). Radial tuyeres connected to a bustle pipe (15) open through the lower end of the stack. The stack may be cooled by a water spray from pipe (16). The charge is made up of mill scale, intermingled with dense impermeable briquettes of ground sand and coke. The carbon is slightly in excess of that required for the reduction of the silica. A charge consists of approximately 169 parts of mill scale, 269 parts sand and 139 parts coke (80 per cent. carbon). The pre-heating of the charge is effected in the portion of the column above the tuyeres by the combustion of the carbon monoxide rising from below. The charge is introduced in the form of briquettes and a temperature of about 2,000°C. is needed in the final zone where the silicon is reduced. Air is introduced through the tuyeres to effect combustion of the excess carbon monoxide not used in reducing iron. The process is operated continuously.

Black Body Radiation. A Paper has recently been published by Mr. W. W. Coblentz, of the Bureau of Standards, on "Present Status of the Determination of the Constant of Total Radiation from a Black Body."

The first part of this Paper gives a summary of the methods used and the values of the constant of total radiation obtained by various observers. Corrections for losses by reflection, for atmospheric absorption, and for lack of blackness of the radiator were applied. After making these corrections to the most reliable measurements the large variations in the radiation constant have disappeared, giving a value of the coefficient which is of the order of

$$\sigma = 5{\cdot}7 \times 10^{-12} \text{ watt cm.}^{-2} \text{ deg.}^{-4}.$$

This Paper gives also the correction (about 1 per cent.) for lack of "blackness" of the radiators from an unpainted porcelain tube radiator and for the atmospheric absorption in 1·2 metre of air containing a determined amount of water vapour, the radiator being at about 1,050° C. The data obtained in a previous Paper have been corrected for losses by diffuse reflection from the receiver and combined to give a value of the coefficient (the so-called Stefan-Boltzmann constant) of total radiation from a black body, as determined by means of an absolute thermopile of the type previously described. The correction applied to all the data for diffuse reflection is taken as being 1·5 per cent. This correction may be 0·1 to 0·3 per cent. too high for lampblack, but it will eliminate, in part, atmospheric absorption and the possible lack of blackness of the radiator.

Of the 13 receivers used, three were known to be defective, and receiver No. 1 (which was one of these three) was used mainly for relative measurements on the effect of using water-cooled diaphragms having different openings. The mean value of the radiation constant (corrected by 1·5 per cent. for reflection) as determined by 12 receivers and representing 348 pairs of measurements is

$$\sigma = 5{\cdot}77 \times 10^{-12} \text{ watt cm.}^{-2} \text{ deg.}^{-4}.$$

If we exclude receivers Nos. 8 and 9, which is permissible in view of the fact that they were known to be defective, the value of the coefficient of total radiation, representing the mean of 304 pairs of determinations, is

$$\sigma = 5{\cdot}74 \times 10^{-12} \text{ watt cm.}^{-2} \text{ deg.}^{-4},$$

which is but little smaller than the value obtained for all the receivers. This value is based upon the mean of all the data tabulated in Table 5 of the "Bulletin" of the Bureau of Standards, Vol. XII., page 531, excepting the measurements in which there was no slit in front of the receiver, in which moisture was present, and in which an unblackened radiator was used. All the determinations are given the same weight in finding the mean value. Each tabulated value represents two sets of measurements, each one of which is a complete determination consisting of 5 to 10, or more, readings when the receiver was heated electrically and when it was heated radiometrically. From the data at hand it appears that the value of the radiation constant is of the order of

$$\sigma = 5{\cdot}75 \times 10^{-12} \text{ watt cm.}^{-2} \text{ deg.}^{-4}$$

or

$$\sigma = 1{\cdot}375 \times 10^{-12} \text{ gr.-cal. cm.}^{-2} \text{ deg.}^{-4}.$$

Using Planck's equation and Millikan's value of the unit electric charge, the value of the constant of total radiation indicates that the constant of spectral radiation $c_1 = 14{,}500$ cm. deg.

PERSONAL.

Sir William Crookes, O.M., F.R.S., and Lady Crookes celebrated their diamond wedding on the 10th inst.

Senhor Don Francos Rodrigeez has been appointed Director-General of Spanish Posts and Telegraphs.

A second list of members and associate members of the Institution of Electrical Engineers who have distinguished themselves in the field is given in the "Journal" of the Institution for April. These are as follows:—*Military Cross*: Lieut. A. C. Sparks, R.E. *Mentioned in Despatches*: Major A. S. Angwin, R.E., Capt. H. Carey-Thomas, R.E., Major L. Evans, R.E., Lieut. R. K. Morcom, Divisional Engineers, R.N.D.

Anticipating the calling up of his "Group," Mr. G. W. P. Page, who for the past two years has been engaged chiefly on publication and other technical work in the publication department of the General Electric Co. (Ltd.), has enlisted in the London Electrical Engineers.

APPOINTMENTS VACANT AND FILLED.

A junior shaft engineer is required at the new temporary station, Nechells, Birmingham. Commencing salary £104, rising to £200 per annum. Applications (on forms to be obtained from the Secretary, Electric Supply Dept.) to the city electrical engineer and manager (Mr. E. A. Chetwode), 14, Dale End, Birmingham, by 24th inst. *See an advertisement.*

An electrician is required for the Gold Coast Government waterworks. Salary £200, rising to £250, with free quarters. Applications to the Crown Agents for the Colonies, 4, Millbank, London, S.W.

A draughtsman is wanted for electrical instrument work in a Government department at Portsmouth. *See an advertisement.*

A first-class foreman armature winder, used to a.c. and d.c. winding, is advertised for.

Heywood Corporation require an assistant for their motor and meter department. Commencing wages £2. 10s. per week. Applications to Borough Electrical Engineer.

Prof. Gilbert T. Morgan has been appointed to the chair of chemistry in the City and Guilds Technical College, Finsbury, in succession to the late Prof. R. Meldola.

Mr. J. B. Peace, fellow and bursar of Emmanuel College, has been appointed manager of the Printing Department of the Cambridge University Press, in succession to the late Mr. John Clay, [illegible].

Mr. W. H. S. Clarke, now distribution assistant at Newport (Mon), has been appointed installations assistant at a commencing salary of £140 per annum. Mr. C. E. Illingworth, at present senior engineer-in-charge at Lanarth-street works, has been promoted to be directly responsible to the electrical engineer (Mr. A. Nicholls Moore) for the supervision of those works, the Mili Parade sub-station and certain of the transforming stations, at £130 per annum.

INSTITUTIONS AND SOCIETIES.

Institution of Electrical Engineers (Manchester Section).—The annual general meeting of this Section of the Institution of Electrical Engineers was held on Tuesday, April 4th. The chairman (Mr. B. Welbourn) presided, and there was a good attendance of members. Votes of thanks were accorded the chairman, hon. secretary and assistant secretary for their work during the session. The Committee of the Engineers' Club were also thanked for the use of the club premises for the holding of the meetings. The voting took place for the chairman, hon. secretary and committee for the next session, and resulted as follows, viz., Chairman, Mr. A. E. McKenzie; vice-chairmen, Messrs. C. J. Beaver, A. P. M. Fleming; committee, H. Allcock, Dr. Wm. Cramp, Prof. A. B. Field, A. G. Livesay, S. L. Pearce, J. S. Peck, H. A. Rateliff, J. A. Robertson, H. D. Symons, Ald. Wm. Walker, Prof. Miles Walker and S. J. Watson. At the close of the meeting a lecture on "Recent Researches in X-rays" was given by Prof. Sir E. Rutherford, of the Manchester University.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, April 14th (to-day).

PHYSICAL SOCIETY.

5 p.m. At Imperial College of Science, South Kensington, S.W. Paper on "The Variation of Resistance with Voltage at a Rectifying Contact of Two Solid Conductors, with Applications to the Electric Wave Detector," by D. Owen, B.A., B.Sc.; also Paper on "The Electrical Capacity of a Gold-leaf Electroscope," by T. Barratt, A.R.C.S., D.Sc.

THE ROYAL INSTITUTION.

5.30 p.m. At Albemarle-street, W. Discourse by Prof. Sir J. J. Thomson, F.R.S., on "Genesis and Absorption of X-Rays."

INSTITUTION OF MECHANICAL ENGINEERS.

6 p.m. At the Institution of Civil Engineers, Great George-street, S.W. Annual General Meeting.

SATURDAY, April 15th.

THE ROYAL INSTITUTION.

3 p.m. At Albemarle-street, W. Lecture by Prof. Sir J. J. Thomson, F.R.S., on "Radiations from Atoms and Electrons" (Lecture V.)

TUESDAY, April 18th.

INSTITUTION OF CIVIL ENGINEERS.

5.30 p.m. At Great George-street, S.W. Annual General Meeting of Corporate Members only.

ENGINEERING INSTITUTIONS' VOLUNTEER TRAINING CORPS.

Officer Commanding: Lieut.-Col. C. B. CLAY, V.D.

The following orders have been issued for the week commencing April 17, 1916:—

Drills: 6.25 to 7.25. 7.25 to 8.25 p.m.

Monday, April 17th. Sections 1 and 2, Technical; Sections 3 and 4, Squad Signalling Class and Platoon.

Tuesday, April 18th.—6 to 7 p.m., School of Arms. 7.15 to 8.15 p.m., Recruit Drill.

Friday, Saturday, Sunday, Monday, April 21st to April 24th.—Easter Training.

Sections for Technical, Parade at Headquarters, London Electrical Engineers, 46, Regency-street, S.W.

Unless otherwise ordered, all parades at Chester House.

Members who have not yet been measured for uniforms must call on Samuel Bros., Ludgate Hill, as soon as possible. Payments for uniforms to be made to the Adjutant.

MR. A. P. M. FLEMING ON INDUSTRIAL RESEARCH.

Under the auspices of the Council for the organisation of British Engineering Industry, a lecture on "Industrial Research" was given in the Manchester School of Technology on Tuesday, April 4. The chair was taken by Mr. Chas. Day (Messrs. Mirrlees, Bickerton & Day), who mentioned that at the works in which he was interested a small laboratory was provided in which new ideas were tried and developed before being finally adopted on engines supplied. The laboratory certainly cost something to run and maintain, but it paid for itself in many ways. It was a mistake to embody new ideas without first having tested and given them a thorough trial. He said the last person to try experiments on was a customer.

In what follows we give Mr. Fleming's lecture *in extenso*.

While research is receiving increasing recognition as an essential factor in industrial work, little attention has been given to the manner in which scientific resources in this country can best be directed to meet national industrial needs. A description of the manner in which the United States is dealing with this matter may be useful in throwing some light on our problem, and incidentally the evidence of the progress in that country of industrial research may be inspiring to English manufacturers who may be somewhat sceptical as to the value of science in industry.

The term "industrial research" is often very loosely applied, and it is necessary first of all to define what it really comprises. One may consider it to be focussed in a simple fundamental principle that an industry depends for progress on a continual influx of new knowledge, and it may be conceived that industrial research embraces all means whereby this new knowledge having application in industry can be obtained, whether it is from the accumulated experience of individual workers; or from the efforts of trained investigators directing their efforts to the solution of manufacturing problems impeding the progress of industry, requisitioning where necessary the aid of contemporary science; or whether from new discoveries resulting from investigations in pure science which ultimately find their application in industry.

Industrial research in the United States is mainly accomplished by individual firms, although a good deal is done in the universities and national institutions. With certain exceptions, noted later, the greater part of the university work, however, is directed to pure science investigations having no immediate commercial object.

As regards the work of individual firms, during the past 10 years there have been very considerable sums spent by the leading manufacturing corporations to provide facilities for scientific investigation. Annual expenditures for this purpose of £25,000, £50,000 and even £100,000 are not uncommon. The leading firms possessing private research laboratories include the General Electric Co.; at Schenectady; the Westinghouse Electric & Mfg. Co., East Pittsburg; the Eastman Kodak Co., Rochester, New York, this firm representing the manufacture of photographic chemicals and apparatus; the Du Pont Powder Co.; the American Rolling Mill Co., producing sheet iron and steel; the National Electric Lamp Association, representing a large number of electric lamp manufacturers; the General Chemical Co.; the General Bakelite Co.; the United States Steel Corporation; the Edison Laboratories; the Pennsylvania Railway Co., which deals with all kinds of materials and investigations pertaining to railway requirements; and many others.

Among the important features of the work of many of these laboratories is the equipment of full-scale manufacturing plant which enables discoveries in the laboratory to be fully tried out and manufacturing methods perfected, relieving the manufacturing departments from the hampering effects of new developments. Many of the laboratories also are equipped for the manufacture on a commercial scale of some of the commodities developed from their discoveries which are not of a character adapted to production in the manufacturing departments. The laboratory production in such cases is continued until it reaches such dimensions as to justify the starting of a separate works. There is a growing tendency in many of the research laboratories to devote more and more attention to the investigations in pure science having no immediate commercial object in view, with an appreciation of the fact that almost invariably such investigations result in some industrial application, sometimes resulting in the development of entirely new industries. Prominent examples of this kind are represented by the work of the General Electric Co.'s laboratory, at Schenectady, and the National Electric Lamp Association. In connection with such work, a very broad-minded policy is shown by the publication of the scientific investigations carried out. It is also noteworthy that these research laboratories serve as very effective advertising means by inspiring confidence in the minds of purchasers as a result of such visible evidence of scientific working.

There appears to be no doubt that these laboratories have proved financially successful, not only in that they afford the greatest possible assistance to the works with which they are connected in solving manufacturing troubles, developing new materials, methods, tools and making discoveries which result in new industrial developments, but also in the direct manufacture and sale in many cases of valuable products straight from the laboratory.

A great deal of the research work for the Universities is devoted to purely scientific investigations arising in connection with the preparation of degree theses by students, and from work done by the staff in their spare time. Apart from this, however, many investigations directed to the solution of particular manufacturing problems are carried out for private firms, and in a number of cases experiment stations have been arranged, the staff of which devote all their time, or at least most of it, to research investigations. Prominent examples of such experiment stations are those of the Illinois State University; Massachusetts Institute of Technology now incorporated with the School of Engineering, Harvard University; Ohio State University, the experiment station of which has recently been inaugurated; and the Universities of Iowa, Kansas, &c.

In connection with Columbia University, it is proposed to erect a laboratory specifically devoted to research, the cost of which, it is estimated, will be of the order of £130,000 for buildings and equipment, and it is expected that an endowment fund for extension and maintenance of from £400,000 to £1,000,000 will be required. This proposal appears to be inspired to some extent by the success of the research laboratories associated with the large industrial corporations already referred to, and it is realised that there are many smaller manufacturers who are unable to support individually the burden of such laboratories who would be glad to avail themselves of the opportunities which this university research laboratory would afford. An important feature of the proposal is the intention of devoting means to the collection of all possible information bearing on the industrial problems that are likely to be considered.

The most striking features of the research work of the universities is this provision of research facilities and the use of a staff of highly trained scientific men who can devote their whole efforts to scientific investigation without the handicap of a great deal of teaching work and as well as of financial anxiety. It is also noticeable that increasing numbers of young men who have taken their bachelor's degree proceed to a doctor's degree, possibly on account of the increasing number of opportunities for employment now presented by the increasing number of research laboratories for men of the highest scientific training.

While the students themselves do not generally participate in the investigational work of the experiment stations, this work cannot fail to be of considerable inspirational value. The researches of the experiment stations are freely published and in connection with the Illinois State University already over 80 important bulletins have been issued, some of them comprising the most authoritative work on the subjects with which they deal.

The work of the Mellon Institute of Industrial Research, associated with the University of Pittsburg, has often been described in the English Press. Manufacturers are invited to bring their problems to the Director of the Institute and to provide fellowships to support the men who will carry out their investigations. Usually these fellowships may be tenable for a period of one or more years and be of value of from £100 to £400 or £500, according to the nature of the investigation. The Director then selects suitable men from the universities or other institutions, who proceed to the manufacturer's works, study the problem under practical conditions, and then carry out the investigational work in the laboratories provided by the Institute under the supervision of a permanent scientific staff. Some 75 researches have already been carried out during the past four years, including such subjects as copper leeching, cement manufacture, timber preservation, smoke prevention, glass production, bread making, paper manufacturing, &c.

Important features of the work of the Institute comprise the educative influence it has on the manufacturers in focussing their attention on the possibilities of industrial research, and the fact that many of the young men who have successfully carried out researches have been absorbed into the industry with which they became temporarily associated, and in this way become powerful advocates for industrial research. To a limited extent this process tends to the permeation of industry with young men having keen appreciation of the application of science in industry.

Of the national institutions, the most important is the Bureau of Standards, which at present does a great deal of investigational work for the Government departments and is prepared to carry out researches where it can be shown that these are likely to benefit an

appreciable section of the public, in which case it is done at the public expense. Already in this connection much valuable work has been done in such subjects as the manufacture of refrigerating machinery, paper making, investigation of alloys, &c. A series of publications is issued by the Bureau of Standards, comprising popular and technological bulletins, and bulletins recording the results of scientific investigations.

The Department of Agriculture is of some interest in that it carries on a scheme of investigational work on national lines. Connected with it are some hundreds of experiment stations in different parts of the States which deal with experimental work relating to the growth of crops, including fertilisers, pests, &c., cattle breeding, including the treatment of various diseases. Bulletins are issued to the agricultural communities, both in popular and scientific form, and the organisation provides for lectures dealing with special features of interest to different sections of the agricultural community.

While there is as yet no national plan of industrial research there are tendencies in that direction, some of which are directed to linking up the efforts of the universities, the extension of the experiment station scheme to a number of universities and colleges, and the co-ordination of the work of some of the existing laboratories connected with industrial concerns. In this connection there is always the evidence of the successful working of the Department of Agriculture to serve as an inspiration to those who desire to see national scientific facilities made applicable to manufacturing interests.

The work done in the United States is of considerable value to us in this country in enabling us to shape our own schemes with reference to research, and although this country is considerably behind in the development of such schemes, some advantage accrues in being able to make use of the experience the States have already gained. Of that experience full use should be made.

The distinguishing feature of work done in America is that it is mainly in the hands of private companies, and is carried out in order that one company may more effectively compete with another. The development of the internal resources of the country has occupied most attention, and little work has been done with a view to encouraging export trade. In this country our export trade is of the first importance and it is here that the country most feels the pinch of German competition. The opportunity, therefore, arises to make the greatest possible advantage of laxity in the past and at the same time to take steps to conserve our overseas trade.

This can only effectively be done by co-operating and pooling our scientific resources, which have hitherto lacked organisation. Doubtless each manufacturer will in future provide himself with a small laboratory where manufacturing difficulties peculiar to his own works can be solved, but the big advances in the future can only come by concentrating advanced research in a large central institution. The materials, tools and processes which are common to any industry would be considered in such an institution and efforts devoted to improving them for the common benefit of the industry. Processes which are the monopoly of any individual firm would have to be left out of such a scheme. Differences of factory organisation and management and methods of distribution would still enable manufacturers to compete among each other, but the whole industry would be lifted to a higher plane through discoveries arising from work done at a research institution, which would enable foreign competition to be met most successfully.

Such an institution would comprise a laboratory for each of the great industries—engineering, shipbuilding, soap making, dyeing, rubber, paper, metal and textile manufacture, mining, &c.—housed in a large central building. Much of the work done would be along lines of pure science investigation so as to ensure priority of new applications in industry. Patents would be taken out on behalf of the Government, and manufacturers in this country or the colonies licensed to manufacture at a nominal charge.

The advantages of such a scheme over a system of isolated laboratories in different centres are as follows:—

(1) Work would be done without the overlapping which inevitably occurs among a number of different institutions and which results in great lack of economy.

(2) Administrative expenses would be kept to a minimum.

(3) Since one research frequently leads to others quite unexpected originally, if all the work were done in one building fresh investigations could be carried out with the least loss of time and the greatest possible efficiency.

(4) The problem of collecting information on problems considered would be reduced to a minimum by housing copies of all matter required in one library.

(5) The problem of distribution of information would in the same way give as little trouble as possible if handled by a bureau attached to the institution.

(6) It is of the greatest possible value to have a number of men engaged in research problems housed in one building where opportunities arise for frequent meetings. The stimulation arising from intercourse in this way can scarcely be over-estimated. This would be very largely lost in a system of isolated laboratories.

The advantages the above scheme presents over any proposal to distribute the research work among the universities are equally obvious. The universities are now mainly teaching centres and the research work done by students is of little real value except to the students. Lecturers and professors are generally too much occupied with teaching to devote time continuously to research, and the complexity of modern research demands above all things continuity of application. If the universities adopt the plan of having two separate staffs, one for teaching and the other for research, then there would be an obvious gain in transferring the research workers to the central institution where the best possible equipment and facilities would be obtainable. At present good research workers at the universities are often spoiled by having to undertake teaching, while really capable lecturers seldom make first-class research men.

English people seem to possess a certain industrial genius which assured them priority in the industrial world in the past, and the records of her inventors and discoverers lead to the belief that what has happened in the past may with suitable organisation be repeated in the future.

In view of the fact that industrial research can be made to pay for itself, it would be an excellent investment if manufacturers in this country would devote the necessary percentage of the gross profits arising from industrial processes required to collect and maintain a research laboratory planned on a comprehensive scale.

A critical survey of the work already accomplished in the States affords evidence in favour of the success of such a national attempt at industrial research, and ultimately such a scheme might be extended to embrace not only the interests of this country, but also to link up the efforts made in our overseas dominions; such as those of the recently established Bureau of Science and Industry for the Commonwealth of Australia.

LIGHT AND ILLUMINATION.*

BY DR. C. P. STEINMETZ.

Summary.—After a preliminary survey of the problem, the emission of light by various filaments in vacuo and in gases is considered. The limitations in the various cases are dealt with, and the trend of recent progress referred to.

After referring to illumination as a most encouraging branch of engineering, it is pointed out that the artificial production of light is quite a recent invention. Light appears to be a by-product when heat is generated. Noises and musical notes are then compared to illustrate definite frequency, and the author proceeds to consider atoms in motion, and the effect of high temperature as a mode of generating rapid oscillations, and consequent emission of light. The use of electricity for producing light, first by heating a platinum wire, is then referred to, and the advantages of the carbon filament pointed out. The question then arises: Why could not the carbon be operated at a higher temperature and thus at higher efficiency? If instead of running at a temperature of 1,800 deg., requiring 4·5 watts per candle-power of light produced, the carbon was raised to 2,500 deg., the candle-power would be doubled for the same watts. But the limitation there was, not that the filament melts or boils, but evaporates. We know materials can evaporate below their boiling point, for example, that water at ordinary temperatures will evaporate within a few days, and that even ice and snow below the melting point gradually disappear. The carbon filament at 1,800 deg. below the melting and boiling point, also slowly evaporated, the carbon vapour being deposited on the lamp bulb. With continuous evaporation the filament got thinner, thereby the temperature went down and the light became less. The deposited carbon vapour also obstructed the light. If the filament were raised to 2,500° C. the temperature would rapidly go down through excessive thinning of the filament by evaporation, and the deposited carbon on the globe would blacken it to such a degree that even the filament itself would only faintly be seen through the glass.

So we were limited as to the operating temperature of the carbon filament because it had to be kept below the melting or boiling point, where the rate of evaporation does not unduly reduce the light production, and efficiency of that production, within a reasonable

* Abstract of Paper read before the Electrical Section W.S.E. and Chicago Section A.I.E.E.

time, say, 500 hours or so. That was the limitation to the efficiency of the old carbon filament light.

The problem later was to make it possible to run carbon at higher temperature without undue evaporation, and thereby get higher efficiency. Carbon is a rather indefinite body. There is carbon and carbon; for instance, the carbon obtained from bamboo fibre, the carbon from silk strands and that from cellulose, and so on. The material obtained by carbonising fibre evaporates rather rapidly, but carbon deposited from gasoline at high temperature is of another kind, which does not evaporate so easily, and thus can be run at higher temperatures. Therefore, if a shell of carbon from hydrocarbon vapour is deposited upon the carbon filament produced from fibre, it can be run at higher temperature with equal falling off in light and blackening of globe, but we will get a higher efficiency.

About 10 or 12 years ago another useful modification of carbon was found, represented by the so-called metallised carbon filament, which to some extent possesses the strength and resiliency of a hard-drawn metallic wire, and evaporates still less rapidly than the earlier carbon.

But the temperature of the metallised carbon lamp is still a long way below the temperature of boiling. We can produce light by running the temperature of carbon up to the limit, that is, to the boiling point, nearly 4,000°C. We cannot do it with a filament, however, but must use the arc lamp, in which the current passes through hot vapour in the space between two slightly separated carbon rods and raises the tip of the positive carbon to the boiling point. The light emitted has the efficiency that would be obtained at about 4,000 deg.; all the evaporation takes place at the positive carbon, and probably 8 or 10 per cent. of all the vibrations radiated are visible. Thus the arc lamp would give a very high efficiency were it not that an excessive amount of heat energy is conducted off by the carbon rods and carried away by the air.

The problem thus became one of finding something that can stand higher temperatures than carbon under all practical requirements. Tantalum, osmium and tungsten are all metals of extremely high melting points, but they have a characteristic advantage over carbon in that their rate of evaporation is much less at high temperatures. Tungsten, unlike carbon, can be run up high in the temperature scale nearly to the melting point with very little evaporation. So you see that the melting point, or boiling point, and the evaporating point have no necessarily fixed relation for different substances. Benzine and water, for example, boil at about the same temperature, but a plateful of benzine will evaporate long before a plateful of water. If carbon and tungsten are kept at the same high temperature, the carbon will evaporate rapidly, while evaporation from the tungsten will be very much slower. Therefore we can run tungsten at much higher temperature than carbon with the same evaporation, although really the tungsten would melt before the carbon.

In respect of the three metals mentioned, osmium proved very good as the illuminant in a lamp, but is too rare to be generally used. Tantalum gave good results, having a higher resistance than carbon, but has been superseded by tungsten because the melting point of the latter is much higher, and it can thus be run at a higher temperature, and it is now used in all lamps having metallic filaments. The so-called "Mazda" is a tungsten lamp. Since the tungsten lamp can be operated at a much higher temperature than any carbon lamp, a greater percentage of all the vibrations produced come within the visible three-quarter octave.

Two per cent. is, however, very little. Most of the vibrations are still outside the visible range, either too slow or too fast. So the further problems has been somehow to get a still higher operating temperature. In the carbon and tungsten lamps a vacuum has been used. Naturally, the lamp having a carbon filament must at least be exhausted of air to prevent its combustion, but that is not the fundamental reason for the vacuum, because the lamp-bulb might be filled with a gas in which carbon will not burn, such as nitrogen, hydrogen, or argon. But to maintain the carbon filament in such a gas at the temperature it would have in a vacuum would require much more energy. By conduction and convection the gas will carry away a very large part of the energy supplied to the filament, which will be given up to the glass globe and dissipated uselessly, and therefore a much greater energy consumption is required if the filament is to be maintained at the proper temperature. Without the extra supply of energy the filament would not attain a light-giving temperature. So the reason for the vacuum in incandescent lamps has been to avoid the enormous loss of energy through heat conduction and convection were the globe filled with a gas.

The use of a vacuum, however, is disadvantageous, because it facilitates evaporation, and thus sets a lower and less efficient limit to the temperature to which in practice the filament should be raised.

Now, suppose that instead of having a vacuum in a 100-watt tungsten lamp it is filled with inert gas, say, nitrogen at atmospheric pressure. To maintain the filament at the same temperature as before will require more energy, because much of the heat is carried away by the gas, the pressure of which, however, will cause the evaporation to be much less, therefore the filament can be raised to a still higher temperature with an evaporation no greater than with a vacuum. The pressure has raised the boiling point and reduced the evaporation rate for equal temperatures.

Assume the evaporation in a vacuum to be such as to limit the life of the lamp to 1,000 hours at the temperature produced by 100 watts, then, with nitrogen at atmospheric pressure we could use, say, 200 watts with the same rate of evaporation and blackening. But this would raise the temperature, so that while 100 watts will give 200 candles, 200 watts would give 600 candles, were it not that the nitrogen carries a lot of heat away from the filament. Consequently an additional 100 watts must be supplied to make up for this loss and raise the temperature sufficiently to give the 600 candles. In this way the candle-power of the lamp has been increased from 200 candles with an expenditure of 100 watts to 600 candles for 300 watts with the same evaporation, blackening and life, which means an increase in efficiency over the vacuum lamp from 1 candle per watt to 2 candles per watt.

Now, suppose we take another lamp, say one requiring 20 watts with a vacuum. If filled with nitrogen, the temperature could be raised, probably not so high as to get six times as much light, because a 20-watt filament is so thin that the evaporation, even at the lesser rate due to the pressure, would wear it away too fast. Furthermore, the percentage of energy lost through the gas is very much greater, because the surface of a thin filament in contact with the gas is much larger compared with its volume than in the large filaments of lamps of high candle-power. Whether the loss of energy due to the gas will be more or less than the gain made by the higher temperature and higher efficiency depends upon the relation of surface to bulk of the filament. With a filament in the form of a closely-wound helix, where there is a relatively small surface to carry away heat, the gain may be considerable. But with a straight filament of exceedingly small wire there may be only an insignificant gain, and even a loss. In the big units of 300 or 500 watts, very much more is gained than lost by using the gas. The gas-filled lamp represents a compromise based on allowing a big loss by heat conduction and convection by the gas, which is more than compensated by the higher temperature permissible.

While large lamps may be filled with nitrogen, in the smaller type of gas-filled lamps, say, 100-watt lamps, in which nitrogen would result in no appreciable gain, it pays to use argon.

In the gas-filled tungsten lamp, the efficiency is raised from the 5 watts per candle of the early carbon filament lamp of Edison to 2 candles per watt, an increase in the ratio of 10 to 1, due to the gas pressure keeping down the rate of evaporation and permitting a higher operating temperature.

True selective radiation was found out some years ago by Auer von Welsbach and utilised by him in greatly improving gas lighting. In investigating various elements he discovered that the rare oxides of some metals, as thorium and cerium, when heated to incandescence, give out much more light than materials in general, say, for example, carbon or platinum, at the same temperature. Thus these materials have the curious property at flame temperatures of producing an abnormal number of vibrations of high frequencies falling within the visible three-quarter octave. Such oxides are in practice formed into a mantle, which is heated by a Bunsen flame, resulting in an increase of lighting efficiency much greater than is obtainable directly from gas. The high efficiency cannot be due to the temperature, because the temperature of a gas-mantle is relatively low.

The question arises, is it possible to gain the same advantage for the incandescent lamp that has been obtained in gas lighting from the Welsbach mantle by using such a selective material for the filament?

Now, in the Nernst lamp the temperature is much higher than the gas flame, so that we obtain, say, 20 times as much light as from the gas flame. And since the mantle gives 10 times as much light as the gas flame and the Nernst filament gives 20 times as much light as the gas, the increase in efficiency of the Nernst lamp, partly due to selective radiation and partly to the higher temperature, is only 50 per cent. So the Nernst filament is more efficient than the carbon filament at the same temperature, but the increase is very small compared to the increase in the Welsbach mantle. The percentage of light added by luminescence in the Nernst filament is probably the same as that in the mantle, but the filament itself gives so much more light, due to the higher temperature alone, that eventually very little is gained.

Let us see which of the gases and vapours give a large percentage of visible rays. Atoms of the same material, for instance mercury vapour, will give the same vibrations regardless of whether the temperature is high or low. With higher temperature the intensity will increase, but the frequency remains the same, just as with the

violin string the note is the same whether the string is bowed heavily or lightly, only in the former case the intensity or volume of sound will be greater than in the latter, it will be louder. So with atoms of vapour; whether they be highly heated or not, whether a large or a small current is sent through them, they still keep the same frequency of vibrations, only more or less intense, and thus giving more or less light, although there will also be other vibrations too fast or too slow to come within the visible range.

In order to secure efficient lighting in this way, that is, by luminescence, we should select those chemical elements that happen to have a considerable percentage of their natural vibrations in the visible range. There are practically three of them: mercury, calcium and titanium. In mercury vapour the green colours predominate, in calcium the orange and red, and in titanium vapour the atomic vibrations have frequencies fairly well distributed over the whole visible range. With any one of them, under favourable conditions, as much as 20 per cent. of the total radiation comes within the visible range, the three-quarter octave, which is several times more than can possibly be obtained from an incandescent body at any temperature, even at the temperature of the sun. There is, therefore, a possibility in this direction of an efficiency in lighting materially higher than is possible with incandescence.

This brings us to the final consideration of the question: What improvements are possible? Take the gas-filled "Mazda" lamp with which 2 candles per watt are obtained. Possibly the economy may be increased by going to a still higher temperature, close to the melting point of tungsten, and there is still quite a latitude permissible in this direction. It would mean higher gas pressure to keep the evaporation down, and a transparent globe of different composition than at present used, because the gas would be very much hotter. Then the loss from heat conduction and convection under the greater gas pressure would be much increased. A better gas for the purpose than nitrogen might be used, perhaps argon. Possibly an improvement up to 3 candles per watt could be obtained, but the prospect of any substantial gain is limited.

Another question is: Can we find a material, a metal, having a higher melting point than tungsten? Doubtless, it must be an element, because for chemical reasons the melting point of any compound of two materials must lie somewhere between that of either of the materials entering into it. For example, all tungsten compounds have lower melting points than tungsten itself, all carbon compounds have lower melting points than carbon, and so on.

In conclusion, we may hope to increase the efficiency from 2 candles, to 3 or 4 candles per watt by incandescence. In the case of the luminous spectrum produced by an electric current flowing through a gas or vapour there is no theoretical limitation because definite rates of vibration result. With the most efficient vapours, those of mercury, calcium or titanium, we can probably get something like 8 to 10 candles per watt under favourable conditions, an efficiency much higher than can ever properly be expected from incandescent radiation, but this is under the most favourable laboratory conditions, not as yet at all attainable in any arc lamp in commercial practice. It shows, however—and now we are considering theoretical possibilities—that within the range of luminescent lighting, exemplified in the vacuum tube, and in the luminous arc and flaming arc, there is no theoretical limitation of efficiency, while in incandescent lighting there is a limitation set by the unavoidable production of all kinds of vibration, of which the useful embrace only three-quarters of an octave. By luminescence we may, as already stated, probably attain an efficiency of 8 candles per watt, but should some new way of producing luminescence be discovered by which all the vibrations would have a frequency, say, between four and six hundred millions of millions of cycles per second, about 50 candles per watt would be obtained. This can be done, because the firefly does it, but we do not yet know how he does it.

DESIGN OF MILLION-VOLT EXPERIMENTAL TRANSFORMER.*

BY G. L. BAYLEY.

The 1,000-k.v.a. high tension transformer installed at the Panama Pacific International Exposition for use in connection with high tension experimental work is of interest to engineers on account of the originality shown in its design and construction and its remarkable performance under abuse. As shown in the accompanying illustrations, the transformer is of the core-type with all of the coils mounted on one leg of the rectangular-shaped core. The core is 16 in. by 16 in. in section, and the opening has a clear length of 7 ft. with a clear height of 40 in. The weight of the transformer, which is 32,000 lb., is carried by the bottom horizontal member of the core.

* From the "Electrical World," slightly abbreviated.

Construction and Arrangement of Windings.—The most radical departure from standard practice is found in the construction and arrangement of the windings. All coils are circular in shape and machine-wound with flat conductors which are separated by paper insulation. Each low-tension coil consists of 44 turns of 0·281-in. by 0·020-in. copper ribbon with two layers of 0·006-in. paper between conductors. The high-tension coils, with the exception of the graded end coils, are each made up of 212 turns of 0·135-in. by 0·008-in. aluminium foil with three layers of 0·006-in. paper between turns. The paper used is slightly wider than the conductor, and great skill has been shown in the construction of the coils.



FIG. 1.—VIEW DURING ERECTION SHOWING LOW-TENSION COILS IN PLACE.

The low-tension coils, of which there are 122, are spaced ¾ in. apart and form, when assembled, a unit 67 in. long, 23 in. inside diameter, and 28 in. outside diameter. Each coil is wound for 1,150 volts, and two coils in series form a group, of which there are 61 connected up in parallel to copper 'bus bars. The claim is made that the use of the series-parallel system of connections results in a uniform distribution of voltages among the high-tension coils. One of the 'bus bars is grounded to the frame and earth, thus interposing a ground shield between the primary and secondary windings which effectually prevents any static disturbance from reaching the low-tension windings.



FIG. 2.—VIEW SHOWING HIGH-TENSION COILS AND PAPER INSULATING TUBE.

The 190 high tension coils are connected in series by a top-bottom connection method in order to distribute uniformly the stress between coils. The spacing between coils is 7 32 in., and when the coils are assembled they form a tube 71 in. long, 43 in. inside diameter and 51 in. outside diameter. One terminal of the high-tension winding is grounded to the frame and earth, while the other is protected against dielectric rupture of oil and adjacent insulating materials by having placed about it a generously proportioned electrostatic guard-ring or shield.

The general assembly of the transformer is shown in Fig. 3. The low-tension windings were slipped over the top yoke of the magnetic circuit and separated from the high-tension coils by means of a paper tube of unusual proportions. This tube is 92 in. in length, 6 in. thick, 42 in. outside diameter, and weighs approximately 2,000 lb. Special interest attaches to this tube as the impregnating and winding were done in a large steel-plate cylinder under a high vacuum. All of the mechanism for winding was installed in this cylinder, and glass openings were provided for observing the process.

Oil Insulation Arrangements.—The transformer was installed in an open-type concrete tank or pit lined with galvanised iron. The depth of oil over the electrostatic shield was 6 in., and 225 barrels of oil were required. The surface of oil in the tank had an exposure of 288 sq. ft., and some fear was felt that there would be considerable absorption of moisture from the air. Contrary to expectations, the dielectric strength of the oil improved after the transformer had been operated for a short period. Before use, the oil tested from 18,000 volts to 20,000 volts with a gap of 0·2 in. between 0·5-in. diameter spheres, but under the electrostatic stress accompanying operation the dielectric strength rapidly rose until on test the oil stood a voltage of 40,000, at which value it remained throughout the period of operation.

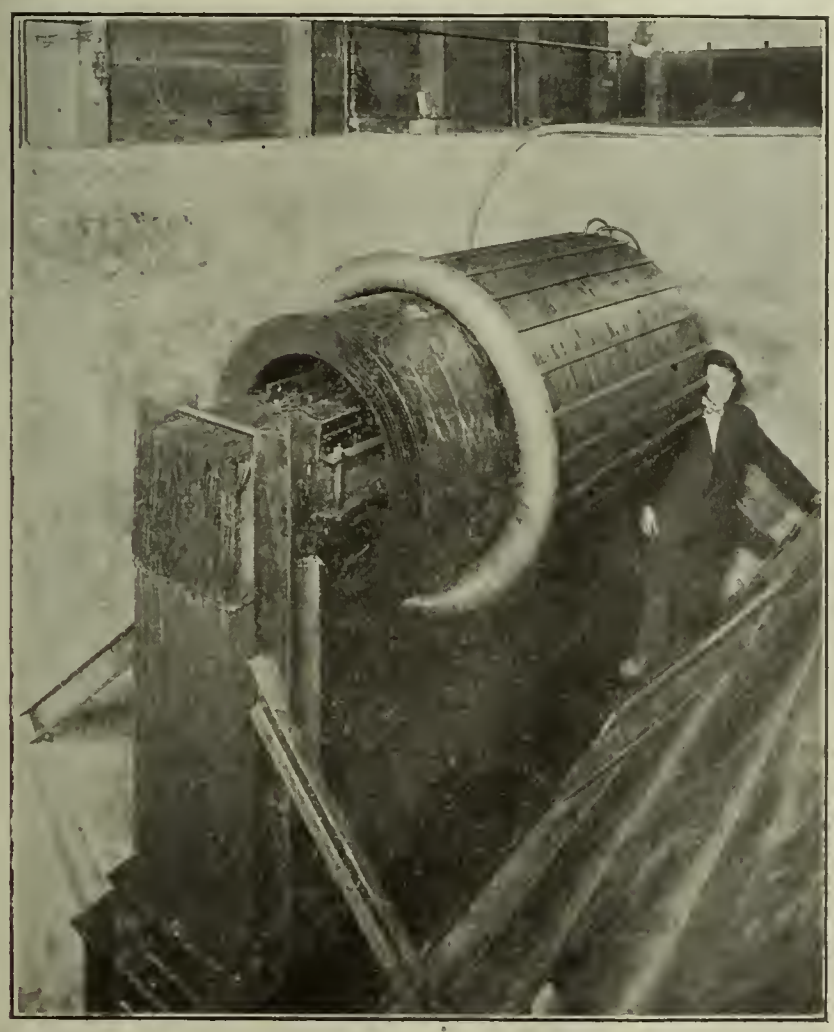


Fig. 3.—View of Complete Transformer showing Shield-ring and Paper Insulating Tube.

The high-tension lead was brought out vertically through the oil to a clear height of 11 ft. and there connected by means of a horizontal lead 100 ft. in length to an aerial-screen or network of wires supported 25 ft. above the ground and exposing an area 50 ft. by 50 ft. to the earth. An adjustable horn-gap discharge to earth was installed in the main lead to the screen, connection to the ground being made through a water jet. The network and conductors were supported and insulated by tarred ropes, electrostatic shields being placed at the points where connections were made between the ropes and the conductors.

Severe Conditions Imposed on the Unit.

The conditions were ideal for high-frequency oscillations, the system being nothing more or less than a wireless oscillation circuit on a large scale. With about 450,000 volts, and the horn-gap discharging, standing electrical waves were established throughout the system, which were made evident to the eye by a corona glow having well-defined nodes and loops spaced about 8 ft. apart. Each loop of visual corona was about 10 in. in diameter, which phenomenon, with due regard to the distances from surrounding objects, indicates that standing waves having potentials of 2,000,000 volts must have existed. This extreme punishment severely strained the insulation, and as a consequence, at a later time, when the same circuit conditions obtained with higher voltages, 120 insulating spacers were broken down. Under normal conditions these spacers would be required to stand only 5,000 volts, but on subsequent test they stood 40,000 volts each, thus indicating that the stress between coils at breakdown was eight times the normal. In spite of the loss of these spacers, others were quickly substituted, and in little more than a day's time the transformer was operating again. The ease and speed with which the repairs were made illustrate the great advantage of an open type of construction, as without doubt any transformer having taped coils could not have undergone similar punishment and been repaired in such a short time.

Another advantage in this type of construction was that the conductors were all exposed to the oil and the heat generated in the windings was rapidly transferred to the oil. The arrangement of the coils was such that a rapid circulation of the oil is possible, and under test it was found that the difference in temperature between the windings and the oil at full load was about 3°F., which difference did not appear to increase materially at overloads, owing doubtless to the increased circulation of the oil at the higher temperatures. The transfer of heat to the oil and the circulation of oil around the coils was so perfect that the danger of over-heating was eliminated with satisfactory means for cooling the oil.

With a supply voltage of 500,000 to the wire screen the electrostatic field beneath and adjacent thereto was so strong that a vacuum-tube held within the field would glow and sparks could be drawn from metal bodies, which were insulated from the ground. When an arcing ground was established at the horn-gap, the electrostatic field was so intense, owing to surges, as to cause an involuntary bending of knees on the part of those standing in the vicinity of the screen. At night, the corona effects were most impressive, particularly in the transformer house, where the conductors and basket screen were aglow. The ozone from the discharge was quite noticeable.

In attempting to bring this transformer up to its rated voltage of 1,000,000 it was found that at 600,000 volts the oscillations or surges, probably resulting from the corona discharge and heavy leading current, caused short-circuiting between coils and from coils to the grounded lining of the tank. At such times the arcing around the high-tension coils gave the transformer the appearance of an electric furnace working under oil, and the ability of the coils to withstand such treatment without breakdown was one of the most impressive features of the trials. For charging the aerial lines and screens, which were composed of several hundred feet of wire, about 400 k.v.a. was needed when the voltage was around 500,000. The transformer was made at the personal expense of Mr. C. H. Thordarson, and valuable assistance was rendered by Prof. H. F. Fischer in making tests and overcoming many of the difficulties encountered. Unfortunately, the installation was completed at so late a date that it was impossible to carry out the experimental work planned. The transformer, however, is to be erected in Mr. Thordarson's laboratory in Chicago, and no doubt technical data of value will result from his experiments.

TRANSFORMER DESIGN.

BY F. M. DENTON, A.C.G.I.

Summary.—A general discussion is given of the nature of the problem of transformer design, and the author sets out Arnold's method of design for constant potential transformers. He then deals with the conditions ensuring maximum electrical and commercial efficiencies, and discusses the advisability of designing power transformers for minimum cost. A rule is developed by the aid of which designs of power transformers may be based upon commercial efficiency rather than upon minimum cost. The author then gives an outline of the method of design proposed by Arnold in 1910 and a comparison of Arnold's later and earlier methods. Comparative designs are worked out and a schedule is given, based upon Arnold's method of 1904.

To a student the subject of engineering design is usually disappointing. When he looks forward, say, to the design of transformers, having already obtained a knowledge of the theory of the apparatus, its characteristics and its materials of construction, and having become accustomed to definite mathematical reasoning in which the road from data to result is fixed and unchangeable, he feels that to design a transformer will be possibly a difficult but surely a definite process in which, unless he fall into culpable error, he will work direct from the data to the definite result—the one and only correct design. It pains him to discover that his first design comes out all at variance with the specification, and that he has to hammer it

into shape by much trial and error, and it surprises him to discover that other designs which look very different from his own are equally in accord with the specification.

The nature of the problem of transformer design may be considered step by step.

The specification usually gives KVA capacity, frequency, voltage, efficiency and regulation, whilst sometimes the no-load current is specified, and always, of course, the cost must fall within fairly narrow limits.

If the specification involved nothing except, say, the voltage, an unlimited number of designs would be possible, for the only condition would be that the ratio of the turns should be correct. The weight of copper and the weight and dimensions of the iron might have almost any values.

The specification of current as well as voltage would only make the design more definite in setting a limiting minimum to the section of the copper, since obviously the copper would have to be so thick as not to be damaged by the heat produced in it. Such a transformer would, within ordinary limits, be suitable for any frequency.

The efficiency condition, although it would sweep away the majority of the possible designs just spoken of, yet would leave a wide choice. Unless the relation of copper loss to iron loss were fixed there would still be numerous alternative designs available; some would have much copper and little iron, others much iron and little copper.

The fixing of the regulation would not greatly limit the number of possible designs, since the regulation might be varied between wide limits by simply changing the shape or the relative disposition of the primary and secondary coils, without altering the other factors.

If the magnetising current were also fixed, a few of the otherwise possible designs would be eliminated, but since a slight change in the section of the iron (producing a corresponding change in the flux density) might greatly affect the reluctance of the magnetic circuit, and therefore the magnitude of the magnetising current, with but little effect upon the efficiency or the regulation, it follows that many alternative designs would still be available.

The remaining condition—cost—might be satisfied by a multitude of different designs. From among those electrically available it might be possible, for instance, to choose two of equal cost, one of which, though much heavier than the other, would be much easier to assemble and therefore more economical of labour.

The line of thought just outlined is intended to show that, no matter how logical may be the method of design, there is always much left to the choice or even to the mere fancy of the designer. There are many variables whose exact value has out little effect upon the specified characteristics of the apparatus, and there are many different designs which will satisfy the same specification.

It is on account of this unavoidable latitude in design that such a variety of methods are in use. Since for many of the quantities involved a number of alternative values are available, all leading to good results, it is usual to assume for such quantities trial values such as have proved satisfactory in apparatus already designed. To some extent then every practicable method of design becomes a method of trial and error.

Some designers go to the extreme of basing a design solely upon trial. Such crude methods, if coupled with patience and perseverance, lead to successful results, and they are popular. This is unfortunate, for such methods tend to retard progress. Improvement seldom follows, except from intelligent understanding, and this comes only from thought. The method of trial and error is essentially lavish of labour and sparing of thought. It is the method of the untrained savage, and in matters of daily life the favourite method of us all. We respect its usefulness, but at the same time feel pride and pleasure in producing its converse—the method which derives the perfect design by a logical process based upon first principles.

In transformer design trial methods are especially successful, because whilst there is difficulty in predetermining the dimensions which shall produce a desired result there is none in predetermining with fair accuracy the results which will follow from given trial dimensions. In fact, if a man had sufficient patience and a little common sense he might design a transformer solely by trial and error, using no more elaborate basis for his first trial design than, say, a random sketch.

Methods of Transformer Design.—If the core of a transformer is traversed by an alternating flux of maximum value Φ, the change of flux during one-half wave is from zero to Φ, and again from Φ to zero, a total change of 2Φ, the average rate of change being 2Φ divided by $1/2f$ where f stands for the cycles per second. It follows then that the average voltage induced in each turn of both primary and secondary windings is $(4f\Phi\times10^{-8})$ volts, and that the root-mean-square EMF induced in t turns is

$$E=4f\Phi t\times10^{-8}\times k,$$

where k stands for the ratio of the root-mean-square ordinate to the average ordinate of the flux wave.

If I_2 be the secondary current output of the transformer, the volt-ampere capacity will be

$$VA=E_2I_2=4kf(t_2\Phi)I_2 10^{-8}.$$

This statement is the basis of all transformer design. The difference between the various methods of design lies often in the way in which the individual factors Φ and t of the product

$$\Phi t=(VA/4kfI10^{-8})$$

are determined, and it is obvious that transformers all for the same KVA rating will be widely different in general proportions according to the relative values that have been chosen for Φ and t. A design in which Φ is relatively great and t small, will usually have a relatively high proportion of iron to copper and vice versa.

One method which finds much favour is that which starts with an expression for the weight of the iron in terms of the KVA capacity, the frequency and the method of cooling. The weight of the iron having thus been chosen, trial dimensions are taken for the core and a value is assumed for the flux density. This method is brief and straightforward, and when used in conjunction with good tables of heat emissivity ensures satisfactory conditions both of temperature rise and of iron loss. It is here being classed among the "trial and error" methods, but in the important matter of temperature rise it is superior to the method of Arnold, which will shortly be discussed, as typical of the theoretically more logical methods.

Perhaps the most usual method of all is that which assumes, at the outset, a value for the "volts per turn" of the transformer. From this assumed value the number of turns and the ampere-turns follow at once. Then the value of the flux is got from the E.M.F. equation. Values for flux density and of current density having been assumed a trial value is deduced for the cross section of the core. Assumption of the depth of winding and the space factor leads to the dimensions of the window, and thus the preliminary design is ready to be checked for losses, regulation and temperature rise.

In this method the KVA capacity is generally considered as a plausible criterion for the choice of "volts per turn." Perhaps the best of the volts per turn equations is that which states

Volts per turn = a constant $\times\sqrt{}$ (the volt-ampere capacity of the transformer).

From the E.M.F. equation

$$E=4{\cdot}44\Phi f10^{-8}$$

we have

$$\text{Volts per turn}=4{\cdot}44\Phi f10^{-8},$$

and

$$\Phi=\frac{E}{4{\cdot}44ft10^{-8}},$$

or

$$\Phi^2=\frac{E\Phi}{4{\cdot}44ft10^{-8}}=\frac{EI}{I}\cdot\frac{\Phi}{4{\cdot}44ft10^{-8}},$$

whence

$$\Phi=\sqrt{\left(\frac{\text{volt amperes}}{It}\cdot\frac{\Phi}{4{\cdot}44f10^{-8}}\right)}.$$

and the expression for the volts per turn becomes,

$$4{\cdot}44f10^{-8}\sqrt{\left(\frac{\text{volt amperes}\times\frac{\Phi}{It}}{4{\cdot}44f10^{-8}}\right)},$$

i.e., volts per turn $=\sqrt{(\text{volt-amperes})}\times\sqrt{\left(4{\cdot}44\frac{\Phi f}{It}10^{-8}\right)}$.

Thus it is seen that the statement volts per turn $\propto\sqrt{VA}$ implies that $(\Phi f/It)$ is constant, or that Φ/It, the flux per ampere-turn, is inversely proportional to the frequency. Now the flux per ampere-turn will be great when the cross section of the core is great, and so the transformer in which Φ/It is great will be heavy for its output. But from the E.M.F. equation it is seen that for a given voltage and number of turns Φ is inversely proportional to the frequency, and that therefore the weight of iron in a transformer of given capacity and voltage is likely to be inversely as the frequency. The statement $(\Phi/It)\propto(1/f)$ is thus seen to be not unreasonable.

Not all those designers, however, who use the volts per turn basis follow even approximately the condition just named that volts per turn shall be proportional to the square root of the volt-amperes capacity of the transformer. Reference, for instance, to Hobart's "Design of Static Transformers" shows the following values of volts per turn and KVA:—

25 ∼	V/t	1·4	1·8	2	2·2	2·4			
	KVA	10	30	60	70	100			
50 ∼	V/t	1·5	1·85	2	2·25	2·4			
	KVA	10	30	45	70	95			
	V/t	13	18	24	30	35	40	52	65
	KVA	500	1000	1500	2000	2500	3000	4000	5000

giving for the constant named in the above equation the following values:—

KVA	10	30	60	70	100			
$\frac{\sqrt{(VA)}}{V/t}$	71·5	95	122	120	132			
KVA	10	30	45	70	95			
$\frac{\sqrt{(VA)}}{V/t}$	66·7	92	106	118	128			
KVA	500	1000	1500	2000	2500	3000	4000	5000
$\frac{\sqrt{(VA)}}{V/t}$	54·5	55·6	51·4	47·3	45·2	43·5	38·5	34·5

the constant varying from 34·5 to 132. The logic underlying this wide variation is not apparent; yet all the designs here given by Hobart are such as have proved successful in actual practice.

Amongst trial and error methods is also that of Prof. Fleming, given in his classic book on transformers. Here the copper loss and the current density are assumed, and from them the total length of copper wire is calculated. A trial value is taken for the flux density, and the cross section of the core and the size of window readily follow. By this method several trials will usually be needed in order to find designs giving suitable iron loss, weight of iron and total cost.

The methods above outlined are typical of the trial and error methods. A more detailed outline will now be given of Arnold's method, which may be taken as representative of the few really practicable methods which are to be found amongst those claiming to be theoretically logical. Attempts have been made to treat transformer design as a mathematical problem for which an absolutely general solution may be found. Of these attempts perhaps the best known and most successful is that of Bohle and Robertson, given in their book on "Transformers." Methods of this sort do not, however, find favour with the practical designer. The man of the mathematical method finds that the cross section of a really well-designed transformer should be like that of an apple, and he thinks it an annoying and entirely accidental circumstance that engineering methods demand a rectangular section; they do, however, demand it, and the mathematical method, soul-satisfying though it is, has to accommodate itself to practical demands and becomes just as mundane as, and a good deal longer than, the ordinary methods.

Arnold's Method of Transformer Design.—(*See* E. Arnold's "Die Wechselstromtechnik," Vol. II., 1904 edition.) Though taken as typical of the logical methods the method of Arnold involves, as no doubt all really practicable methods must, a certain amount of trial and error.

In this method distinction is made between lighting transformers and power transformers. The former are for more or less intermittent loads, in which a long period of full load is followed by a considerable period in which, whilst the load is negligible and consequently the copper loss small, the iron loss has still the same value as for full load. For such transformers the best average electrical efficiency is obtained by so designing the transformer that the iron loss is smaller than the copper loss. By power transformer is understood one which, when not on full load, will be entirely disconnected from both the load and the source of supply. For the best average electrical efficiency it must be designed so that the constant losses are equal to the variable losses. The condition of highest electrical efficiency for a power transformer would be satisfied by making the iron loss equal to the copper loss since the former is about constant and the latter variable.

First will be given that part of Arnold's method which applies equally to both lighting and power transformers. It is intended that most of the symbols used shall be self-explanatory.

The E.M.F. equation, common to all transformers, reads

$$E=4{\cdot}44ft\Phi10^{-8},$$

and if "m" be the number of phases for which the transformer is to be built we have also

$$mEI=4{\cdot}44mftI\Phi10^{-8}.$$

Let the ratio Φ/It, the flux per ampere-turn be called "C." It readily follows that

$$KVA=4{\cdot}44fm(\Phi^2/C)10^{-11},$$

whence $$\Phi=\sqrt{\left(\frac{KVAC10^{11}}{4{\cdot}44fm}\right)}=10^6\sqrt{\left(\frac{KVAC}{44{\cdot}4fm}\right)}.$$

The quantity C must now be expressed in terms of the densities of flux and of current, and the weight of iron and of copper. Let $E_i=(G_i/KVA)$ be the kilogrammes of iron per KVA, and let "Q" be the iron cross section in square centimetres, corresponding expressions for the copper being $K_u=(G_k/KVA)$, and "q" the copper cross section in square *millimetres*.

Let $L_i\times m$ be the total length of a mean line of force in the core, in centimetres, and L_k the mean length of a turn of the copper (the average of primary and secondary). Then we have

$$\Phi=BQ=\frac{BE_i}{7{\cdot}8}\frac{KVA}{L_im}10^{-3},$$

and $$K_u\times KVA=2mtqL_k\times8{\cdot}9\times10^{-5}(I^2sq),$$

"s" being the current density in amperes per square millimetre. Then,

$$It=\frac{K_uKVAs}{2\times8{\cdot}9L_km}10^5,$$

and finally, $$C=2{\cdot}28\frac{L_k}{L_i}\frac{E_i}{K_u}\frac{B}{100s}$$

The correctness of form of this equation is almost obvious for $C=\Phi/It$ and Φ is equal to QB, which is proportional to E_iBL_i, whilst $IT\propto qst$ and qt is proportional to K_uL_k, whence Φ/It is proportional to E_iB/L_i divided by K_usL_k, that is, to L_kE_iB/L_iK_us.

It follows also from the equations just given that $CBsK_uE_iKVA/L_kL_i$ is a numerical constant.

Power Transformers.—The reasoning now to be introduced is applicable only to power transformers. The specification for a power transformer always includes: The KVA capacity, the primary and secondary voltages, and the frequency. For such transformers *the condition for minimum cost*, as given by Arnold in his 1904 edition, is that E_i/K_u shall be equal to $£_k/£_i$, where $£_k$ and $£_i$ signify respectively the costs per kilogramme of copper and iron (including insulation and all labour for the finished transformer). Thus for a given line of power transformers the ratio of the weights and therefore of the volumes of iron and copper should be constant. And

from this it follows, if the transformers are of similar type and pattern, that the ratio of the mean length of the magnetic circuit should bear an approximately constant relation to the mean length of a turn. Thus in applying the equation $C=2{\cdot}28L_kE_iB/L_iK_u100s$ to power transformers L_k/L_i may be combined with the constants 2·28 and 100, and the equation written $C=(1/\gamma)(E_iB/K_us)$, in which γ is a constant depending upon the type of the transformer. Comparison of the two expressions for C shows that $\gamma=44\frac{L_i}{L_k}$. The element of trial and error introduced by the choosing of a value for γ is unavoidable, and makes the process of design much longer than it otherwise would be. The value first chosen for γ proves seldom to be the value which accords with the first trial dimensions, but it should be remembered that the value $44\frac{L_i}{L_k}$ can readily be changed by changing AS, the ampere-turns per centimetre of height of the core. The volume of the iron of the transformer in cubic centimetres divided by m times the iron cross section in square centimetres, gives L_i in centimetres, whilst L_k is the average of the lengths of a mean turn in the primary and in the secondary. Arnold gives for the constant γ, when ordinary iron is used, values ranging from 100 to 125 for single-phase core-type transformers, and from 60 to 100 for three-phase core-type, whilst 50 is the value assigned to shell-type transformers. For transformers in which alloyed iron is used the values of γ should be much lower. Appended to the schedule of alternative designs, given later, is a table in which the values of γ have been worked out for six of the transformers, built with alloyed iron, of which particulars are given in Arnold's 1910 edition. He gives no proof of the condition for minimum cost stated above, but the matter may be considered thus: The most economical distribution of iron and copper will be that from which slight deviation may be made without effect upon the total cost. That is to say, if the weights of iron and copper have been properly chosen it will be found that to change the weight of the iron by, say, 1 per cent. (making, at the same time, the necessary corresponding change in the copper) will produce no change in the total cost. Now if the section of iron and so also its weight were reduced by 1 per cent. the flux would be similarly reduced (in order that B might remain unchanged), and the turns would, therefore, have to be increased by 1 per cent. (since the E.M.F. must remain unchanged) with a similar increase in the weight of copper. The condition that this decrease of 1 per cent. in the weight of the iron and increase of 1 per cent. in that of the copper shall produce no change in the total cost is obviously that 1 per cent. of the total weight of iron shall be worth as much as 1 per cent. of the total weight of the copper, or that

(Cost of iron/cost of copper) = (weight of copper/weight of iron),

and therefore that $E_i/K_u = E_k/E_i$.

Trial values for B and s must now be chosen; suitable values lie usually between the limits,

for B_{max} 8,000 to 13,000 lines per square centimetre for ordinary iron, or 10,000 to 14,200 for alloyed iron,

for s 1·2 to 1·8 amperes per square millimetre, or in cases of specially well-cooled designs s may be taken as high as 2·5 amperes per square millimetre.

The factor determining the limits allowable for B and s is temperature rise. For each value of B there is, for every lamination thickness and frequency, a definite figure for the watts iron loss per kilogramme of iron depending upon the quality of the iron. Similarly for each value of s there is a definite figure for the watts copper loss per kilogramme of copper. Both losses appear, of course, in the form of heat, and this heat must be carried away at such a rate that the temperature of iron and copper shall be below that at which either the quality of the iron will be affected, the insulation of the copper be burned or the resistance of the windings be greatly increased. Experience has shown that even when using water-cooled transformers the flux and current densities ought not greatly to exceed the limits named above.

Efficiency of cooling depends largely upon the ratio of surface to volume of the hot body, and with bodies of similar shape, such as transformers of similar type, this ratio is greater for the small bodies than for the large. This consideration would lead to the choice of higher values of B and s for the small transformers. In practice, however, the higher values are usually found in the larger designs. The reason for this is that the larger transformers are at such a great disadvantage in point of cooling surface that the method of cooling used for the smaller designs —natural air cooling—is found inadequate for the larger sizes. In other words if the larger sizes had to be designed for natural air cooling it would indeed be necessary to use, for them, lower values of B and s. It is found, however, more economical to provide artificial cooling, by water or by air-blast for the larger designs, and so efficient does the cooling then become that values of B and s may be used exceeding those allowable in the natural draught designs of smaller capacity. Comparative figures for B and s should always take into account the method of cooling employed as well as the capacity of the apparatus.

(To be continued.)

THE USE OF CONTINUOUS CURRENT FOR TERMINAL AND TRUNK LINE ELECTRIFICATION.

The following is an abstract of the discussion of Mr. N. W. Storer's Paper at the Manchester meeting of the Institution of Electrical Engineers on the 21st ult. An abstract of this Paper appeared in our issues of the 17th and 24th ult.

The Chairman (Mr. B. Welbourn) endorsed the plea which the author made for some attempt to be made before too late to secure the standardisation of voltage and collector systems in this country. It was to be hoped that, in connection with railway electrification work, we should not have a repetition of what had happened in the electric supply industry.

Mr. W. A. Barnes, in reference to standardisation, thought the Paper bristled with debatable points, and was, perhaps, a little in advance of time. Its value was not lessened thereby, as it sounded a note of warning against the confusion which would arise from a multiplicity of systems. It was unfortunate for standardisation that direct-current electric traction had progressed from low to high-voltage, and had not yet reached finality. Whilst high-voltage equipment would deal with low voltages, the reverse was not the case, and before standardisation could take place in the principal items connected with electric traction it was necessary to standardise voltage. An important point to be considered was that direct-current traction was competing very strongly with alternating-current traction in the only advantage the latter possessed, namely, high-voltage transmission—and on this account it would not be policy at the present time to standardise, say, 1,200 or even 2,400 volts. The author stated that 1,500 volts was about the maximum voltage which could be used on a four-pole railway motor, whereas on the Holcombe-Brook section of the L. & Y. Railway motors were operating successfully with 1,800 volts across their terminals. Another point against standardisation at the present time was that such a course would tend to stop progress, a parallel case being the standardisation of the 4 ft. 8½ in. gauge for railway tracks, which had seriously hampered the progress of the steam locomotive. This point, however, had not been lost sight of in this country, and the question of location of the third-rail had been brought before a meeting of railway engineers held in the Railway Clearing House, London, as long ago as March, 1903, when it was decided that the most advantageous position for the third rail was such that the contact surface be 3 in. above the track rail, and that the horizontal distance between the centre of the track and the centre of the third-rail be 3 ft. 11½ in. This was adopted for an over-running shoe, and it was thought that 600 volts would not be exceeded for direct-current electric traction. The above recommendation had been adopted by railway companies who electrified since 1903; in fact, the Liverpool Overhead Railway changed over their system from a central third-rail to the standard, which permitted the inter-running of trains with the Liverpool–Southport section of the L. & Y. Railway. During the past two years, however, the direct-current traction motor had been greatly improved, so much so that the 1,200-volt motor was probably more reliable than 600-volt motors of 10 years ago. The 600-volt third-rail was not sufficiently safe and well protected to be used at 1,200 volts, and the problem had been to decide whether to keep to the 600-volt system, with its attendant transmission losses, or to depart from the standard in order that the rail should be thoroughly protected against accidental contact with the staff. The question of overhead construction was not considered owing to the many disadvantages. On the Manchester–Bury section of the L. & Y. Railway, where 1,200 volts was in operation, this had led to the adoption of the side contact rail adequately protected along its entire length, and this progress had nullified the earlier standard set up. This side rail was mounted in the same relative position as the standard, and, apart from the question of protection, could be used with an over-running shoe.

In the section dealing with control the author had shown diagrams of arrangements of gear to operate at various voltages. With the arrangements shown, 56 and 36 switches respectively were required, the greater number of which would have to be designed for the maximum voltage of 2,400. It was undesirable to carry these under the car, and therefore room would have to be found on the car floor. This space, together with that occupied by the equipment for regenerative control and the apparatus mentioned for changing the position of the shoe, would seriously limit the passenger-carrying capacity of the car, and would cost more for maintenance and running charges. It was probable that in trunk line electrification any one railway company would adhere to one system, and only inter-running trains would be affected. The speaker suggested that such trains be ordinary stock worked by electric locomotives which would be changed at the junction of two systems, and where through coaches only were involved, trailer coaches should be used in conjunction with motor coaches in the usual way. The author had pointed out that the unsaturated motor would operate more efficiently than a saturated motor on a frequent stopping service. Whilst this was true, an examination of Fig. 1 showed that the tractive effort for a given current was less, and therefore the acceleration less, a state of affairs which was not desirable for the service in question. If the same acceleration was required with the unsaturated motor it would have to be larger—a difficult matter to arrange in high-pressure cars owing to the limited space available. The choice of motors depended on the relative importance of efficiency of working and efficiency of service.

Mr. FERGUSON thoroughly endorsed the author's view in regard to standardisation, and considered that the first step should be to standardise line voltage. The inter-running of trains over systems employing different voltages had been amply dealt with in the Paper, and the numerous diagrams indicated the complications to be expected, also the relatively large number of switches required. In maintaining equipments of this kind, however, it was well to remember that, so far as the main control was concerned, it was only necessary to deal with a number of similar contactors or reverse-type switches, all of which were fairly well known pieces of apparatus; hence the maintenance was only increased by multiplying the number of similar pieces of apparatus. The case of auxiliaries for high voltages and various voltages was very different, and by far the most difficult part of the problem, necessitating as a rule new types of apparatus, more or less exploited and undeveloped. The author had described an easy way out of the difficulty by using storage batteries connected to the negative side of the circuit, thereby permitting the employment of standard compressor motors and blower motors, as well as standard control voltages. This obviated the difficulties which ensued from the employment of dynamotors, double commutator motors and other such devices. Regarding field control, the author defined very clearly the starting point for such considerations in stating in connection with the shunt motor: "Moreover, no greater speed variation is possible with it than with the series motor, because this depends on the armature and the allowable ratio between the field and armature ampere-turns necessary to secure stability." The field-controlled motor and also the non-saturated field motor was used primarily as a means for reducing the energy consumption in the rheostats. The author went into considerable detail to illustrate how the rheostatic losses increased, and the curve given seemed to follow a square law. The reduction of energy loss in the rheostats could be accomplished either by accelerating on the rheostat with a strong field motor and weakening the field immediately the strong field motor curve was reached, or by designing a motor without field control but with a non-saturated field. In the former case, if the limit defined by the author did not exist, then the obvious thing would be to make a slow-speed motor with a ratio of full field to armature ampere-turns of about 1·1 or 1·2 and then weaken the field considerably so as to obtain the desired schedule speed; by so doing, however, the aforesaid ratio immediately became too small, making the motor very sensitive and liable to flash over. It was necessary, therefore, to decide upon the lowest ratio for safe operation in the weak field condition and then work backwards by strengthening the field as much as possible for the full field curve. Unfortunately, in strengthening the field, saturation was so soon reached that the drop in speed and saving in energy loss was not so great as desired. In the case of a non-saturated field motor there was seldom trouble with regard to minimum ratio of field to armature ampere-turns, as the air-gap was usually fairly long and absorbed considerable ampere-turns. In a motor of this type the best economy was obtained when the accelerating current was made as high as possible, as the speed at which the motor curve was reached came down comparatively quickly as the accelerating current increased. There were, therefore, two effects: (1) Increasing the acceleration and consequently decreasing the time on the rheostat; (2) reaching the motor curve at a lower speed. In the case of equipments having to run at comparatively high speed on the suburban parts of a railway, say 2 to 4 miles between stops, and also on city lines, with only ½ mile stops, the field control was the proper thing; but in deciding such a question for a particular case it was to be remembered that field control required extra switches and extra cables, involving additional capital cost and maintenance, and there were cases where it would be advisable to put the money and material into building a large motor having a non-saturated field. The author had pointed out that a field control motor or non-saturated field motor could not be obtained at the same cost as a standard motor, and the speaker entirely agreed with him in stating "that if these points were thoroughly borne in mind the manufacturers of the non-saturated field motor would not be penalised on account of small ratings, or on account of greater weight with equal ratings, and the railway company would operate with greater efficiency."

Dr. WM. CRAMP said the Paper naturally divided itself into two parts, the first part referring to the suitability of the series motor for railway electrification, especially as regards torque characteristics. There were several points requiring explanation. For instance, emphasis was laid upon what were called saturated and non-saturated fields, and no indication was given as to the point at which the distinction between saturated and non-saturated was drawn. Perhaps Mr. Peck would give some idea of the ratio of field conditions in the two cases. Later the author referred to the "sluggishness" of shunt fields. Did this mean that the field did not respond so quickly to current changes because of the greater self-induction due to the large number of field turns, or was some other meaning attached to the expression? The most important point in this section of the Paper was the plea made by the author for a revised specification for railway motors. It was pointed out that the one-hour rating did not produce that motor which was best suited for railway electrification, and whether the plea for the unsaturated as against the saturated was justified or not, one thing was certain—viz., that a case had been made out against the rating of railway motors on the one-hour basis. It was to be hoped that the Institution of Electrical Engineers or the Engineering Standards Committee would go into the question with the object of sanctioning a more rational basis for specifications. Such a basis had already been suggested by Dr. Pohl in two Papers, "Journal" Inst.E.E., Vol. XLV., 1910, and Vol. XLVIII., 1911, and the test basis laid down there was much fairer than the one-hour rating usually adopted. The author also raised the question of regenerative control, and gave some diagrams, one of which was merely $V^2/2g$ plotted against V, V being the initial velocity of the train in miles per hour. The speaker then discussed some of the curves in the Paper. He thought the second part of the Paper was a most eloquent plea for standardisation, and showed into what confusion railway equipment would be thrown if some control was not quickly exercised. It should be remarked incidentally that the adoption of the single-phase system would obviate many of the difficulties mentioned: in fact, the Paper might be turned into a demand for the single-phase system so long as there was no co-ordination between the railway companies as regards voltage. In the single-phase system only frequency needed to be standardised, and that only within certain limits, which should not be difficult to decide upon. Series-parallel operation of transformer or motor windings would meet all other variations. It was ridiculous to construct trains on such short lengths of line as existed in this country, with so much complicated apparatus to change from one railway company's system to another. If it were necessary to have voltages varying over the range suggested by the Paper, the continuous-current system should not be adopted at all. The only solution seemed to be some form of control which would prevent a company adopting a system different from that adopted by another company without showing good cause for the difference.

Prof. E. W. MARCHANT said, with regard to the difference between saturated and unsaturated motors, it would be of interest to have some idea of the limits of flux-density in the two motors, as it was only a matter of degree of saturation. The saturated motor was obviously a cheaper machine than the unsaturated motor. The author had put forward the series-parallel controller as having been developed mainly on the ground that it enabled speed regulation to be easily effected. One of the main advantages of series-parallel control lay in the greater efficiency on starting. The maximum possible efficiency in starting with series-parallel control and two motors was 67 per cent.—that was to say, 33 per cent. energy was wasted in the rheostat, whereas starting with ordinary rheostatic control the loss was 50 per cent. What was the maximum current obtainable from a trolley? Taking the ordinary limit accepted in this country of from 150 to 200 amperes, it was clear that very high voltage would be required on the trolley-wire in order to obtain the power required to drive a railway train. Regarding the question of the continuous-current voltage possible on a dynamo or motor, Mr. Cattersen-Smith had experimented some four or five years ago, using a motor designed to work under compressed air at 200 lb. per square inch. The armature was designed for 3,000 volts, and he succeeded in getting an output of about 3 kw. from the machine, which was two pole and had a commutator only 4 in. in diameter. The design of the bearings was a most difficult matter on account of the pressure of 200 lb. per square inch on one side and nothing on the other. The experiments were made with a view to use the machine for high-voltage continuous-current traction, but the mechanical difficulties involved were too serious to warrant much hope of final success. Regarding standardisation, Ald. Walker had, at one of the annual dinners, referred to the desirability of standardising electric railway equipment, but a representative of the manufacturers said this would be a mistake as it would stop all progress. This position had been reversed by the author in recommending the standardisation of motors, and undoubtedly it was a great step forward.

Mr. A. P. M. FLEMING asked for an explanation of the expression "less trouble than might be expected" as applied to high-voltage working. He expected a great deal of trouble with these high voltages, particularly in view of the extremely arduous conditions under which railway services operated in regard to moisture, dust and oil. What were the maintenance costs likely to be, using voltages of 3,000 or 5,000? It was also of interest to know whether the mercury vapour control was really successful, also what were the limits of its use and at what voltage it became necessary economically to use such an apparatus. At what voltage was it the practice in the States to use insulated instead of grounded returns?

Mr. C. H. WORDINGHAM was invited by the chairman to address the meeting, and whilst he did not feel in a position to discuss the Paper, he most strongly deprecated the nationalisation of railways. Every

country which had nationalised its railways had done so to its own detriment. Once the feeling of competition was removed, bad as railways might be in certain respects at present, they would be infinitely worse if nationalised, and it might be said without doubt that a Government Department was not in a good position to conduct trading operations successfully or with advantage to the public. Regarding standardisation, it was to be recognised that directly standardisation took place progress was to a certain extent limited. A great deal depended upon the method of standardisation. Taking general standards, such as dealt with by the Engineering Standards Committee, it was essential to confine standardisation chiefly to questions of interchangeability, and not to attempt to standardise design. In connection with railway work a great deal could be done in the way of standardisation, and it paid to standardise details which could be common to various items of plant without tying design too much; but by adopting a rigid standardisation, mechanical or electrical, there was a grave danger of stifling progress.

Mr. J. S. Peck said that, whilst he had read the Paper on behalf of the author, the following remarks should be taken as an expression of his (Mr. Peck's) own opinion. Doubtless the author would desire to reply to the discussion himself. Regarding the remark of Mr. Barnes that it was not advisable to standardise voltage at the present time, the speaker agreed that, at any rate, it was not possible to standardise completely, as by so doing progress might be seriously hampered: but if certain provisional standards were adopted, say, 600, 1,200 and 2,400 volts, it would prevent one railway company from adopting, say, 1,200 volts, and an adjacent company 1,300 volts, 1,500 or other odd voltage, which seemed at the moment to possess some special advantage. Unless some effort was made to standardise, very soon there would be the same multiplicity of voltages that existed in the States, where they had 500, 600, 750, 1,200, 1,500, 2,400, 3,000 and 5,000 volts. In this country we had 600 volts, which was more or less standard for low pressures, also 1,200 and 1,500 volts. Mr. Barnes' suggestion of using electric locomotives operating only on their own system seemed a very important solution of the problem. If the railways were ever amalgamated, one of the first things would be to adopt a standard voltage, which would necessitate scrapping a large amount of expensive equipment. Why should not standard voltages be adopted, as would be the case if all the railways in this country were under one management? Regarding the multiplicity of switches referred to by Mr. Barnes, the author probably used this as a horrible example of what might be required if voltages continued to be multiplied. Regarding the saturation of field and ratio of field to armature ampere-turns, referred to by Dr. Cramp, the speaker could only refer to Mr. Pannell's recent Paper, where the theoretical limit for unsaturated and saturated motors were shown. The question of the shunt motor being more sensitive to fluctuations in line voltage was explained by the self-induction of the shunt motor field, due to many turns of fine wire, being much higher than that of the series motor with a few turns of large wire. If the line voltage went off and was suddenly thrown on again, or whenever there were large fluctuations in line voltage, there was a tendency for very large rushes of current to occur. The field of the shunt motor was sluggish in building up, and the very heavy armature current distorted the field and was apt to produce flashing. Contrary to Dr. Cramp's idea of a figure in the Paper, this seemed a very useful figure, as it indicated perfectly clearly the height to which the track at the station should be elevated in order to pull up the train without braking when running at different speeds. The first curve showed the total storage energy, and there was a certain amount of rotational energy taken into account. The second curve in the Paper was the total available stored energy after deducting the amount remaining at a speed of 10 miles per hour. The third showed the stored energy less the loss due to resistance as the train slowed down. The lowest curve was simply the amount of energy which could be returned to the line, assuming 80 per cent. efficiency in motors. Dr. Marchant asked for the maximum current which could be collected from a trolley-wire. The figure varied a good deal, and was dependent upon the type of trolley and size of wire; but 250 to 200 amperes could be collected without much difficulty even at high speeds. An advertisement some time ago showed a double pentograph trolley which would collect 4,000 amperes at 40 miles per hour. The experiments of running a small 3,000 volt commutator under compressed air were very interesting. In reply to Mr. Fleming, the author probably meant that he expected a certain amount of trouble with the 3,000 volt control equipment, but had had none. The author had written Mr. Peck to say that the only difficulties they had experienced so far were due to earths on the resistance due to running through slush and snow. As to maintenance costs, Mr. Peck did not think there were any figures available at present even on the 2,400 or 3,000 volt equipments. It was difficult to get much information when a new road was first put into service. Regarding mercury vapour converters, the speaker could say very little, although they appeared to be nearly in commercial shape. A certain number of these converters were running in parallel with 600 volt rotary converters for supplying railway lines, but definite information was lacking. Regarding the voltage at which insulated return was used, so far as the speaker was aware, insulated return was only used when there was fear of electrolysis.

BOOKS RECEIVED.

"On the Relation of Imports to Exports," by J. Taylor Peddie. 2nd edition. (London: Longmans, Green & Co.) Pp. xix + 148. 3s. net.

"The Dynamical Theory of Gases," by J. H. Jeans. 2nd edition. (Cambridge: The University Press.) Pp. vi. + 436. 16s. net.

THE ELECTRICITY SUPPLY OF GREAT BRITAIN.*

BY ERNEST T. WILLIAMS.

Summary.—I. Introduction. II. A proposed Electricity Board for the control of the electricity supply of the country and for the co-ordination of the various electrical interests. III. The generating stations problem. IV. The distribution of electrical energy in bulk. V. The distribution of electricity in detail. VI. Procedure to bring the scheme into operation. VII. Summary. VIII. Conclusion.

I. Introduction.

As originally submitted this Paper dealt with three aspects of the subject of "the electricity supply of Great Britain," viz.:—

(*a*) A review of the present state of the electricity supply industry; (*b*) A review of the new conditions brought about by the war and of the urgent need for electrical engineers to work together for meeting the country's need for a cheaper and more extensive electricity supply, and (*c*) a proposed scheme to meet this need.

The Council's decision to hold a general discussion on this important subject made it desirable to reduce considerably the ground covered by the introductory Paper, and for this reason sections (*a*) and (*b*) have been almost entirely deleted.

The progress of the electricity supply industry has been one of fairly well defined stages, viz.:—

(1) Small private plants; (2) larger plants supplying a group of consumers; (3) supply undertakings dealing with very limited areas: (4) town supplies absorbing many of the smaller systems in outside areas; (5) power schemes.

If the policy of centralising the generating plants in larger power stations has been economically sound, even though this involves transformation losses and additional mains, then why should we hesitate in taking the next logical step of considering the eventual replacement of the large number of small, costly, comparatively inefficient electric supply stations by a few modern interconnected power stations for dealing with the electricity supply of the country as a whole?

Such a method of dealing with the problem would result in the following advantages:—

(1) Lower capital costs per unit of output due to ...
- (*a*) Cheap sites.
- (*b*) Reduced expenditure on buildings.
- (*c*) Large generating units.
- (*d*) Decreased percentage of reserve plant.

(2) Lower working costs per unit due to .....
- (*a*) Higher load factor.
- (*b*) Higher plant factor.
- (*c*) Lower fuel costs.
- (*d*) Lower establishment and labour charges.
- (*e*) Lower maintenance costs.

Against this must be set the increased cost of bulk distribution mains and transforming plant and the loss in efficiency due to the transformation.

If we are to attain something of the position clearly possible for the electricity supply industry, it will be by taking Great Britain as a whole and so ordering our development from year to year that by gradual steps the transition from the present conditions to those suggested will be economically brought about.

The area of Great Britain is comparatively small, but no country offers so great promise for a sound and economical electricity supply if taken as a whole.

In considering this problem we may divide it into three main sections, namely, (*a*) Technical considerations; (*b*) financial issues; (*c*) basis of organisation.

After careful consideration and much thought the author has come to the conclusion that the first of these sections offers the least difficulty, and that the second is one in which we can largely be guided by present experience and knowledge. It is the third section, "the basis of organisation," which most urgently demands our attention. The more deeply we consider the subject the more apparent and convincing does it become that it is the fundamental principles of organisation and establishment which must be settled on a sure foundation, if we are to make the best progress and see the consummation of the ideal for which we aim.

It is not assumed that the proposals herein made give the ideal arrangement. We cannot start *de novo* and ignore, even if we wished to do so, what has already been done, the capital invested, the natural prejudices and interests, and the human factor all closely bound up with present achievement. It is only right that we should recognise that the prominent position occupied by the industry and the

* Abstract of a Paper read last night at the opening of the discussion on "The Present Position of Electricity Supply in the United Kingdom" before the Institution of Electrical Engineers.

splendid progress of a few short years have been due to the courage, energy and foresight of those engineers, and others, who have been the pioneers. The honour due to them we fully concede, and the right of vested interests we clearly recognise ; yet while doing this we need not, nay we must not, lose sight of the fact that the electric supply industry is *not* on the most efficient or satisfactory basis and is not playing that fuller beneficial part in the lives of our people that it deserves and that they have the right to expect.

II. The Public Control of Electricity Supply.

The public control of electricity supply is at present vested directly in Parliament, in the Board of Trade, in the Local Government Board and in the Home Office. It is desirable for the highest success of our scheme as a whole that this control shall be co-ordinated by a central body directly responsible to Parliament. It is most desirable that such a body shall not be an existing Government Department having various other interests ; also that it shall not be a Government Department at all in the accepted sense of the word and acting under the multifarious restrictions with which Government Departments are essentially bound. At the same time this central body must have all the weight of Government authority and be able to authorise or raise big loans on Government security at low rates of interest.

It would be desirable that the President of the Board at the outset at any rate, should be a man of wide knowledge and experience in public affairs, and a man whose name carried weight and confidence with the public and men of affairs. Like the other members he should preferably be a paid official and expected to devote most of his time and interests to the work of the Board. Finally, the Board would have its permanent Secretary in whom—under the President—the organisation would be centralised. This is shown diagrammatically in the following diagram :—

Looking into the future, we can see a number of very large power stations, mostly owned by and worked under the Board, supplying into a bulk network spread over the country.

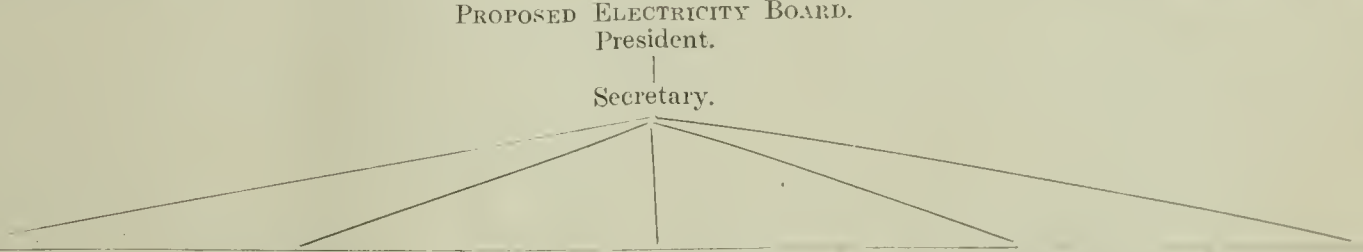
It does not require to be demonstrated that the lower the price at which we can supply electric energy the greater will be the demand, and conversely, the greater the demand the lower the cost at which we can supply. The result is thus cumulative, and it is safe to say that if the cost can be brought low enough the demand will be so great as absolutely to dwarf the present load. The two chief items of generating cost at present are the capital charges and fuel, and it is very evident that under favourable conditions and with a large demand these can be reduced to a small fraction of the present average generation costs throughout the country.

Important as are the capital and working costs per unit, there is a third item which has a direct bearing on these and one which our scheme would take full advantage of ; this is the plant factor and the load factor.

Under the scheme outlined we do not interfere with the present stations and the capital invested in them.

IV. Bulk Distribution.

The third item of electricity supply is the "distribution of electricity in bulk." For convenience of reference we will divide the bulk-supply network into main and subsidiary. The main network should be the property of the Board, which with its powers would have the right to carry its overhead or underground mains through any district. The subsidiary network might belong either to the Board or to existing undertakers according to circumstances. For example, there appears no reason whatever why the power companies and the large municipal undertakings should not themselves supply current in bulk on their own mains, taking the supply from their own power stations, from the Board's bulk network, or from both.



6 Elec. Eng. Managers.	1 Legal Member.	1 Accountant Member.	1 Financial Member.	1 Parliamentary Member.
Responsible for the entire electricity supply in their respective districts whether directly or indirectly under the Board.	Responsible for all legal advice, agreements, arrangements, &c.	Responsible for all accounts under the Board and for auditing the accounts of all offices in the various districts under the electrical engineer managers.	Responsible for advising on the raising and repayment of loans and the work in connection therewith and generally for financial questions coming under the Board.	Responsible for representing the Board in Parliament and for attending Parliamentary Committees and other departments of the Government.

To the Electricity Board proposed in the foregoing clauses all the questions relating to the electricity supply of Great Britain would be referred. It would become the authority—under Act of Parliament—on all the various questions and issues involved in the supply and application of electricity. Matters now dealt with by the Home Office, the Board of Trade, the Local Government Board and by Parliament itself, would be gathered together under its control. The only reservation would be the right of appeal from the Board's decisions to the higher authority of Parliament.

III. Generating Stations.

Never before in the history of our country has it been so evident that we must conserve our capital and resources. Our suggested scheme would, therefore, at the outset interfere with present generating stations to the minimum extent. When, however, stations under municipal control reached the limit of their capacity, or desired to replace their obsolete plant, they would require to obtain the Board's authority for the expenditure.

It would be for consideration whether limited companies should be brought compulsorily under this ruling or not, for they are placed under different conditions from municipalities, and generally would prefer to purchase their current in bulk, if by so doing they could obtain it at a lower cost, than to sink further capital in their existing generating stations.

We have referred to a bulk network. What stations would feed into this network and under whose control would they be ? It is known that there are several large stations in the country which are highly efficient, modern, and capable of extension in large units. These stations would be the initial ones in our greater scheme which would be planned in order to embrace them. They would be interconnected by a bulk supply network into which they would supply their surplus power.

The bulk network would have to be designed with a view to ensuring reliability of supply, so that if any one power station failed it would not affect the main supply, or if any one section of the bulk network was destroyed the supply of current would go on automatically to the subsidiary network. This reliability of supply is of the utmost importance, taking the premier place even before low cost. In the past we have seen disastrous results due to large power stations or bulk networks failing, and one of the strongest arguments for the new scheme would be its greater reliability, owing to the number of stations and the alternative routes of cables. If the railway and large industrial power demands, mines, pumping stations, docks, &c., are to be entirely dependent on the electricity supply of the country, that supply must be absolutely reliable and capable of meeting the exigencies of all possible cases save *force majeure*.

There is a further reason why the bulk-supply network generally should come directly under the Board, and that is because the question of giving a supply in any part of the country will require to be regarded not alone from the standpoint of whether it will pay to run the electric mains for the immediate demand, but also from the larger standpoint of whether giving such supply is for the good of the country as a whole. In this way many districts would be given a cheap supply of electricity which under the ordinary commercial conditions of a company operating in a smaller area would not obtain.

V. The Distribution of Electricity in Detail.

Finally, we come to the transformation and distribution of electricity in detail ; that is to say, the last step in supplying current to the small and medium size consumer. On the whole, this place is being well and efficiently filled by the present undertakings and, with the exception of removing a few anomalies and arranging for developments to be on lines which will tend to greater uniformity throughout the country, our scheme would not interfere with the present arrange-

ments. It is in this direction that we shall obtain the support of the present supply authorities, viz., by letting them retain those parts of their own undertakings which are essentially local. It matters little to them whether they generate their own current or receive it as a bulk supply at a much lower cost, but it does matter to them very much whether their undertaking is taken over or not.

Again, we meet the human factor in this matter, which it would be fatal to ignore, for if those at present interested directly or indirectly in the existing undertakings can clearly see that our scheme will not be detrimental to them, but otherwise, we shall readily receive their support. Take, for example, the electricity supply of a town with a generating station which would not be absorbed into the scheme, but which would gradually change into a transforming station and depot under the same control whether municipal or company. By that date, and with the help of the cheap bulk supply obtained from the Board, the electricity undertaking would have far outgrown its present importance, so that all the energies of the present and additional staffs would be absorbed in dealing with the transformation of the bulk supply and its distribution throughout their area. When we consider that practically all indoor and outdoor lighting will be effected by electricity, also that most mechanical power, conveyances, cooking and heating will be electrical, and that the present areas of supply will generally be considerably extended, the importance of that town's electrical undertaking will be comparatively much greater than at present.

In the author's opinion one of the indirect results of our scheme would be the resuscitation of our canal system. Canal routes would in many cases be suitable for carrying distributing networks into various districts, and cheap power alongside the canal would increase the value of the land adjoining both for agricultural and industrial purposes. The use of cheap power would soon make itself felt in the development of mechanical propulsion on canals, and there can be no doubt that a revived and efficient system of transit along canals would be an economic factor of great importance to the country. Hitherto, the question of electrical propulsion has been partly held back by the cost of the electric power system, but when power mains are running along canal routes for other purposes the problem will be simplified.

Similarly the great agricultural interests of this country, which it is so important to revive, would receive a great stimulus from a cheap electricity supply. In other lands electricity is being largely adopted in agriculture; and much is to be gained by its aid for lighting, power, heating and transport. Not only directly but indirectly must we assist agriculture by reducing the cost of artificial fertilisers, whether as by-products of generating stations worked with gas-fired boilers or through the cheap supply of current to electrochemical industries.

VI. Procedure to Bring the Scheme into Operation.

It is felt that the time is now ripe to launch this or a similar scheme on to the public notice. There is evidence on every side that men's minds are already actively employed in considering what can be done to enable the nation to support the burden brought about by the war. In what ways can the nation prevent waste and economise, and in what manner can production be increased? Fortunately, the electricity supply problem can play a leading part in both these departments, and because of this there has never been a more favourable time in which a united electrical profession could rapidly obtain public interest in and public support for its schemes. In the words of the Right Hon. A. Bonar Law, M.P.:—

"I hope (they) will realise that the war has made a great difference, that it has made everything plastic, that things which were impossible before are easy now, and that above all it may be found that a big step is not more difficult than a small one."

Or to quote the Right Hon. Edwin S. Montagu, M.P., Financial Secretary to the Treasury:—

"Though no man could say that the only end of the war which was tolerable to us was in sight, yet we ought to see that we were prepared to think of all the enormous problems which awaited us when the war was over. . . . . Be prepared to find coming out of the war a different world from the world which went into the war, and be prepared, therefore, to search your hearts and your minds as to the steps which you desire your country to take when we rebuild what has been devastated by a war into which we were forced."

Whilst the whole subject requires to be handled in a complete and comprehensive manner, yet it is most desirable to keep in mind the main issues and not to introduce various questions and complications with which it will be the business of the Electricity Board to deal.

A possible sequence of procedure is suggested as follows:—

(1) Discussion before the Institution, Technical Societies and in the Press: (2) the formation of the Preliminary Committee of the Institution with representative outside members to draw up a report and proposals for presentation to the Prime Minister: (3) the prompt consideration of the report and proposals by a Parliamentary Committee with the assistance of the Preliminary Committee; (4) the presentation of the Praliamentary Committee's findings to the Cabinet; (5) consideration by the Cabinet, and if approved a Bill to be drawn up without delay; (6) passing of an Act of Parliament; (7) formation of the Board.

VII. Summary.

It should be clearly understood that our proposed scheme is not for the nationalisation of our electricity supply, nor is it for the municipalisation of that supply. Its true function is the co-ordination into one body of the control of the electricity supply, assisting existing undertakings whether municipal or company owned, and taking upon itself only those functions of generation and distribution which are essential to the furtherance of wise development and a supply at the lowest cost.

It should also be clearly understood at the outset that our scheme proposes no confiscation of the rights, privileges and property of either electricity companies or municipalities, and in the event of its being recognised as essential in certain special cases to take any of these over, that full compensation shall be paid not only of the value of the actual plant but of reasonable allowances for potential values. This course is considered to be the only sound, logical and equitable one; for while on the one hand it will prevent a number of undertakings with obsolete plant being put as a burden on to the shoulders of the Board, on the other it will remove all fear of unfavourable or detrimental treatment from those authorities or companies who have been successfully working for present and future results.

In order that these principles shall be ensured, they would be embodied into the proposed Act of Parliament under which the Board would be formed and would act.

In the past there have been three schools of thought, each advocating its own policy as the best. These are, first, those who would nationalise all public institutions of any kind. They do not realise the enormous success and courage of private enterprise and the extent of indebtedness of the country to it. They see some obvious failings and propose nationalisation as the cure for all ills. They fail to see or understand the essential restrictions and limitations of national institutions.

Again, those who have advocated municipalisation to the exclusion of other control, have been able to make a good case in many instances from one standpoint only.

Then there has been the third school which has determinedly set its face against public institutions interfering with private enterprise, clearly pointing out that the duty of the State should be limited to governing.

The author of this Paper having occupied responsible positions in Government, municipal and private concerns, and having seen the inner workings of each, ventures to submit the opinion that each has its proper sphere of action which it alone can best perform, and that the highest efficiency and greatest progress are only attained when these interests work together in the common cause, none trying to usurp the place of the other but all recognising that the success of the whole means success of each in its own department.

VIII. Conclusion.

And while we build may we not hope to work to a better plan? Can we not see the dawn of a new era when an efficient electricity supply at low cost and with the new means of transport will enable men to work under better economic and more humane conditions in the country instead of extending the already densely packed towns? A future in which we shall be conserving our resources to the utmost and by greater efficiency be preparing for the next war, which will be industrial and waged between the economic forces rising both in the East and in the West. Let it not be said of us that we failed.

THE BUSINESS SIDE OF SCIENCE: ITS PART IN THE COMING ECONOMIC CRISIS.

Mr. T. C. Elder (of the British Electrical and Allied Manufacturers' Association) delivered last week, at Newcastle, an address before the N.E. Coast Institution of Engineers and Shipbuilders, for the purpose of opening a discussion.

Mr. Elder first referred to movements towards co-operation. The fact that 23 technical societies and institutions had attended a conference summoned by the Royal Society had decided to form a joint board of scientific societies for several purposes, and that many suggestions had flowed into Whitehall, where, like some rivers in travellers' tales, they had disappeared, showed that war had encouraged a more healthy sentiment.

Science and industry had, in the past, expressed unkind opinions

of each other, and the relationship seemed, like some inexplicable friendships, to be based on mutual contempt. We should not allow ourselves to think that business was carried on by a more or less wasteful and slovenly opportunist adjustment between people who did not know what they want or what was good for them. Before August, 1914, such controversies were carried on with little practical result. Ordinary times were, however, gone, and industrial policy would have to be revised with a bold and sweeping attack in the future, instead of the cautious, defensive policy of the past.

Regarding engineering, the present position compelled us to contrive drastic reform in many respects. Huge new works had sprung up, forests of machine tools had been planted, and an American estimated there would be a great improvement in efficiency later on throughout the whole range of engineering from pig iron to safety-razor blades or watch-springs. At the end of the war we should have the machinery, but whether we should have the markets for our output was another matter.

Anyone could make a speech about the importance of technical education, but little was said about the cultivation of the scientific habit and method in departments of industry and commerce. If one examined the chief departments of a factory, the bookkeeping of the accountant was methodical and accurate, but the neighbouring departments concerned with ascertaining what things have cost, and what they can be sold for, were frequently managed with a good deal of guesswork. In actual manufacturing the popular delusion that the less we turned out the richer we became partly defeated the opportunity for scientific increase of output. Experts who could go into an average works and go through the technical designs, show better and cheaper methods, and sift the machinery and tools, were decidedly scarce. Their services were not to be obtained for a few annual guineas. Recently the various Institutions had joined themselves into a board and manufacturers had firmly seized the idea of association, although they might be slow in following it out to its logical conclusion. An Institution, whether civil, mechanical or electrical, which did nothing but as a technical debating society was deceiving the public and the nation. The kind of manufacturers' association that was wanted was one that would act not as a sedative, but as a tonic. Above all, if the Government yielded to the universal demand for a Ministry of Commerce, let it free itself from the dismal Board of Trade programme of regulating restricting and facilitating.

The scientific purpose of manufacturers' associations was to generalise from a wider range of particulars than that which came before a single firm, and such associations would give help to members in regard to purchase of materials, conditions of labour, technical improvements and sale agencies in foreign markets.

Look at the coming crisis in the engineering industry. For a few months we had had probably the most amazing trade boom on record. Yet, with all this disturbance, what practical consideration had been given to the future destiny of this gigantic instrument? Not until within the last few days had a Board of Trade committee been appointed as though the problem had just been officially discovered.

It was the duty of science to remove indifference and distrust, even if it required the outposts of scientific instruction to become as common as churches. What we required to do was to mix business with patriotism, politics and science, so that industries which were indispensable to peace and prosperity should be given full freedom of development for the unchallenged security and material progress of all the territories of Britannia

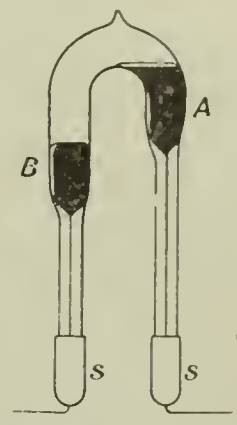
AN ENCLOSED CADMIUM-VAPOUR ARC LAMP.*

BY HENRY J. S. SAND, PH.D., D.SC.

The author first refers to the importance of having well-defined wave-lengths at our disposal and the work of Lowry and Abram. Having been engaged for some years in attempts to construct a cadmium-vapour lamp suitable for more general purposes, I decided to apply the experience gained to the design of a lamp that would meet the requirements of a laboratory appliance as completely as possible. The lamp which I have constructed for this purpose is run at a fairly high temperature, the metal being melted by means of a Bunsen burner before starting, so that the arc may be struck by tilting; and the temperature of the lamp is maintained high enough to keep the metal in a molten condition and to prevent condensation of metal-vapour on the glass.

The principal difficulties to be overcome consisted in the removal of dissolved gases and oxide from the metal and in preventing it from adhering to the glass, which would lead to fracture of the lamp on heating and cooling. As the lamp is constructed of quartz glass there was also the difficulty of obtaining an efficient vacuum-tight seal for the leading-in wires, but this difficulty was overcome in a perfectly satisfactory manner by the lead-seals described about a year ago.* The general appearance of the lamp is shown in the figure. It will be seen that it consists of a quartz tube bent into an inverted U in such a manner as to give rise to a short cathode chamber A and a long anode chamber B. Each of these chambers is continued in a leg consisting of a thick-walled capillary through which a tungsten wire passes, the lead seals *s*, *s* being fitted at the ends of the legs.

The method of filling the lamp is as follows: A small amount of ignited zirconia having been introduced, the lamp is attached to the pump, the piece of cadmium having previously been placed in a side tube connected with the pump by a tube constricted to capillaries for the purpose of filtering the metal. An alternative plan is one in which the capillaries are dispensed with and the metal is placed in a cage made of iron-wire gauze, by means of which the oxide is filtered off. The quartz glass exit tube to the pump is usually connected to the latter by a ground glass joint disposed at right angles to the plane of the Paper, thus allowing the whole lamp to be tilted while evacuated at the pump. After the lamp has been carefully exhausted the metal is melted and allowed to run in. During this process it is freed not only from oxide, but also very largely from dissolved gases. If desired, the metal may be further boiled while the lamp is still at the pump. The lamp when drawn off is now ready



Cadmium Vapour Lamp.

for use. A convenient plan for setting it up consists in holding one leg in a clamp and taping the insulated leading-in wires and terminals on the shank of the clamp, so that they may not be twisted off on tilting. This tilting is effected by rotating the shank of the clamp in its boss head. As already mentioned, the lamp is started by heating with a Bunsen burner from the top until the metal is well molten. When started from the cold it usually lights up even before tilting. It was usually run on a lighting circuit of 100 or 200 volts with a resistance adjusted to take a current of 5 to 7 amperes on short-circuit. The voltage on the terminals of the lamp is low, usually about 30.

* Abstract of Paper read before the Physical Society of London.

Memoirs of the Kyoto Imperial University.—From the College of Engineering we have received copies of the Memoirs recently published by the University. Of the five Papers of interest to engineers those dealing with "The Induction Motor Under Cyclical Operation" and "Leonard Control Applied to Mine Hoists" have already been noted in these columns. The other three Papers referred to deal respectively with "Disturbing Actions of a Shaft Governor," "Tests on Combined Bending and Torsional Strength of Cast-iron" and "Transmission Losses in Telephone Lines." The last-named Paper, by Mr. Morisaburo Tonegawa, will be read with interest by students of telephony. After a short general discussion the author considers the case of a uniform line in a magneto system. He then deals with the case when the telephone line consists of more than one uniform line and with transmission losses in the toll and trunk lines connected to common battery subscribers' loops. Finally the application of the above-mentioned theories is given to the lines chiefly used in Japan at the present time. No less than 32 tables accompany the Paper, and those dealing with the constants of the Japanese telephone lines are likely to be useful to those seeking to trade with Japan in telephone material and apparatus. The diagrams throughout the whole of the memoirs are excellent and the press work is highly creditable to the publishers.

* "Proc.," Phys. Soc., 1914, 26, 127.

The Electrician.

The Oldest Weekly Electrical Journal (established weekly 1861—1878).

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone : City 4698 & 4699. *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITOR. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*

Advertisement Rates, &c., forwarded on application to the Publisher.

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by Wednesday. Renewals of expiring Advertisements, alterations to standing Advertisements and Wrapper Advertisements by Tuesday evening.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **12.30 P.M. THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRICAL MEASURING INSTRUMENTS : THEIR DESIGN, CONSTRUCTION AND APPLICATION. By C. V. Drysdale, D.Sc., and A. C. Jolley *In preparation.*

ELECTRIC LIFTS AND HOISTS. By Gilbert Rowe, M.I.E.E., &c. *In preparation.*

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation*

RADIO-ACTIVITY : AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M.A. Price 4s. nett.

MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by G. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.

PRACTICAL NOTES FOR ELECTRICAL STUDENTS. By A. E. Kennelly & H. D. Wilkinson. Price 4s. 6d.

A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Gelpel and H. M. Kilgour. Price 7s. 6d. nett.

THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.

ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.

THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. G. Bond, M.I.E.E. Price 2s. 6d. nett.

CARBON MAKING FOR ALL ELECTRICAL PURPOSES. By Francis Jehl Price 10s. 6d.

"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Brown, Wh.Ex. M.I.Mech.E. Price 2s. 6d. nett.

THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C.E., M.I.M.E., &c. Price 5s. nett.

ELEMENTARY THEORY OF ALTERNATE-CURRENT WORKING. By Capt. C. L. Hall, R.E. 3s. 6d. nett.

ELECTROMAGNETIC THEORY. By Oliver Heaviside Vol. I. Price 12s. 6d Vol. II. Price 12s 6d. Vol. III. 21s. nett. [postage 3d.

COMMON BATTERY TELEPHONY SIMPLIFIED. By W. Atkins. *Third issue* 3s. nett ;

ELECTRIC CRANES : THEIR DESIGN, CONSTRUCTION AND APPLICATION. By H. H. Broughton, M.I.E.E. Price 2s. nett, postage 2d. (Abroad, 1s. 6d.)

ELECTRICAL TESTING FOR TELEGRAPH ENGINEERS. By J. Elton Young. Price 10s. 6d. nett, post free 11s

STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Price 7s. 6d nett

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie, A.M.Inst.C.E. Price 10s 6d. nett, postage 6d. (abroad, 1s.)

"THE ELECTRICIAN" PRIMERS (84 Primers in all, and a GLOSSARY) Single Primers 3d. each post free. *In One Complete Vol.*, 10s. 6d. *nett, or Three Separate Vols. (Vol. I.* 3s. 6d. *nett ; Vol. II.*, 6s. *nett ; Vol. III.*, 4s. 6d. *nett*). Prospectus free. The Primers are revised or re-written as new printings are called for, and new Primers are added from time to time. Five New Primers : Gas Engines (No. 55). Oil Engines (No. 52A). Common Battery Telegraphs (No. 60A). Electric Clocks (No. 79). Electric Impulse Dials (No. 79A), now ready. Revised Primers 1914 and 1915 : No. 29 (Management of Dynamos and Electric Machinery) ; No. 46 (House Wiring for Electric Light) ; No. 63 (Repairing Submarine Telegraph Cables) ; No. 42 (Electric Ignition) ; No. 49 (Steam Engines) ; No. 54 (Comparative Advantages of Steam and Produce Gas for Power Production) ; No. 59 (Duplex and Quadruplex Telegraphy) ; No. 61 (Automatic Telegraphic Apparatus).

Further portions of this list of "THE ELECTRICIAN" SERIES OF BOOKS appear each week

"THE ELECTRICIAN" TABLES OF ELECTRICITY SUPPLY.

These important Tables and Data relating to Electricity Supply in the United Kingdom in 1916 (which have been published annually since 1887) are now obtainable, price 3s. net, post free 3s. 3d.

The Tables of Colonial (and certain Foreign) Electricity Supply, Power and Traction Stations are also obtainable, price 2s. 6d. net., post free 2s. 9d.

The two sets of Tables are supplied, price 5s. net., post free 5s. 4d.

SPECIAL NOTICE.

With this week's number of "THE ELECTRICIAN" is issued (Gratis the Index to Vol. LXXVI. This includes the Index to the "Commercial and Industrial Supplement."

Complaints of non-receipt should be promptly made to the Publisher.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. : post free, 2s. 4d.

SPECIAL NOTICE.

In order that we may be able to supply the newspaper trade effectively and meet the requirements of the Post Office, we are sending THE ELECTRICIAN to press a few hours earlier every week. All editorial and news matter for the next current issue of THE ELECTRICIAN must reach us as much earlier as possible, but not later than WEDNESDAY MORNING, and advertisement text and blocks must reach the offices as much earlier as possible, but not later than TUESDAY EVENING, during the continuance of the War. Displayed Advertisements not for proof before first insertion can be taken until NOON ON WEDNESDAY, and Official Announcements, Auctions and "Smalls" of all kinds of which no proofs are required before insertion can be accepted up to FIRST POST THURSDAY MORNING.

THE PRODUCTION OF LIGHT.

The production of light artificially is one of those processes which has for years been renowned for its inefficiency, and is, therefore, a problem to which scientific attention is frequently directed. A considerable advance has, however, been made during the last 10 years or so, both in the arc lamp and in the incandescent lamp, to render the methods of light production more worthy of scientific progress. Even so, the efficiency seems absurdly low. Taking the incandescent method of producing light, this inefficiency is inevitable owing to the fact that the greater part of the radiation so produced is in the invisible part of the spectrum, and must remain so however high the temperature that we may hope to reach in practice. Doubtless some further advance may be made by running tungsten at a still higher temperature, or by using it in larger masses, as in the new Ediswan lamp. Or perhaps some other metal, such as chromium, may be used. In any case, however, it does not seem that we shall go beyond 3 or 4 candles per watt by this means.

But we are not limited to incandescence. The other means of attacking the problem is by stimulating the vibrations of the atom itself. Here we come to electromagnetic radiation. By suitable methods the wave length of electromagnetic waves, such as are used in radiotelegraphy, can be reduced to a very small figure, and if it were only possible to continue the process we should eventually reach the wave-length of light. Unfortunately, there is still a considerable gap between the shortest electromagnetic wave so far produced and the longest wave-length in the spectrum of light. It is, therefore, necessary to adopt other methods, and that which promises the greatest prospect of success so far is the stimulation of these vibrations electrically in gases. Fortunately, the spectrum of the light produced by the electric discharge in vacuum tubes does not extend down into the region of heat waves, and, therefore, the pos-

sibility of producing a suitable light from this point of view is much greater—at least a high efficiency appears to be not impossible in this direction, whereas it is physically impossible by means of incandescence. There are, however, other difficulties. The spectrum so produced may be discontinuous, and it may be lacking in certain wave-lengths which are highly desirable, and thus the light so produced may differ very much from daylight. The mercury spectrum is a case in point.

These and other aspects of the problem are brought out in an interesting way by Dr. C. P. STEINMETZ in a Paper which we reproduce to some extent on another page. There is, however, one point of view on which Dr. STEINMETZ does not touch—namely, the commercial gain attained by very high efficiencies. It must be remembered that the charge made for a supply of electric light does not consist simply of a charge for the electrical energy that is used. There are other costs, such as the capital charges on mains and services, the taking of meter readings and the rendering of accounts. There are also establishment charges which have to be borne. These items are largely independent of the quantity consumed. Consequently, if the amount of energy that is required became very small for a given amount of light, it would still be necessary for the charges made for this light to be maintained above a certain figure. It is for this reason that some engineers are in favour of basing their tariffs on the amount of illumination that is supplied rather than on the amount of electrical energy that is necessary for operating the lamps. Obviously, if such a tariff were adopted an improvement in the efficiency of light production would give no benefit to the consumer. Of course this state of things is remedied to some extent by the tendency to higher illuminations. We can imagine that in the days of the rushlight the present-day illuminations would have been looked upon as quite unnecessary and extravagant. It may still be that higher illuminations will be used or that indirect methods of illumination will become general, in which case a still larger amount of energy will be required for a given floor area. On the other hand, the illumination cannot be increased indefinitely without being harmful to the eyes, unless it can be made more nearly to approach daylight illumination, notwithstanding the great discrepancy in the number of foot-candles in the two cases.

Apart from internal illumination, where the commercial incentive for greatly increased efficiency seems likely to fall off, there is still a possibility of using very large units for external illumination, provided these can be made to give their light very efficiently. There are also other possibilities. Thus, it was suggested only the other day, in a discourse at the Royal Institution, that artificial light should be used to increase our agricultural output. Here it is clear that the use of artificial illumination on such a scale as would be necessary in order to produce any results of value would involve prohibitive amounts of electrical energy unless the efficiency of light production were very much higher than it is at present. Whether such an idea has any practical agricultural value we are not prepared to say. So far as we are aware, the successful application of electricity to agriculture has hitherto taken the form of unidirectional electric discharges, and it may, perhaps, be doubted whether mere illumination will produce the desired effect, though possibly ultra-violet sources of light might prove beneficial. In this and other directions, however, there will still be an incentive to find more efficient means of light production, means not merely efficient in themselves, but in which the lamps to be used are comparatively inexpensive in first cost or have a very long life.

REVIEWS.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

Principles of Direct Current Machines. By A. S. LANGSDORF. (London: Hill Publishing Co.) Pp. xxiii.+404. 12s. 6d. net.

The opinion has been expressed that the preparation of text-books on electrical engineering should be supervised or controlled by a committee of engineers and teachers, and we endorse the opinion. This book is one of a series of text-books outlined by a committee composed of engineers whose names and works are as well known in this country as in America. The chairman and consulting editor is Prof. H. E. Clifford, of Harvard, and the other members of the committee are Profs. Elihu Thomson, H. J. Ryan, H. N. Norris, M. C. Beebe, E. J. Berg, P. M. Lincoln and G. W. Patterson, and Mr. W. D. Weaver, a former editor of the "Electrical World." The author is Professor of electrical engineering at the University of Washington, and a Fellow of the American Institute of Electrical Engineers.

This book of eleven chapters has been prepared with the object of placing before junior and senior students of electrical engineering a reasonably complete treatment of fundamental principles. Instead of attempting to touch the "high spots," attention has been concentrated upon certain important features which are vital to a thorough grasp of the subject. For example, the book contains in Chapter III. a full derivation of the rules covering armature windings (following Prof. Arnold), in addition to the usual description of typical windings; Chapters VI. and VII. include a considerable amount of new material concerning the operating characteristics of generators and motors: and in Chapters VIII. and IX. there has been developed a much more extensive treatment of the important subject of commutation than has been heretofore easily accessible to students of the type for whom the book is intended. To many students the information contained in each of the chapters mentioned will be worth more than the cost of the book. In the selection and arrangement of the material dealing with commutation care has been exercised in the elimination of those minute details and excessive refinements that are more likely to confuse than to clarify.

A noteworthy feature of the book is that although the methods of the calculus have been freely used throughout, the mathematical analysis is preceded, wherever possible, by a full discussion of the physical facts of the problem and their relations to one another. The problems at the end of each of the first 10 chapters have, for the most part, been designed to make the student think for himself. These problems are preferable to those in which a student feeds figures into one end of a formula and extracts the result painlessly from the other end by means of a slide rule. The educational value of direct substitution problems is negligibly small, and the solution of many such problems is apt to be harmful to students. We can recommend the book to those students of electrical engineering who desire to obtain a sound knowledge of the fundamental principles of direct-current machinery and apparatus.

An Introduction to the Principles of Physical Chemistry. By E. W. WASHBURN. (London: Hill Publishing Co.) Pp. xxv.+415. 15s. net.

The purpose of this book is to present the principles of modern physical chemistry in the form of a systematic course of instruction and training. While designed primarily for those who intend to become professional chemists or physicists, it will nevertheless be useful to those who wish to obtain a usable knowledge of the subject. The author rightly presents the subject in such a manner as to require the student to do a large part of the reasoning for himself.

A knowledge of elementary chemistry and general physics is assumed as well as a training in mathematics which includes the elements of the calculus. The author is entirely out of sympathy with those authors who assume a somewhat apologetic attitude, and who explain that students must take on faith "these few derivations." With this lack of sympathy we cordially

agree, and we welcome the author's statement that if a student hopes to employ the laws and principles of the subject in an intelligent and confident manner, he is strongly advised to acquire the elements of the calculus before attempting to secure any special training in physical chemistry. It is well that those who intend to take up chemistry as a profession "after the war "should know that the ability to earn a living wage necessitates a good deal of preliminary work.

Apart from the author's use of mathematics, however, we like the book, because the treatment is sound, and because an endeavour has been made to get down to the bed-rock of the subject. As implied by the title, no attempt has been made to deal with laboratory work, and it is assumed that the book will be used in conjunction with a closely correlated laboratory course. We venture to think that many of those who use this modern book would welcome practical guidance by the author and for this reason we hope that a companion volume is contemplated.

The most radical departure from the custom which has prevailed heretofore in most text books on the subject, is in connection with the manner in which atomistics and molecular kinetics are treated. These systems are treated by the author as facts already established beyond the possibility of reasonable doubt, and, together with thermodynamics, are made to serve as the framework for the development of the whole subject. In many cases the development of the principles, and in all cases their applications, are presented in the form of problems, of which the book contains a considerable number. The name index, in addition to the subject index, will be found useful by many readers. We can unreservedly recommend the book to all those who are well grounded in chemistry, physics and mathematics, and who desire to pave the way to bigger books on this most important subject.

LARGE ACCUMULATOR SUB-STATION OF THE METROPOLITAN ELECTRIC SUPPLY CO.

It is some years since the largest battery of accumulators in this country was put down at Manchester for the purpose of meeting the peak load, and in the interval there has been ample time for engineers to satisfy themselves that such an investment can be justified. We now have to record that the Metropolitan Electric Supply Co. have recently completed a new battery sub-station, which contains what is probably the second largest battery in the country, from the point of view of ampere-hours, applied to this class of work.

The sub-station is in Eagle-street, Holborn, and has been erected in order to increase the plant in that district. Provision is made in the building for four complete batteries, one of which has been installed in the basement. It has been supplied by the Chloride Electrical Storage Co. (Ltd.). The battery consists of 110 cells of their C.V.W. 26 type accumulator in lead lined pitch pine boxes, the capacity varying with the rate of discharge as follows:

1,200 amps.	for	10	hours	to	1·8	volts per cell	= 12,000	amp.-hours.
2,000	..	5	..		1·78	.. ..	= 10,000	..
3,800	..	2	..		1·7	.. ..	= 7,000	..
6,000	..	1	..		1·65	.. ..	= 6,000	..
8,000	..	35 minutes						
12,000	..	1 minute						
15,000	..	momentarily						

The normal maximum charging rate of the battery is 1,100 amperes; the maximum continuous charging rate is 2,570 amperes; the maximum charging voltage is 2·6 volts per cell.

The positive plates are of the well known Planté type, supplied by the Chloride Company, and the negative plates are of the box type. The plates are separated by wood dowels carrying board separators, and are suspended on stout glass slabs resting on, and held in position by, lead shoes.

The ampere-hour efficiency at all rates is guaranteed to be 90 per cent. The watt-hour efficiency is guaranteed to be not less than 75 per cent. at the five-hour rate, 72 per cent. at the two-hour rate and 70 per cent. at the one-hour rate. The general data of the cells are as follows:—

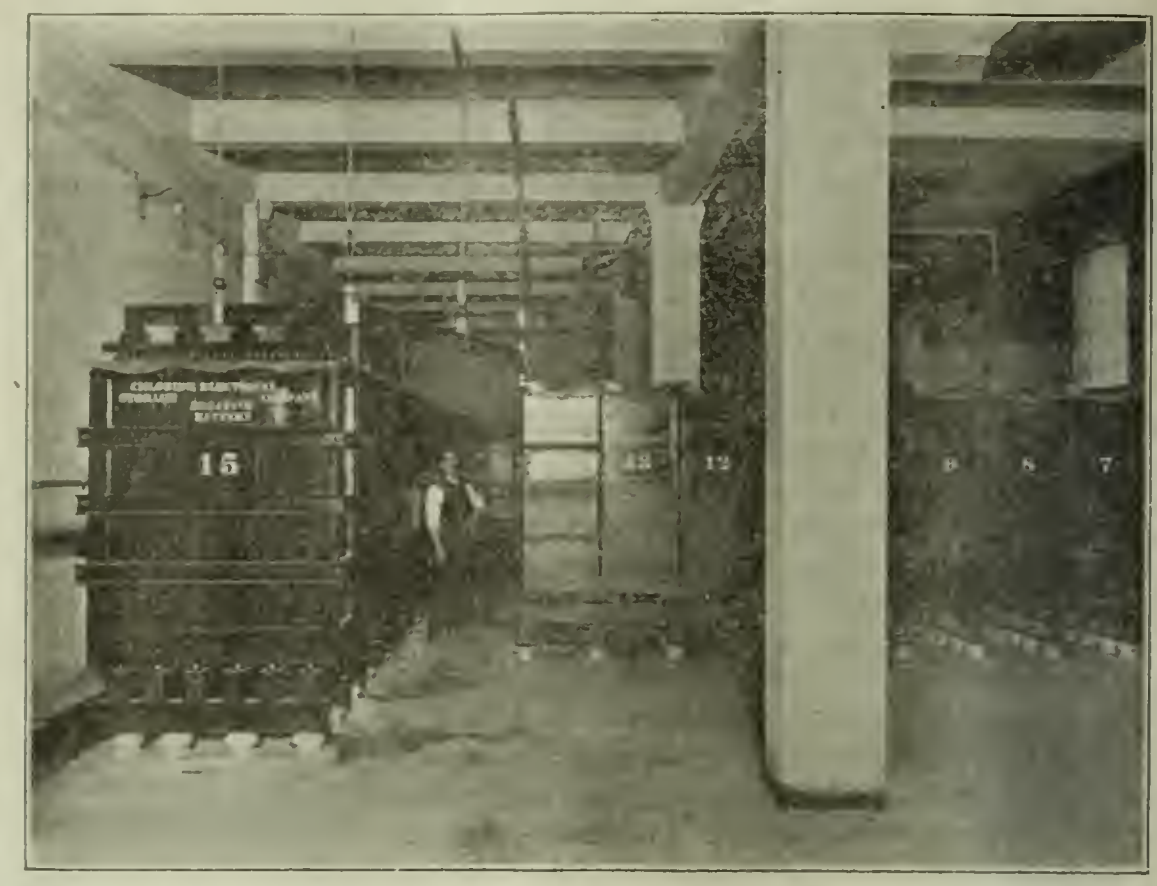


Fig. 1.—View of Battery Room.

Number of positive plates per cell	26
.. negative	27
Dimensions of positive plates	16⅛ in. × 46¾ in. × 7/16 in.
.. negative ..	16 1/16 in. × 46⅞ in. × 5/16 in.
Overall dimensions of cell	21¾ in. × 49⅛ in. × 65⅝ in.
Height of cell overall	68¾ in.
Weight of positive plate	90 lb.
.. full negative plate	41 lb.
.. end negative plate	34 lb.
.. plates in one cell	3,452 lb.
.. acid in one cell	1,700 lb.
.. cell complete with acid	6,080 lb.

Approx. weight of complete battery exclusive of stands, 298 tons 11 cwt.

It will be noticed that the plates are unusually deep in proportion to the width. Each cell is supported on 12 glass insulators of the

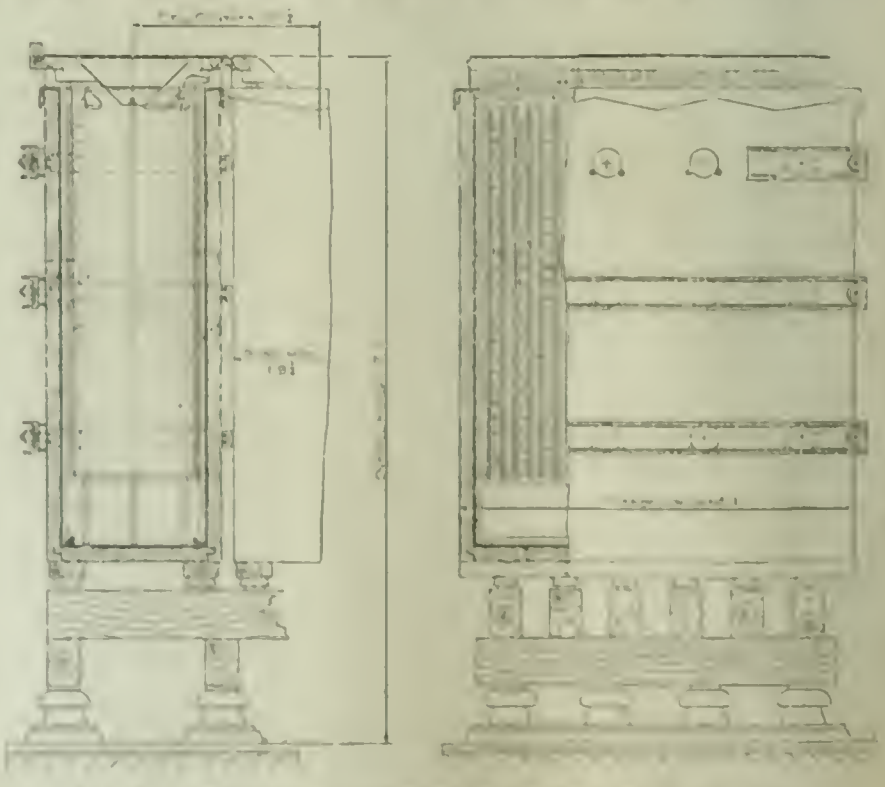


Fig. 2.—Sectional Elevation of Chloride C.V.W. Cell.

"mushroom" type. The stands are of pitch-pine, and are supported on strong glazed earthenware insulators. The different rows of cells are connected together by means of flat copper bars bolted to copper

take-offs cast into the channel bars at end of cells, each connection being composed of four bars, each 4 in. by ¼ in., an air space being left between each bar. These bars are suspended from the ceiling

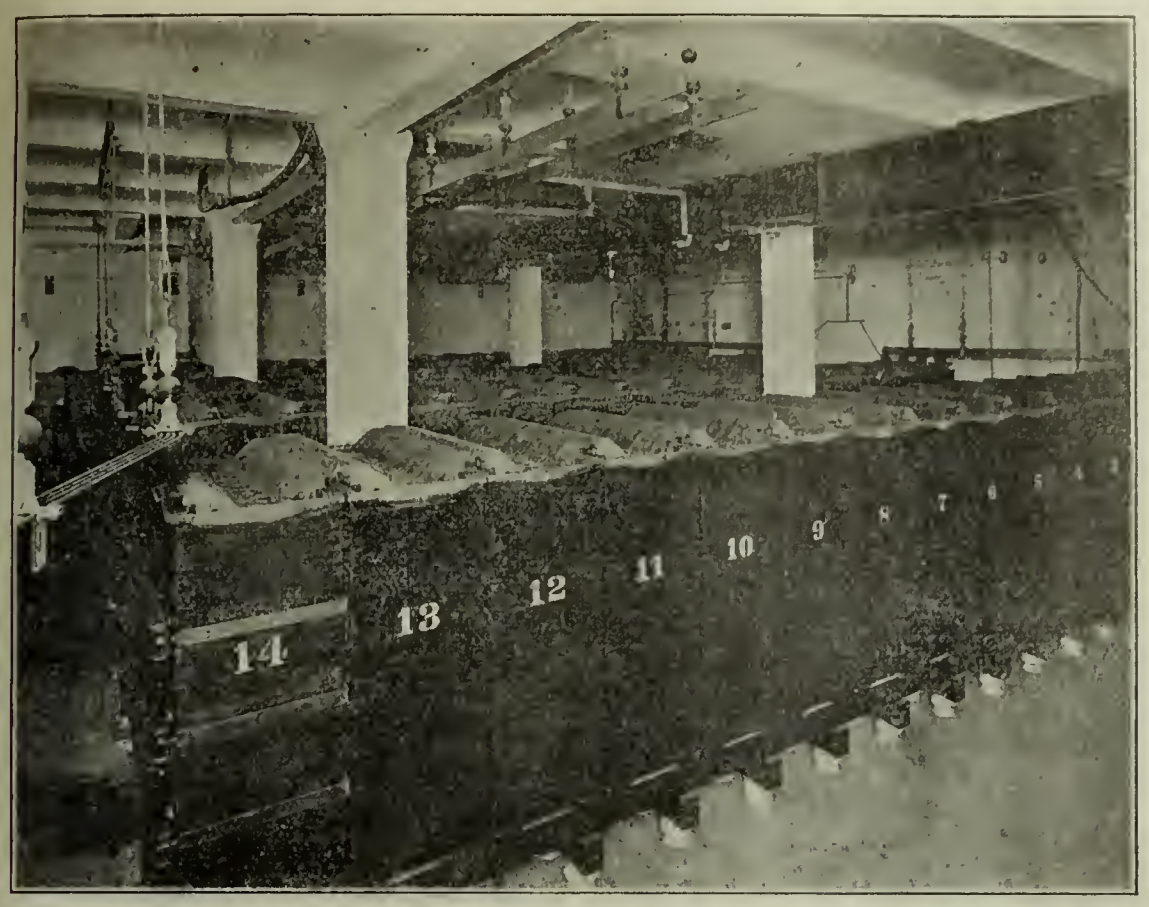


Fig. 3.—View of Battery Room showing Suspension of Conductors and Suction Trunk Ventilator.

by means of iron rods insulated from copper by globe strain insulators and insulated turn-buckles. The battery is also connected to the boosters and switchboard by means of similar bars, the bars being well painted. Figs. 1 and 3 give a good idea of the battery and Fig. 2 shows the details of a cell. Owing to the unusual depth of the cells the necessary floor area is correspondingly reduced.

The battery-room floor is of special construction, as seen in Fig. 4. Metalline bricks are laid on edge in rows of sufficient width to carry the glazed earthenware insulators for supporting the battery stands.

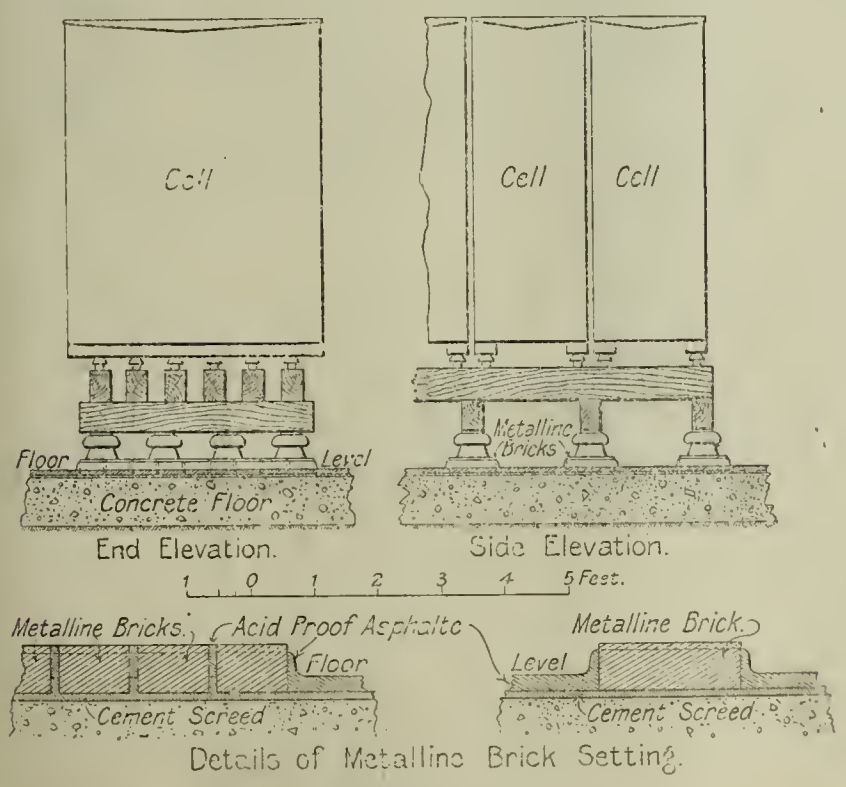


Fig. 4.—Details of Flooring.

These bricks are laid in grout in rows 9 in. wide directly on the cement screed of a concrete floor. A space of about ½ in. is left between each brick, which is filled in with cement to a depth of about 1 in. from the bottom of the bricks. Acid-proof asphalt compound of a thickness of 1 in. is laid over the whole of the cement finish to floor. A fillet is formed round the bricks to 1½ in. above the level of the surrounding asphalte and ironed against the rough surface of the bricks. The ½ in. spaces between bricks are also filled with this compound to the level of the top face and sides of bricks, thus forming an acid-proof floor and making a solid foundation for the batteries. The arrangement is well shown in Fig. 3, in the lower part of which the construction is seen in detail on an enlarged scale. Metalline bricks are non-porous, and therefore are not penetrated by acid; on the other hand, they are strong. This method of construction, therefore, provides the necessary strength to carry the weight of the cells, and at the same time affords protection from acid action on the cement below.

A sump is provided in the floor, into which any acid can be brushed and neutralised before pumping into the drain.

On the roof of the building are two 500-gallon tanks containing distilled water, which is distributed by pipework about the battery room, and is taken to the cells for topping by means of rubber hose with a wooden cock at the delivery end.

Two motor-driven boosters to deal with the present battery have been installed, supplied by the Electric Construction Co., of Wolverhampton. Each consists of one interpole motor of 115 B.H.P., 210/240 volts at 500 revs. per min., and two interpole boosters, the fields of which can be reversed so as to boost up or down, each capable of giving 1,800 amperes at 16·7 volts continuously, 2,500 amperes at 12 volts for two hours and 3,000 amperes at 10 volts for one hour, the boosters being separately excited off 210/240 volts, and each having one commutator which is ventilated through slots in the centre of the commutator between two collector rings. This plant is seen in Fig. 6. The machines are connected by Zodel-Voith flexible couplings, have four bearings on one combination bedplate and are fitted with carbon brushes.

The efficiency of each booster for the loads above mentioned is 69 per cent. at 1,800 amperes, 62 per cent. at 2,500 amperes, and 56 per cent. at 3,000 amperes. The efficiency of the motor is 91 per

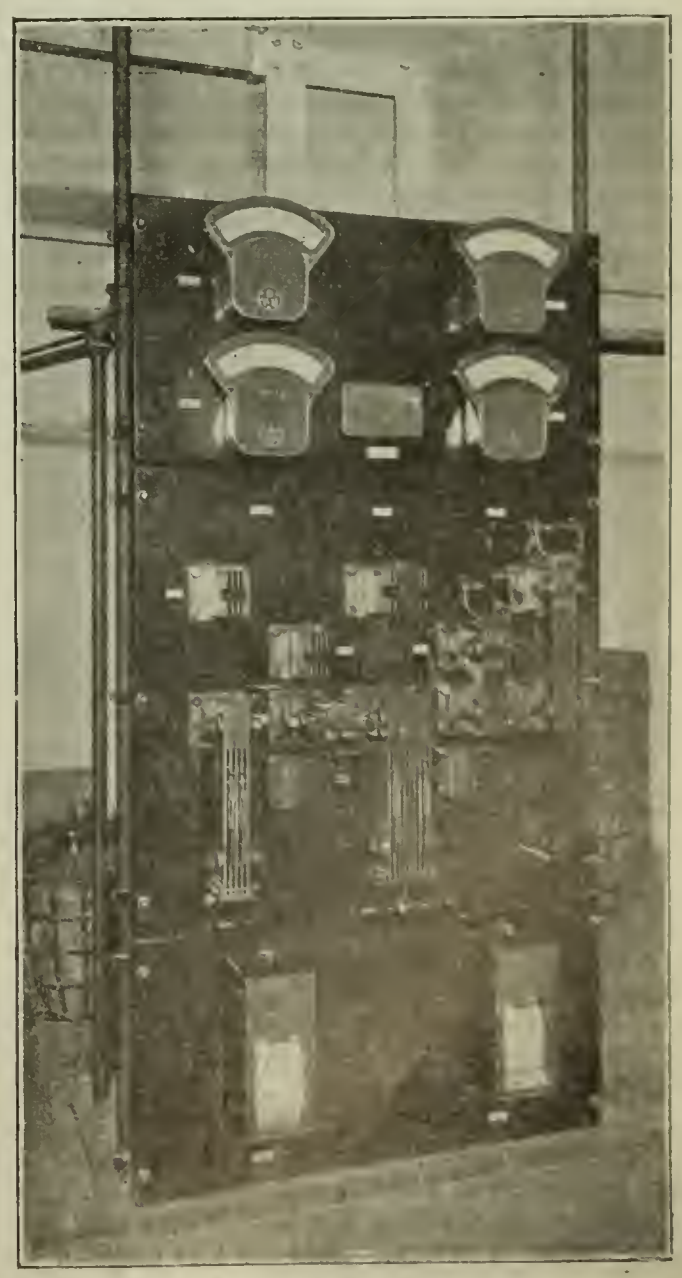


Fig. 5.—Negative Booster-Battery Switchboard.

cent. with each booster when giving 30 kw. The switchgear for each motor is mounted on a panel fixed to the bedplate of the machine. The starting switch consists of nine interlocked slow-break knife switches, and the booster field regulators are of the pedestal potentiometer type. These machines are seen in Fig. 6.

One battery sulking booster, supplied by the Electric Construction Co., has also been installed, consisting of an interpole motor for 220 volts, connected through a flexible coupling to an interpole booster giving 1,500 amperes at 10 volts when running at 575 revs. per min. The machines are provided with four bearings, and are mounted upon a combination bedplate, together with the necessary switchgear. The booster is connected up to copper bars supported by globe strain insulators under the basement ceiling, as shown in Fig. 2. Portable flexible leads are used as connections from these bars to the cells.

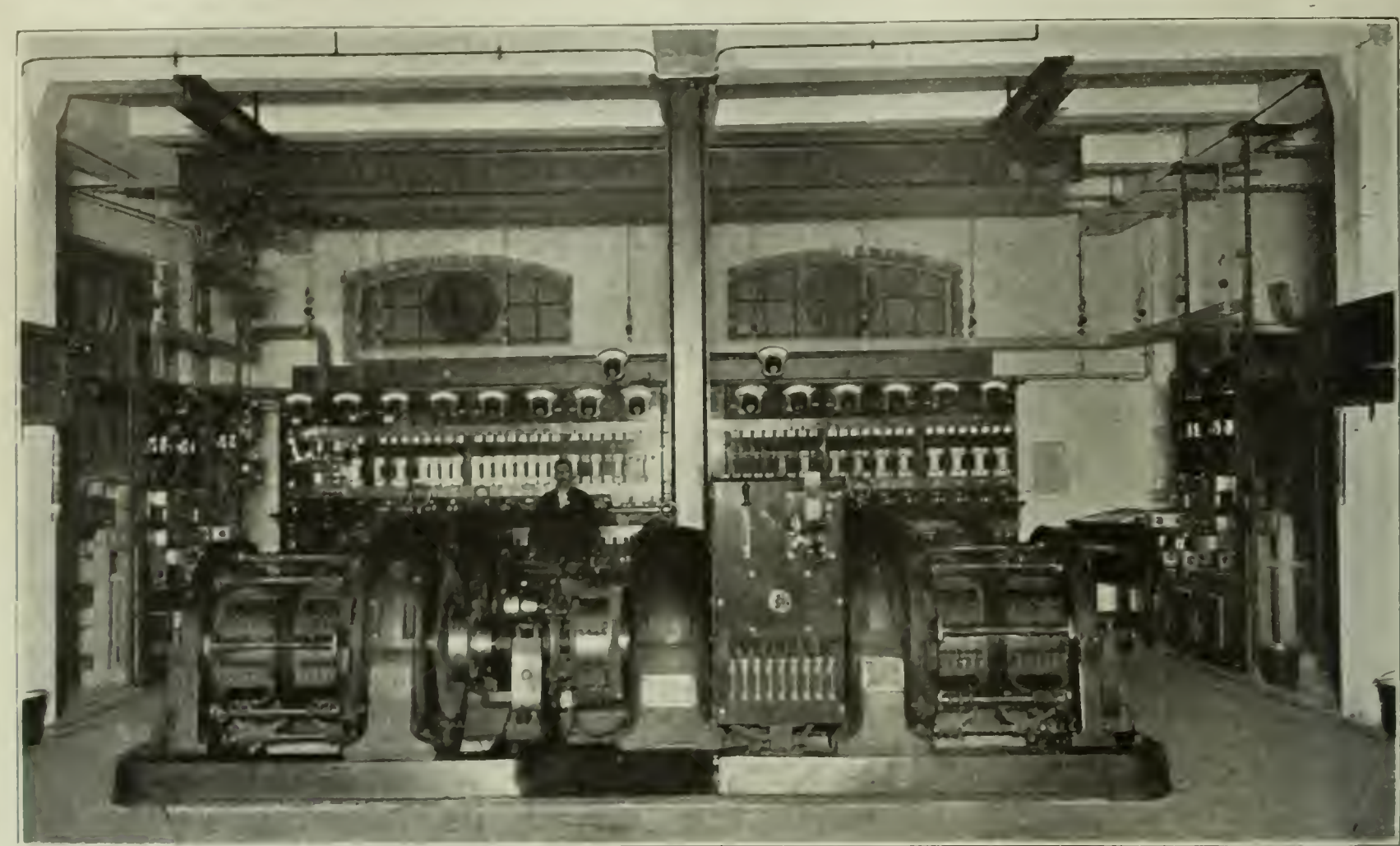


Fig. 6.—Views of Boosters and Switchboard.

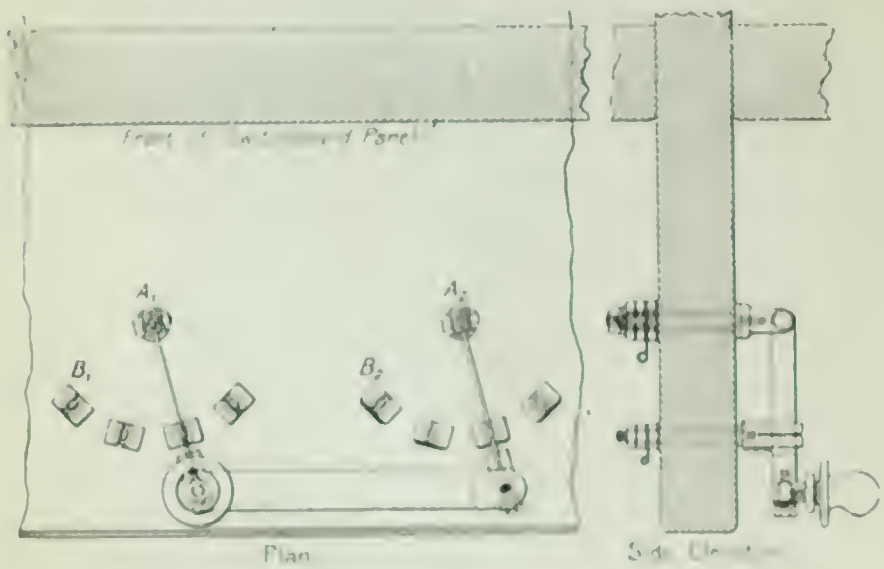


Fig. 7.—Details of Ammeter Switches.

The switchgear, supplied by the British Thomson Houston Co., consists of one main board for feeders, motors and battery, one negative and battery panel, one positive and battery panel and one instrument panel. The main switchboard, shown in Fig. 6, accommodates the battery connections, field and motor connections and 24 triple concentric feeders. It consists of six feeder panels, one motor and battery panel and one panel carrying four 4,000-ampere dividing switches for dividing the feeders into two sections, the neutral bar having a covering plate for this purpose. There are double positive and negative copper 'bus bars, so arranged that feeders or battery and motors can be connected on to either top or bottom 'bus bar, the battery through two 4,000-ampere switches in parallel on either pole, and the motors and feeders through switch fuses, each feeder having two fuses in parallel.

Twelve of the company's feeders, forming part of the network in Eagle-street, were cut, both ends of each feeder being brought into the station and connected to the 'bus bars through neighbouring

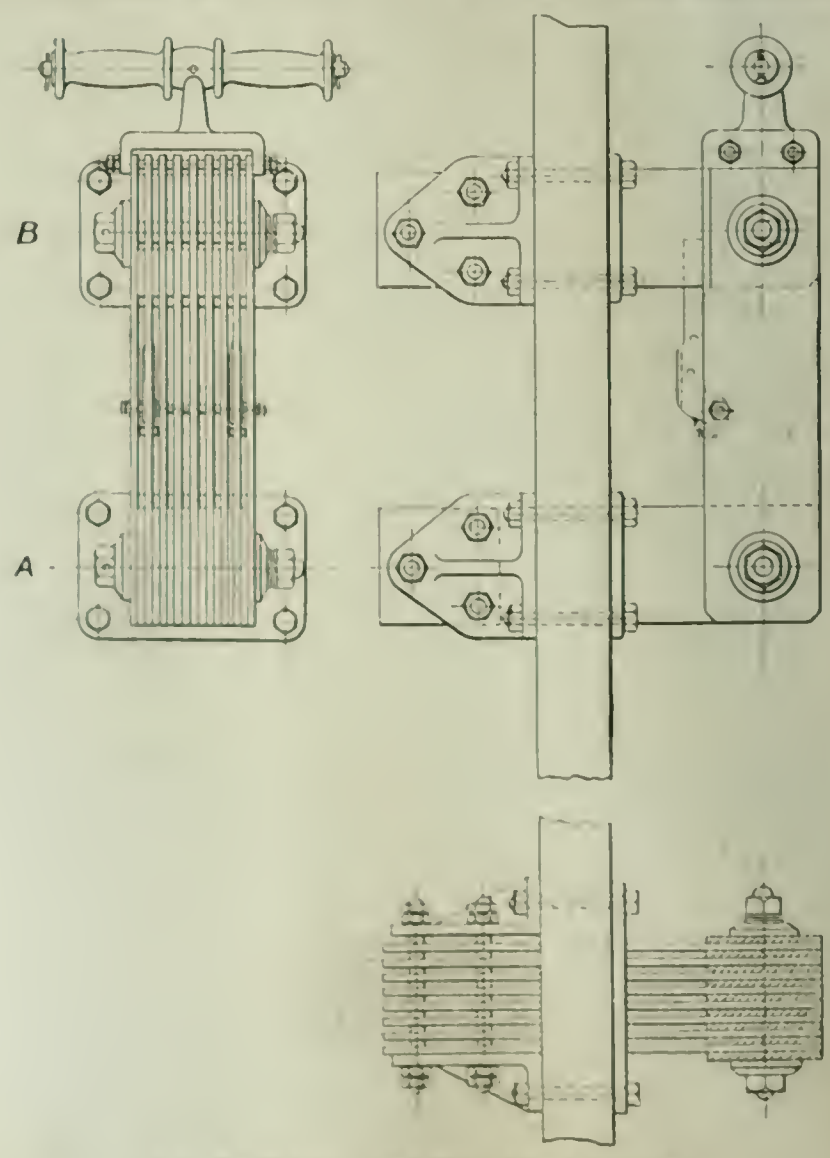


Fig. 8.—Detail of 8,000-ampere Switch.

fuses. The feeders can, therefore, be boosted up as required, and the battery current is available in the feeders in either or both directions.

The triple concentric feeders are of either 0·8 sq. in. or 1 sq. in. in section. Ammeters, voltmeters and switches for these are provided on the board.

The negative booster and battery switchboard and the positive ditto are at opposite sides of the machine room, as shown in Fig. 6. The negative switchboard is shown in Fig. 5 Mounted on it are two 5,000-ampere switches for No. 1 booster, two 5,000-ampere switches for No. 2 booster and one 8,000 ampere switch for the battery connection, four voltmeters, one recording voltmeter and one recording ammeter. The switches on the positive switchboard are similar to those on the negative panel, the instruments being two voltmeters, one ammeter and one charge and discharge Aron watt-hour meter.

These switchboards are arranged so that either the first or second machine, or the two in parallel, can be connected to the existing battery or to a second battery. An instrument panel carrying five ammeters is fixed by the side of the positive panel.

Two interesting details of the switchgear are shown in Figs. 7 and 8. The former shows the linked switches for putting an ammeter on to any one of four feeders. The instrument is connected to the common terminals A_1, A_2, and each shunt to a pair of terminals, B_1, B_2. Since the drop is most important in such cases the contacts are made of ample area. Fig. 8 shows details of one of the main switches. In addition to the hinge-bolt A, the blades are slotted so as to embrace a bolt B. If over-heating occurs both these bolts can be tightened up when the switch is closed.

The basement is ventilated by means of two fans belt-driven from a motor, one a low-pressure fan drawing air from outside and discharging into the basement through wooden trunks situated on the floor and carried nearly the full length of the building at either side; a portion of one of these trunks is shown in Fig. 1. The other fan is a high-pressure one, drawing air through a wooden trunk fixed to the ceiling of the basement and discharging at the top of building; a portion of this trunk is shown in Figs. 1 and 3. In this case, owing to the acid nature of the air, the draught is of the induced type, the shaft being restricted where the fan discharges.

The building consists of a basement, ground, first and second floors. The basement and ground floor were each designed to carry two batteries similar to the one now installed. The first floor was designed to carry all the boosters required for the four batteries, and also the necessary switchgear. For the present, however, the boosters and switchgear are erected on the ground floor, thus saving a considerable amount of copper.

The contractors for the building were Messrs. Geo. Andrews & Co. The steelwork was supplied by Messrs. Drew, Bear, Perks & Co., the architect being Mr. J. W. Stanley Burmester. The building and plant were erected under the supervision of the Metropolitan Electric Supply Co.'s engineers, to whom we would express our thanks for their courtesy in giving us full details of the installation.

CORRESPONDENCE.

METROPOLITAN ELECTRIC SUPPLY CO.

TO THE EDITORS OF THE ELECTRICIAN.

I am sure that everyone with any real business grasp of the problems of electric supply will share your attitude of "astonishment" at the statements forthcoming at the annual meeting of the Metropolitan Company.

It is not a case where any good can come from suggesting personal blame. The indispensable fact stands, however, that things are not going as they ought to go. The obvious course is to begin reformation at the top, and it is at the top—namely, the Board—where one can justly suggest an obvious emendation. For instance, it is a fact that there is not on the Board one man who is *by profession* a specialist on electricity supply. The problems which are involved in running such a company as the Metropolitan demand such men, and a modicum of such should be represented on the Board. Until such man or men are put on the Board there is no hope of the company steering into less troubled waters.

It is clear that there are a good many points in the company's policy, and even system, that come under just criticism. However, the thing at present is to get the company out of its mess, and this can only be done by a supplementing of the Board in such particular.

Incidentally, we can at least give credit to the Board for their exercise of business acumen in the attempt to separate the engineering from the business side, and to put the latter under the direction of a man of commercial experience. As a matter of policy this is, of course, following the most approved practice. But it still leaves open the main question—viz., for the Board to reform themselves.

Worcester, April 7. R. FITZMORRIS.

METHODS FOR DETERMINING THE GRADING OF STARTING AND BRAKE RESISTANCES FOR SERIES-MOTORS.

TO THE EDITORS OF THE ELECTRICIAN.

In the issue of THE ELECTRICIAN of March 3rd there is an article by Dr. C. C. Garrard giving methods for calculating and graphically determining the starting resistances for direct-current motors. The author treats first the shunt-motor as the most simple case, and then gives a graphical method for the series-motor due to Bragstad. This method starts from a supposition which is not correct; it supposes that the back E.M.F. remains constant at the moment of changing over from contact to contact. This would be approximately exact if in the starting period the field-magnets were near saturation. Railwaymen know that in most cases, especially on railways or tramways with some steep gradients where motors of relatively great power are used, this does not conform to the facts. Further, it is not practical to take I_c (being the current at which the torque is equal to the opposing torque) as the minimum current during the starting period, because it takes too much time at each step of the controller for the current to fall to I_c. Therefore, the method as given in THE ELECTRICIAN on p. 773 gives a rough approximation which only in a few cases may be considered as sufficient.

It may be, therefore, of some use to call attention to an article, which I published in 1899 in the "Elektrotechnische Zeitschrift," p. 277, wherein I gave an *exact* method for the calculation and graphical determination of the starting resistances for series-motors. To use this method it is only necessary to know the magnetising curve of the motor—that is to say, the curve of the back E.M.F. as a function of the current at a constant speed (the most practical course is to take the speed of *one* rev. per min.).

This article gives first a discussion of the limits between which the current must fluctuate during the starting period. Then it deals with the calculation and graphical construction of resistances in the most usual case of a series-parallel controller. It treats of the case when, after all the starting-resistances are cut out, the speed of the motor is accelerated by diminishing the magnetic field. The shunt-resistances that must be switched into the field-winding are determined. It shows further that the grading of resistances for a shunt-motor is only a special case of the method for series-motors.

Finally, this Paper gives an exact method for determining the brake resistances for series-motors. This part of the article is important, because it permits us to determine the E.M.F. which may occur when, at a given speed, the electric brake is thrown on. Railway and tramway men know that when the speed is high the tension can become very high and dangerous for the motor and car equipment. The method above mentioned permits us to calculate this tension exactly, and so it is possible to take the necessary precautions.

Arnhem (Holland), March 29. F. ERENS.

POYNTING'S THEOREM AND HYSTERESIS.

TO THE EDITORS OF THE ELECTRICIAN.

Poynting's theorem, which expresses the fact that in any region the flux of energy is in a direction at right angles to the directions of the forces $\mathbf{E}$ and $\mathbf{H}$, has heretofore been developed without taking into account the work done by cyclic electrostatic and electromagnetic hysteresis.

In the following the above hysteresis is taken into account by means of a hysteresis operator, which is a function of the Q_m operators discussed in a Paper on iron losses in THE ELECTRICIAN of July 23, 1915.

Thus, if $\mathbf{H}=\mathbf{H}_{max.}\sin pt$, and

$$\mathbf{B}=\mu_0\mathbf{H}_{max.}\left\{\begin{matrix}\alpha_1\sin pt+\alpha_3\sin 3pt+\\ +\beta_1\cos pt+\beta_3\cos 3pt+\end{matrix}\right\},$$

then it is possible to write $\mathbf{B}=\mu\mathbf{H}$,

where $$\mu=\mu_0\left\{\left(\alpha_1+\beta_1\frac{t_1}{p}\right)+\left(\alpha_3+\beta_3\frac{t_1}{3p}\right)Q_3+\right\}.$$

Then, (using Heaviside's notation, *see* his "E.M.T.," Vol. I. Chap. II.) :—

$$\text{Curl }\mathbf{E}=-\frac{d\mathbf{B}}{dt}=-\mu\frac{d\mathbf{H}}{dt}$$

$$\text{Curl }\mathbf{H}=\mathbf{J}=-\frac{d\mathbf{D}}{dt}=-c\frac{d\mathbf{E}}{dt},$$

with the understanding that μ and c are now scalar differential time operator functions.

The magnetic activity therefore becomes :—

$$\mathbf{H}\frac{d\mathbf{B}}{dt}=-\mathbf{H}\text{ curl }\mathbf{E}=\mu\frac{d\mathbf{H}}{dt}=\tfrac{1}{2}\mu\frac{d}{dt}(\mathbf{H}^2).$$

On the other hand, the electric activity is given by

$$\mathbf{E}\text{ curl }\mathbf{H}=c\frac{d\mathbf{E}}{dt}\mathbf{E}=\tfrac{1}{2}c\frac{d}{dt}(\mathbf{E}^2).$$

Thus, the total electric and magnetic activity, which includes the hysteresis losses, are given by an energy convergence function

$$-\text{div }\mathbf{W}=-\mathbf{H}\text{ curl }\mathbf{E}+\mathbf{E}\text{ curl }\mathbf{H}.$$

By means of the operator ∇ it can be shown that

$$\text{div }\mathbf{W}=\text{div }V'\mathbf{EH}-\nabla V'\mathbf{EH}.$$

Such operator ∇ being in part scalar :—

$$\nabla V'\mathbf{EH}=\mathbf{N}V'\frac{d\mathbf{E}}{d\mathbf{N}}\mathbf{H}+\mathbf{N}V'\mathbf{E}\frac{d\mathbf{H}}{d\mathbf{N}},$$

which can easily be transformed into

$$\nabla V'\mathbf{EH}-\mathbf{H}\text{ curl }\mathbf{E}-\mathbf{E}\text{ curl }\mathbf{H}=\text{div }V'\mathbf{EH},$$

or $$\mathbf{W}=V'\mathbf{EH}.$$

However, the extension of the theorem of divergence given in Heaviside's "E.M.T.," Vol. I., p. 191, formula (148) can be written in the following form :—

$$\int_\tau\nabla(\ )d\tau=\int_S\mathbf{N}(\ )d\mathbf{S},$$

where the ( ) indicates the operand. In this case it is $\mathbf{W}$. Thus,

$$\int_\tau\frac{d}{dt}(\tfrac{1}{2}\mathbf{E}c^2+\tfrac{1}{2}\mu\mathbf{H}^2)d\tau=-\sum_S\mathbf{W}d\mathbf{S}.$$

If $\mathbf{E}$ and $\mathbf{H}$ be in the surface $d\mathbf{S}$ then the flux of energy to make up for the activity within the enclosed surface is at right angles to such surface.

New York. A. PRESS.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914 SPECIFICATIONS.

13,951 NATHUSIUS & WESTDEUTSCHE THOMAS-PHOSPHAT-WERKE GES. Electric furnaces for metallurgical and other purposes.

24,056 SHARMAN. Apparatus for detecting the presence of electric conductors. (Cognate application 8,961/15.)

24,170 BERRY. Electric heat regulators.

1915 SPECIFICATIONS.

247 MILLS-MB-SMITH. Magneto-electric generators for lighting, charging and ignition purposes. (1/7/15.)

3,841 STERLING TELEPHONE & ELECTRIC CO., BELL & BANGLAY. Electro-step-by-step signalling apparatus.

3,856 LANDIS & GYR AKT.-GES. Apparatus for measuring electric current. (10/3/14.)

Apparatus of the Ferraris type for integrating electric power in a three-phase current electric circuit, comprising a main current coil or coils with a shunt coil, whose field is 90 deg. in advance of the field of the main current coil when the load is non-inductive, in combination with a second main current coil in series with a shunt coil whose field is 30 deg. behind the field of the second main current coil.

3,892 LISTER, WATSON & M-L MAGNETO SYNDICATE (LTD.). Magnetos.

3,932 SCHNGUT. Method of and apparatus for winding the armatures of electric machines. (13/3/14.)

3,949 HARRISON. Incandescent electric lamps.

3,950 DE FERRANTI & LODGE. Wireless receiving systems. (1/3/14.)

4,144 HOLT & SMITH. Oil-immersed electric switches or circuit-breakers.

4,229 WADE. (Loewen.) Electrical coils and methods of winding the same.

4,401 WALKER. Electric rotary converters.

4,432 B.T.-H. CO. & WILKINSON. Protective devices for alternating-current systems.

A balancing transformer for the split conductor protective system comprising a three-limb shell-type core through the apertures of which pass in the same direction the two portions of the conductor, the secondary winding being located on the centre limb of the core.

5,017 BARONIO & WOOD. Automatic telegraph transmitters.
5,628 RUDD. Electric lamp lock.
5,766 WOODWARD. Train-signalling and train-control systems.
6,723 ROSENBERG. Equalising field windings for multipolar dynamo-electric machines.
7,492 RAILING & IDE. Electric soldering irons.
8,358 NORTH. Field telephone and telegraph apparatus.
9,428 B.T.-H. CO. (G.E. CO.) X-ray apparatus.

An X-ray tube of increased capacity is provided by rotating the tube as a whole and deflecting the cathode beam out of line with the axis of rotation, thus renewing the surface subjected to the discharge while keeping the focal spot fixed in space.

10,803 EMIL HAEFELEY ET CIE. Vacuum drying and impregnating device, more especially suitable for treatment of the coils of electrical machinery and apparatus. (24/7/14.)
13,754 STANDARD COMPANY. Stationary electrode for igniters. (26/9/14.)
15,989 MARKT. Terminal for electric switches, couplings and the like.
17,690 BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. Electrically-controlled electric circuit-breakers. (29/12/14.)

1916 SPECIFICATIONS.

100,086 BAUMANN, F. P. Dry battery. (16/2/15.)

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

February 28, 1916.

2,920 STEVENS. Means of control for petrol-electric cars.
2,924 GREEN. Controlling the ignition period in magneto-electric machines.
2,945 PETMEKY & SHERIFF. Electrical contacts.
2,950 MCKENZIE & HOLLAND & WOOD. Block instruments for railway signalling, &c.
2,961 GIDDEN. Electrolysis of solutions of alkali chlorides.
2,968 FULLER & FULLER & FULLER. Galvanic batteries.
2,976 CONSTANTINESCO & HADDON. Variable capacity for wave-transmission systems.
2,977 MARKS. (Landers, Frary & Clark.) Electric heaters.
2,986 CALLENDER & CALLENDER'S CABLE & CONSTRUCTION CO. Electric cables.

February 29, 1916.

3,002 KERR. Railway, &c., signalling
3,006 LAMBERT. Ships' telegraphic apparatus, &c.
3,029 HAMILTON. Electric battery lamp.
3,036 B.T.-H. CO. & SHUTTLEWORTH. Polyphase alternating electric-current commutator machines.

March 1, 1916.

3,052 O'GORMAN & WHIDDINGTON. Electric condensers.
3,057 GREEN. Magneto-electric machines.
3,059 GROCOTT. Cleat for carrying two separate wires or cables.
3,062 AUSTIN. Sparking-plugs for internal-combustion engines.
3,067 ETCHELLS & GREAVES. Electric furnaces.
3,074 MARDEN-RANGER. Searchlight gun.
3,076 STROHMENGER. Electric welding or fusion-deposition of metals.
3,087 BROCK & HIRST. Electric switches, especially for controlling electric motors.
3,088 STOBIE. Reducing electrode consumption in electric steel-melting furnaces.
3,114 SCHNEIDER. Regulating voltage of direct-current dynamo.
3,122 HOLLISTER. Magneto-electric machines.

March 2, 1916.

3,134 CLARKE. Condenser for laboratory purposes.
3,161 WALKER. Battery cells. (17/3/15, U.S.)
3,164 EWEN & MARCONI'S WIRELESS TELEGRAPH CO. Suspending and insulating electrical conductors.
3,165 DOWSETT & MARCONI'S WIRELESS TELEGRAPH CO. Studs or electrodes of electric dischargers.
3,192 CHITTY Dynamo-electric machines.

March 3, 1916.

3,224 FORD. Power transmitters.
3,227 BOOTHROYD & CALLENDER'S CABLE & CONSTRUCTION CO. Earthed concentric electric wiring systems.
3,230 B.T.-H. CO. (G.E. CO.) Driving mechanism for machines.
3,233 EWEN & MARCONI'S WIRELESS TELEGRAPH CO. Measuring instruments, relays, &c.
3,234 WALKER. Dynamometers.
3,254 WUNSCH. Electrical measuring apparatus. (4/3/15, U.S.)
3,255 GILLMER. (Sperry Gyroscope Co.) Voltage-regulating systems for electrical circuits.

March 4, 1916.

3,266 NEIL. Signalling appliances for collieries, &c.
3,286 EDWARDS & WOOD. Electric-cable drums, reels, &c.
3,294 B.T.-H. CO. (G.E. CO.) Electric incandescent arc devices.
3,298 MIDGLEY & VANDERVELL & CO. Electric switches.
3,299 MIDGLEY & VANDERVELL & CO. High-tension magnetos.

March 6, 1916.

3,331 STEVENS. Control for petrol-electric cars.
3,334 ECK & KNAPTON. Arc lamps.
3,336 CORNEILLE. Incandescent electric lamps.
3,346 JOEL & MAWDSLEY. Dynamo-electric machinery.

March 7, 1916.

3,363 NEIL. Signalling appliances for collieries, &c.
3,364 COATES. Electric time switches.
3,376 DAVIS. Magnetic separators.
3,379 FLEMING. Apparatus for transmission of speech.
3,382 BRYAN & BRYAN. Electrically-illuminated flexible cords or ropes.
3,388, 3,389, 3,390 WAYGOOD-OTIS (LTD.). (Otis Elevator Co.) Alternating-current electromagnets.
3,391 B.T.-H. CO. (G.E. CO.) Vacuum apparatus.
3,394 SULLIVAN. Telegraphic or signalling systems.
3,410 OLDHAM. Miners' electric safety lamps.
3,413 DAWSON & HOLME. Controlling apparatus for electric motors.

March 8, 1916.

3,420 HIGHFIELD. Means for operating electric lamps.
3,455 HIRST. Treatment of metallurgical.
3,474 WINK. Overhead contact circuits.
3,480 BROWN. Laying feed telephone wires, &c.

March 9, 1916.

3,490 NEIL. Signalling appliances for collieries, &c.
3,509 LYNDEN. Electric relays.
3,515 B.T.-H. CO. (G.E. CO.) Electron discharge devices.
3,533 SIGNAL CO. Multiple-unit microphones. (9/1/15, Germany.)
3,534 GILES. Electric interrupter or valve. (9/3/15, Germany.)
3,536 MERICH. Electric motor cars with propulsive retro-action.
3,543 CLARKE. Apparatus for recording electric signals.

March 10, 1916.

3,559 ALBION MOTOR CAR CO. & MURRAY. Electric car lighting equipments.
3,566 MCCALL. Protective relays for alternating-current systems.
3,598 BALMFORTH & CO. & KITCHEN. Electric furnaces, &c.
3,599 PETTIFER & SIEMENS BROS. & CO. Circuit arrangements for telephone exchanges provided with selecting devices.
3,601 LYNDEN. Thermit telephones and microphones.
3,603 B.T.-H. CO. (G.E. CO.) Obtaining high vacua.
3,622 DEWAR. (Soc.) Silvering and colouring electric lamp bulbs

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

COMMERCIAL TOPICS	59	Industrial Lanterns. Illustrated	10
Imports and Exports of Electrical Manufactures	60	"Reason" Manufactures. Illustrated	11
LEGAL INTELLIGENCE	60	"Efesca" Lanterns. Illustrated	13
Educational Notes	61	An Interesting Portable Plant. Illustrated	14
Business Notices	61		
Liquidations, &c.	61	Tenders Invited	64
Electricity Supply	61	Tenders Received & Accepted	65
Traction Notes	63	Municipal Accounts	65
Telegraph and Telephone Notes	63	Companies' Meetings and Reports	66
Foreign Notes	63	New Companies	67
Miscellaneous Notes	63	City Notes	67
		Electrical Companies' Share List	68
The Round Table	7		
Robey Semi-Portable Steam Engines. Illustrated	8		

COMMERCIAL TOPICS.

Progress of Automatic Telephony. At the recent meeting of the Automatic Telephone Manufacturing Co. (Ltd.), the chairman (Mr. James Taylor, J.P.) gave an interesting account of the progress made by the company in equipping automatic telephone exchanges. He said that during the past year they had succeeded in bringing into service automatic telephone exchanges at Rosario (Argentina), Newport (Mon.), Accrington and Chepstow, as well as several smaller but important exchanges. With regard to the smaller exchanges it might be interesting to note that in cases where a 24 hours' day was being worked it frequently became desirable to install an automatic exchange as compared with eight hours a day conditions, because three operators instead of one were displaced. The company had in hand important automatic exchanges at Portsmouth, Paisley, Leeds and Blackburn. These exchanges were in an advanced state, but owing to the war progress was slow. The Leeds exchange might be further delayed on account of a large extension, but it was hoped that the other three would be completed and brought into use during the current year. He also stated that all the automatic exchanges in use in this country, as well as in Argentina and in India, were working quite satisfactorily. Further progress will probably be checked by the war, as the Post Office, though convinced that automatic apparatus can give a satisfactory service, may like further experience under normal working conditions.

* * * *

Indian Industrial Development. The Government have appointed a Commission to examine and report upon the possibilities of further industrial development in India, with special reference to possible openings for the profitable employment of Indian capital and the development of the resources of the Indian Empire.

Though the Commission will not meet until October, the chairman (Sir Thomas Holland) is going to Bombay to make a preliminary tour and arrange for a prompt investigation. It is to be hoped that the changes in Imperial and international relations rendered inevitable by the war will provide opportunities for Indian development. In addition to the chairman two other members will go out to India and assist in making local investigations. These members are Sir Horace Plunkett and Dr. Edward Hopkinson, M.A. Dr. Hopkinson is well known to our readers as managing director of Messrs. Mather & Platt and deputy-chairman of the Chloride Electrical Storage Co. He is a vice-president of the Institution of Mechanical Engineers, a member of the Institutions of Civil and Electrical Engineers, &c., and is well qualified to act as a member of the Commission.

* * * *

Registration of Firms. The Government have decided that the Registration of Firms Bill cannot be treated as a non-contentious measure, and under the circumstances there is not much chance of the Bill becoming law in the current session. We regret this, because we think the measure could be so modified in Committee as to become quite a useful piece of legislation.

Trade of the Empire after the War. An interesting speech was delivered by Lord Crewe at the recent luncheon given in honour of the Hon. Sir Thomas MacKenzie (High Commissioner for New Zealand), the Hon. W. P. Schreiner (High Commissioner for South Africa) and the Hon. Sir G. H. Perley (Acting High Commissioner for Canada).

Lord CREWE said that he believed that the result of the war would be a closer connection between the Old Country and the Dominions. The most ardent evangelist of a new fiscal system would admit that the project of an economic union between the different parts of the Empire could only be carried out by surmounting great difficulties, affecting not only the domestic relations of different parts of the Empire, but also the extensive relations of the Empire and other countries. There was no upholder of our existing system who would not be prepared to admit that those difficulties demanded further study and examination in consequence of this vast convulsion, which had affected not merely the commercial relations but all the relations of the whole world. In the future we should be bound to consider a closer union, with practically the annihilation of distance as regards ordinary communication. If we ever got a cable service or wireless system both cheap and universal—and vast improvements had taken place and would be sure to take place in the possibilities of individual communication, and the time might come when the shortest and cheapest route to the Dominions would be through the air—the time might not be very distant when a closer form of union between the Dominions and ourselves might be propounded.

Sir GEO. PERLEY agreed that steps should be taken to make the Empire self-contained and economically independent; and Sir THOMAS MACKENZIE also agreed that a scheme for closer union should be evolved.

* * * *

Patent Law Reform. At the recent annual meeting of the Society of Dyers and Colourists the new president (Dr. Réeas), in returning thanks for his election, referred to the present position of our patent law. He said he had been particularly interested in the question of patent law as affecting the chemical and aniline colour industry. The patent law as it was to-day was in favour of the foreign manufacturer and against the best interests of the home manufacturer, and they would all agree with him that one of the first things that would have to be done to help the industry in which they were much interested would be to alter that law in such a way that that crying injustice might be done away with. He was quite satisfied that, with reasonable assistance in various directions, there was no reason why the colour industry should not be established on really successful lines in this country.

* * * *

American Profit-sharing Scheme. The directors of the General Electric Co., of New York, have recently decided to give all employees who have been with them for five years or more a bonus of 5 per cent. of their annual salaries. The company employs over 60,000 persons, and fair proportion of this number will share in the distribution.

It is stated that the bonus has nothing to do with any incidental profits made from war orders or with present good earnings, save so far as the profits have given the proper financial basis upon which to initiate the profit-sharing policy. It would appear to be the opinion of the board that after labour and stockholders have each had their share of income the balance remaining belongs not to the stockholders alone, but partly to stockholders and partly to labour. The right of stockholders is recognised in the form of a stock dividend, and the right of labour will now be appraised in the extra remuneration or profit-sharing scheme. The proposal was a purely voluntary step, but it seems to us to show the breadth of vision and business capacity of the men who are controlling the company. While no promise is made as to the continuance of the scheme, it is reported that it will be regularly continued so far as the earning capacity of the company permits.

* * * *

Australian Electrical Trade. From time to time we have referred to the importance of cultivating the Australian market for electrical plant and supplies. The uses of electricity are extending in the various States, and we believe that there will be a fine field for electrical manufacturers and exporters in the Commonwealth and in New Zealand. In many districts the old stocks of electrical goods are running out and fresh supplies are now urgently required. Government departments and local authorities are entering the electric supply field, thus creating a demand for electrical machinery and plant. The advertisement of the firm

of engineering merchants in Western Australia which appears in another column is a good illustration of this point. The firm desire to add a first-class electrical agency to their business, as, owing to the large power station erected by the West Australian Government in Perth, the use of electricity is bound to increase rapidly for both power and light. In this connection it is interesting to note that since the war Japanese manufacturers have quadrupled their exports to Australia. Notwithstanding the high tariff, this has been possible because of the cheap labour and organisation in Japan. Among the articles exported by Japan to the Commonwealth are electric-light apparatus, insulators, glass, scientific instruments, porcelain, &c. There is a strong desire in Australia to help the Mother Country and to give a preference to British goods. British manufacturers, merchants and exporters should take advantage of the present trend of things, and they should do everything possible to extend their business in the Commonwealth.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From April 1, 1916, *to* April 8, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

GRIMSBY.—*Denmark:* Electrodes, 95 pkgs.

LIVERPOOL.—*U.S.A.:* Carbon electrodes, 176 pkgs. *Spain:* Elec. carbons, 49 pkgs.

LONDON.—*U.S.A.:* Elec. machinery, £1,414; elec. lamps, £171; elec. motors, £334; wire and cable, £282; unenumerated, £2,375. *Holland:* Elec. lamps, £9,429—1,010 pkgs.; incandescent elec. lamps, 178 pkgs.; elec. glow lamps, 32 pkgs.; wire cable, £440; unenumerated, £3,998. *France:* Insulating material, pkgs. 42; unenumerated, £188—60 pkgs. *Switzerland:* Elec. machinery, £1,706; unenumerated, £91. *Italy:* Wire and cable, £223; elec. machinery, £160; elec. wire, 23 pkgs. *Japan:* Elec. lamps, £300; unenumerated, £347. *Denmark:* Unenumerated, £145. *Sweden:* Elec. lamps, £1,559.

MANCHESTER.—*U.S.A.:* Elec. lamp bases, 28 pkgs; unenumerated, 134 pkgs.

SOUTHAMPTON.—*France:* Elec. batteries, 10 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Elec. glow lamps, 2,464 (No.); wire and cable, £398; elec. machinery, £123; telegraph material, £28; unenumerated, £129. *Melbourne:* Elec. machinery, £1,321; wire and cable, £2,429; unenumerated, £614. *Sydney:* Wire and cable, £2,319; elec. machinery, £445; elec. glow lamps, 10,950 (No.); unenumerated, £1,249. *Perth:* Unenumerated, £73. *Christchurch:* Wire and cable, £292; unenumerated, £484. *Dunedin:* Unenumerated, £361. *Lyttelton:* Elec. machinery, £421; wire and cable, £1,288. *Brisbane:* Wire and cable, £172; telegraph material, £46; unenumerated, £443. *Adelaide:* Wire and cable, £215; unenumerated, £1,025. *Napier:* Unenumerated, £16. *Hobart:* Wire and cable, £106; unenumerated, £165. *Newcastle:* Elec. motors, £798. *Gisborne:* Unenumerated, £88. *Wellington:* Wire and cable, £213; elec. machinery, £619; unenumerated, £1,237.

AFRICA.—*Durban:* Elec. machinery, £129. *Cape Town:* Elec. machinery, £171; unenumerated, £133; wire and cable, £390; unenumerated, £626. *Chinde:* Unenumerated, £10. *East London:* Unenumerated, £94. *Port Elizabeth:* Unenumerated, £475. *Beira:* Elec. machinery, £136; unenumerated, £45. *Delagoa Bay:* Unenumerated, £66.

SOUTH AND CENTRAL AMERICA.—*Buenos Ayres:* Wire and cable, £891; unenumerated, £1,064. *Rio de Janeiro:* Unenumerated, £28. *Colon:* Unenumerated, £35. *Guayaquil:* Unenumerated, £80. *Monte Video:* Unenumerated, £89.

U.S.A.—*New York:* Unenumerated, £171.

MOROCCO.—*Casablanca:* Unenumerated, £45.

FIGI.—Unenumerated £73.

WEST INDIES.—*Trinidad:* Unenumerated, £46. *Demerara:* Unenumerated, £70. *Jamaica:* Unenumerated, £138.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Wire and cable, £207 elec. machinery, £407, unenumerated, £1,461. *Calcutta:* Elec. machinery, £1,271, wire and cable, £2,257, unenumerated, £3,720. *Ceylon:* Elec. machinery, £21; unenumerated, £283. *Karachi:* Unenumerated, £48. *Singapore:* Wire and cable, £207; unenumerated, £384. *Bankok:* Unenumerated, £29.

CHINA.—*Shanghai:* Telegraph material, £49, unenumerated, £456. *Hongkong:* Unenumerated, £151.

HOLLAND.—*Amsterdam:* Wire and cable, £125; unenumerated, £397. *Rotterdam:* Wire and cable, £300; unenumerated, £161.

FRANCE.—*Paris:* Unenumerated, £513. *Dieppe:* Elec. machinery, £25; unenumerated, £147. *Dunkirk:* Unenumerated, £789. *Boulogne:* Unenumerated, £51. *Calais:* Elec. cable, £998; unenumerated, £5[illegible].

DENMARK.—*Copenhagen:* Unenumerated, £1[illegible].

GREECE.—*Piræus:* Unenumerated, £34.

NORWAY.—*Christiana:* Wire and cable, £113, unenumerated, £332.

SPAIN.—*Barcelona:* Unenumerated, £20.

ITALY.—*Genoa:* Unenumerated, £1,519.

EGYPT.—*Alexandria:* Wire and cable, £213; unenumerated £295. *Port Said:* Wire and cable, £282; unenumerated, £295.

SWEDEN.—*Stockholm:* Wire and cable, £188.

CANADA.—*Montreal:* Unenumerated, £12[illegible]. *St. John:* Elec. machinery, £177; unenumerated, £2,189.

JAPAN.—*Yokohama:* Unenumerated, £423.

FOREIGN GOODS (duty paid and free).

Bombay: Unenumerated, £14. *Paris:* Unenumerated, £1,212. *Rotterdam:* Unenumerated, £24. *Amsterdam:* Unenumerated, £111. *Brindisi:* Unenumerated, £134. *Calcutta:* Unenumerated, £116. *Christiana:* Elec. machinery, £1,014; unenumerated £161. *Colombo:* Unenumerated, £27. *Copenhagen:* Unenumerated, £132. *Madras:* Unenumerated, £66. *Port Elizabeth:* Unenumerated, £50. *Petrograd:* Unenumerated, £48. *Rangoon:* Unenumerated £14. *Wellington:* Unenumerated £2[illegible].

IN TRANSIT.

Melbourne: Elec. lamps, £559. *Adelaide:* Elec. lamps £8[illegible].

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

LEGAL INTELLIGENCE.

Warranty with Secondhand Motor.

In West London County Court recently, the Electric Generator Co. sued the Forge Motor Works Co. for £9 paid on a false warranty.

The solicitor for plaintiffs explained that, in answer to an advertisement of a secondhand motor which defendants had for sale, his clients opened up correspondence, and defendants guaranteed the motor (a 6 H.P. one) to be in good working order, and quoted the price at £9. Plaintiffs made the stipulation that if the motor was found on testing to be defective they were to be at liberty to return it and have their money back. A cheque for £9 was sent, but the motor was not despatched to them for a fortnight. When it did arrive they happened to be exceptionally busy and could not test it. When this was done, however (in 10 days), it was discovered that it was practically useless. Defendants declined to return the £9, alleging that the machine should have been returned immediately.

For defendants, it was said the motor had been used to drive a band saw. It was about 15 years old. Defendants' manager said his firm had never used it or tried it, and they had paid £7 for it: it had been disposed of to them to give place to two new motors for more extensive work. His firm would have repaid the £9 if the plaintiffs had returned the motor in reasonable time.

HIS HONOUR: But it took you three weeks to deliver it, and you can't complain if they retained it the same time.

DEFENDANT: But they have not returned it yet.

Judgment was given for plaintiffs for £9 (to be paid when the motor was returned), with costs.

Magnetic Separation of Wolfram.

On Friday last the Patent Court heard the application of the Rapid Magnetting Machine Co. (Ltd.) for a licence to use three of Krupp's patents for a magnetic separator for treating ores. The patents are 14,082 of 1908, 29,230 of 1911, and 4,595 of 1913.

Mr. Hunter Gray appeared for applicants; Sir Geo. Croydon Marks, M.P., represented Messrs. Edgar Allen & Co. (who opposed); and Mr. Rushen (Messrs. Haseltine, Lake & Co.), the patentees, who also opposed.

Mr. GRAY said the patents were held by a firm whose name they heard from time to time in that Court, and he seldom had a more pleasant task in seeking to get German patents suspended than in the present case.

Sir GEO. C. MARKS said he intended applying for a dozen patents in connection with that machine at a future date, and he did not know how the applicants thought they could get on with only three.

Mr. GRAY said that they had made a judicious selection. The Rapid Co. was incorporated in 1903 and it supplied many public departments and companies. Its catalogues showed 14 different types of magnetic separators, made in 100 or more different sizes, and ranging in price from £200 to £1,000. The principle of the machine applied for was that of a number of magnet poles placed in a ring over which rotated a disc-shaped magnetisable body. The electro-magnets below, with the attached pole-pieces, were excited by coils, and a rotating shaft, to which the upper ring or disc-shaped armature was attached, ran through the centre of the circular iron body which carried the magnets. Between the magnets and the armature rotating above them the material, from which the metal was to be drawn, was fed in from a hopper. Round the underside of the revolving piece went concentric magnetisable axially-adjustable rings, wedge shaped below, at graduated distances from the magnets. The outermost ring-edge was the furthest away from the horizontal pole surfaces, and therefore produced the weakest zone in the magnetic field. This attracted particles of the highest permeability, whereas the inner ring-edge was nearest the pole-surfaces, produced the strongest zone, and consequently attracted substances of lower permeability. Thus, the material was graded midway between the magnets, the attracted particles fell off the rings, the place of minimum magnetic intensity having been reached, and were carried away in different directions in their separated and graded form. In the 1911 patent the armature-rings were fixed, and the "field" below was fixed, and there was a curious zig zag-shaped trough running from the centre through which the ore travelled. It was this trough now that revolved. The result was that the ore did not "stick," but it was carried away equally in graded sizes. It was an adjustment of the same principle and an improvement, and it was called the dry treatment. There was a further modification known as the wet treatment, where water was played upon the points of the wedge shaped rings to drive off the ore as it got out of the field.

Sir GEO. C. MARKS complained that applicants' managing director had written a letter to the technical journals, casting doubt on the special value of that machine, and he could not understand why he now came to ask for a licence to manufacture it.

Mr. GRAY: Because the public wanted it—misguidedly and foolishly they wanted it—and his firm had more experience than any other for making and selling it. They suggested the usual royalty of 5 per cent. on the selling price, and would give an undertaking that the price at which they sell shall be at least not more than the price charged by the patentees before the war. Krupps sold them here, through their agents, before war broke out. A gentleman from the Malay States, who said it was time to cultivate the East as a field for magnetic separators, had expressed his preference for a Wetherill or an Ullrich, because, as it happened, strangely enough, it was all you could see in the School of Mines; there was not an English machine there at present, and anybody who came

from the colonies to see the latest development in appliances for mining work was humiliated to find not a single British machine recommended.

Mr. H. H. THOMPSON, managing director of the Rapid Co., stated that he was not aware that the Ullrich machines were required in this country and had actually been ordered on behalf of the British Government, and that facilities have been given that that machine might be copied.

Sir GEORGE: And in consequence of facilities having been given to copy the machine Messrs. Edgar Allen & Co. are making it. If Messrs. Edgar Allen & Co. may have a licence for a 5 per cent. royalty too, that will simplify matters considerably. We are prepared to develop the sale. The Government allege they have found that no machine will do what that one does.

Mr. THOMPSON: I tell the Government we will do everything the German will do, absolutely. Perhaps this is a good opportunity for the public to know that the Government are not investigating a British machine which will do anything and everything that can be done by a German machine. He insisted that it was an extraordinary thing that the Government had not a British magnetic separator at the Imperial College of Science at South Kensington. His firm had only pushed their high-intensity magnetic separator since the war broke out, and had not had the opportunity to make the authorities a present of one.

Mr. GRAY: This place, being the home of the electric magnet, it is ludicrous to say that the Germans can make them anything like so well.

An adjournment was asked for by Mr. Rushen to bring into Court Mr. Walter Sully, whose wife's daughter was the inventor Ullrich's wife, in order to say he had practically concluded arrangements, when the war broke out, for erecting a factory for supplying the machines in this country.

The CONTROLLER: Why doesn't he come to this Court and get a licence at 15 per cent. instead of paying 30? I am afraid his evidence would not be much use without his documents. If he cannot carry on the business I don't see why he should wish to oppose. What did he propose to sell at?

Mr. RUSHEN: A two-field machine at £420. Of this £150 would be premiums; 15 per cent. would go to Krupps and 15 per cent. to Mr. Ullrich. At any rate 5 per cent. is sheer forfeiture.

Mr. GRAY: I don't know. We shan't have the advantage of the drawings and his exclusive licence—and we shan't get the parts from Germany. We shall have no professional assistance.

Mr. RUSHEN, in reply to a question, said a four-field machine under Mr. Sully's scheme would have cost £700 and a six-field £1,050.

Mr. THOMPSON: And we shall supply at from £200 to £1,000.

The CONTROLLER said he thought the application satisfactory. The only question was the royalty, and he should hear more about that next week. In the public interest he thought it advisable that the machine should be made in this country, and clients' letters he had seen showed the estimate in which it was held. The applicants desired to say: "We can supply an efficient British-designed machine, but if any customer is unpatriotic enough to require another type we can give him it." Their position was quite intelligible. The machine must be made in this country to meet the demands, and, that being the position, he thought the Rapid Magnetting Machine Co. should have their licence.

Munitions Tribunal Appeal.

On Friday last Mr. Justice Atkin heard an appeal by the Micanite & Insulators Co. (Ltd.) from the decision of a Munitions Tribunal that they were not an engineering firm within the meaning of the Munitions of War Act, and therefore it was unnecessary for an employé to have a certificate on leaving their employ.

Mr. ALEX. NIELSON (for appellants) said that they were the makers of insulators and insulating materials for dynamos, &c., that 95 per cent. of their work was for Government contracts, that during the last day or two workers in that trade had been put in the exempted list, and skilled men in the Army had been fetched back. Appellants' works were the only works of any substance to make micanite in this country, and he argued that that brought them under the definition of munition works.

Mr. Comyns Carr appeared for the Ministry of Munitions, and evidence was called.

In giving judgment, his LORDSHIP said the finding of the tribunal was that appellants' business did not consist wholly or mainly of engineering, and therefore a leaving certificate was not necessary. But appellants had tendered evidence to indicate that their business was of a wide and different kind, and he was satisfied from that that they were engaged exclusively in making by means of machinery articles which were the necessary parts of dynamos and other machines which were used for war purposes and for the production of power. Under those circumstances the question arose whether it was right or wrong to find that they were not engaged in engineering. The meaning of the word "engineering" had to be read in connection with the definition of munitions works in the Act. That definition applied to a factory or workshop engaged in manufacturing arms, explosives, the repair of arms, naval and military buildings, and the supply of light, heat, water and power to such buildings. Having regard to that, he came to the conclusion that the finding of the tribunal was incorrect, and that their decision must be set aside.

Re Cia de Electricidad de la Provincia de Buenos Ayres.—Last week Mr. Justice Neville sanctioned a petition by the company to a scheme of arrangement. It was stated that the company had got into difficulties with its sinking fund. There was one series of 900,000 5 per cent. gold bonds. The scheme provided that in 1916 and 1917 the interest was to be at the rate of 4½ per cent. In 1919 it was to be 6 per cent., but except for that the interest was to go on at 5 per cent. The sinking fund was to be suspended until 1919 except in so far as the net profits were sufficient, and the sinking fund was to be recouped out of future profits if the profits were sufficient. The sinking fund is for the future to be divided into two parts, half to be paid in any event and the other half only if the profits were sufficient.

EDUCATIONAL NOTES.

University of Liverpool. In the faculty of engineering of this university there are full courses in civil, electrical and mechanical engineering, naval architecture, marine engineering, chemistry, physics, &c. The special matriculation examination or the entrance examination must be passed in order to secure admission to the courses in the faculty, and prospectuses may be obtained from the registrar, Mr. Edward Carey.

Crystal Palace School of Engineering. The home of this school will in future be at Anerley-hill, S.E.

Education after the War. The President of the Board of Education has appointed a Departmental Committee to consider what steps should be taken to make provision for the education and instruction of children and young persons after the war, regard being had particularly to the interests of those

(1) Who have been abnormally employed during the war;
(2) who cannot immediately find advantageous employment;
(3) who require special training for employment.

The chairman of the Committee is Mr. H. Lewis, M.P., and there are 14 other members of the Committee of which Mr. J. Owen, H.M. Inspector, is secretary.

BUSINESS NOTICES.

A firm of engineering merchants in Western Australia advertise that they are desirous of adding a first-class electrical agency to their business. Applications to Messrs. Hopcraft & Broadwater, 4, Fenchurch-avenue, London, E.C. *See an advertisement.*

Plant for Sale.—Gas driven electric station plant, consisting of two gas engines (80 H.P. and 100 H.P.), two gas producers, dynamos, storage battery, switchboard, &c., is advertised for sale. Particulars from the manager, Corporation Electricity Department, Mr. C. Nelson Hefford, 1, Whitehall-road, Leeds.

In an advertisement particulars are given of second-hand Parsons' steam turbo sets which are offered for sale.

An advertiser offers a 5 kw. Berry transformer for sale.

Plant Wanted—An advertiser requires a turbine engine in first class condition. Applications to "Phillipps," 31, Bishopsgate, London, E.C

An advertiser requires large quantities of steel tubes and lampholders, various sizes and patterns.

LIQUIDATIONS, &c.

Collings-Bishop (Ltd.) is being wound up voluntarily, and Mr. E. W. J. West, 67, Queen Victoria-street, London, E.C., has been appointed liquidator.

A meeting to receive an account of the winding-up of Inventions and Appliances (Ltd.) will be held at 36, Church-st., W. Hartlepool, May 15.

Mr. J. H. Stephens, 6, Clement's-lane, London, E.C., has been appointed liquidator (without a committee of inspection) of the Admil Electric Co. (Ltd.), Artillery-lane, London, E.C.

ELECTRICITY SUPPLY.

EXTENSIONS.

Accrington.—The Council have authorised certain extensions of the electricity supply works at an estimated cost of £15,000 or £16,000.

Bexley.—The Urban Council have decided to extend the electric supply cable to Halcot.

Bradford.—The Electricity Committee is putting down additional plant at the Valley-road electricity supply works, and the L.G. Board have been asked to sanction the borrowing of the necessary money.

Carnarvon.—Owing to the increasing demand for electrical energy the National Electric Construction Co. is putting down an additional Diesel oil engine set at a cost of £2,780. 10s., and the Council have applied for sanction to borrow this sum.

Rotherham.—The Town Clerk has received a certificate under the Munitions of War Amendment Act in respect of the electricity undertaking.

The Electric Lighting Committee proposes to purchase an additional rotary converter (at £690) to meet the demand from Tinsley. The cost will be defrayed out of the renewals fund.

Sheffield.—Electric supply mains are to be extended in various parts of the city at a cost of £479.

The Town Clerk has been authorised to complete the purchase of a plot of ground at the junction of Fulwood and Endcliffe Vale-roads as a site for a sub-station.

Watford.—The Urban Council have applied to the L.G. Board for sanction to a loan of £3,300 for the electric supply department.

Wolverhampton.—The Electricity Committee reports that owing to the continual demand for electrical energy it is necessary to make extensions to the generating plant in order to cope with the load which will be required during the winter of 1917.

Having considered reports of the electrical engineer (Mr. S. T. Allen) the Committee recommends extensions of the boiler house plant (at £17,160), including two water-tube boilers, each having an evaporative capacity of 40,000 lb. of steam per hour, mechanical stokers, &c. (£8,000). feed, steam and blow-off piping, forced draught, feed pump and coal and ash-conveying plants, &c. The Committee also recommends that application be made for sanction to borrow the above-mentioned sum, and that a tender be accepted for the supply of two boilers, two superheaters and two sets of mechanical stokers, at £8,221. 15s. be accepted.

It is also proposed to apply for permission to borrow £6,600 for defraying expenditure on extensions to mains, &c.

GENERAL.

Aberdeen.—In reply to an application by the Aberdeen District Committee for an abatement in view of the discontinuance of the public lighting of Culter, the Town Council have decided to allow an abatement of one-half the annual charge per lamp for electricity supply during such period as the lamps are not being utilised, but the charge for maintenance (10s. per 50 c.p. lamp per annum) will be continued.

Battersea (London).—The Electricity Committee has been in communication with Fulham as to the supply of energy in bulk.

The engineer (Mr. F. A. Bond) has reported as to tests made by arranging for Fulham to give a supply of energy during January, February and March. The tests have proved satisfactory and the Committee is, therefore, arranging for a continuance of this supply during the year ending March, 1917.

Belfast.—At the last meeting of the Corporation, Councillor McCaughey, in presenting the minutes of the Tramways and Electricity Committee, explained that they were not at present keen on giving stand-by supplies of electrical energy, especially as they had no great margin to deal with.

The Committee felt their first duty was to the shopkeepers and other consumers who took current all the year round. They were being badly hampered in the way of expenditure in order to meet the ordinary demands of the public. In regard to the wages and bonus question, he was anxious to secure uniformity, and in regard to contracts being given to cross-Channel firms the Committee had, as they were bound to do, accepted the lowest tenders.

Coal Supplies.—A circular letter has been issued to the engineers of electricity works by the Incorporated Municipal Electrical Association, stating that the Board of Trade had now instituted committees on coal and coke supplies in districts throughout the country, and suggesting that local authorities should approach their local committee.

Dartmouth.—The local electric supply company has increased the charge for electric current for power by 10 per cent.

Fuel Economy.—A meeting of fuel producers and fuel users was held in Sheffield last week to consider the question of fuel economy after the war. The meeting, which was held under the auspices of the Sheffield Society of Engineers and Metallurgists, was presided over by Prof. Arnold, and Prof. W. A. Bone was among those present.

Prof. Arnold said at present it was no use, from a practical point of view, in Sheffield to consider the waste gas from beehive ovens, as the beehive coke was, so far, the only reliable coke for melting crucible steel. The waste energy of the South Yorkshire coalfield would have to be harnessed, either as gas or as electrical energy, for iron or steel melting, machine driving and lighting. He thought the electrical proposition would be the best course.

Prof. Bone said our whole economic future was dependent on our ability to maintain abundant supplies of relatively cheap coal. Only 2·6 per cent. of the total coal reserves of the world were located in Great Britain, and the question of the better utilisation of our coal supplies was one of very serious economic importance. We now transacted 70 per cent. of the seaborne coal trade of the world. An export duty of 1s. per ton could be imposed without in the least injuring the trade. It would produce a fund of £5,000,000 per annum, and he suggested that this should be ear-marked by the Treasury for financing large scale experiments in the direction of fuel economy and for the provision of loans for installing efficient fuel-consuming appliances.

Prof. L. T. O'Shea spoke of the economies which might be effected by extending the use of by-product coke ovens. He urged the importance of investigations with a view to producing a satisfactory steel-melting coke from by-product ovens. If the steel manufacturer would meet the coke maker with an open mind, the time ought quickly to come when the beehive oven would disappear from England. A large amount of coke oven gas was being wasted in the neighbourhood. It could be used for the production of power in the same way that gas obtained from the retort was used, and also for the generation of electricity. At Wharncliffe Silkstone Mr. G. Blake Walker had used the surplus gas from the ovens in order to electrify the colliery.

Mr. G. Blake Walker spoke of the tremendous amount of coal that was lost to the country through the custom of working only the best coal. It was essential that they should deal with inferior coals, and that could be done by the use of washers and gas producers. In his opinion, what had been done in Durham would have to be done in that district—electricity would have to be sold very cheaply and substituted for the present wasteful use of steam. He thought it not impossible that by the use of a central power station electricity might be produced at a cost of 0·25d. per unit, which would facilitate economies at the collieries themselves, and the expansion of the use of electricity for heating and other purposes in Sheffield. He believed it to be a thoroughly uneconomical thing for every manufacturer to produce his own power.

Prof. Ripper also advocated the distribution of electricity from a central power station. There was almost unlimited power available in the great coalfield surrounding Sheffield. If they could bring current in at the figure mentioned by Mr. Walker it would make an enormous difference to the city. The present industries would be vivified, and a number of new ones would be induced to arise.

Mr. S. E. Fedden, manager of the Corporation electricity department, urged that the supply of electricity and power throughout the country should be vested in the hands of the Government. Big power houses should be put down in suitable places, and we should have an Electrical Minister. He also urged that the way to secure efficiency and economy in the use of power was to stop dumping, which would enable the works to carry on at a good load factor and at reduced standing charges.

Several other speakers took part in the discussion.

Fulham (London).—The Electricity Committee recommends that Mr. G. Hicks, assistant mains superintendent, be also appointed supervisor of meters at a salary of £160, rising to £200 a year.

Hammersmith (London).—The Board of Trade has consented to power not exceeding 200 kw. being supplied to the Council's underground sub-stations. The premises of 57 additional consumers have been recently connected to the mains.

Lighting of Workmen's Dwellings.—Dublin Corporation have decided to adopt electric lighting for the workmen's dwellings to be erected under the New Spitalfields, North Lotts and Newfoundland Street housing schemes.

Rathmines.—In order to economise in street lighting it has been decided that every alternate electric lamp is to be left unlighted during the current year.

Sheffield.—The L.G. Board have extended for one year from March 31, 1916, the time limited by the Sheffield Corporation Act, 1912, for the continuance in force of the provisions of sec. 130 (2) of that act enabling the Corporation to borrow by way of temporary loan or overdraft for providing temporarily during any financial year for certain current expenses.

Torquay.—The Electric Lighting Committee reports that the consumption of electrical energy for the first two months of the current year created a record, whilst the figures for 1915 showed a net profit of £1,200, which had been used in extending the services and the business of the electric supply undertaking generally. There was no possibility of the price of electric current for lighting being reduced at present.

Walsall.—A certificate under the Munitions of War (Amendment) Act has been received in respect of the electricity undertaking.

The Electricity Committee has decided to place certain sums received on the sale of superseded plant to a special account to be utilised in repayment of the outstanding debt on plant.

Westminster.—The St. James' & Pall Mall Electric Light Co. has advised the City Council of their inability to renew the existing contract for the supply of current to the Council's premises, and that they will be compelled from June 24 next to charge the supply for lighting at 4d. per unit net. It is not proposed to increase the charge for power supply.

Wigan.—The Council have decided to appoint Mr. H. Dickinson, city electrical engineer of Liverpool, subject to the sanction of Liverpool City Council, as consulting engineer to prepare a report on the present position of the electric supply undertaking.

Wimbledon.—It is proposed to make a 10 per cent. increase in the charges for the supply of energy to ordinary consumers for the ensuing six months.

It is not considered desirable to enter into contracts this year for periodical supplies to the electricity department. Offers have been obtained from a number of firms for the supply of various goods, and it

is proposed to accept these and to purchase the remainder of the supplies as required at the lowest prices obtainable.

Worksop.—It is reported that the electrical engineer (Mr. J. P. Crowther) has been given leave of absence to join the Army, and he will be paid half his salary during his absence, while the electricity works will be placed in charge of the station superintendent (Mr. J. Fletcher), who will get an additional salary of £25 per annum.

TRACTION NOTES.

Burnley.—The Tramways Committee has increased the charges for all privileged tickets by 7½ per cent.

Colwyn Bay.—It is stated that the report of the Board of Trade inspector (Col. Druitt) has been presented.

Col. Druitt favours the use of double-deck tramcars being allowed to run on the electric tramway between Old Colwyn and Penrhyn Bay, subject to certain parts of the track which are showing signs of slight settlement being re-packed. Col. Druitt states that he found the line for the most part very well laid and equipped, and recognised the difficulties of the company in obtaining the necessary labour for maintenance during the war.

Dover.—Owing to the great difficulty in getting coal from the railway station the borough electrical engineer (Mr. L. W. Woodman) suggests the use of tractors to transport the coal to the works.

Mr. Woodman also suggested that the matter of increased storage capacity should be again considered. It was, however, decided to refer the matter to the chairman, the vice-chairman, councillor Barnes and Ald. Lewis as a sub-committee.

Ipswich.—In future the tramcars will stop running one hour after sunset.

Motor Road Sweepers.—Recently the Shoreditch (London) Borough Council were charged with duty on an imported motor road-sweeper, but owing to the protest made by the Council it is now announced that motor road-sweepers will in future be regarded as exempt from the ad valorem duty.

Middlesex Tramways.—Metropolitan Electric Tramways (Ltd.) has asked the Board of Trade for sanction to run trailer cars.

Nelson.—The Electricity and Tramways Committee has decided to place on record its appreciation of the gallantry of Corporal J. W. Smith, a tram conductor in the employ of the department, who has been awarded the D.C.M.

Perth.—The Corporation have granted an increase of 2s. per week to their tramcar drivers.

Rotherham.—The Tramways Committee recommends the Corporation to exercise the option to purchase the additional 11 bogie tramcars from Oldham Corporation.

Tramway Strike.—The strike which broke out on the South Metropolitan Tramway Co.'s system last week, owing to a dispute as to the employment of women tramcar drivers, continues.

On Tuesday it was announced that the Board of Trade had intervened in the dispute. It was suggested that the points at issue should be referred to arbitration, but though the South Metropolitan and the London United Tramway Companies were willing the Croydon Corporation to whose system the strike had spread) refused. At Croydon about 200 drivers and conductors of the Corporation tramways came out in sympathy with the South Metropolitan workers, who originally struck because two women had been taught driving. Only 18 cars were running in Croydon on Tuesday, against the usual 60 or so, and on Wednesday the service started at 8 o'clock with only ten cars and finished at 8 p.m. The increased wages and other concessions asked by the workers would (it is stated) cost £10,000 a year, or a 2½d. rate.

Tramway Transfer.—It is proposed to lease the tramways in Swinton and Pendlebury Urban District to Salford Corporation.

The lease provides that the Corporation shall reconstruct and equip the tramways for electric traction ; the period of the lease is 21 years ; the Corporation to pay the Urban Council a rental sufficient to pay off in equal annual instalments in 21 years the capital outlay incurred in the purchase of the tramway and the costs in connection therewith.

TELEGRAPH & TELEPHONE NOTES.

Radiotelegraphy.—"Engineering" announces that a large new wireless station is about to be erected at Ooresäter (Norway), and that the contract has been let to the Gesellschaft für Drahtlose Telegraphie of Berlin.

The station, which will have masts of 100 metres in height, is intended for correspondence with the large European wireless stations. It is also proposed to erect a smaller station for shipping. It is expected that the new station, which will be equipped on the same principle as that at Nouen, will be ready in the autumn, and the cost will be about £22,000.

FOREIGN NOTES.

Spain.—The Ministerio de Fomento has granted permission to Don Tomás Garmendía to utilise, at the rate of 2,570 litres per second, the waters of the Reburdiejos and Sejos streams, in the district of Los Tojos (Province of Santander) for the production of electric power for industrial purposes.

Swedish Exports.—Manganese ore and gas meters have been added to the list of goods which are prohibited for exportation from Sweden.

Swedish Water-power Plants.—The Swedish Water-power Association has published a pamphlet, by Mr. Axel Rappe, on new water-power plants in Sweden in 1915.

The total is 23,000 H.P., exclusive of the State works at Porjus and Alfkarleby, and the purposes for which the new plants are used include the iron and mining industry, 9,000 H.P. ; timber, wood pulp and paper industries, 12,000 H.P. ; chemical industry, 1,500 H.P. ; textile industry, 500 H.P. ; and sundry purposes, 5,000 H.P.

Venezuela.—The Ministerio de Fomento has granted permission to La Cumaca Electrical Co., of Valencia, State of Carabobo, to erect electric power transmission cables and to construct telephone lnes.

The Ministerio de Fomento has granted permission to General León Jurado, of Coro, to construct a telephone line (about 31 miles) in Silva and Acosto, Falcón State. Telephone concessions have also been granted to Señores Umérez and Herrera, of El Consejo, for a line (of about 6 miles) in the Ricaurte district of the State of Aragua, and to Visitación Lugo and Manuel Gómez, of Lagunetas, for a line of about 9 miles in the municipality of San Pedro, State of Miranda.

The Ministerio de Fomento has granted permission to Senor Alfredo Jahn, of Caracas, to construct a telephone line, about 25 miles in length, connecting his lands in the Department of Vargas with the capital.

MISCELLANEOUS NOTES.

Alien Enemy Patents.—Messrs. Edgar Allen & Co. have applied for licenses under eight patents granted (in 1909, 1911 and 1913) to Fried. Krupp Akt. Ges. Grusonwerk for magnetic separators.

It is announced hat the British Thermit Co. (Ltd.) has obtained a licence to use eight of the Thermit patents.

Application for Extension of Patent.—Messrs. F. G. Creed, W. A. Coulson and Creed, Bille & Co. have petitioned the High Court to extend the term of letters patent No. 22,653/1902, and notice of opposition must be lodged before May 23 at the chambers of Mr. Justice Sargant.

Contracts with Alien Enemies.—Gateshead Corporation have adopted the resolution recently passed by Manchester Corporation not to enter into contracts with persons of German or Austrian nationality or companies controlled by similar persons.

Last week Salford Corporation also decided to adopt the resolution recently passed by Manchester City Council—viz., "No contract shall be entered into with any person of German or Austrian nationality."

Electricity Supply Undertakings and Munition Works.—By Sec. 9 (1) (D) of the Munitions of War (Amendment) Act, 1916, the Minister of Munitions has authority to certify undertakings supplying light, heat, water-power or tramway facilities to be of importance for carrying on munition work.

The effect of granting such certificate is that the undertaking will be subject to the provisions of Part I. of the Munitions of War Act, 1915, which prohibits strikes and lock-outs. Under sec. 4 of the Munitions of War Act, 1915, certified undertakings may be declared controlled establishments, but the Ministry of Munitions does not propose to take this course at present. The provisions of the Munitions of War Acts relating to leaving certificates will apply to undertakings so certified.

More Enemy Firms Wound Up.—The Board of Trade has now issued orders for the winding up of 100 companies or firms controlled by alien enemies :—

The latest list includes Ferrum (Ltd.), agents for hydraulic pipes, 199, Winchester House, Old Broad-street, London, E.C.: Allolit Co., agents for aluminium foil, 4, Charles-street, Hatton Garden, London, E.C.: Berkefeld Filter Co. (Ltd.), 121, Oxford-street, London, W.: Maschinenfabrik Augsburg-Nurnberg A.G., Caxton House, Westminster, S.W.: and P. M. Krebs & Co. (Ltd.), dealers in heating apparatus, &c., 3, Old Gloucester-street, London, W.C.

Supplementary Examination in Electric Light Switching.—At the end of this month the results of the competition just closed will be published in this journal. Meanwhile we are asked by Messrs. A. P.

Lundberg & Sons to announce the fact that, owing to the success of this competition, a supplementary examination will be conducted shortly on the same sets of problems.

Particulars will be issued to old and intending new competitors early next month, and meanwhile those who have a copy of the February examination pamphlet should keep it by them. Those who have not can obtain one on application to the firm at 177-187 Liverpool-road N. within the next three weeks.

Trading with the Enemy.—The Foreign Trade Department has issued recently several instalments of a statutory list of firms of enemy nationality or association with whom all dealings by persons carrying on business in this country are prohibited.

Transactions with such firms are prohibited, subject to the same penalties as transactions with firms in enemy countries, except in cases where a general or special licence has been granted, permitting the transaction. Application for licences should be addressed to the Controller, Foreign Trade Department, Lancaster House, St. James', London, S.W., giving name and address of applicant, name and address of the buyer, date of order of goods, nature of the goods, prospective date and port of shipment, &c., if ready for shipment, marks and numbers, and name of the actual consignee, whether the goods are season goods, and if so when season commences, all other current orders from same buyer.

Further lists of firms and persons in neutral countries with whom trading by persons in the United Kingdom is prohibited were published in the "London Gazette" of April 7. These include the following: *Netherlands:* Allgemeine Electricitäts Gesellschaft, Amsterdam; Continental Caoutchouc & Gutta Percha Co., Prinsengracht 1077, Amsterdam; Ozonwerken "Nederland," Schiedam.

The following is removed from a previous list: *Greece:* Karl Weber, Athens.

The following is a variation of an entry in the list published Feb. 29: *Netherlands:* Deventer Glas Maatschappij (N.V.) Deventer, should read: Deventer Glas Maatschappy Vorheen J. Pouvels Coelingh (N.V.) Deventer.

Trading with the Enemy.—The Controller of the Foreign Trade Department wishes to impress upon houses engaged in foreign trade with neutral countries the necessity of complying with the Royal Proclamation of Feb. 29, 1916, containing a statutory list of firms of enemy nationality or association with whom dealings by persons and firms resident or carrying on business in this country are prohibited, and to the subsequent additions which have been made to the list by Orders of Council and published in the "London Gazette" of March 16 and 24 and April 7.

It is desired to point out that all transactions with persons or firms on the statutory list are strictly prohibited under similar penalties to those attaching to transactions with persons or firms in enemy countries, except under a general or special license granted by the Foreign Trade Department. It is also desired to point out that transactions with persons or firms on the statutory list include, as well as actual sales to or purchase from such persons or firms, all correspondence therewith in regard to past or pending business, and the receipt or payment of money.

The Controller wishes to warn all concerned of the necessity of making themselves acquainted with, and strictly observing, these regulations, as notwithstanding a previous notice and the publication of the lists in various trade journals, a large number of individuals and firms appear to be unaware of their obligations in the matter, and of the penalties to which they are rendering themselves liable by neglecting them. Houses engaged in foreign trade with neutral countries are strongly advised to ensure that they obtain the lists as they appear by ordering them to be supplied regularly. All applications for licenses should be marked "Application for License" on the envelope and addressed to the Controller, Foreign Trade Department, Lancaster House, St. James', S.W.

Tribunal Cases.—At Burnley last week an electrician made application for his motor repairer and armature winder.

The Mayor: It will be easy to have this work sent away?—Not at present. We are doing work for firms on Government work.

Application was refused.

At Cupar and St. Andrews an electrician employed at Guardbridge Paper Works was granted until June 30.

TENDERS INVITED.

Water Tube Boilers.

Tenders are invited by the electricity department of the County Borough of WEST HARTLEPOOL for the supply and erection of two Water-tube Boilers, with Superheaters and Mechanical Stokers. Conditions of contract, specifications and form of tender from the borough electrical engineer, Mr. J. W. Spark, and tenders, addressed to the Town Clerk, must be delivered by April 28. *See an advertisement.*

Switchgear.

SALFORD Corporation require tenders by noon April 17 for the supply, delivery and erection of Three-phase Extra-high-pressure and low-pressure Switchgear for three 5,000 kw. sub-station equipment. Specifications, &c., from the burgh electrical engineer, Mr. J. A. Robertson, Frederick road, Salford.

Electricity Meters and M.D. Indicators.

The Council of the City of MELBOURNE (Australia) invite tenders for the supply of Electricity Recording Meters and Maximum Demand Indicators. Specifications, &c., from the Agents for the City Council, Messrs. Mellwraith, McEacharn & Co. Pty. (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders are to be sent by noon, May 1.

Turbo-Alternator, Gas Producer Plant, &c.

The NEW SOUTH WALES GOVERNMENT Railways and Tramways Department invite tenders for the supply and erection of a 2,500 kw. Turbo-Alternator for the Zarra street (Newcastle, N.S.W.) power house. Specification (No. 470) from the Electrical Engineer, N.S.W. Government Railways and Tramways, 61, Hunter-street, Sydney. Tenders to Chief Commissioner for Railways and Tramways, Phillip-street, Sydney, by noon May 3.

WANGANUI (N.Z.) Borough Council require tenders by noon May 9 for the supply and erection of Additional Plant at their tramway power house, including Pressure-type Gas Producer Plant, Gas Engine, Electric Generator and Switchgear. Specification, &c., from the Town Clerk.

Sub-Station Equipment.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. April 26, for the supply of Electrical Equipment and Accessories for sub-station for the Sandringham-Black Rock tramway (contract No. 29,762). Specifications and forms of tender from the Victorian Railway Commissioners, Melbourne.

Tramway Construction, Tramcars, &c.

The Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, require tenders by May 19 for the construction and working, for 60 years, of an electric Tramway in BILBAO, connecting the existing system with the Irala-Barri district. Minimum rolling stock required to commence is one motor and one trailer coach for passengers, and one motor goods coach and two trailer goods wagons. An option on the concession is held by the Sociedad Tranvia Urbano de Bilbao.

DUNEDIN (N.Z.) City Council require tenders by 5 p.m. May 17 for six Electric Tramcars and sections of Cars (Bodies, Electrical Equipments and Trucks). Specifications, &c., from the Town Hall, Dunedin.

JOHANNESBURG (Transvaal) Council require tenders by noon June 6 for supply of two Manganese Steel Crossings. Specification, &c., from the Municipal Offices, Johannesburg.

Telegraph and Telephone Material, &c.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. April 18 for supply of 8,500 Fuses (schedule 1,299) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification from Deputy Postmaster-General, Melbourne.

Tenders will be received until 3 p.m. April 26 by the Deputy Postmaster-General, Brisbane, for supply at Toowoomba Exchange (Queensland) of five Sections of Trunk Line Switchboard (Schedule 342) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specifications, &c., from the Deputy Postmaster-General.

Car Lighting Material, &c.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. April 26 for Car Lighting material, including i.r. Cable, Switches, Lamp Cartridge Fuses, Plugs, Sockets, &c. (contract No. 29,784); and by 11 a.m. May 10 for Motor Generator and Accessories for Battery Charging of Baggage Trucks, also Switchboard and Connections (contract No. 29,796). Specifications from Spencer-street, Melbourne, Victoria.

Electric Elevator.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. May 17 for the supply and erection of a 2-ton Electrically operated Goods Elevator at the Jolimont car shed. Specifications from the Commissioners' Office, Spencer-street, Melbourne

Water Softening Plant.

WALTHAMSTOW Urban Council require tenders by 5 p.m. April 26 for the supply and erection of a Water-softening Plant, to deal with 5,000 gallons of water per hour, for the electricity department. Specification, &c., from the Engineer, electricity department, Priory-avenue, Walthamstow.

Wiring and Fittings.

MANCHESTER Guardians require tenders by April 17 for Electrical Materials required in connection with the additional electric lighting of the main side of the Withington Institution. Particulars from the Acting Master of the Institution, Nell-lane, West Didsbury, Manchester.

PORTSMOUTH Corporation want tenders by 10 a.m. April 18 for the installation of Electricity Supply in the extension of the Infectious Diseases Hospital, Milton. Forms of tender, &c., from the Borough Engineer.

Boiler Plant and Economiser.

WARRINGTON Electricity and Tramways Committee require tenders by noon April 26 for supply of Boiler Plant and Economiser. Specification from Borough Electrical Engineer.

TENDERS RECEIVED AND ACCEPTED.

PORTSMOUTH.—The corporation has accepted the following tenders for stores for the tramways department:—

Bromall Patents Co., insulating materials; Scholey & Co., steel tramway tyres (£3. 19s. per tyre); Spicer Bros., P. R. Jackson & Co., Micanite & Insulators Co., Mica Mfg. Co., General Electric Co. and Carr Bros., insulating tapes; British Thomson-Houston Co., incandescent lamps; Fleming, Birkby & Goodall and F. Smith & Co., overhead line material; Engelbert & Co., Vacuum Oil Co. and Worsingham & Co., lubricating oils, &c.

MANCHESTER.—The Guardians have accepted the tender of R. Springer, at £57. 10s., for completing the wiring of the Withington Institution.

LIVERPOOL.—The tender of J. C. Nicholls (Ltd.) has been accepted for six months' supply of glass to the lighting department.

SHEFFIELD.—The following tenders have been recommended to the City Council for acceptance:

W. Marlow & Sons, erection of Sidney-street sub-station, £1,910, and erection of Stanley-street sub-station, £1,216; Mortimer, Lyon & Co., increasing efficiency of the six-cell unit at Lumley-street destructor by 75 per cent., £1,029; Edison Accumulators (Ltd.), 3-ton wagon, £1,200, 2-ton wagon, £1,090.

WESTMINSTER.—The guardians have accepted the tenders of Popes Lamp Co. for six months' supply of electric lamps, and that of the General Electric Co. for electrical fittings, &c.

WOLVERHAMPTON.—The Electricity Committee recommends the Council to accept the following tenders:

Brush Electrical Engineering Co., two transformers (300 kw. each), £399.10s.; A. Reyrolle & Co., switchgear, £796; Stirling Boiler Co., two water-tube boilers, two superheaters and two sets of mechanical stokers, £8,221. 15s.

CARDIFF.—The tender of the General Electric Co. has been accepted for the supply of electric lighting sundries to the Welsh Metropolitan War Hospital, Whitchurch.

BINGLEY.—The Council has accepted the tender of the Electrical Apparatus Co. for 12 months' supply of house service meters.

KEIGHLEY.—The Council has accepted the tender of Mather & Platt (£122. 15s.) for a 32 B.H.P. motor for driving a pump on the Fleece Mill Co.'s estate.

ARGENTINA.—The Post and Telegraph Department has been authorised to purchase 500 insulators from Colson, Brookhouse & Pyne (Buenos Ayres), for $425 m/n. and 35,000 kilos of No. 7 wire from H. Fuhrmann & Co. (Buenos Ayres) for $5,965.75 m/n.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Dover.—The accounts of the electricity department for the year ended March 31, 1915, show total capital expenditure £191,907, of which £6,227 has been repaid.

Year's revenue was £29,669, and working and general expenses were £11,070, gross profit being 14,598. The net surplus, after providing for capital charges, was £3,080. Units generated were 1,778,787 and sold 1,518,657.

Huddersfield.—At a recent meeting of the Corporation the electricity department accounts for the year ended Dec. 31 were approved.

The gross profit was £3,442 (against £1,026 for 1914), of which £1,292 (£1,925. 12s. 3d.) was transferred to depreciation and contingencies account and £2,150 (£2,100) to relief of rates. Depreciation and contingencies account shows a balance in hand of £8,176 (£8,090).

Ald. MARSLAND, who moved the adoption of the accounts, said the quantity of fuel used had increased from 20,781 tons in 1914 to 28,242 tons in 1915, an increase of 36 per cent., and the cost had risen from £11,215 to £19,634, increase of 75 per cent. The average cost per ton was 13s. 11d. (against 10s. 10d. for 1914), and so far this year it was just over 15s. Wages at station increased £884, caused by extra cost of handling coal, due to delay in completing the coal-elevating and storage plant, which was now working; to the payment to men on military duties, and to the increased wages granted to employees. Units sold were 10,536,374, increase 30·5 per cent., due to the large demand for power. A large part of the energy used had been taken by consumers who had been working at night and had considerably improved the load factor.

Ald. WHEATLEY contended that almost the whole of the increase in the cost of fuel was due to the requirements of the power consumers, and that it would be no hardship if an adjustment of prices to them were made. The differentiation was carried too far and became almost a subsidy. The committee also proposed to allot £2,150 in preparation for a subsidy of the rates. As the committee had only £8,000 or £10,000 with which to meet any catastrophe they should have put the sum to the contingencies fund, which should be built up.

Coun. BUCKLEY thought large and small consumers should be placed on the same terms, with the variation of a small discount.

In reply, Ald. MARSLAND said fuel costs were higher when supplying light only, due to the losses on the works during the daytime, when light was not required; but the serious difference was due to the standing charges which had to be met by the average use of the lights for one hour per day, whereas the power consumer could meet the charges by spreading them over an average of eight hours per day. Without the opportunity which the power supply gave them of increasing their output the cost of lighting would be very much more. The metallic filament lamps reduced the cost of current to the consumer by two-thirds, and the half-watt lamps now reduced the cost to one-half.

The minutes were then adopted.

Ilford.—The accounts of the tramways department for the year ended March 31, 1915, last, show total capital expenditure £149,573 (no increase), of which £50,043 has been repaid.

Revenue was £31,980 (against £25,792 in 1914) and working expenses were £23,520 (£20,878), gross profit being £8,460 (£4,914), instalments of loans required £5,251 (£5,069), and interest £3,786 (£3,969). Total revenue per car-mile was 8·12d. (7·48d.) and working expenses per car-mile, including power, were 5·97d. (5·877d.). Passengers carried on Ilford system were 9,203,077 (against 8,036,552), and car-miles run in Ilford 773,490 (827,863) and in Barking 104,323 (nil).

Marylebone (London).—The revenue account of the electric supply department for the quarter ended Dec. 31 last shows total income £69,991 (increase £5,832 over corresponding quarter of 1914).

Revenue from consumers, including meter rentals, was £60,469 (increase £5,920). Working and general expenses were £21,636 (increase £2,197). Average price per unit was 3·075d. (against 2·979d.), and expenses were 1·042d. (1·012d.). Average cost of coal per ton was 22s. 1d., compared with 14s. 3½d. in 1914, representing an extra expense of £3,168 on the 8,131 tons used. Special war expenses were £1,981 (against £923).

The Electric Supply Committee report that in reference to advertisement for tenders for six months' supplies, a number of tenders were received practically all of which are subject to special reservations due to prevailing conditions. So far as small house cables, flexible cords, rubber goods and insulating materials are concerned the prices quoted are indefinite, and the committee have decided not to accept any tender, but to buy in the open market as occasion arises.

The committee has informed the secretary of the National Amalgamated Union of Enginemen, Firemen, Motormen, Mechanics and Electrical Workers that the application of members of the said union in the Council's employ for an advance of 4s. per week cannot be granted.

Oldham.—The net profit on the tramways for 1915-16 was £3,985.

Out of the gross revenue £5,225 was paid in allowances to dependents of men with the colours; £1,000 was spent on an extension to Hollinwood

depot and £548 for an improvement in Rippondon-road. The gross profit was over £10,000, which is considered one of the most satisfactory results in the history of the undertaking. On the three motor 'buses there had been a loss of £720 on the year.

Rochdale.—The total receipts of the Corporation tramways were £82,816 for the 12 months ended March, an increase of £1,477.

The car-miles run were 1,690,687, a decrease of 88,535 miles: 13,705,871 passengers were carried, an increase of 298,553. The receipts were nearly 12½d. per car-mile run, more than 1d. per mile in excess of 1914-15.

Wigan.—The revenue of the municipal tramways for the past year was £79,419, against £75,270 in 1914-15, an increase of £4,218.

The passengers carried were 14,650,035, compared with 13,811,709 (increase 838,326), but the car-mileage was only 1,440,617, against 1,495,786 (decrease of 55,169). The expenses per car-mile were 13·12d., against 12·07d. per mile, an increase of 1·05d.

COMPANIES' MEETINGS AND REPORTS.

ALTRINCHAM ELECTRIC SUPPLY (LTD.).—Mr. C. J. Ford presided at the meeting last week, and stated that during the past year further debentures to the amount of £5,060 had been issued in order to provide the necessary capital for extensions of plant, &c. The results were not equally favourable as in 1914, mainly due to increased cost of coal and economies exercised by private consumers. In addition, many firms who it was anticipated would have been consumers of current for power had experienced difficulties in obtaining delivery of their plant, and that had the effect of somewhat restricting the amount of current which the directors had hoped would have been sold for that purpose during 1915. The chairman reminded the shareholders that in 1915 he intimated that steps were being taken to obtain a fresh provisional order, having for its sole object the remodelling of their capital. That step appeared to have been wholly misinterpreted by some local authorities, in consequence of which opposition was filed with the Board of Trade, who, in consequence, refused to sanction the provisional order. No additional powers whatever had been sought under the order in question which would possibly affect the right of the local authorities or the position of the company's customers, and he felt that that gratuitous intrusion of the local authorities into a matter which was purely a domestic one, and affected solely the interests of the company's shareholders, was much to be regretted, and did not tend to assist the friendly relationship which it was very desirable should exist between the company and the local bodies.

BRITISH WESTINGHOUSE ELECTRIC & MFG CO. (LTD.).—The chairman (Mr. J. Annan Bryce, M.P.), in moving the adoption of the annual report at the meeting last week, stated the balance carried forward (£44,632) represented an increase of £36,511 over last year. A large carry forward was necessary in view of the legislation of last session. Under the Finance (No. 2) Act of 1915 there was imposed a tax of 50 per cent. of all excess profits of businesses whose accounts were made up from September, 1914, to July, 1915, and as their accounts were made up on Dec. 31, 1914, the tax fell upon the profits made by them in the year 1914, and was, therefore, retrospective. The tax was imposed largely in deference to the demand of workmen that their labour should not be exploited by manufacturers making exceptional profits through war conditions. If the tax had been imposed solely on profits due to the war no exception could have been taken, but it speedily appeared that it would have been difficult, if not impossible, to determine profits arising from the war from profits made during the war. Naturally, the Treasury chose the course which not only was simpler, but brought a great deal more grist to its mill, and accordingly the tax was imposed on all businesses which had made more profit during the war than before it. But it was evident that in the case of a very large number of businesses the result was most unfair. It was unfair in all cases where a business was in a state of development and where the larger profits in 1914 had no necessary connection with the war, and where, indeed, in many cases they would have been still larger but for the war. That was pre-eminently their own case. The war began on Aug. 4, 1914, and their accounts were closed on Dec. 31, 1914. They had, therefore, in their accounts only five months of the war, during the first of which business was almost paralysed and during the last four of which it was exceedingly difficult to conduct owing to the loss of much of their skilled labour, partly by recruiting and partly from the sudden demands of the Government factories, which, by enormous wages, tempted away many of their best men. Moreover, during the last four months of 1914, not only labour but materials advanced in price, so that their costs were higher than estimated. Furthermore, in a business like theirs, the profits were not realised till long after the order was taken, and it might be said that none of their profits in the year 1914 were due to orders taken during the war months of that year, or even to orders taken in the pre-war months of that year. Not only were their larger profits of 1914, as compared with previous years, not due in any sense to the war, but were actually smaller than they would have been had there been no war. Yet they were called upon to pay to the Government half of the excess profits of 1914 over those of two out of the three pre-war years 1911, 1912 and 1913 merely because, as the result of hard thought and hard work, their profits happened to be on an ascending scale, while other concerns which had reached their development sooner were, though making far larger profits than themselves, entirely exempt from the tax. Surely nothing more unfair can be imagined, yet the Chancellor turned a deaf ear to every argument, and in the Budget which he has just introduced he proposes to increase the injustice still further by raising the tax from 50 to 60 per cent. They would, therefore, see that a large provision was necessary against the uncertainties of the situation, and he was by no means sure that if the report had been delayed till after the Budget their directors would not have decided upon a still greater provision. The net profit was £176,752, against £151,627 for 1914, an increase of £25,125. That was not so large an increase as that shown in the 1914 accounts over those of 1913, but under the circumstances it might be considered satisfactory. With regard to their business generally during 1915, their total orders received (compared with 1914) showed an increase of about 73 per cent., but that included one large single order for the electrification of an important railway, amounting to about £500,000, to which there was no corresponding order in 1914. After eliminating those two items, the general orders still showed an increase over 1914 of some 30 per cent. A considerable part of that increase was probably due to the absence of German competition, from which they had suffered so much in the past. They must hope that when peace was concluded that competition would be scotched for some time to come. Both their domestic and Continental orders showed a good increase, but as was only natural, having regard to prevailing conditions, their export sales showed some falling off. The increase in orders was not an altogether unmixed blessing. There was considerable congestion in their works, as shown by the fact that their orders in hand at Dec. 31 were far in excess of what they were in 1914. They had had the minimum of friction with their workpeople, and generally speaking the most whole-hearted assistance; and much credit was due to the tactful manner in which those in charge had dealt with the many difficult problems presented by present conditions. The labour as a whole was naturally less efficient than before the war, owing to the number of skilled men who joined the colours or took other employment, but in that respect they believed that they were in no worse a position than their neighbours. The principle of the dilution of labour had had to be pursued. The employment of women had been largely extended with satisfactory results, and might be carried further. Orders were still coming in well, and at the moment were slightly in excess of those at the corresponding period of last year, but it must be remembered that the large railway order in 1915 to which he had alluded to was an exceptional one. Customers were aware that considerable delay must inevitably take place in the completion of their orders, and it might conceivably happen that much of the profit which should accrue to them on the orders in hand might not be available in the current year's balance-sheet. Last year he discussed at some length the destruction of capital likely to be caused by the war, and hazarded an estimate of 5,000 million pounds. That estimate was by some considered excessive, but to-day it appeared absurdly moderate. The figures of war expenditure were every day becoming more colossal, and, alas, every day becomes more appalling the waste of young life at its most productive stage, life without which fresh wealth could not be created. Certainly, therefore, they must look to a diminished purchasing power in the world, and a consequent depression in industry, but that depression would probably not show itself immediately after the war ended, and he still held to the view he expressed last year that even when it did come it might not affect, at least at first, industries such as theirs, which were necessary for the purposes of reconstruction and the economical working of other industries, especially as in their particular business the pressure of German competition was not likely to be so severe. It was partly due to their anticipation of post-war conditions that, with a view to broadening the basis of their business, they acquired the controlling interest in the French company. In France, as in England, German competition was before the war exceedingly keen, while after the war it was even less likely to be felt than here. The Italian company, in which they held (through the French company) a controlling interest, was also fully employed, but there also the post war prospects were good. The use of electrical apparatus both for railway and other purposes appeared likely to increase largely, while in Italy also a diminution of German competition appeared probable, though perhaps not to so great extent as in France. They would see that, in view of the adverse conditions under which they were at present working, their hopes of any considerable development of their business must depend on the ending of the war. Of that ending there was at present no sign.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.).—The report for 1915 states that the volume of output has been maintained, but high wages, shortage of skilled labour and heavy increases in cost of fuel and materials have all tended to offset the improvement that would otherwise have been apparent in the net earnings. After providing for general charges, maintenance of plant and buildings and interest on debenture stock and loans, there remains (with £7,095 brought forward) a total of £21,366. It is recommended that £8,000 be applied for depreciation, £2,044 in payment of the further 1 per cent. interest to which the holders of the 6 per cent. prior lien participating second debenture stock are entitled out of the first net profits available for dividend in any year, that £5,000 be placed to general reserve and £9,321 carried forward. The sum of £31,963 has been expended on capital account during the year.

CAMBRIDGE ELECTRIC SUPPLY CO. (LTD.).—The profit for 1915 (including £2,647 brought forward) was £12,000. After placing £3,000 to depreciation account, the directors have declared a further dividend of 3 per cent., making 5 per cent. for the year, compared with 6 per cent. for each of the two preceding years, carrying forward £2,753.

CITY OF SANTOS IMPROVEMENTS CO. (LTD.)—The net revenue in 1915 was £71,759, and with £6,628 brought forward, the total was £78,387, compared with £88,769 in 1914. The reduction in revenue is entirely due to the fall in the value of the milreis. After transferring £5,000 to reserve and setting aside £4,000 to tramways renewal account, a dividend of 3 per cent. on the ordinary shares is recommended, leaving £7,517 to be carried forward. The number of passengers carried on the tramways was 14,870,776, a decrease of 475,586. The number of public electric lamps was 1,373, an increase of 35, and the number of private consumers 2,699, an increase of 339. The number of motors was 248, an increase of 39.

CLEVEDON, PORTISHEAD & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—In their report for 1915 the directors state that the growth of the undertaking has been satisfactory in spite of the very unsettled conditions prevailing, the gross revenue of the company being almost exactly double that of 1914. The number of consumers connected to the mains in Portishead increased from 130 to 179, and the new sub-station at Bower Ashton is now complete and is supplying the South Liberty Colliery. Owing to difficulty in getting delivery of their apparatus, the colliery company were not ready to receive the supply until Michaelmas. This supply has proved very satisfactory, and the colliery company are already putting down further motors which will considerably increase their rate of consumption. The total receipts were £1,737, compared with £887, and, notwithstanding the increased costs for fuel and other expenses, the gross profit was £696, compared with £444. After deducting interest and other sundry charges the net profit was £487, compared with £344, and this with the balance brought forward (£72) makes a total of £558. The directors recommend payment of the dividend on the 6 per cent. preference shares and a dividend of 2½ per cent. on the ordinary shares, to apply £150 to depreciation fund, to write down preliminary expenses by £100 and to carry forward the balance of £36. 12s. 11d. The number of units sold during the year amount to 209,524, compared with 56 096 in 1914. The directors express their indebtedness to Messrs. Christy Bros. & Co. for advancing the sums necessary to complete several very lucrative extensions. An application to the Board of Trade for leave to extend the mains through the village of Long Ashton has been made.

CORK ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The revenue for 1915 was £63,905. 4s. 9d. and expenses were £42,415. 1s. 7d., leaving £21,490. 3s. 2d. Adding balance brought forward (£2,480. 10s. 7d.), and deducting interest on debentures (£4,600) the balance is £19,370. 13s. 9d. The two half-yearly dividends on the 5 per cent. cumulative preference shares absorbed £6,163. 10s. ; a sum of £6,500 was added to reserve for depreciation and renewals, £1,776. 10s. 11d. written off wiring consumers' premises, &c., and £889. 19s. 5d. written off investments. The directors recommend that the balance of £4,040. 13s. 5d. be carried forward. The lighting and power business continues to show satisfactory progress, agreements for 147 connections being concluded during the past year, the additional connections representing a total gain of 405 kw., compared with 467 kw. in 1914. The year's revenue showed an increase of £2,301. The lighting and power revenue was £1,920 in excess of that of 1914, but the traction revenue showed a small increase of £52. The other items show an increase of £329. The expenses were £42,415, compared with £37,958. The large increase was entirely due to operating under war conditions, the high price of coal and war bonuses and allowances involving increased charges amounting to £5,800. The directors have written off out of revenue £1,777 against wiring consumers' premises, repair shop equipment, plant on loan, &c., and £850 to bring down investments to market value. They have also set aside £6,500 to reserve for depreciation and renewals, and the net revenue shows a material reduction, and the directors regret that they are unable to recommend a dividend on the ordinary share capital, as it is necessary to carry forward a larger sum than usual to provide against the still further increase in the price of coal and other materials during the current year. As expenses increased to such an abnormal extent the company's lighting and power tariff was raised from July 1 last, but the additional charges to the consumers represents a very small percentage of the increased cost of operating. The year's capital expenditure (£1,663) has been mainly for house services and cables. Delivery of the 1,250 kw. Curtis turbine referred to in the previous report will be made shortly.

W. T. GLOVER & CO. (LTD.)—The chairman (Mr. A. L. Ormrod) presided at the meeting on Monday and said that the company had arrived at so sound a position that in a time of unexampled national strain the directors were able to produce a stronger balance-sheet than ever before, with a larger profit, resulting from an increased turnover, and they had been able to render great service to the State. Much as they would have liked to have done so, they felt they could not recommend a higher dividend. Money was wanted in the business ; raw materials were never higher in price, nor the difficulties of obtaining them so great, and they must have such materials in the works. Last year they made £54,438 on their trading. If he deducted the interest on the first and second debenture stock and the amount to be paid on the preference capital the figures showed that they earned nearly 37 per cent. on their ordinary capital. The shareholders were going to receive 5 per cent., or less than one-seventh of the amount actually earned. The balance of 32 per cent. was not wasted : in course of time full advantage would be reaped from the great bulk of it. Their debentures were being redeemed, and the ordinary shares year by year were getting into a better position, either by an accession of assets or by a diminution of charges in front of them or by a combination of both. They were glad to be able to give the Government some excess profit for the national needs. It did not do to point a finger at other traders who were more leniently dealt with as regards excess profits. They received interest on their holding of debentures and dividend on preference shares of the Trafford Power Co., but as yet nothing on the ordinary shares, because the demands for capital by the Trafford company were continuous. They were engaged in an industry which for a long period had suffered from German attack and competition, and they had had to fight with their hands tied behind their backs. He would ask the British public and British Corporations, particularly when the war was over, not to support German industries or those of German origin, at the expense of British, but to support firms such as Glovers, which was British to the core.

WYCOMBE (BOROUGH) ELECTRIC LIGHT & POWER CO. (LTD.)—During 1915 the connections to the consumers' mains rose from 2,275 kw. to 2,392 kw., an increase of 137 kw. Including £1 . 7s. 8d. brought forward, the year's profit is £7,065. 2s. 3d., and after paying interest on debentures and outstanding accounts (£3,263. 7s. 7d.) the balance is £3,801. 14s. 8d. The directors recommend payment of a dividend at rate of 2½ per cent. for the year (absorbing £1,600), and that £2,000 be placed to reserve for renewals, leaving £801. 14s. 8d. to be carried forward.

YORKSHIRE (WOOLEN DISTRICT) ELECTRIC TRAMWAY (LTD.)—The past year's revenue was £71,593, compared with £65,3 7 for 1914. A sum of £4,000 has been placed to reserve (against £2,000), and a dividend of 4½ per cent. per annum on the ordinary shares (against 3½ per cent.) is recommended, carrying forward £2,948, against £2,587.

NEW COMPANIES.

ASSOCIATION OF BRITISH MOTOR & AIRCRAFT MANUFACTURERS (LTD.) (143,507).—Reg. April 4 as a company limited by guarantee with 100 members, each liable for £1 in the event of winding up, to protect the British motor and aircraft industry. Management is vested in an executive committee, the first members of which are E. Manville and A. Spurrier. Only persons engaged in the British motor and aircraft industry are eligible for membership of the committee. Secretary : H. Wyatt. Reg. office : 173, Fleet-street, E.C.

H. G. COOPER (LTD.) (143,526).—Reg. April 6, capital £2,000 in £1 shares, to take over the business of an electrical engineer and office furnisher, carried on by H. G. Cooper. Private company. First directors are H. G. Cooper, G. S. Edwards and Alice H. Cooper. Reg. office : 6, Fen-court, E.C.

JAMES SMITH HOISTING MACHINERY CO. (LTD.)—Capital £10,000 in £1 shares (1,000 founders' and 9,000 ordinary), to carry on business of manufacturers of and dealers in hoisting machinery and cranes of all kinds, engineers, founders, &c. Private company. First directors are G. H. Buckley and C. E. Partridge (appointed by holders of ordinary shares), and J. Smith (appointed by holders of founders' shares).

E. POWELL (LTD.) (143,534).—Reg. April 7, capital £4,000 in £1 shares, to take over the business of an electrical engineer, motor and cycle agent, &c., carried on by E. Powell at Tunbridge Wells. Private company. First directors are E. Powell, senr. (permanent), E. Powell, junr., and P. Powell.

SELECTIVE SIGNAL CO. (LTD.) (4,330).—Reg. in Dublin on April 4, capital £5,000 in £1 shares, to acquire any interests in patent rights, licences, &c. Private company. First directors are W. J. Lyon, W. Conan, F. P. Griffith and G. M. Meares. Reg. office : 17, Westland-row, Dublin.

CITY NOTES.

MEMORANDA (April 12).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 57⅛. Consols Pay Day, May 4. Stocks and Shares Ticket Days, April 27 and May 11. Pay Days, April 28 and May 12. Price of silver, 29⅞d.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units sold to consumers during the four weeks ended Feb. 25, 1916, amounted to 1,362,833, compared with 990,763 in the corresponding four weeks of 1915.

DIRECT UNITED STATES CABLE CO. (LTD.)—The board have resolved to pay a final dividend of 2s. per share (less tax at 3s. 2d.), payable on and after the 29th inst., and making with the three interim dividends already paid a total distribution of 4 per cent. for the year ended March 31. The transfer books will be closed from the 12th to 26th April, inclusive.

EASTERN TELEGRAPH CO. (LTD.)—It is announced that, subject to final audit, the directors at the forthcoming general meeting to be held next month, propose to recommend the payment of a final dividend of £2. 5s. per cent. and a bonus of 2 per cent., both tax free, making, with previous payments on account, a total distribution of 8 per cent. on the ordinary stock for the year ended Dec. 31, 1915.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) Subject to final audit, the directors at the forthcoming general meeting to be held next month, propose to recommend the payment of a final dividend of 4s. 6d. per share, together with a bonus of 4s. per share, both tax free, making with previous payments on account a total distribution of 8 per cent. on the share capital for the year ended Dec. 31, 1915.

GIANT'S CAUSEWAY, PORTRUSH & BUSH VALLEY RAILWAY & TRAMWAY CO.—The net revenue for 1915 was £608, and, after meeting mortgage charges, &c., the adverse balance of £158 brought forward, was reduced to £88.

LANCASHIRE DYNAMO & MOTOR CO. (LTD.)—It is announced that, owing to various causes, the company's balance-sheet cannot be issued until some weeks later than usual, but the directors have decided to pay a further interim dividend of 4½ per cent., tax free.

LEAMINGTON & WARWICK ELECTRIC CO. (LTD.)—The accounts of 1915 show an available sum (after transferring £1,000 to renewals account and including £1,827 brought forward) of £5,383. A dividend of 5 per cent. has been declared, compared with 3 per cent. for 1914, and £1,883 has been carried forward.

MONTEVIDEO TELEPHONE CO. (LTD.)—An interim dividend at the rate of 6 per cent. per annum, less tax, has been declared on the ordinary shares for the past half-year.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—The directors recommend (subject to final audit) payment of the following dividends: At rate of 6 per cent. per annum on the preference shares for the half-year ended Dec. 31 last (less tax), and a final dividend of 6 per cent. on the ordinary shares (tax free), making a total of 10 per cent. for the year.

RIO TRAMWAY, LIGHT & POWER CO. (LTD.)—The directors have declared a quarterly dividend of 1¼ per cent. on the issued capital stock.

SAO PAULO TRAMWAY, LIGHT & POWER CO. (LTD.)—The directors have declared a dividend of 2½ per cent. on the common stock.

SIR W. G. ARMSTRONG, WHITWORTH & CO. (LTD.)—The directors announce that, as it will not be possible under existing circumstances to complete the 1915 accounts for some time, they have decided to pay the final dividend on the preference shares (less tax), and a further dividend of 1s. 8d. per share (tax free) on the ordinary shares.

WESTERN TELEGRAPH CO. (LTD.)—The directors will be able to recommend to the shareholders at the next general meeting, should the present net revenue be maintained, the payment of a bonus of 2 per cent., which, together with the ordinary dividend of 6 per cent., will make a total distribution of 8 per cent. (tax free) for the current financial year.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date, April 11, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17d.
Solid Drawn Copper Tubes	18½d.
Brazed Copper Tubes	18½d.
Brazed Brass Tubes	19d.
Brass Wire	16½d.
Copper Wire	18d.
Rolled Brass	16½d.
Brass Sheets	16½d.

	per ton.
Copper Sheets	£148 0 0
Spelter	£97 0 0
English Lead	£35 0 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£100 0 0
Clean Brass Scrap	£66 0 0
Brazlery Copper Scrap	£92 0 0
Old Lead	£27 10 0
Old Zinc	£60 0 0
Hollow Pewter	£120 0 0
Black Pewter	£85 0 0
Gun Metal	£82 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date April 11, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£120 0 0
Clean Mixed Brass	£70 0 0
Clean Copper	£102 0 0
Brazlery Copper	£92 0 0
Gun Metal	£80 0 0
Old Lead	£29 10 0
Tea Lead	£27 10 0
Old Zinc	£70 0 0
Hollow Pewter	£130 0 0
Shaped Black Pewter	£90 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £115; Blowpipe Solder, £120.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, April 11. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., April 11.	Rate per cent. Yielded. £ s. d.	Dividend Due.
		Electricity Supply.			
10	6%	Bournemouth & Poole E.L. Ord.	9⅛ †	6 10 2	Mar, Sept
10	4½%	†Do. 4½% Cum. Pref.	9⅛	4 15 8	Feb, Aug
10	6%	†Do. 6% Cum. 2nd Pref.	10⅛	5 16 4	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅛	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	5 0 0	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	80½	4 13 6	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 11	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	7 1 2	..
5	5%	Do. Ord.	3½	8 0 0	Aug, Feb
5	4½%	Do. City Pref.	2⅛	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	4½	4 6 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	11½ †	6 15 5	Feb, Aug
10	6/0	Do. 6% Pref.	10⅛ †	5 14 11	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	89	5 12 6	Jun, Dec
10	7%	County of London Ord.	10⅜ †	6 17 5	Mar, Sept
10	6%	Do. 6% Pref.	10	6 0 0	Feb, Aug
St.	4½%	Do. 1st Deb.	96½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	91	4 13 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	78	6 0 0	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6%	London Elec. Supp. 6% Pref.	4½	7 5 5	..
St.	4%	Do. 4% Mort. Debs.	80	5 0 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅝ †	6 19 2	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	89	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db St	91½	5 9 3	Mar, Sept
4	6%	North Metropolitan E. P. Supn. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	3⅛	6 10 7	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., April 11.	Rate per cent. Yielded. £ s. d.	Dividend Due.
		Electricity Supply—*cont.*			
5	8%	St. James' & Pall Mall Ord.	5⅞	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅞	6 0 3	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp 4½% Db. St.	83†	5 8 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅛	7 10 7	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅜	6 1 9	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4⅞	5 11 7	Jan, July
		Electric Railways & Tramways.			
2[illegible]	5%	British Elec. Traction 5% Debs.	78½	6 4 8	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	70½	8 10 10	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	67½	5 19 1	..
St.	4%	Do. do. Assented Def. Ord.	65½	6 2 2	..
St.	4½%	Do. 4½% Pref.	99½	4 10 3	Jan, July
St.	4%	Do 4% Deb. St.	93½	4 5 9	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	62½	8 0 0	Feb, Aug
10	1½%	London Electric Ry. Ord.	2	6 5 0	Jan, July
St.	4%	Do. 4% Pref.	64½	6 4 6	Mar, Sept.
St.	4%	Do. 4% Debs.	85	4 14 4	Jan, July
St	1%	Metropolitan Ry. Con. Ord.	24⅞	4 1 7	Feb, Aug
St	3½%	Do. 3½% Pref.	77½	4 10 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	74½	4 13 9	Feb, Aug
St	3½%	Do. 3½% A Debs.	82½	4 4 6	Jan, July
St	3½%	Do. 3½% Debs.	83½	4 4 1	Jan, July
St	..	Metropolitan Dist. Ry. Ord.	19⅝	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	92	4 7 0	May, Nov
St.	4½%	Do. 4½% First Pref.	70½	6 7 8	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 4	Jan, July
St.	4%	Do. 4% Debs.	71½	5 12 1	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	68	5 17 7	Mar, Sept
		Electric Manufacturing, &c.			
1	14%	Babcock & Wilcox Ord.	2⅝	5 3 0	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	5%	Brit. Aluminium Ord.	1⅜	4 6 6	Mar
10	5%	Do. Prior Lien Debs.	89	5 12 4	Jan, July
1	6%	Do. 6% Pref.	⅞	6 12 5	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10⅛	7 1 2	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm.6% Pref.	⅛	6 17 2	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	7 1 2	April
100	6%	Do. 6% Prior Lien Debs.	99½ †	6 0 7	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	64	6 5 0	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	11½	6 10 5	Jan, July
5	2/6	Do. 5% Pref.	4⅝	6 10 9	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	3⅝	1 17 2	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	⅝	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	⅛	8 0 0	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs	72	5 11 1	Jan, July
10	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9⅞	6 10 4	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15⅛	6 11 2	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4⅛	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	9⅛	10 7 10	Feb, Aug
10	5%	Do. Pref.	7⅛	6 15 7	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	35	6 18 0	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1⅛	4 2 9	May, Aug
1	6d.	Do. 5% Pref.	⅞ †	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	80	5 0 0	Jun, Dec
St.	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jun, Dec
St.	4%	Willans & Robinson B. Cum. Pref.	41½	9 12 9	..
St.	4%	Do. 1st Mt. Deb. St.	50½	7 18 5	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	97½	6 3 1	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	21⅛	7 2 5	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69†	5 15 11	Ja.Ap.Jly,O
10	5%	Cuba Submarine Ord.	7⅛	6 1 8	May, Nov
10	10%	Do. 10% Pref.	13⅝	7 5 1	..
5	5/0	Direct Spanish 10% Pref.	7⅛	6 13 4	..
10	4%	Direct United States	5⅛	6 18 8	Ja,Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	130	5 7 8	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	63½	5 10 8	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	79½	5 0 11	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77⅛	5 2 10	Feb, Aug
10	7%	Do. Ord.	13	5 7 8	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co.	34⅛	6 6 2	Ja, My, Jly
25	13%	Indo-European	49⅝	6 10 4	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2⅛	4 11 5	April
1	7%	Do. 7% Pref.	1⅝	3 13 5	July
10	1%	West India & Panama Ord.	1⅛	8 18 10	May, Nov
10	6%	Do. 1st Pref.	7⅝	7 12 11	May, Nov
10	7%	Western Telegh. Co.	12⅛ †	5 6 2	Mr,Jly,O,Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½	4 10 3	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅝	6 12 5	Nov.
1	10%	Oriental Telephone Ord.	1⅝	5 8 6	Apl. Oct
St	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	5⅛	6 16 2	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅝	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	84½	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust.	10⅛ †	5 12 11	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	11⅜ †	5 19 4	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	8⅛	6 1 9	Ja, Apl, Jly,O
5	4%	Do $100 Pref	69½	5 14 9	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	124	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
1	3/0	Adelaide Elec. Supply 6% Pref.	4½	6 10 8	Mar, Sept
St	5%	Do. 5% Debs.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10⅛	5 18 6	..
St	4½%	Do. 4½% Debs	87½	5 2 10	Jan July
5	9%	Calcutta E. S. Corp. Ord	6⅞	7 5 5	May, Nov
5	5%	Do. 5% Pref	4⅛ *	5 1 3	Mar, Sept

* And 13⅓% bonus. † Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,979. [Vol. No. 3. LXXVII.] **FRIDAY, APRIL 21, 1916.** PRICE SIXPENCE (by post 7d.)

Abroad 9d., or 20 cents. or 1 fr., or 90 pf.

CONTENTS OF THE CURRENT NUMBER.

NOTES	69	ELECTRICITY SUPPLY IN GREAT BRITAIN	86
Arrangements for the Week	71	REVIEWS	87
Electrical Diagrams. By P. Rayner-Smith. Illus.	72	The Electric Railway [Buck]. Principles of Dynamo-Electric Machinery [Bailey].	
Insulating Oils	73	Sir J. J. Thomson on Radiation from Atoms and Electrons. Illustrated	88
Electric Welding. By Julius Sauer	75	"Speeding Up" in an Engineering Factory. By R. Rankin, B.Sc. Illustrated.	90
Magnetisation by Rotation. By S. J. Barnett. Illustrated	76	CORRESPONDENCE	92
Transformer Design. By F. M. Denton, A.C.G.I.—*Continued*	78	"Methods for Determining the Grading of Starting and Brake Resistances for Series-Motors" (Charles C. Garrard).	
The Electricity Supply of Great Britain.—*Discussion.*	80	Physical Society	92
On Radium Antennæ. By E. Leimer	82	LEGAL INTELLIGENCE	93
New Method of Determining Ionic Velocities. By Constance Harrison Griffiths, B.Sc. Illustrated	82	PARLIAMENTARY INTELLIGENCE	94
Flywheel Effect	84	**The "Electrician" Commercial and Industrial Section**	95-102
Performance of Diesel-Engine Plants in Texas. Illus.	84		

NOTES.

Loan Periods for Accumulators.

FOR some years it has been the custom of the Local Government Board to permit loan periods which are distinctly short for certain classes of plant. For example, the period for meters is five years; for arc lamps it is also five years, and for accumulators seven years. With regard to the first two items, perhaps no great exception can be taken. In the case of accumulators, however, a period of seven years is extremely short, especially when it is remembered that maintenance contracts considerably in excess of seven years are almost the invariable rule. Consequently, the effect of such a period is to leave an asset which should be of very considerable value for some years after the loan has been paid off, and after the time when nominally, according to the conventional idea in such matters, the item of plant is of no value. Generally speaking, it is scarcely worth while to raise loans for short periods; and this may partly be the object of the policy, namely, to encourage the purchase of such plant as meters and arc lamps out of revenue. In the case of accumulators, however, the effect of an unduly short loan is to make this plant appear, from the financial point of view, in a much worse light than it would with more ordinary business methods. We are, therefore, glad to note that the British Electrical & Allied Manufacturers' Association has now induced the Local Government Board to extend the period from seven years to ten years, which will certainly afford some relief from the conditions we have indicated.

Electric Welding.

IN the present issue will be found an account of some of the modern processes and machinery employed in the art of electric welding. It is quite possible that this method will always be to some extent limited in its application by circumstances connected with the nature of the work and the local facilities available. But some kinds of manufacturing processes can be quite easily dealt with, even under conditions where no special arrangements have to be made beyond the supply of electric energy and the provision of simple and suitable plant. The earlier processes were devised on the assumption that special plant was hardly necessary, but with a more extended use of the electric weld, it is now found that an unskilled worker with an automatic or semi-automatic machine can do in a day much more work than was formerly done by highly-skilled labour. Welding machinery of this kind is now a matter of general interest, seeing that the welding of sheet-metal, chains and other small objects is now carried out in factories by routine methods and unskilled labour. When it comes to a matter of repairs, this always needs skilled work, not of an unskilled kind, and for this class of work there are also various rival methods, giving results on which it would be difficult to improve, and among which a choice must be made according to conditions. With a proper lay-out, there is no question that the electrical method is very suitable for many classes of work, and will become increasingly important.

Electricity or Energy: Which?

ENTITLED "Some Mechanical Analogies in Electricity and Magnetism," Prof. W. S. FRANKLIN contributes to the last issue of the "General Electric Review" an article which students of electrical engineering would do well to read. Apart from several excellent analogies between mechanics and electricity and magnetism, there is one showing that it is not electricity that one uses but work or energy. The almost universal misunderstanding of the matter is illustrated by Prof. FRANKLIN by considering a mechanism in which a pulley drives another pulley by means of a belt. "A person knowing nothing at all about machinery, and *especially a person having no available words to use in describing such an arrangement*, might look at the continuous stream of leather coming off the driving pulley and decide to call this pulley a leather generator, and the driven pulley a leather motor. Everyone knows, however, that a driving pulley does not generate leather: it gives up work or energy, and the work is transmitted to the driven pulley by the belt. It seems very ridiculous to speak of a belt pulley as a generator of leather, and it is equally absurd to speak of a battery or dynamo as a generator of electricity." This will be disconcerting to those who are of the opinion that for a few coppers they can buy a unit of electricity, and it will be equally disconcerting to those who believe they can sell electricity.

"Seek and Ye Shall Find."

TILL the other day we shared the pessimism of a certain section of the daily Press. The fact that a commission in the

Royal Engineers has recently been granted to a highly qualified engineer of our acquaintance alters the outlook. In view of this, who shall say that "square pegs in round holes" is the rule and not the exception? To our knowledge, equally able engineers are available by the score. Men who at the present time are helping to win the war either by scrubbing barrack-room floors or by engaging upon work that could be more efficiently performed by charwomen, labourers or navvies. The result of employing laymen on engineering work is that some of our "patriots" employed by the War Department are paying their men 7*s.* and are attempting to charge their country 6*l.* for the work. All in good time we hope to publish the figures.

Amateur and Professional.

Under the heading "Tragic Results of Amateur Work" is given an account, in a recent issue of the "Journal of Gas Lighting," of the death of a youth through an electric shock owing to a 200-volt electric lamp falling into the water in which he was having a bath, and causing it to "become alive." The lamp, it was stated, was fixed by the deceased's brother, who was an amateur at electrical work. According to our contemporary: "At the inquest the coroner (Mr. J. Kenyon Parkes) commented on the fact that there did not appear to be any regulations to prevent people making unauthorised connections to electric light fittings. He thought this tragic incident should be a lesson to people not to interfere with electrical work." We express thanks to our contemporary for giving publicity to the coroner's sensible remarks. At the same time we seem to remember that on several occasions people have come to an untimely end in their bath rooms owing to the defective installation, by professed gas fitters, of gas-heated water boilers and other abominations. It is only fair to the amateur to record the fact that the work of the professional occasionally gives rise to tragic results.

Full-Size Models.

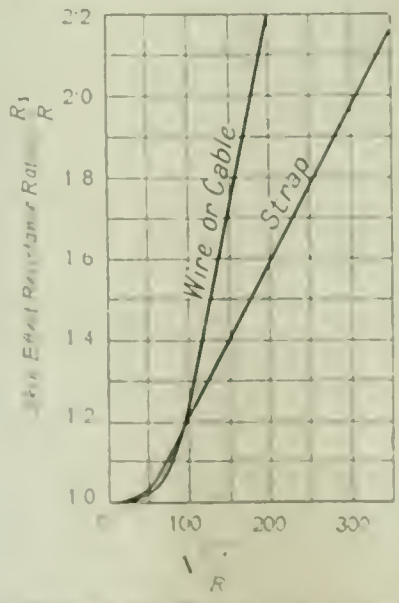
In his Presidential Address to the Institution of Locomotive Engineers, Mr. R. E. L. Maxwell suggested the advisability of constructing a full-size model of the cab and boiler front when a design for a new class of engine is being prepared in order to settle the best and most convenient position for the details. Although such a model may serve some useful purpose, it is doubtful whether the suggestion will be favourably received by those who make locomotives in competition with other firms. For certain purposes models are invaluable, but one would imagine that, in the case of a locomotive, the money expended on a full size wood and canvas model of the footplate and cab could be used to much better purpose in studying one of the many problems connected with the design, construction or performance of the locomotive. If the construction of a model be necessary for settling the position of details on the footplate of a locomotive, then such models are equally necessary in many other cases, both mechanical and electrical. In these the draughtsman can see, in its three dimensions on the drawing-board, the machine which he has designed as surely as if he were standing in front of the machine. In addition to making a model of the cab, in the case of a tank engine Mr. Maxwell advocates the making of a model of the boiler, side tanks and coal bunker to ensure that the tanks do not unduly interfere with the outlook from the footplate. Here, again, we believe that the properly qualified draughtsman is well able to attend to these matters. It is to be regretted that as these extraordinary views were brought forward in the course of a Presidential Address other engineers were debarred from discussing them. We venture to think that the opinions of those whose business it is to secure a satisfactory margin of profit when prices are cut fine, as they usually are, would lead one to the conclusion that there are less expensive methods than the construction of full-size models of the locomotive for settling the positions of details.

"Archives d'Electricité Médicale." We have received No. 101 for March, 1916, which contains a series of articles, dealing with the siesmophone in deafness, extraction of bullets from the skull, and other Papers of interest to medical readers.

Hydro-Extractors. The "Textile Mercury" refers to a hydro-extractor for use in chemical dyeing, or bleach works, made by Messrs. T. Broadbent & Sons, Ltd., Huddersfield. A wire cage or basket is revolved rapidly, and the moisture thrown off by the articles in it is caught in a cylindrical casing and drained off. The rotor of the electric motor is mounted on a sleeve revolving about the spindle of the machine. To the upper parts of the sleeve are attached friction shoes which are controlled by centrifugal force and from a friction clutch with the spindle. The starting of the machine is quite automatic, and the attendant cannot damage the machine by switching on too quickly.

Centrifugal v. Ram Pumps. The "Iron and Coal Trades Review" reported recently a discussion at the meeting of the Mining Electrical Engineers at Manchester, when Messrs. Izod & Roullard's Paper on "Centrifugal Pumping Plant of the Durban Roodeport Deep, Ltd.," was read. It was pointed out (referring to high lifts) that for equal outputs a ram pump had to run for a certain time before its higher efficiency turned the balance of costs in its favour. Quartzite grit in the water might ruin a centrifugal impeller in 24 hours. A case was referred to where an impeller driven by an 80 B.H.P. motor worked against a very low head. It sometimes went in one direction, sometimes in the other. This was presumed either to be due to leakage or to the fact that the impeller of cast-iron may have become magnetised by the stray field of the motor.

Skin Effect in Strap Conductors. Mr. F. B. Dwight, writing on the above in the "Electrical World," gave a curve calculated from the experimental results obtained by Messrs. A. E. Kennelly, F. A. Laws and P. H. Pierce as shown below. The thickness of the strap should not be more than one-tenth the width, and there must be an air space between it and the return conductor greater than the width of the strap. The curve applies to a single strap, and not to such cases as ventilated bus bars. The resistance referred to in $(f R)^{\frac{1}{2}}$ is the resistance at the temperature in question, and f is the frequency in cycles per second. Owing to the fact that the skin effect for straps shown in the figure approaches its asymptote and becomes a straight line, considerable labour is saved in calculating the same effect for this portion of the curve for round wire. The curve applies to all sizes of strap, and the law



Skin Effect Curves for Strap and Wire Plotted to show the Straight Line Form.

is the same as that for wire. The curve for strap is an empirical one, whereas that for wire or cable is exact. The results for strap conductors are approximately correct.

On Avoiding Collision at Sea.—In a recent Paper before the Royal Society, Prof. H. C. Plummer gives a method which is of greater simplicity, both in idea and practical detail, than Joly's, by introducing the relative speed of the two ships. The speed and course of an approaching ship being communicated by wireless, the relative speed is easily obtained without calculation by a combination of scales, which is, in fact, identical with Prof. Joly's collision predicter. The one ship may then be considered stationary and the locus of the approaching ship at successive signals becomes a series of concentric circles. In the case of impending collision the rate of approach is a maximum along a radius and equal to the relative speed. Two methods are suggested for comparing the indications of the signals as received with this critical speed, the one involving the use of two direct-reading scales, the other an equivalent arithmetical operation of the simplest kind.

OBITUARY.

Killed in Action.—Second Lieut. James C. Smith was killed on March 27. The deceased officer was educated at All Saints' School, Bloxham. He became an electrical engineer, and shortly after war broke out joined a Public School Battalion. In February, 1915, he received his commission, and in February, 1916, he went to the front.

The death is also announced of Lieut. Douglas Tweedy-Smith, Royal Flying Corps (second son of Mr. R. Tweedy-Smith), who died on April 10 at the Red Cross Hospital, Netley, aged 19 years. He was a member of the London University O.T.C., and on the outbreak of war he received a commission in the 15th Middlesex Regiment, and was appointed quartermaster of a newly-formed battalion. He was transferred early last year to the Royal Flying Corps. He was educated at Palmer's College, Grays, and his twin brother is Second Lieut. Leslie Tweedy-Smith, of the East Surrey Regiment. Mr. Tweedy-Smith's eldest son, Alan, was killed at Loos on Oct. 13 last.

APPOINTMENTS VACANT AND FILLED.

Belfast Corporation invite applications for the appointment of general manager of their tramways. Salary £800, rising to £1,000. Applications to the Town Clerk (on forms supplied) by May 13.

A junior shift engineer is required at the new temporary station, Nechells, Birmingham. Commencing salary £104, rising to £200 per annum. Applications (on forms to be obtained from the Secretary, Electric Supply Dept.) to city electrical engineer and manager (Mr R. A. Chattock), 14, Dale End, Birmingham, by 24th inst.

Mr. W. H. Collier, B.Sc., has been appointed lecturer in engineering at the Ballarat (Victoria) School of Mines, in succession to Mr. Hoadley, resigned.

Oldham Tramways Committee have selected Mr. P. Priestley, general manager and engineer of the Mexborough & Swinton Tramways Co., for the position of manager of the Corporation tramways.

INSTITUTIONS AND SOCIETIES.

Faraday Society.—Dr. W. Rosenhain, F.R.S., of the National Physical Laboratory, recently delivered a lecture, illustrated by cinematograph pictures, on "The Making of a Big Gun." The chair was taken by the president, Sir Robert Hadfield, F.R.S. The lecturer began by contrasting the "big guns" of olden times with the gigantic weapons of to-day. The older guns were made of cast-iron, and guns of that material reached their highest development in the American Civil War. The conditions existing in modern guns were illustrated by sectional diagrams relating to guns of fairly recent date, in which pressures of 18 tons per square inch and muzzle velocities of 2,500 ft. per second occurred. To resist these conditions, the best possible steel was required, and even that only served for a comparatively short time. The work of modern guns was illustrated by some photographs of gigantic projectiles which had been recovered intact after penetrating great thicknesses of modern armour. The effect of use on the inside of a gun was illustrated by photographs showing the "erosion" and the cracking which occurs as the result of the high temperature of the explosion gases. The lecturer then proceeded to describe the modern process of gun-making by the aid of a series of cinematograph pictures of the most interesting and striking stages of the process. These films had been prepared and lent to him by the courtesy of Messrs. Vickers, Ltd., at whose Sheffield works they had been taken. The series began with the blast-furnaces in which the iron ore is reduced by the aid of coke and limestone; next came the open hearth steel furnace and the processes of filling were shown, and particular attention was drawn to a picture which clearly showed the "boiling" of the molten steel within the furnace. Throughout the various stages of the process, including the refining of the iron to transform it into steel, the various stages of forging, hardening and tempering, the lecturer gave in popular terms the scientific reason for each step, illustrating his remarks by a series of photomicrographs showing the minute structure of the steel at each stage, and showing how each step served to bring the steel nearer to the ideal condition of perfect homogeneity. The lecturer naturally avoided reference to those confidential matters which relate to the most recent products of the steel-maker's art as directed to the production of guns, but as an indication of the direction in which modern practice tended, he showed the extremely minute micro-structure which can be produced by proper treatment in modern special or "alloy steels." The extreme importance of accurate scientific control, both of compositions, temperatures and rates of cooling, throughout the process, was strongly emphasised and illustrated. By means of the series of cinematograph films the gun was followed through its various stages, from the freshly cast ingot weighing 80 tons, through the processes of "cropping" and "trepanning," as the first piercing of the ingot to form a rough tube is called, on through the forging press until it attains its requisite length—in some cases over 70 ft. Then follow the machining operations, and then what is, perhaps, the most delicate part of the process—hardening and tempering, in which the roughly machined tube is heated to a uniform and carefully regulated temperature in a tall chimney-like vertical furnace, from which it is lifted at the proper moment to be plunged into an oil-bath contained in a deep cylindrical well. The process of rifling and the finishing of the outside, after the application of the wire-winding, were also shown. Finally, as a relief to the more severely technical portions of the lecture, some films were shown illustrating the testing and firing of big guns.

Sir Robert Hadfield, in proposing a vote of thanks to the lecturer, supplemented what he had said by some further interesting information with regard to the achievements of modern artillery. He spoke, for example, of 16 in. American guns firing a shell of 2,400 lb. weight a distance of 21 miles, and of 12 in. armour-plate fired at from a distance of 1½ miles being cracked but not perforated. The wire-wound gun described by the lecturer was found to be the finest in the world, and it had the advantage of being cheaper than enemy patterns. It was not usually realised that the life of a large gun, based on the time of actual fire, was not more than three seconds. A curious fact was that the soft nosed cap used on modern shell expanded so rapidly on striking an object as to allow the complete shell to pass through it. In referring to the great importance of metallurgy in gun-making engineering, Sir Robert Hadfield told of a 15 in. shell which can pass through 15 in. armour plate in no more than $\frac{1}{1000}$ of a second, and of a 6 in. shell fitted with a modern cap which he had seen fired three times before the shell was broken.

Royal Institution.—The Day Lectures after Easter will include two by Dr. T. M. Lowry on "Optical Research and Chemical Progress," and two by Prof. W. H. Bragg on "X-Rays and Crystals." The Friday Evening Discourses will be resumed on May 5, and will include a discourse by Sir J. M. Davidson on "Electrical Methods in Surgical Advance," and one by Prof. C. G. Barkla on "X-Rays."

ARRANGEMENTS FOR THE WEEK.

ENGINEERING INSTITUTIONS' VOLUNTEER TRAINING CORPS.

Commanding Officer: Lieut.-Col. C. B. Clay.

Orders for week commencing April 24, 1916:—

Drills: 6.25 to 7.25. 7.25 to 8.25.

Monday, April 24th.—Easter Training at Otford.

Tuesday, April 25th.—School of Arms, 6 to 7 p.m. Recruits' Drill, 7.15 to 8.15 p.m.

Thursday, April 27th.—Shooting for Sections 3 and 4. Recruits, 7.45 to 7.45 p.m.

Friday, April 28th.—Sections 3 and 4, Technical. Sections 1 and 2, Squad and Platoon. Signalling Class and Recruits.

Saturday, April 29th.—Adjutants' Instruction Class at 2.30 p.m.

Sections for Technical: Parade at Headquarters, London Electrical Engineers, 46, Regency-street, S.W.

Sections for Shooting, Parade at Miniature Ranges. Unless otherwise stated, all parades at Chester House.

ELECTRICAL DIAGRAMS.

BY P. RAYNER-SMITH.

In considering any standard scheme for uniformity in drawing electrical diagrams such as that propounded by Prof. Kapp in THE ELECTRICIAN of March 10, 1916, it would be well to consider the new series of electrical symbols prepared this year by the United States Patent Office as a chart for draughtsmen.

These number 89, but their scope is not the same as that of Prof. Kapp's series. They do not deal with arrows or the like as applied to E.M.F. current, and so on; but, on the other hand, they include many matters not in the other series. On the whole, they are very expressive and, generally speaking, simple: but in some instances their drawing would take a comparatively great time.

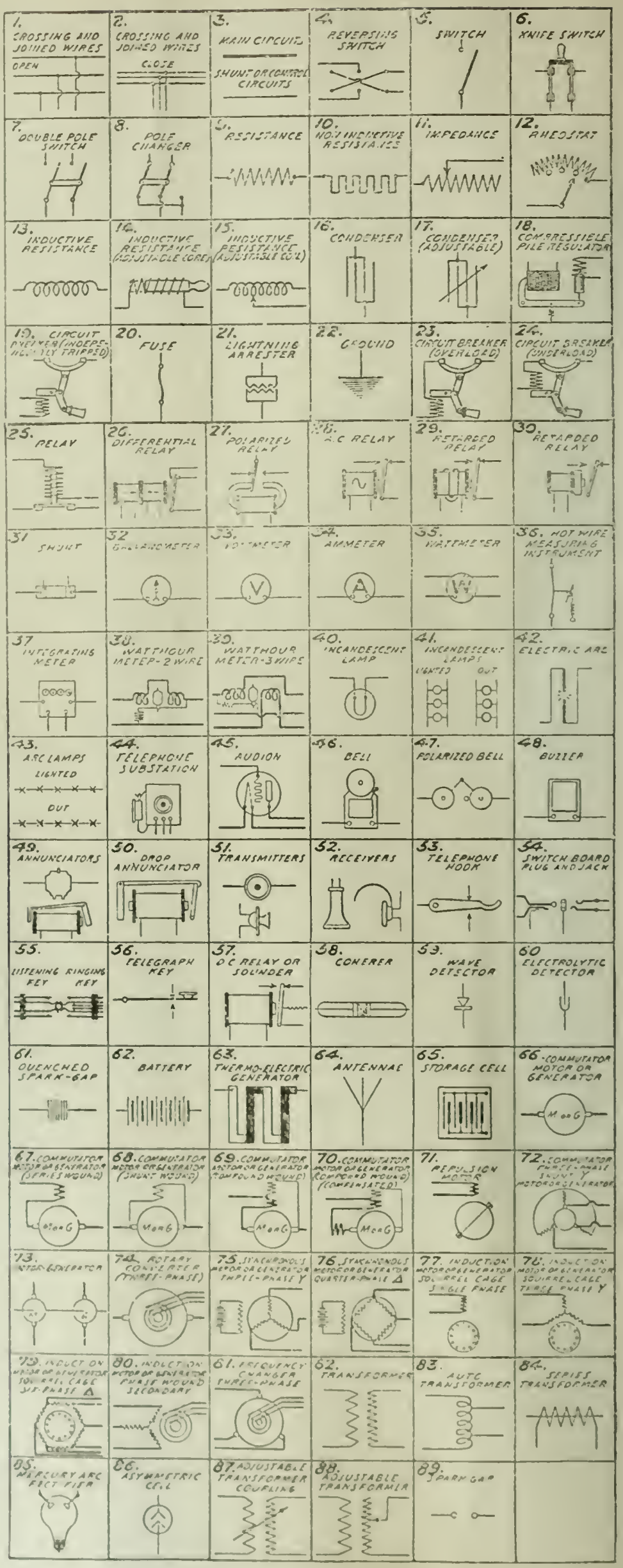
Referring to the diagrams Nos. 1 to 5 for wires and certain switches are conventional and good. 4 and 5 are simpler than the Kapp symbols. The knife-switch symbol, 6, might be simplified by substituting a plain thick line for the handle, which as it is shown involves the drawing of an arc. The switches 7 and 8 are good and so is the resistance 9. The non-inductive resistance 10 is simple, but 11 is not very suitable for an impedance. The type shown in 13 is much better, although more difficult to draw. 12 calls for no comment, nor 14, except that the core might be represented by a straight line

The symbol chosen for the condenser in 16 is the same as that used by Prof. Kapp, but it would be better to substitute for this the other form, which can be quite well drawn without confusing it with a battery. 18, the pile regulator, is practically never required. The set of circuit-breakers, 19, 23 and 24, are complicated, but almost necessary if it is intended to go to the refinement indicated.

20 to 22 show convenient conventional symbols. There is no especial point in Nos. 25, 26, 27 and 28, dealing with relays; but 29 and 30 are not very clear. It would be better to black in the projecting end of the core. 31 to 35 are all good, and much more convenient for drawing than the instrument symbols of Prof. Kapp. 36, for the hot-wire apparatus, should not be required. Conventional lettering could be employed instead. The same applies to 37 to 39.

The lamp series, 40 to 43, are by no means good. Plain circles can be used for incandescent lamps, whether lighted or not and crosses for arc lights. Nos. 44 to 56 call for no special comment, as they are self-explanatory. 57 is liable to be confused with 30. 58 to 62 are quite good, but general. 63, the thermo-electric generator, is not often required, and 65 would be confused with 62. The motor and generator series, 66 to 81, are all explicit, but it does not follow that it is necessary to employ them in every diagram. Often a conventional sign as 66 would be sufficient, but when more detail is required it is well provided by the symbols given.

The transformer figure, 82, is open to the same criticism as the impedance 11. The auto-transformer in 83 is satisfactory, but the series transformer 84 is not clear. The rectifier 85 and the asymmetric cell 86 can readily be understood, but 85 is somewhat difficult to draw well and quickly. The transformers 87 and 88 are open to the same criticism as 82. There is no special point in 89.



ELECTRICAL DIAGRAMS PREPARED BY THE UNITED STATES PATENT OFFICE AS A CHART FOR DRAUGHTSMEN.

INSULATING OILS *

The Sub-committee have considered the suggestions received with regard to the proposed tests, which in the first place are being limited to transformer oils. An abbreviated account of the tests, most of which have been in practical use for some time, will be found below. The points that now require investigation are :—

(1) How far are the results consistent when made by different observers on the same sample of oil ? (2) Could the results of the tests be relied upon to indicate with certainty the behaviour of the oil under practical working conditions ?

The Institution has received a grant from the Advisory Council for Industrial Research for this work, and the Sub-committee propose, therefore, to put the experiments in hand at once, especially in view of the delays caused by the war.

In order to judge the suitability of an oil for use as a cooling insulating medium it is necessary to know its characteristics in the following respects :—

(1) Tendency to sludge, (2) loss by evaporation, (3) flash point, (4) viscosity at different temperatures, (5) chemical reactions, (6) density and coefficient of expansion, (7) cold test (solidification), (8) moisture absorption, (9) dielectric strength, (10) specific resistance, (11) thermal transference, (12) specific heat.

The detailed methods of investigation for each characteristic recommended in the following pages may be first briefly reviewed.

General Review.

Sludging.—The object of this test is to obtain an idea of the tendency of the different oils to form solid deposits when they are subjected to the action of heat and air. This action is considerably influenced by the presence of certain metals. The method recommended is a modification of that used by Dr. Michie. The oil contained in a flask is subjected to the action of heat and oxygen for a given time, a piece of the metal in question of given surface area being present in the oil during the test. It would be of interest to obtain comparative figures for copper, iron, lead, tin, zinc and aluminium, and, in view of the importance of copper in electrical work, data should also be obtained for tinned copper, silver-plated copper and copper covered by insulating material, such as cotton.

Besides the formation of solid deposits in the oils after these have been subjected to the conditions of the test, note should be made of any corrosive effects on the metals, the formation of water and acids and the extent to which the oils have darkened in colour. The depth of colour of the oil can be accurately measured in degrees on a permanent colour scale by means of Lovibond's tintometer No. 7 set for standardising merchantable petroleums.

Loss by Evaporation.—Two different methods of carrying out this test are described. A definite volume of oil is heated in a beaker at 100°C. for eight hours. In one method the body of the beaker is immersed in the heating bath, its open mouth being exposed to the air of the laboratory but shielded from draughts. In the second method the beaker is carried in a revolving tray in a hot-air oven. The result is expressed in terms of loss of volume and ratio of surface to volume of oil, the height of beaker wall above oil surface at the commencement of the test being stated.

"Closed" Flash Point.—The temperature at which vapours accumulating above the oil in a closed vessel become inflammable is determined by means of either the Pensky-Martens or Gray's instrument. The oil is rapidly heated to about 25°C. below its suspected flash point, the heating being continued beyond this at the rate of 2½ deg. to 3 deg. per minute. At each additional degree of temperature the cover is opened and a flame inserted. The lowest temperature at which flash occurs is thus determined.

Viscosity.—The standard method in Great Britain for this determination is that of Redwood, which notes the time in seconds required for a definite volume of oil to run through an aperture of fixed dimensions. Measurements are made at 15·5°C., 50°C., and 80°C.

Chemical Reactions.—The oil is tested for acidity and alkalinity. An iodine test is also recommended, as it is believed that this test gives a good general indication of the tendency to sludge.

Density and Coefficient of Expansion.—The density is determined at the three temperatures 15·5°C., 50°C. and 80°C. by means of specific gravity bottles or pynkometers, preferably of the Sprengel tube type. From this data the coefficient of expansion is obtained.

Cold Test.—This test determines the temperature at which the oil commences to congeal. A knowledge of this characteristic is of importance in connection with oil switches used in exposed situations and cold climates.

Moisture Absorption.—This test is made to determine the tendency of an oil to absorb moisture from the atmosphere, and is made by taking dielectric (breakdown) tests upon the originally dry oil after successive intervals of exposure.

Dielectric Strength and Specific Resistance.—These are familiar laboratory tests.

Thermal Transference.—A certain amount of information is available regarding the relative cooling effects in a transformer with oils of different viscosities, but it is felt that more exact information would be of value, and a method of investigation recommended by the National Physical Laboratory is here described in detail.

Specific Heat.—The method of performing this test is left to the judgment of individual experimenters. Data should be obtained at 15·5°C., 50°C. and 80°C. Reference is given to published data upon this subject. It is suggested that specific heat tests at 15·5°C. might with advantage be made upon the oils both in their original condition and after drying, but for the test at higher temperatures dried oil (*see* section 10) should be employed.

Tests.

Sludging Test.—This investigation should be conducted as follows:

One hundred cubic centimetres (100 cubic cm.) of the sample are introduced into a clean, dry, round-bottomed flask, having a neck 11 in. to 12 in. (28·0 cm. to 30·5 cm.) long and ¾ in. (19 mm. internal diameter, and a bulb of 2·75 in. to 3 in. (70 mm. to 76 mm.) diameter, which has a capacity of 200 cubic cm.

Next is introduced a piece of pure sheet copper having a "planished" surface (bright rolled and polished), and a thickness of 0·004 in. (0·1 mm.), and measuring 1 3/16 in. × 2½ in. (3 cm. × 6 cm.). A fresh piece of copper should be used for each test. The total area of the copper, which equals 2·82 sq. in. (18·19 sq. cm.), is immersed in the oil.

To introduce the strip it is wrapped round sufficiently to overlap itself slightly and to slide easily down the neck. The copper strip must be so bent that when in the flask the edges spring apart, leaving an opening about ¼ in. (6 mm.) wide to facilitate circulation. The coiled strip stands vertically on the bottom of the flask. Before introduction the surface of the copper is carefully polished clean by means of washleather and a little soft polishing paste.

The whole of the bulb of the flask is immersed in an oil bath, and the neck passes through a hole provided in the lid of the bath. The bath can be heated by gas or electric current, and must be fitted with a thermostat heat-regulating device and a motor-driven stirrer, so that the temperature is even throughout and can be maintained constant to within ±1°C. of the selected temperature.

The neck of the flask, which projects above the lid of the oil bath, is water cooled by means of a water jacket 10 in. or 11 in. (25·4 cm. to 27·9 cm.) long, connected to the water supply in the usual manner. The mouth of the flask is fitted with a rubber bung having two holes, and carrying two glass tubes of 0·157 in. (4 mm.) internal diameter, which are respectively the exit and inlet tubes for passing a stream of oxygen through the oil.

The exit tube ends nearly flush with the inside of the bung, whilst the inlet tube reaches to within ⅛ in. (3 mm.) of the bottom of the flask, and passes axially through the cylinder of copper, which thus aids in the distribution of the oxygen throughout the body of the oil. The portions of the exit and inlet tubes outside the flask are bent to a convenient angle for connection to the following apparatus :—

Before entering the flask the oxygen is made to bubble through a layer of oil of 2 in. (51 mm.) depth, contained in a "tell-tale" bottle of 8 oz. capacity, which is fitted with a two-hole rubber bung carrying two glass tubes for inlet and exit of the gas.

The inlet tube is of 0·313 in. (7 mm.) internal diameter, and reaches to within ½ in. (1·3 cm.) of the bottom of the bottle.

The exit tube is of 0·157 in. (4 mm.) internal diameter, and projects not more than ¼ in. (6 mm.) inside the bottle. It is coupled up to the inlet tube of the flask.

The inlet tube of the tell-tale bottle is joined up to the following purifying train :—

The oxygen supply as purchased should be of not less than 99 per cent. parity, and it is further purified before entering the tell-tale bottle by passing it through three wash bottles containing respectively caustic soda solution of specific gravity 1·355, 10 per cent. silver nitrate and pure strong sulphuric acid.

The sample in the flask having been placed in the oil bath, and joined up to the tell-tale bottle and oxygen supply, is then raised to the temperature selected for the experiment. It is maintained at this temperature for a continuous period of 45 hours, and during the whole of this time a steady stream of oxygen is passed through it. The rate of flow of the oxygen, as shown by the bubbles at the 7 mm. inlet tube of the tell-tale bottle, is adjusted to three bubbles per

* Abstract of a report of a Committee of the Institution of Electrical Engineers.

second; this is equivalent to 6·7 litres (0·23 cubic ft.) per hour measured at 20°C.

For the purposes of this research each sample should be tested at 60, 70, 80, 90, 100, 110 and 120°C., duplicate tests being taken at each temperature. The amount of sludge, or, if no sludge forms, the change of colour (darkening) produced is determined for each test.

At the end of the 45 hours' reaction the oil is cooled and diluted with petroleum spirit in the ratio of 3 volumes of petroleum spirit to 1 volume of oil, taking care that all the deposit is removed from the flask. The whole quantity is mixed and transferred to a beaker, which is then covered and allowed to stand 12 hours for the sludge to settle out completely. The liquid is then decanted through a fine grained filter paper and the precipitate of sludge thoroughly washed on to the paper with petroleum spirit, and further washed until free from oil. The petroleum spirit used for the experiment should have a specific gravity at 15·5 C. of 0·70 to 0·72, and not less than 75 per cent. by volume should distil over below 110 C. (230 F.).

By means of hot benzol (pure benzene, C_6H_6, specific gravity at 15·5°C., 0·885) the sludge is then washed from the filter paper into a weighed vessel and its weight ascertained after evaporating off the benzol and drying at 100°C. until of constant weight. (As the residue when dry is usually very hygroscopic, the evaporation should be commenced on a water bath and the drying completed in a water oven.)

Knowing the specific gravity of the oil and the volume taken for the test, the result can be calculated out and should be stated as the percentage by weight of sludge yielded by the oil. All the results obtained for each particular sample are then plotted on squared paper with temperatures as abscissæ and percentages of sludge (by weight) as ordinates.

Change of Colour.—In those cases in which no weighable precipitate is obtained the change of colour should be recorded. An instrument specially devised for this purpose is Lovibond's "tintometer," known as "No. 7 set for standardising merchantable petroleums." By means of this instrument the depth of colour in the sample under investigation is matched to a corresponding shade in a series of coloured glasses numbered according to the depth of colour.

Evaporation (Loss on Heating).—The evaporation is determined by ascertaining the loss in weight produced by heating a standard weight of oil for eight hours at 100 C.

Two different methods now in use for this purpose are described—namely, Dr. Michie's toluene vapour-bath method, and the B.T.-H. Company's (rotating oven method).

Closed Flash Point.—This is to be determined by means of either the Pensky-Martens or Gray's instrument, under the standard conditions as specified in Sir Boverton Redwood's book, "A Treatise on Petroleum," 1913 edition (for Gray's tests *see* Vol. II., p. 269; and for the Pensky-Martens tests Vol. II., pp. 238 and 267). Standardised thermometers should be used for this test.

The following procedure in the method of employing the Gray apparatus has been found to yield satisfactory results in practice at the National Physical Laboratory.

A rough determination of the flash point is first made; a fresh sample of the oil is then put into the oil cup and is heated rapidly to within about 20 deg. of the flash point first observed. The rate of heating is then reduced to about 2½ deg. or 3 deg. per minute, and the test flame is applied to the oil vapour at each degree rise in temperature, in the usual way, until the flash occurs: this temperature is then recorded and the necessary thermometer correction is applied. The mean of three concordant results on fresh samples of oil is taken as the desired flash point.

Viscosity.—The viscosity is to be determined by means of a standardised Redwood viscometer at each of the following temperatures:—

15·5 C. (60 F.) 50 C. (122 F.) 80 C. (176 F.)

The method is given in detail in Sir Boverton Redwood's treatise, "Petroleum and its Products," Vol. II., pp. 600-602 (second edition). Care must be taken in the use of the instrument at temperatures above that of the air.

The viscosity should be expressed at the time in seconds required for the outflow of 50 cubic cm. of the sample. Standardised thermometers should be used for determining the temperatures.

Chemical Tests.

(*a*) *Acidity.*—25 grammes of the original oil are shaken up with 100 cubic cm. of neutral ethyl alcohol containing 95 per cent. by volume of anhydrous alcohol), 1 cubic cm. of a 1 per cent. alcoholic solution of phenol phthalein indicator is added, and the liquid titrated with aqueous N/10KOH (deci-normal caustic potash), and the result reported as the number of milligrammes of KOH (potassium hydrate) required per gramme of oil.

(*b*) *Alkalinity.*—25 grammes of the original oil are shaken up with 100 cubic cm. of warm distilled water, the liquid is cooled, and 1 cubic cm. of a 0·1 per cent. solution of methyl orange indicator is added, and if the solution reacts alkaline it is titrated with N/10HCl (deci-normal hydrochloric acid), and the result reported as the number of milligrammes of KOH (potassium hydrate) equivalent to the acid used per gramme of oil.

(*c*) *Iodine Absorption Value. Hübl's Process.*—This "constant" is determined by following the general directions for the Hübl method as described in "Chemical Technology and Analysis of Oils, Fats and Waxes," by Dr. J. Lewkowitsch (Vol. I., p. 311, 1909 edition; Macmillan & Co.), but using from 1·0 to 1·25 grammes of the oil, with 10 cubic cm. of chloroform and 50 cubic cm. of the standard iodine solution, and allowing the reaction to proceed for not less than 18 or more than 24 hours.

Density and Other Tests.

Density, Coefficient of Volumetric Expansion.—These two determinations are combined in a way which only requires accurate specific gravity determinations of the oils.

The density is to be determined by means of specific gravity bottles or pynkometers at each of the following temperatures, and compared with pure water at the same temperature.

15·5 C. (60 F.) 50 C. (122 F.) 80 C. (176 F.)

A pynkometer of the Sprengel tube type will probably be found very convenient. With due care the probable errors on the specific gravity should not exceed ±0·001.

Cold Test.—For this determination a volume of 25 cubic cm. of the oil is placed in a thin-walled glass test tube of 6 in. length and 1¼ in. internal diameter (capacity=150 cubic cm.). The oil must be free from moisture.

A cork carrying a standardised thermometer reading from −40°C. (−40°F.) to +40·5°C. (+105°F.) is lightly fitted into the mouth of the test tube so that the bulb of the thermometer is situated in the centre of the oil. The graduations of the thermometer should be engraved upon its stem, and should read to ½ C.

The test tube is then immersed in a suitable freezing mixture so that the whole of the oil is surrounded by the latter. The oil is stirred until nearly solid and then left until no sign of fluidity remains. The test tube is then removed from the freezing mixture and allowed to warm slowly with constant stirring by a thermometer until the temperature is reached at which the oil will flow from end to end of the tube, which temperature is recorded as the cold test temperature.

Moisture (Absorption).—The term moisture as here used excludes "free water"—*i.e.*, visible water or finely subdivided water or emulsions which will separate as distinct layers if the oil is permitted to stand undisturbed for, say, 48 hours in a room at 15·5 C. (60°F.) to 25 C. (77 F.). For such instances the term "free water" should be used.

It is considered that there does not exist any really accurate and satisfactory quantitative method for estimating the minute percentages of moisture held in solution by mineral oils, which causes them to be termed "undry" in the electrical sense. Drying by heating the oil to 100 C. or 110 C. drives off some of the more volatile constituents of the oil as well as such moisture. Chemical methods are of no value.

The presence of moisture can be qualitatively demonstrated by means of the dielectric strength test, using the standard method given below. Therefore the object of the following test is to ascertain the relative powers of oils to absorb moisture from the atmosphere after they have been dried and proved to be so in the electrical sense by means of the standard dielectric test. Although this test is primarily qualitative, yet, since the qualitative effect of traces of absorbed moisture upon the dielectric strength is already known approximately, it can also be interpreted up to a certain point in rough quantitative terms.

The method of performing the test is as follows:—

Some of the oil as originally received is first tested for its dielectric strength by the standard method below.

Four and a half litres of it in the same condition are then put into a clean, dry enamelled iron pan which has a flat bottom roughly 12 in. in diameter and vertical sides 6 in. deep. This is then heated for four hours to a temperature of 100 C. It is then cooled and some of it tested by the dielectric test. The oil used for this test is rejected.

The four hours' drying at 100 C. is repeated and followed by a dielectric test. This process is repeated until no further significant increase in the dielectric test is produced. At this stage the oil is considered perfectly dry in the electrical sense. All portions of the oil which have been subjected to the dielectric test should be rejected; they are not fit for further use.

The oil remaining from the above tests is then exposed to the air of the laboratory for one hour, the wet and dry bulb readings are noted and the dielectric strength again obtained. Free access of

air to the surface of the oil should be arranged for, but the oil must be protected from particles of dust, &c., during the whole testing process—*i.e.*, both during "drying" and "absorbing."

The remaining oil is now exposed to the air for 24 hours; wet and dry-bulb readings are taken at least twice during this period, and then the dielectric test is repeated.

This procedure of 24-hour exposures and testing is continued until the dielectric test has fallen to a value so low that the oil would be considered to be below a safe one for any insulating purposes (or the whole 4½ litres have been used up). The results are to be plotted as a curve having dielectric values as ordinates and time as abscissæ.

NOTE.—If the value of oil required for each dielectric test is 250 cubic cm. (about 8½ oz.), 16 or 17 tests can be made from the quantity originally dried.

Dielectric Strength.—This test should be made with ½ in. diameter (12·7 mm.) spheres with a separation of 0·15 in. (3·81 mm.). Duplicate tests should be made. The spheres can be made of brass, but a pure metal of high melting point, such as platinum or tungsten, would probably wear better. The electrodes should be immersed in the oil to a distance of not less than 1¼ in. from the surface. The volume of the oil used per test should not be less than 250 cubic cm. (roughly 8½ fluid oz.). The temperature of the oil should be between 15·5°C. and 20°C.

The containing vessel and the electrodes must be made absolutely clean and dry before performing each test, and great care taken to avoid any contamination of the next oil examined. For this reason horizontal electrodes are probably preferable, but whichever method is used it must be so arranged that the electrodes can be readily removed bodily from the containing vessel for the purposes of cleaning and drying them and adjusting the gap distance. If the electrodes become pitted by the action of the spark they should be renewed.

The voltage at which sparking first commences, and also that at which complete breakdown with continuous sparking occurs, should be recorded.

The oil used for this test should not be used for any other research tests.

Specific Resistance.—This test should be made upon the oil as received, and also after perfectly drying it in the manner detailed under "Moisture."

It is not thought necessary to specify the full details for this test, but it is very strongly recommended that the tests be always conducted upon very thin films of oil between electrodes in order to avoid excessively high values; the latter have no practical significance.

The temperature at which the standard specific resistance test is to be performed should be between 15·5°C. and 20°C., and as near 15·5°C. as possible with the apparatus.

Thermal Transference.—A figure illustrating simple convection flow is given in the article, after which there is an application of Poiseuilles' equation for flow in capillary tubes.

If the relation were shown to be roughly true, the determination by direct experiment of either (1) the thermal transference coefficient or (2) the values of the specific heat, the density and the coefficients of viscosity and expansion, would serve to decide the value of an oil for use in a transformer from the point of view of its cooling effect.

The above notes on thermal transference must be regarded as a suggestion for an experimental investigation, and the conclusions arrived at require verification at a convenient opportunity. In the meantime the coefficient of thermal transference as here defined might be employed in estimating the suitability of any oil of which the physical constants had been determined.

Specific Heat.—The method of performing this test is left to the judgment of individual experimenters, but it should be taken at 15·5°C. (60°F.). It would be advantageous to determine the effect of increase in temperature upon this value over a range of temperature from 15·5°C. (60°F.) to 80°C. (176°F.).

ELECTRIC WELDING.*

BY JULIUS SAUER.

The arc method of welding employs only direct current at a voltage between 40 and 65, the current varying from 100 to 800 amperes. The common methods are those known by the names of Bernados, Slavianoff and Zerener. The Bernados method is very simple: One electrode is connected to the weld, and the other consists of a movable carbon. Between these an arc is started, which causes fusion at the welding point. It is mainly used for welding cylinders of fairly thick plate, for tramway rail joints, and for repairing defects in steel castings. But small pieces of carbon from the electrode are torn off and embedded in the weld. This makes the weld harder than the surrounding metal. The process can, therefore, only be employed in cases where this variation in hardness is permissible, otherwise we must have recourse to the Slavianoff method. This differs from the Bernados process inasmuch as the second electrode is not made of carbon, but of the same metal as that used for the weld. Almost any metal can be used, but it is mostly employed on grey cast iron and steel castings. Broken pieces can be repaired in this way, and superficial blowholes and cracks can be made good. There is a temperature fall of 900° C. from the positive to the negative electrode. Difficultly fusible metals, like cast steel, are therefore connected to the positive pole, and the negative pole is joined to the more easily fusible metal. With easily fusible metals, like copper and cast iron, the opposite plan is used. On the Zerener plan the two carbon electrodes are placed at an acute angle, and a magnet is used to blow the arc downwards on the weld: plate metal can be welded in this way, as on the autogenous process. For all these methods direct current is used. Formerly a shunt machine giving 110 volts was employed in combination with series resistances, batteries, &c., which caused a steady loss. Lately machines giving 65 volts have been used, and these are so constructed that on short-circuit the voltage disappears. So-called "cross-field" machines have been constructed by the Allgemeine Elektricitäts Gesellschaft in sizes giving 200, 460 and 800 amperes. The operation is completely sparkless on short-circuit. Machines have also been made on the Krämer patent, being partially self-excited and partially separately excited. The separate excitation serves the purpose of limiting the current on short-circuit. As for the amount of energy and time required to repair castings, it is not easy to give any general figures. As a rough estimate, it may be stated that two kilowatt-hours are required to fuse 1 kg. of iron. In a certain case a cast-iron ring, weighing 165 kg., was cracked in the middle. The gap required 2·4 kg. of material, which consisted of cast-iron rods with a high silicon content, 10 mm. in diameter. The current amounted to 500 amperes, the voltage was 50, and the energy consumption was 4·2 kw.-hours, the job lasting half an hour. In order to avoid internal stresses the work was heated by burning charcoal. Plates can also be cut by the arc process, which gradually melts the metal. In all these cases the metal is fused and the weld is effected in this way.

The electrical-resistance method is, however, quite different in principle. The heat is internally generated at the welding point. We may take the case of the welding of a tyre as typical. At the point of junction there is a high resistance when the two butt ends are brought together: this causes the local generation of heat and the consequent weld. The voltage required for the operation is very low, and varies according to the section from 2 to 8. The current, however, may amount to several thousand amperes, and alternating current is almost exclusively employed, seeing that the transformer is a very convenient method of generating a large current at a low voltage. The transformer is usually placed inside the welding machine, and the secondary cables are made as short as possible. On the primary side there are usually several tappings in order to produce suitable variations in the voltage and temperature at the weld. If a special alternator is used it is a good plan to provide this also with tappings, so as to have a double method of regulation. The fact that the heating takes place locally only at the point where the weld is to be made tends to economy in energy consumption, the two butt ends being pressed together and heated by the passage of the secondary current through the imperfect contact at the joint. Metallurgically considered, there are great advantages from the fact that no impurities enter the joint, as no auxiliary electrodes are used. The temperature can also be adjusted with great exactness, and there is, therefore, no question of burning the metal. The inside of the metal at the joint is also thoroughly heated, because the heat passes from the inside of the metal to the outside. The author gives photographs of several typical machines of this kind. One of the photographs shows a machine for welding the rims of the wheels of a motor car, having an output of 40 k.v.a., and being suitable for welding sections up to 1,000 sq. mm. The secondary voltage is 4 volts, and at full load the current rises, therefore, to 10,000 amperes. Another photograph shows a larger machine of the same kind, suitable for sections up to 6,000 sq. mm., and with an output of 200 k.v.a. The electrodes, to which the weld is clamped, are cooled with water. The links of chains can be welded in the same way on a semi-automatic machine, of which a photograph is also given. By pressing on a lever the attendant passes from one link to the next, and 15 links can be welded in a minute out of metal 5 mm. in diameter. All sorts of small welds can be made in the same way, levers, connecting rods and the like, it being necessary so to design the parts that the heat is equally distributed on both sides of the weld. Generally speaking it may be said that a weld is best made

* Abstract of an article in the "Elektrotechnische Zeitschrift," Nos. 43 and 44, 1915.

as quickly as possible. Curves are given showing the factors on which the variations of energy consumption depend. The distance between the clamps should be kept as short as possible. The following table gives particulars as to the energy consumption and time required for welding tyres of a given section—viz., 9 mm. by 9 mm., or 81 sq. mm. and shows how this depends on the diameter of the tyre or ring. The smallest diameter is 20 mm., and it is increased till the diameter becomes infinite or the ring becomes flat.

Table I.—*Showing the Time and Energy Consumption required for Welding Rings of Different Diameters having a Section of 9 mm. by 9 mm.*

Diameter of ring in mm.	Power applied.	Second required.
20	20	6·0
45	18	6·0
90	17	5·75
150	16	5·5
220	15	5·25
320	13	5·0
500	12	4·75
850	10	4·5
∞	9·5	4·0

Another kind of weld is "spot welding," in which the welds are made in sheet metal at a series of points. The secondary winding of this transformer is brought to two electrodes; the lower is fixed, and may be regarded as a kind of anvil, while the upper arm is movable, and performs the functions of a hammer. The hammer is moved by the agency of a pedal. When the pedal is depressed the two plates of sheet metal are pressed together, and a further motion of the pedal closes the primary switch. The sheet metal is thus heated at the point of pressure, and a weld is formed at this point. As soon as the pedal is released the primary switch is opened, the pressure is removed, and the sheets can be moved into a new position for a fresh weld. Machines of this kind have been very quickly introduced into practice owing to the many conveniences they afford. The two plates merely need to be superimposed, and there is no need for any adjustments of corresponding holes in the design; the weld, too, is very quickly made. A photograph is given of a spot welding machine with an output of 7·5 k.v.a., on which an unskilled operator can make 12,000 spot welds in a day. Different kinds and sizes of these machines are made, with outputs from 1 kw. to 40 kw. With the larger sizes of sheet metal, the pressure must not be removed too quickly from the weld, which must be allowed to cool sufficiently to secure adhesion. A device for this purpose is usually provided, so that the mechanical pressure remains when the voltage is switched off. A photograph shows an apparatus for steaming potatoes constructed entirely in this fashion. With plates 10 mm. thick the voltage falls from 2 to 1·25 during the making of the weld; with the butt-end method the voltage rises instead of falling. Curves are given showing the variation of energy consumption with plates of different thickness, and also the variation in the time required for the operation. The energy consumption is apt in practice to be found to be a very variable quantity, depending on the circumstances of the case. A good deal turns on the shape, configuration and size of the metal on which the weld is to be made. Under certain conditions it may act electrically as a choking coil, especially if it forms a closed circuit on itself, and the self-induction also depends to some extent on the area of the surfaces. If there are large masses of iron between the electrode arms, this affects the course of the proceedings, and the author gives curves showing what may be expected under these conditions. The spot weld gives a very strong joint, which may be 50 or 80 per cent. stronger than one made on a kind of riveted joint. If two plates 0·7 mm. in thickness are welded by two spot welds and then torn apart the force required to break the joint is 509 kg.; if the same plates are riveted with rivets 2·5 mm. in diameter the breaking force amounts to about 325 kg. Watertight seams can be produced with spot welds if the points are sufficiently close to one another. If really good watertight joints are needed, the point weld may be improved on by using a kind of roller as the electrode, and here we get a weld almost continuously along a line; the roller can be worked by hand or by a motor-driven device. Special machines have been constructed for welding iron cylinders, and these range in sizes up to those suitable for sheet iron 1·5 mm. thick and for cylinders 650 mm. long. With a machine of this kind it is possible, in factories for enamel ware, to make as many as 2,400 basins in a day, each standing 300 mm. high. The attendant has only to place the cylinders in position and to keep the machine in operation. Portions of the mountings for arc lamps can be made in this way: The parts are cut out of sheet metal, then the weld is made, and finally the thing is shaped, if necessary, by pressing it in wooden moulds. The result of these various operations is that the metal is more weakened by the pressing and shaping process than by those connected with the making of the weld. When torn apart the weld often remains intact, while the breakage takes place at some other part. Brass bands can be welded with great neatness, so that when they are polished no trace of the joint remains. With brass the energy consumption is about half as much again as with iron. The machines must be arranged to work with very light pressures, and the delicacy of the operation is therefore much greater in this case. The article contains a number of illustrations of machinery manufactured for these purposes by the Allgemeine Electricitäts Gesellschaft, and of some of the finished products turned out by these methods.

MAGNETISATION BY ROTATION.*.

BY S. J. BARNETT.

Summary.—The author discusses the theory of magnetisation by rotation, and the converse effect. Experiments on the magnetisation of steel rods by rotation are described, and the effect predicted is believed to have been found. Some subsidiary experiments are also described in the Paper.

In 1909 it occurred to the author, while thinking about the origin of terrestrial magnetism, that a substance which is magnetic (and, therefore, according to the ideas of Langevin and others, constituted of atomic or molecular orbital systems with individual magnetic moments fixed in magnitude and differing in this from zero) must become magnetised by a sort of molecular gyroscopic action on receiving an angular velocity.

Thus, consider a cylinder of iron, with zero magnetic moment in its initial state. If it is given an angular acceleration about its axis, each individual system, which we may suppose for simplicity to consist of a number of electrons revolving in fixed orbits with constant average velocities about an oppositely charged nucleus, will change its orientation in such a way as to contribute a minute angular momentum, and therefore, a minute magnetic moment, parallel to the axis of the cylinder. If the revolving electrons are all negative, in conformity with most of the experimental evidence, the cylinder will become magnetised in the direction in which it would be magnetised by an electric current flowing around it in a direction opposite to that of the angular velocity imparted to it. This corresponds to the direction of magnetisation of the earth and the sun.

Preliminary experiments made at the Tulane University of Louisiana at the time this idea occurred to me appeared to show, though doubtfully, a very minute effect of the sort in question. Later observations made in much the same way, but with an attempt at improvement in apparatus, failed to confirm this result with any certainty; and further investigation of the subject was postponed until better facilities were available.

In 1912 a similar idea was advanced by Schuster † in his presidential address before the Physical Society of London. He also appears to have been led to his views by considering the origin of the earth's magnetism. The author then refers to Schuster's hypothesis that the rotation determines the magnetic intensity which may or may not cause magnetisation according to circumstances.

It occurred to the author that the effect under investigation was the converse of the effect predicted and looked for by O. W. Richardson, in 1907-8—viz., the production of rotation by magnetisation; and it became apparent that both effects were immediate consequences of an idea advanced long ago by Maxwell.‡ who constructed apparatus for experiments upon the subject as early as 1861.

Maxwell pivoted an electromagnet in a frame, so as to be free to rotate about a horizontal line through its centre of mass and perpendicular to its magnetic axis. With the magnetic axis making an angle θ with the vertical, the frame was rotated at a high speed, and changes in θ were looked for. No change was found.

A quantitative theory is then developed, and it is shown that if ω is the angular velocity of the molecular system Ω the angular velocity of rotation of the body, then the intrinsic intensity of rotation is given by:—

$$H = 2\frac{m\Omega}{e}\left(1 - \tfrac{1}{2}\frac{\Omega}{\omega}\cos\theta\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The values of Ω experimentally attainable are so small in comparison with ω that the second term is negligible.

If we assume that e/m has the value ordinarily accepted for the negative electron in slow motion—viz., $-1{\cdot}77 \times 10^7$, and put $\Omega = 2\pi n$,

* From the "Physical Review," Vol. VI., No. 4, October, 1915.

† "Proceedings," Phys. Soc. London, Vol. XXIV., p. 121, 1911-12.

‡ "Electricity and Magnetism," § 575.

where n is the angular velocity in revolutions per second, we obtain for the intensity per unit angular velocity :—

$$H/n = -7{\cdot}1 \times 10^{7} \text{ gauss per rev. per second} \quad . \quad . \quad . \quad (2)$$

This is on the assumption that the negative electron alone is effective. If the influence of the negative electrons is preponderant the number in (2) gives the *maximum* magnitude of H/n, attained when the negative electrons alone are effective.

The relation of proportionality must hold also between the angular velocity and the magnetic flux density and intensity of magnetisation, which are very minute and, therefore, proportional to the intrinsic intensity ; but these quantities will depend not only upon the intensity but also upon the material and shape of the rotating body. Thus, in the case of a diamagnetic substance it is shown in the Paper that the effect in zero.

In one set of experiments the magnetic circuit was almost wholly of iron, but the reactions masked the minute effects looked for. In another series of experiments, which has given definite and conclusive results, two nearly similar rods of steel shafting (A and B, Fig. 1) were mounted with their axes horizontal and approximately at right angles to the magnetic meridian, and two similar coils of insulated wire were mounted about their centres. These coils were connected in series with one another and with a fluxmeter, and were oppositely wound like the coils of an ordinary U-shaped electromagnet, so that any variations in the intensity of the earth's field, acting in the same way on both rods, might produce no effect on the fluxmeter. One of the rods, which will be called the compensator, as A, remained at rest, while the other, called the rotor, as B, was alternately rotated and brought to rest, the change of flux being determined by the fluxmeter.

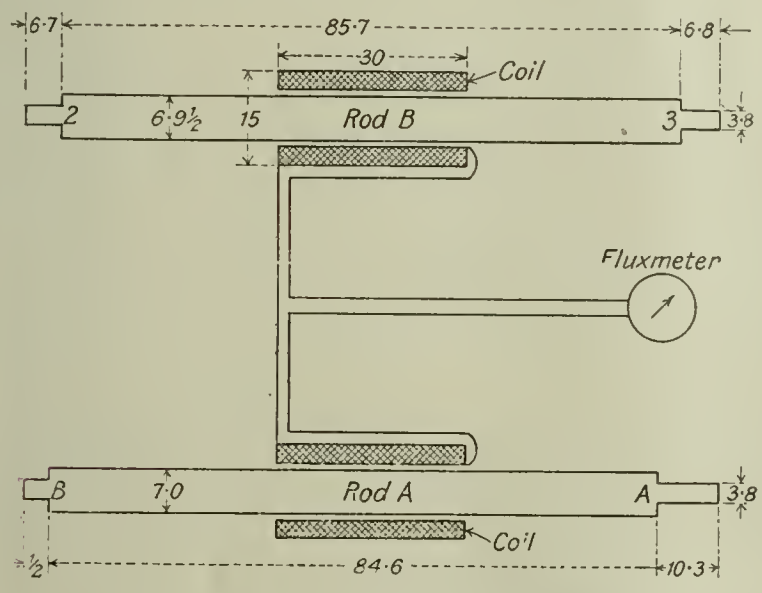


FIG. 1.—ARRANGEMENT OF STEEL RODS.

The approximate dimensions of the rods A and B, as they were used in nearly all of the work, are shown. The dimensions of the two coils used in most of the work are also indicated in the figure. Each of these coils was wound on a brass bobbin with about 5,000 turns of No. 14 D.C.C. copper wire, the winding being made very regular on account of other investigations for which they were primarily designed. A third coil, of somewhat different construction, was substituted for one of the coils in some of the experiments.

In the first part of the work the rotor was mounted in brass bearing-pieces inserted in bronze castings bolted to the cement floor of the laboratory, all parts being accurately fitted so that there was as little play as practicable. The rotor was driven by a brass rod 1·4 metres long and 1·1 cm. in diameter, itself direct-connected to a countershaft and pulley system driven by belt from an alternating-current motor of the repulsion type. The countershaft and pulley system was entirely of brass, bronze and wood, and moved in brass castings bolted to the floor, with thin iron sleeves for bearing pieces. The motor pulley was similar to that of the countershaft, except that it was mounted on an iron sleeve.

The fluxmeter was a Grassot instrument provided with a concave mirror with approximately 2 metres radius of curvature. It was mounted on a slate shelf cemented into the laboratory wall, and the scale distance was usually 8 metres.

In order to eliminate residual drift and other extraneous disturbances, readings were ordinarily taken in sets of eight, as follows : Two with counter-clockwise or *negative* rotation (as seen from the west end of the rotor) four with clockwise or *positive* rotation, and two more with counter-clockwise or negative rotation, the order of the positive and negative rotations being sometimes reversed.

To determine H_0, the intrinsic magnetic intensity of rotation per millimetre of fluxmeter deflection at the scale distance 8 metres, a series of experiments were made, and these showed that the deflection produced by the solenoid alone was 1·6 per cent. of that produced by the solenoid and core.

A second experiment was necessary to determine this deflection at 8 metres, produced by B_0, and I_0, the flux density and intensity of magnetisation produced by the rotation, and the result obtained was :

$B_0 = 7{\cdot}7 \times 10^{-4}$ maxwells per square centimetre per millimetre.

The intensity of magnetisation at the central section of the rotor per millimetre deflection, denoted by I_0, is approximately

$$I_0 = B_0 \, 4\pi.$$

With the apparatus, over 25 sets of observations were obtained The rotations of one group were made with rotor .1, most of them at about 50 revolutions per second, two at about 18 revolutions per second. Each of the groups gave a mean result (differential deflection) in the direction predicted by theory on the assumption that the revolving electrons are negative, the mean deflection (reduced to 8 m. scale distance) per unit speed being about 0·04 mm. ; but the discrepancies were large, partly on account of imperfect compensation of the earth's intensity owing to the large distance between rotor and compensator, partly on account of non-uniformity and imperfect compensation of fluxmeter drift, and partly on account of mechanical vibration and other causes.

An elaborate series of precautions were made, and arrangements altered, in order to eliminate error, and the experiment repeated. From these results Fig. 2 was obtained. The large circles designate the observations which needed no reduction for speed differences : the smaller circles and crosses, those for which reductions were made. The circles designate observations made with end 2 of the rotor east ; the white circles corresponding to those made with the compensator end A east, the black circles to those made with compensator end B east : the crosses designate observations made with the rotor end 3 east and compensator end A east.

The continuous straight line in the figure is drawn with a slope

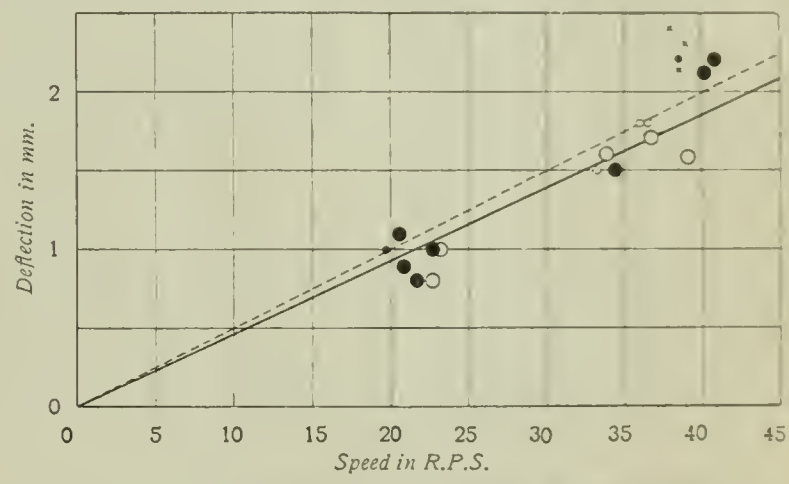


FIG. 2.—DIFFERENTIAL DEFLECTION AND SPEED.

obtained by dividing the sum of all the differential deflections for the observations which needed no reductions by the sum of all the corresponding speeds, and thus gives the weighted mean deflection per unit speed, on the assumption of proportionality between them. This quantity is 0·046 mm. per revolution per second.

The broken straight line is drawn in the same manner for all the observations made with the earth's intensity compensated, reductions having been made when necessary, as indicated above. From this line the mean deflection per unit speed is 0·050 mm. per revolution per second.

From the figure it appears that the deflection is proportional to the speed within the limits of the experimental error. Within these limits this deflection is independent of the orientation of the rotor or compensator or the distance between them. The average departure of the differential deflection for a single set from the ordinate of the (broken) straight line corresponding to the speed is 12 per cent.

The intrinsic magnetic intensity of rotation, and the change of magnetic flux density, per unit speed were found to be about

$$-3{\cdot}1 \times 10^{-7} \text{ gauss per revolution per second.}$$

and $-1{\cdot}9 \times 10^{-5}$ maxwells per square centimetre per revolution per second respectively.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"An Introductory Course of Continuous-current Engineering," by A. Hay, D.Sc. 2nd edition. (London : Constable & Co.) Pp. xii.—360. 6s. 6d. net.

"Elementary Strength of Materials." By E. S. Andrews, B.Sc. (London : Chapman & Hall.) Pp. viii.—216. 4s. 6d. net.

TRANSFORMER DESIGN.

(*Continued from p. 46.*)

BY F. M. DENTON, A.C.G.I.

Summary.—A general discussion is given of the nature of the problem of transformer design, and the author sets out Arnold's method of design for constant potential transformers. He then deals with the conditions ensuring maximum electrical and commercial efficiencies, and discusses the advisability of designing power transformers for minimum cost. A rule is developed by the aid of which designs of power transformers may be based upon commercial efficiency rather than upon minimum cost. The author then gives an outline of the method of design proposed by Arnold in 1910 and a comparison of Arnold's later and earlier methods. Comparative designs are worked out and a schedule is given, based upon Arnold's method of 1904.

Lighting Transformers. The specification for a lighting transformer usually includes: The KVA capacity, the primary and secondary voltages, the frequency, the percentage iron loss (p_i) and the electrical efficiency η. The condition of minimum cost determined, for the power transformer, the way in which the formula

$$C = 2{\cdot}28 L_i E_i B\ L K_u\ 100s$$

should be applied. The minimum cost condition was held to be more important than that of maximum possible efficiency, and the exact division of the losses between the iron and the copper was not made a determining factor in the design. The wisdom of this will later be discussed. In the case of a lighting transformer, however, the precise value of the iron loss must be regarded as part of the specification since this is a continual source of loss, and its value greatly affects the economy of working. Thus it comes that in a line of lighting transformers, all of approximately the same type, the ratio of volume of iron to volume of copper, and that of L_k to L_i, may be not even approximately constant. The following additional considerations are therefore needed:

$$L_k = k_1 \sqrt{Q}.$$

where L_k is the mean length of a turn in centimetres, Q is the cross section of the core in square centimetres, and k_1 is a constant depending upon the type of the transformer. The truth of the statement is obvious: the mean length of a turn embracing a core of given shape of cross-section is proportional to the square root of the area of the core. Further

$$L_i = k_2 \sqrt{N(t_1 q_1 + t_2 q_2) f_k} = k_2 \sqrt{(2N t_1 I_1 s f_k)}$$

where L_i is one mth of the total mean length of a line of force in centimetres, N is the number of phases per window (N is 2 for the ordinary three-phase core-type transformer having two windows), t stands for turns, q for square millimetres copper section, s for amperes per square millimetre, and f_k for copper space factor (the ratio of the total copper cross section per window to the total area of the window). This statement is like the preceding one: the flux in this case forming a belt around the copper, just as in the former case the copper formed a belt around the flux. Combination of these equations and the preceding ones, k_1 and k_2 being included amongst the constant quantities, gives

$$C = 1{\cdot}\beta (L_i K_u)^2 B f_k s,$$

β being a constant depending on the type of the transformer. The choosing of a value for β introduces an element of trial and error into the method. β depends upon the relative dimensions of iron and copper in the finished transformer, and cannot be known exactly until the complete design is known. Usually, however, the designer knows from previous designs what value β is likely to have in a given case. Expressed in terms of k_1 and k_2, β may be written

$$\beta = 7{\cdot}700 \frac{m}{n}\left(\frac{k_2}{k_1}\right)^2.$$

The derivation of this expression for β is as follows:

In the equation $C = 2{\cdot}2s \dfrac{L_i E_i B}{L_i K_u 100}$,

L_i is the length of a mean turn in centimetres, whilst $(L_i - a)$ is the total length of mean path of the flux in the iron cores, and we may write

$$7{\cdot}8 \times Q \times L_i \times m = 1{,}000 \times KVA \times E_i$$

or

$$Q = \frac{1{,}000}{7{\cdot}8} \frac{KVA \times E_i}{L_i \times m},$$

and

$$8{\cdot}9 \frac{2 I_1 I_1 N}{100 s} L_k = \frac{2}{n} \times KVA \times K_u \times 1{,}000.$$

"n" stands for the number of limbs in the transformer and "N" is the number of phases per window. For a single-phase core-type transformer "n" is two and "N" one, whilst for a three-phase transformer with two windows, "n" is three and "N" two.

From the equations $L_k = k_1 \sqrt{Q}$ and $L_i = k_2 \sqrt{(2 I_1 t_1 N / s f_k)}$ we have $L_k / L_i = k_1 / k_2 \sqrt{(Q s f_k / 2 N I_1 t_1)}$, and if we insert in this last equation the values of Q and of $s / 2 I_1 t_1 N$ derived in the previous paragraph, we find

$$\frac{L_k}{L_i} = \left(\frac{k_1}{k_2}\right)^2 \frac{8{\cdot}9}{200 \times 7{\cdot}8} \frac{n}{m} \frac{E_i f_k}{K_u}.$$

Inserting this value of L_k / L_i in the equation for C the latter may be written

$$C = \frac{1{\cdot}3}{10{,}000} \frac{n}{m} \left(\frac{k_1}{k_2}\right)^2 \left(\frac{E_i}{K_u}\right)^2 \frac{f_k B}{s},$$

and comparison of this with the β equation shows that

$$\beta = 7{,}700 \frac{m}{n} \left(\frac{k_2}{k_1}\right)^2.$$

By aid of this equation β may be found for any transformer whose linear dimensions are known. The equation $L_k = k_1 \sqrt{Q}$ says that k_1 is the mean length of a turn in centimetres divided by the root of the iron cross section in square centimetres, whilst the equation for L_i says that k_2 is equal to one mth of the total length of flux path in centimetres divided by the root of one-hundred times the cross section of a window (in square centimetres). Arnold gives values for β as follows:

Single-phase core-type transformers	40 to 75
Three-phase core type	25 to 50
Shell-type transformers	18 to 30

Here again the choice of trial values for B must be left to the discretion of the designer. As the iron loss has usually to be made small the limits allowable are as a rule lower than the limits for power transformers, suitable values often lying, for 40 to 60 cycle transformers of, say, 10 KVA to 60 KVA capacity between 4,500 and 7,000 lines per square centimetre, or with larger specially-cooled transformers, between 7,000 and 9,000 when ordinary iron is used, or between 9,000 and 11,000 when alloyed iron is used. The current density must be deduced as follows:

The percentage copper loss p_k is $W_k / 10 KVA$, where W_k is the total copper loss in the transformer, and may be written

$$W_k = m\ (1 + 0{\cdot}004\ T)\ 5700 \{k_r\ l_1 t_1 (s_1 q_1)^2\ q_1 + l_2 t_2 (s_2 q_2)^2 q_2\}$$
$$= 2{\cdot}6 s^2 K_u KVA,$$

or

$$s = 1{\cdot}96 \sqrt{(p_k / K_u)},$$

where T the temperature rise above room temperature is assumed to be 40° C. and k_r is a constant, here assumed to be 1·15, by which allowance is made for power loss in the windings resulting from the inequality of current density in the cross section of the copper caused by eddy EMFs.

Next, a relation is found between the weights of iron and of copper in terms of $\mathfrak{L}_i$ and $\mathfrak{L}_k$. By combining the equations deduced for the general transformer it can be shown that

$$(B s f 10^6)^{1{\cdot}5} (\sqrt{(KVA f_k)})\ E_i K_u = a,$$

a numerical constant. This may be written

$$E_i K_u (B s)^{1{\cdot}5} = a 10^9 f^{1{\cdot}5} \sqrt{(KVA f_k)}$$

a constant for a given transformer of given KVA and f.

Curves of total (eddy plus hysteresis) iron loss for ordinary laminations 0·35 mm. thick show that, approximately, the percentage iron loss for a transformer may be written

$$p_i = W_i / 10 KVA = (w - 10) E_i = (10^{-5} \cdot 150) B^{1{\cdot}65} E_i$$

or

$$B = 15 \cdot 10^{3} / E_i^{0{\cdot}606}.$$

Combining these with the equation $E_i K_u (B s)^{1{\cdot}5} =$ constant, and $s = 1{\cdot}96 \sqrt{(p_k / K_u)}$, we find $E_i K_u (B s)^{1{\cdot}5}$ is proportional to

$E_i^{0\cdot09}K_u^{0\cdot25}$, it being assumed that p_i and p_k are given; that is to say, $E_i^{0\cdot09}K_u^{0\cdot25}$ is constant, or $K_uE_i^{0\cdot36}$ is constant, for plates 0·35 mm. thick. The condition for minimum cost of material and labour may then be found thus:

Total cost$=E_iKVA£_i+K_uKVA£_k$. The total cost will be a minimum when $d(E_i£_i+K_u£_k)=0$, in which equation, since $K_uE_i^{0\cdot36}$ is a constant, we may write for K_u the expression $g/E_i^{0\cdot36}$, and the equation becomes

$$d\{E_i£_i+(g/E_i^{0\cdot36})£_k\}/dE_i=0.$$

the solution of which is

$$E_i/K_u=0\cdot36£_k/£_i.$$

This is the condition which must be satisfied when using plates 0·35 mm. thick. For plates 0·5 mm. thick the corresponding condition would be

$$E_i/K_u=0\cdot46£_k/£_i.$$

With modern alloyed steel (*see* a Paper read by Woolridge before the Am.I.E.E., in February, 1911) the exponent of B for total iron loss approaches, for densities of the order of 10,000 to 12,000, the value 2, and the condition for minimum cost of a transformer becomes more nearly $\frac{E_i}{K_u}=\frac{£_k}{£_i}$, the same condition which holds for power transformers.

In the design of lighting transformers the procedure, therefore, is as follows:

First the quality and thickness of the laminations are chosen, then a value is assigned to B, and from the iron loss curve w_i is found the iron loss per kilogramme of iron. The total iron loss for the transformer having been given in the specification, the weight of iron per KVA, E_i, and the total weight of iron in the transformer follow at once. The designer must next estimate the ratio $£_k/£_i$. This ratio depends upon many factors, the relative importance of which can be learned only by experience. In addition to cost of raw material there must be taken into account cost of labour, degree of skill of the workers, processes of manufacture and availability of up-to-date machinery. Arnold gives the following values for the ratio $£_k/£_i$:

For 10 KVA to 50 KVA transformers.....$£_k/£_i$ 4·75 to 4·25
For larger transformers..... 4·5 to 3·5

Then by applying the formula of the preceding paragraph K_u, the weight of copper per KVA, and the total weight of copper are at once obtained. Next s and C are found by the appropriate formulæ given above. In the formula for C a value has to be assigned to f_k, the winding space factor. In Arnold's tables f_k ranges in value between 0·45 for 2,000 volt to 0·22 for 30,000-volt air-cooled transformers, and 0·26 for 2,000 volt to 0·14 for 20,000-volt oil-cooled transformers.

The schedule appended to this article is a concise statement of Arnold's method, as applied both to lighting and to power transformers.

The equation given for the leakage reactance drop is expressed in the symbols used in Kapp's book on Transformers, to which, on this point, Arnold refers. The determination of the inductance of a coil from its dimensions is very difficult if great accuracy is required, but the use of Kapp's formula to find the leakage inductance of the windings of a transformer is found quite satisfactory. The inductive drop in a transformer is usually of the order of 1 to 4 per cent., and in the determination of such a small quantity an error of even 10 per cent. is of no great consequence. A method which will predetermine as 1·1 per cent., a drop which proves to be actually 1 per cent., is sufficiently accurate for practical purposes.

An instance will serve to illustrate the accuracy of Kapp's method. The following are the details of a 2,350 KVA 42-cycle three-phase 9,000-40,000-volt transformer, which, when tested, was found to have an impedance voltage of 2,030 volts (that is to say, when the 9,000 volt side was short-circuited an applied voltage of 2,030 volts was required to send the normal full load current of 33·8 amperes through the 40,000-volt winding):

$\Phi=16\cdot7\times10^6$, $t_1=745$, $I_1=33\cdot8$ amperes.
$b=3\cdot7$ cms., $a_1=2\cdot8$ cms., $a_2=3\cdot8$ cms.
$p=242$ cms. $l=85$ cms.

whence the percentage inductive drop,

$$0\cdot19\frac{N}{d_{1\cdot67}}\left(b+\frac{a_1+a_2}{3}\right)\frac{p}{l}=1\cdot8 \text{ per cent.}$$

The resistances were

$r_1=2\cdot31$ ohms, $r_2=0\cdot086$ ohm } whence $R=2\cdot34-0\cdot086\left(\frac{10}{9}\right)^2=1\cdot04$ ohms per phase.

and the percentage resistance drop for 33·8 amperes

$$=100\frac{33\cdot8\times1\cdot04}{\frac{1}{\sqrt{3}}\times40{,}000}=0\cdot6 \text{ per cent}$$

The percentage short circuit voltage should therefore be

$$\sqrt{(1\cdot8)^2-(0\cdot6)^2}=1\cdot83 \text{ per cent.}$$

The voltage found by experiment was 2,030 volts, or 5·1 per cent.

In illustration of the application of the schedule the complete design is worked out for a 500 KVA 50-cycle 6,600-440-volt three-phase transformer. For the purpose of comparison the design is treated first as that of a power transformer and then as that of a lighting transformer. Readers who may refer to Arnold's book, 1904 edition, will find a somewhat similar design worked out for a 600 KVA transformer. In this design Arnold has made a serious error, he has assumed a very high flux density ($B=14{,}500$), such as would lead to a no-load current, equal to about 15 per cent. of the full-load current, but through a slip in the calculation the value has come out less than 2 per cent.

It will also be noted that the value $£_k$ $£_i=3\cdot25$, which Arnold assumes at the outset, does not agree with the final value found for E_i/K_u (=2·56/1·09), so that the design as worked out is not the cheapest possible.

For comparison with the method just outlined a brief statement of the procedure recommended in Arnold's 1910 edition may be given as follows:

Having decided upon the type (whether core or shell), and the method of cooling to be employed, take a trial value for the ratio G_i/G_k, and for the values of B and s. Then find Q from the equation,

$$Q=C\sqrt{\left(\frac{KVA\frac{G_i}{G_k}10^9}{fBs}\right)}.$$

a trial value being chosen for C. Using various values of l find the corresponding values of h, and then, assuming f_k, find the width of the window and check G_i G_k which need only be accurate to, say, 10 per cent. of the value first chosen.

The derivation of the Q equation is as follows:

$$E=4\cdot44ftBQ10^{-8},$$
$$I=sq,$$
$$KVA=4\cdot44ftBQsq10^{-11}$$
$$=C_1tqQ10^{-11}, \text{ if } B \text{ and } s \text{ are constant.}$$

The weights of iron and of copper may be expressed thus:

$G_i=Ql_i7\cdot8\times10^{-3}$ kgs., l_i being the total iron length,
$G_k=2tql_k8\cdot9\times10^{-5}$ kgs., l_k being the mean length of a turn,
$G_i/G_k=\frac{Ql_i7\cdot8\times10^{-3}}{2tql_k8\cdot9\ 10^{-5}}$, which, as l_i l_k is usually constant,

may be written

$$\frac{G_i}{G_k}=C_2\frac{Q}{wq}10^2.$$

This, when combined with the KVA equation, gives

$$Q=C\sqrt{\left(\frac{KVA\frac{G_i}{G_k}10^9}{fBs}\right)},$$

an equation which holds for all types of transformer.

Approximate values for C are usually as follows:

Core type { 0·5 for single-phase transformers having round coils.
0·61 for single-phase transformers having rectangular coils.
0·37 for three-phase transformers having round coils.
0·47 for three-phase transformers having rectangular coils.

Shell type { 0·9 for single-phase transformers.
0·6 for three-phase transformers.

Appropriate values suggested by Arnold for the ratio G_i/G_k are :

Lighting Transformers.

KVA.	G_i/G_k. Ordinary iron.		Alloyed iron.
50	2 to 3	.....	1·8 to 2·0
Larger	to 4	.....	2·0 to 2·2

Power Transformers.

Up to 1,000	3·5 to 4·5	.....	1·8 to 2·2
Larger	4·5 to 5·5	.....	2·2 to 2·8

Suitable limits for B and s are given in the schedule at the end of this article.

The theoretical condition ensuring minimum cost is deduced as follows :

$G_i = C_1 Q l_i$ and $G_k = C_2 l q l_k$, whence $G_i G_k = C_1 C_2 Q l q l_i l_k$,

$$Q l q = C_3 \frac{KVA}{fBs},$$

$$G_i G_k = C_4 \frac{KVA}{fBs} l_i l_k \text{ and since } \frac{l_i}{l_k} \text{ is assumed constant,}$$

$$G_i G_k = C_5 \frac{KVA}{fBs} l_k^2. \quad \text{Here writing } l_k = C_6 \sqrt{Q} \text{ we have}$$

$$G_i G_k = C_7 \frac{KVA}{fBs} Q.$$

Replacing Q by its value found for the Q equation, we have

$$G_i^2 G_k^2 = C_8 \left(\frac{KVA}{fBs} \right)^3 \frac{G_i}{G_k}, \text{ or } G_i G_k^3 = C_8 \left(\frac{KVA}{fBs} \right)^3,$$

that is to say, $G_i G_k^3$ = constant.

The total cost is $G_i £_i + G_k £_k = \frac{C}{G_k^3} £_i + G_k £_i$ which, when differentiated with respect to G_k and set equal to nought, gives, as the condition for minimum cost.

$$\frac{G_i}{G_k} = \frac{1}{3} \frac{£_k}{£_i}.$$

The chief practical distinction between Arnold's 1910 method and that of 1904 is that in the earlier method the designer was asked to state from experience the ratio $£_k/£_i$, and was given values for γ or for β, both of which depend upon the ratio l_i/l_k, whilst in the later method the designer is given values for G_i/G_k and also for C, which again depends on l_i/l_k. Practically, therefore, the methods are much alike; there is, at any rate, no difference in principle between them.

In the theoretical discussion of the condition for minimum cost there is, however, a radical difference, for whereas in 1904 the designer was told that, both theoretically and practically, the ratio of weight of iron to weight of copper in a power transformer should be made equal to that of the price of copper to the price of iron, he is told in 1910 that the ratio of the weights should, theoretically, be only *one-third* of that of the prices, and that practically he had better not worry about price ratio at all, but simply assume a certain value, taken from previous designs, for the ratio G_i to G_k.

In view of this somewhat unsatisfactory position it is of interest to carefully compare the two methods of searching for the minimum cost condition, which give such widely different results, and it is hoped by this comparison to show that the 1904 method is the correct one whilst the 1910 method is based upon wrong assumptions.

Arnold's 1910 method, just given, may be expressed in words, as follows :

In searching for the cheapest design for a transformer of given type and rating a trial design might be taken, and by modifying its dimensions attempts might be made to cheapen it.

In making such modifications Arnold assumes that the ratios l_i/l_k and $l_k/\sqrt{Q}$ ought to be constant whilst, of course, B and s are to remain constant.

Let the trial design be, say, a core type transformer, and let an attempt be made to cheapen it by modifying the cross-section of the core (Q). Let Q be increased by, say, 2 per cent. Then, if we assume $l_k \propto \sqrt{Q}$, we see that l_k will be increased by 1 per cent. But l_i/l_k is to be kept constant, hence l_i must be increased by 1 per cent. Thus, G_i will have been increased by (2—1 per cent.)=3 per cent. Now, l_k, having become 1 per cent. greater, G_k would become 1 per cent. greater if the number of turns remained unchanged. As, however, Q and, therefore Φ, have gone up 2 per cent., the turns must be reduced 2 per cent. to keep the voltage right. The effect on G_k of the increase of 1 per cent. followed by this decrease of 2 per cent., is a decrease of 1 per cent. We then see that whenever the weight of iron is changed by 3 per cent., that of copper will suffer a 1 per cent. change of opposite sign. This imples that $G_i \times G_k^3$ must be constant, for when this product is constant a 3 per cent. increase in G_i must entail a 3 per cent. decrease in G_k^3 that is to say, a 1 per cent. decrease in G_k. The condition for minimum cost is then, obviously, that $G_i G_k = £_i^{\frac{1}{3}} £_i$.

This condition is quite different from that given in 1904 for power transformers—namely, that the ratio of the weights should be the reciprocal of that of the costs—and it must now be shown how the difference arises. But first it is interesting to remark that whereas Arnold in 1904 proposed that the ratio G_i/G_k should equal $£_k/£_i$ and stated that this ratio could readily be estimated by each firm, his proposal in 1910 is that $G_i G_k$ should, theoretically, be equal to $£_k^{\frac{1}{3}} £_i$, but that this ratio is almost impossible of predetermination, and that it does not form a suitable criterion for the choice of $G_i G_k$. He advises the designer to assume a value for this ratio, based upon previous designs, the values advised (for power transformers) being of the order of 4 to 6 for ordinary iron and 2 to 3 for alloyed iron. The values are quite at variance with the 1910 ratio $£_k^{\frac{1}{3}} £_i$, yet agree fairly well with the limits 3·5 to 5·5 (for ordinary iron) given in the 1904 edition as the value of $£_k/£_i$, to which G_i/G_k was to be made equal.

(To be continued.)

THE ELECTRICITY SUPPLY OF GREAT BRITAIN.

The following discussion took place upon Mr. Ernest T. Williams' Paper * on the above subject at the meeting of the Institution of Electrical Engineers on the 13th inst.

Mr. C. H. Merz said he wished Dr. Ferranti, who had put before them some years ago what some of them considered the ideal, had been there to open the discussion. It was first put forward by Dr. Ferranti in substance 20 years ago, and had been reviewed by Committees of Parliament and others, and there had been endless schemes for attaining something of the ideal for large districts, and yet there had not been much progress made. It was well, in considering the reason for this, to face the facts. Mr. Williams suggested that the technical and financial sides were simple, and that the difficulty was one of organisation. He begged to differ from him. He thought the reason greater progress had not been made was that the profession as a whole was not convinced that the ideal was the right one. If that was so, they had better begin by seeing whether some of them were wrong and whether the majority were right. It could not be argued that a thing was right or wrong for this country because it was right or wrong for other countries. The more he had travelled the more he had been dissatisfied with what was almost the average English engineering attitude. Any idea that the matter could be proved as to what could be done from experience in other countries ought to be got rid of. The United Kingdom was in a different position from any other country in regard to electrical distribution. It was very different from Germany as regards geography, and totally different from the United States. Our area was much more congested, and the congested areas were much closer together. This seemed to point emphatically to the electrical operation of the railways within a reasonable time, and also to a general distribution system. With regard to security of supply, so long as it was a question of supplying a certain area from a power station up to 5,000 kw. or so, the question did not come very prominently forward, but we had advanced so far that considerable communities depended upon power stations for their supplies of power, heating and lighting which were vital to the area. If large areas were allowed to continue to depend upon one central station there would be some serious collapse; the more given areas depended upon electric supply, the more important it would be that they should not put all their eggs into one basket. Assume a situation, which was quite common, where there were four stations in adjacent districts. In each station 5,000 kw. sets were installed and the number of these in each station was gradually extended to eight—40,000 kw. Each of the four areas depended on one station. If a bomb were dropped on that station, or there were some interference with coal delivery or failure of the circulating water system the condition of affairs in that area would be serious. Say there were two spare sets in each station and spare capacity of 33⅓ per cent. Work-

* THE ELECTRICIAN, April 14, p. 48.

ing these stations separately, capital cost, operating costs and wages were higher than if they were worked in combination. He thought the four stations should each contain three units of 15,000 kw. each, and that they should be connected by a trunk system of mains. Assuming the load on each station to be 30,000 kw., there would be one complete spare station for the four areas and four spare sets, as against two for each area in the first case, and spare capacity in the four stations of 50 per cent., a lower capital cost and a very much lower operating cost. He was satisfied that that was the safest and the most economical system. Instead of assuming 5,000 kw. and 15,000 kw. units for the two cases, perhaps to-day 10,000 and 30,000 would be better. With the larger units which could be now used, a coal economy per unit sold of from 30 to 60 per cent. could be made, compared with what could be done with independent stations. Actual plants were being laid down which would attain such results. It was commonly said that doubling the size of generating units effected 10 per cent. economy, but that was not so. It was becoming more and more apparent that in a small station one could not go in for the special refinements (or complications if one liked to call them so) necessary to get the highest economy. The improvement in load-factor resulting from connecting up big areas was also of paramount importance. He showed on the screen the North East Coast Power Co.'s average daily load curve, which showed that it was easy to get up to 60 per cent. and over. The first thing necessary was for the technical side of the business to more or less agree as to what were the right lines to go upon. Parliament could not be expected to come to a proper solution if they were divided amongst themselves as to how the matter should be tackled. In that respect they might borrow something from other countries. The thing was to get it to be a fashion to deal with such a question by certain methods. They did that well in America. It was the fashion in many areas to take supplies from public stations, and if the engineers adopted a fashion of dealing with their systems in the same way, a great deal would be accomplished.

Mr. R. A. Chattock said the lines upon which Mr. Williams had gone were similar to what he (Mr. Chattock) recommended about two years ago in his address to the I.M.E.A., and had developed the idea on sound lines. The only way in which consumers could be attracted was by reducing the price of current. The ordinary British manufacturer would not think anything about "fashion" if it was going to affect his pocket. He wanted a cheap, plentiful and reliable supply. The idea that he could get it and that prices were going down was what they should stimulate and follow up. In the industrial areas in this country the power sold per head of population was only about one-tenth of what could be sold if the supply were developed on proper lines, but they were gradually approaching that end in the way they were developing the supplies. Small stations supplying at high prices were hampering that development, and a scheme such as Mr. Williams proposed should be brought forward and run not to make large profits, but to attract consumers, and if necessary face a loss for some years. The money should be found by the community, because it was necessary for the development of the industries of the country. As the output increased, the cost of production decreased, and it was only carrying that to a logical conclusion fully to justify the scheme Mr. Williams put before them. He did not think, however, that old, uneconomical stations should go on running; it was better to face the conditions that these must be cut out as generating units, though they could be used as distributing units. An arrangement such as the four connected stations suggested by Mr. Merz was what they would come to, but he thought those stations would approximate to 300,000 kw. capacity each or more, because if the price were really a popular one the demand would increase enormously. The large stations would have to be put fairly close to the large centres of industry, so that the minimum amount of current would have to be transmitted to a distance. Probably drastic powers would have to be obtained to prevent the cost of obtaining wayleaves for the trunk lines from crippling the scheme. He was afraid Parliament would hardly be able to deal with such a scheme at present, but it should be got ready to put before them when they could deal with it.

Mr. J. S. Highfield said he agreed that engineers and financial people should come to an agreement before putting forward a scheme, but when Mr. Chattock said they were not to earn any profits, and that they were to raise money on somebody's credit and lay mains all over the country he was horrified. They had been labouring hard to get a profit, and if it was suggested that they should go back to the dreadful old days when there was no profit he thought that was wrong. If money were raised on municipal or Government credit the interest would have to be found. It would have to be shown that they could put down plant and mains and earn an early profit. He did not agree that the present position of electric supply was so defective as had been suggested. The supply over large areas of the country was good, and manufacturers availed themselves of it, and when new factories were started the electric people were on the doorstep to offer a supply. It was wrong to belittle what had been achieved. The curve shown by Mr. Merz of what had been done on the North East coast was an example of magnificent engineering and financial courage. He did not suppose any part of the world could show anything better. That system should be extended gradually. He did not agree, however, that a lot of money should be spent simply because they could put four stations like those described by Mr. Merz in different corners of the country and wait for profits until houses were planted about them to make a load. Mr. Williams suggested additional legislation, but the industry had suffered from legislation. Mr. Williams rather discarded history, but many of the great industries had been developed by private enterprise. Whenever the Government stepped in to help them it generally caused trouble. It would be well to remove the damage done by past legislation. The railway companies and gas supplies started with permanent tenure. The Railway Act allowed free competition, and, although it resulted in a certain amount of waste of capital, it brought into the field two promoters, two engineers and so on, and the development was much quicker than it would have been under a monopoly. The same applied to the gas companies. If the same liberty had been given to electrical undertakers they would be in a better position to-day. He did not understand to whom the board proposed by Mr. Williams would be responsible, and it would have two mutually destructive powers, a very powerful judicial capacity and also the power to erect stations. If it were restricted to the judicial and technical side, so that it could act as a skilful guide, it might be useful. An improved Board of Trade, independent of politicians, might be of use to every trade. A Board of Trade consisting of men like Mr Trotter would remove half their difficulties and they would get on. If that was Mr. Williams' suggestion he heartily approved of it.

Mr. H. Faraday Proctor said the scheme proposed was a happy medium between nationalisation, municipalisation and private ownership. The published tables of costs showed that there should be some overhauling of the present system—or lack of system. In London charges varied from 8d. to 3d. for similar purposes, and there ought to be united efforts to bring things to a more parallel basis. They ought to get a move on, and get a board formed as the author suggested and let them get a scheme out for the whole kingdom. If it were left to that Institution there were so many interests that they would each want to run their own scheme. Mr. Williams's scheme had the merit that it did no injustice to existing undertakings. They could maintain their separate identities so long as they were justified by their costs. They could generate their energy or buy from the board, or if their costs were low enough they might find a good consumer in the board. The scrapping of existing capital assets at once would mean the introduction of a difficulty that would postpone the scheme almost indefinitely. He agreed with the author that local authorities should be subject to the control of the board as regards the expansion of their existing station, but the author was not equally definite in dealing with the works of limited companies. If the terms were equitable they should be equally applicable to companies. They had better err on the side of over-compensation to each of those authorities or companies rather than let the industry suffer. Such a scheme as the author put forward might enable some of the small though desirable undertakings to be developed with the object of creating new industrial areas. The railways and canals, coal supplies and power supplies all ought to be co-ordinated and organised under one governing body.

Mr. W. B. Woodhouse said the previous speakers' opinions were extremely diverse. He thought Mr. Merz's remarks really most to the point. The electrical engineers should first of all agree as to what was to be done. Electricity supply was only one link in the bigger problem of the fuel economy of the country, but it was an indispensable link. It would be necessary for the engineers and also the chemists, metallurgists and geologists to get together in consultation. That had been started, and he hoped the active steps the B.A. were taking would have some beneficial result. He hoped it might be said that electrical engineers were agreed as to the broad principle of interconnection and centralisation. The problem was very much a financial one. Cheap capital could only be got if satisfactory security and the prospect of a reasonable return were given to the investor. Large experiments would have to be carried out in conjunction with the chemists and metallurgists and all other people who tried to extract valuable properties from coal, and, therefore, it was not a suitable thing for Government management. National funds should not be used in speculative ventures. On the other hand, a great deal of the work was non-speculative, and if the State could finance that without taking a hand in the management—in the way of loan capital—it would be beneficial to the proposed development. He could not go so far as to say that the basis of organisation should be settled first. The important thing was to bring home to the public what the present evils were and what the future prospects were. The public must be educated to appreciate whatever the electrical engineering industry put forward as the great formula or dogma that was to be followed. That was the first step—to agree upon what they wanted to tell the public about and to keep on telling them.

Mr. C. H. Wordingham said the value of the Paper was augmented because Mr. Williams views the situation from a detached position, and had no axe to grind. He (Mr. Wordingham) had seen power supply from both sides of the hedge. It was he who projected the first power scheme in this country—which had developed enormously—and he gave evidence in opposition to the first power scheme brought before Parliament. A number of the power companies seemed to be in business from purely philanthropic motives. Mr. Merz's exposition was different from what was originally put forward by the power company promoters, concentration on one station. The real secret was to get a big diversity, which might not be got even in a large station. The most successful power station owned by a company in this country had a number of power stations linked up to serve a comparatively small area, which he believed was the secret of its success. He would deprecate strongly Government interference with that sort of enterprise. He did not believe it possible for a Government department to run any commercial concern (he did not mean national concern) on commercial lines. An element of success in a scheme of that kind was the power of bargaining. If the cheap supply they believed necessary was to be provided it could only be done by the ablest men working unfettered.

Mr. W. L. Madgen said, although he was sure the author in his description of the Hydro-Electric Commission of Toronto had given an honest reflection of what had been represented to him, he (Mr. Madgen) felt bound to warn the members against accepting that description as accu-

rate. He was familiar with the operations of the Commission, and he never met a more reprehensible body. It had power to adjudicate on questions arising between consumers and supply undertakers, it had charge of legislation affecting the industry, and at the same time it was a supply authority able to enter into competition with other undertakers. It was crushing out enterprise; every branch of industry was suffering, and the consulting engineers were gradually disappearing—a result he could not contemplate in this country. If the author took the Hydro-Electric Commission of Ontario as an augury of success of such a concern here he thought he was bitterly mistaken. If the body proposed to be formed were divested of the function of operation it might prove useful once the engineers had decided upon what they wanted.

Mr. T. Bolas said he thought the electrical profession were agreed upon the necessity of a general scheme, and that if every electrical supply engineer were sure of being in charge of one of the supplies under the proposed scheme he would support the scheme. As Mr. Williams said, it was the human factor. It was asking the engineers of the smaller stations to commit professional hari-kari on the altar of patriotism to ask them to support such a scheme. The municipalities would not be willing to hand over their undertakings unless just cause was shown. The electrical committeemen and chairmen had not had it put to them. The engineer had not put it to them because he was afraid it would affect his own job. If the Institution could get the sympathy of the engineers for the scheme the engineers would get the sympathy of their committees. It was time the matter was lifted from the plane of talk to the plane of action. If the Institution would take up this matter and look into it it would add to the dignity of the Institution and benefit the electric supply industry and the consumers.

The PRESIDENT said Mr. Merz taught him and a great many others 11 years ago the real factors and the essence of the business, but we were still stumbling over the same ground. The real reason was not that the engineers did not recognise what was the right principle. As Mr. Bolas said, it was the human factor. If a supply was offered in bulk at 1½d., 1d. or ½d., the engineer of the existing station set to work to show he could maintain a supply for less. Some body had to be set up to deal with these people. If the industry was going to grow there was plenty of use for all the people who were of any use at all. The scheme had to come about. The real principle was the concentration of fuel and the using of that fuel in such a way that the by-products were obtained for the chemical industry. Cheap power was important, but the conservation of fuel was of far greater importance. People from the provinces thought that in London things were all anyhow. It was not so. Prices from 8d. to 3d. had been mentioned, but it was possible to buy power in London at fractions of a penny. Things were not so bad in London as many people thought. He hoped people throughout the country would consider what steps they could take to help to solve the problem dealt with in Mr. Williams's Paper. The author's reply to the discussion would appear in the "Journal."

A vote of thanks to the author, proposed by the President, concluded the meeting.

ON RADIUM ANTENNÆ.*

BY E. LEIMER.

On the results of Szilard with radium-coated lightning conductors becoming known to the author he was led to consider the possibility that radium might exert some effect upon the reception of radio-telegraphic signals. The first tentative experiments seemed to give evidence of positive effects; but as the author was obliged to discontinue them in consequence of the war he now publishes his results with a view to stimulating further research and also obtaining independent confirmation of his own conclusions.

The first experiments were made with an indoor antenna consisting of a wood rod 20 mm. in diameter and 3 metres long, closely wound throughout its length with wire 0·2 mm. diameter, enamel coated, the rod being directed towards a sending station, FL, about 300 km. distant from it. This antenna was suspended in a room. The receiving set used comprised a galena detector, 4,000 ohm telephones, and a tuning coil 50 mm. in diameter and having 800 turns of 0·4 mm. enamelled wire. No signals were audible from FL at any position on the tuning coil. Signals were, however, at once distinctly audible as soon as a sealed glass tube containing radium bromide of 50,000 units (and thus very weak) was brought near. The signals vanished when the shunt resistance was 220 ohms, using the shunted telephone method. The tuning was not at all sharp, and showed no maximum for any length of included wire between 80 and 120 metres. A change in the position of the radium did not produce any noticeable differences; but the orientation had a marked effect. At angles greater than ± 30 deg. the reception ceased entirely.

Encouraged by these results, the author continued his investigations in order to determine the effect of radium on ordinary antennæ. The antenna consisted of two parallel 1·5 mm. phosphor-bronze wires held 1 metre apart and 8 metres above the ground, directed towards the station FL, as was also the connection to the receiving set. For this latter the same tuning coil was employed; but an electrolytic replaced the galena detector, and in place of the telephones a special moving-coil mirror galvanometer, of 500 ohms resistance and period two seconds, was used. The signals utilised were the 10-second time signals from FL, the wave-length of which was 2,350 metres. With the best tuning and 56 metres the telephones gave 80 ohms for silence: the galvanometer showed 20-21 microamperes. With the antenna disconnected the current through the detector was 0·7 microampere. On the radium tube being brought near to the free end of the antenna the galvanometer reading was 50-53 microamperes: to reach this maximum the tuner had to be shifted from 56 to 48 metres. In this position the reception without radium was quite as mistuned as it was in the 56 metres position with radium. When the radium was fastened at the mid point of the antenna no reception was possible, even with the telephones. With the radium arranged at the connected end of the antenna the current through the detector increased to 35-38 microamperes at the 40-metre tuner position. All the results have been definitely confirmed as a result of numerous control experiments, made under conditions as nearly similar as possible.

These experiments show that by suitably bringing up radium in proximity to the antenna the vibration image of the latter is changed in the direction of an apparent shortening of the wave; further, that a considerable increase in signal strength, as measured in the detector circuit, is occasioned by the proximity of radium, which must in any case be caused by a higher received primary current.

The proximity of radium to the tuning coil itself has, however, the effect of rendering distinctly worse the previously distinct telephonic reception, without it being possible to discern any definite mistuning, and this applies whether the radium tube be insulated or earthed. On the other hand, the radium tube has no noticeable effect on any of the other parts of the receiving equipment.

* Abstract of an article in the "Elektrotechnische Zeitschrift." Vol. XXXVI

NEW METHOD OF DETERMINING IONIC VELOCITIES.*

BY CONSTANCE HARRISON GRIFFITHS, B.SC.

Summary.—In the method described the total change in weight of the cathode, and the electrolyte in its neighbourhood, is found by direct weighing. Hittorf's migration ratio is plotted, and the results compared with those of other experimenters.

THEORY OF THE METHOD.

Let the diagram represent the cathode and the containing vessel.

Let m_1 be the mass of the cations per cubic centimetre: u cm. sec. the component of their velocity upwards relatively to the liquid: m_2 the mass of the anions per cubic centimetre: v cm. sec. the component of their velocity downwards relatively to the liquid: c the current in amperes: and A the area of cross-section of the lower end of the electrode vessel in square centimetres.

Consider the passage of ions across the section P. Then *loss of weight* in electrode vessel per second would equal

$$(m_2 v - m_1 u) A \text{ grammes}$$

if the liquid were at rest. Allowances must be made for the movement of the liquid. Let q = the quantity in coulombs of electricity required to deposit 1 gramme of cations; then mass of deposit per second = c/q grammes. If the density of the deposit is d, *increase of volume of electrode* per second = c/qd cubic centimetre. *Total mass of salt* in cathode vessel diminishes at the rate of $(m_1 + m_2).Av$ gm. sec., since $m_2.Av$ grammes of anion leave the vessel per second, and there are always equal numbers of positive and negative ions in the liquid in the cathode vessel. When a salt is dissolved in water there is in general an *increase in volume*. Let δ = the increase in volume produced by dissolving 1 gramme of salt. Then decrease in volume of solution in vessel = $(m_1 - m_2).Av\delta$ cubic centimetres.

∴ Total decrease in volume in vessel = $(m_1 - m_2).Av\delta - c/qd$ cubic centimetres.

Unchanged liquid to this amount will, therefore, enter the vessel, and if its density is ρ the gain in weight will be

$$(m_1 - m_2).Av\delta - c/qd \cdot \rho \text{ grammes.}$$

∴ Total loss in weight of the suspended system

$$(m_2 v - m_1 u).A - (m_1 - m_2).Av\delta - c/qd \cdot \rho \text{ grammes.} \quad . \quad (1)$$

This is one relation. Now there is a second relation. Let N = number of gramme equivalents of copper per cubic centimetre and e = quantity of electricity associated with 1 gramme equivalent: then

$$Ne(u - v).A = \text{total current in amperes.} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

* Abstract of Paper read before the Physical Society of London, March 24th

Therefore, we have the two equations

$$(m_2r - m_1u)A - \{m_1 + m_2\}A v\delta - c/qd\} \rho$$

=total loss of weight of suspended system per second.

$$Ne(u+v)A = c.$$

An alternative method of considering the theory is then given, and the same final result obtained.

Apparatus.

In the diagram, B is the plan of a balance from which hangs the cathode K and the cathode vessel C.

A is the anode and anode vessel, and T the tank which contains the solution used for the experiment.

Cathode.—The cathode consists of a disc of copper 2·7 cm. diameter, perforated by two holes fitting loosely into the cathode vessel C. The *cathode vessel* consists of a glass tube 8·9 cm. long and 2·7 cm. diamter. open at the lower end. The upper end of the cathode vessel is narrowed and terminates in a piece of 2 mm. bore tubing about 3 cm. long.

Suspension of Cathode.—The cathode and cathode vessel are suspended by means of gutta-percha-coated copper wire. This wire is

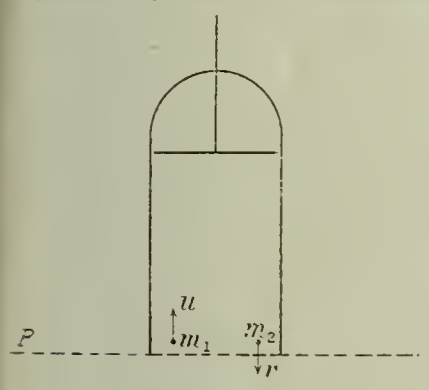


Fig. 1.

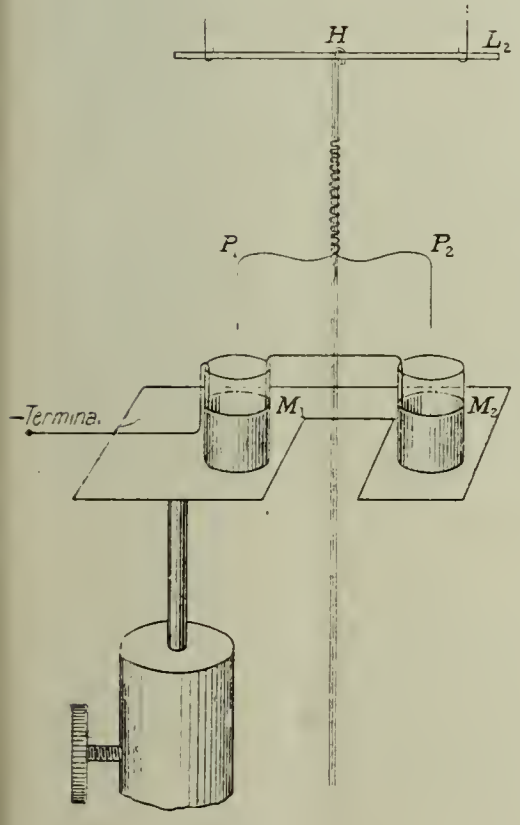


Fig. 3.

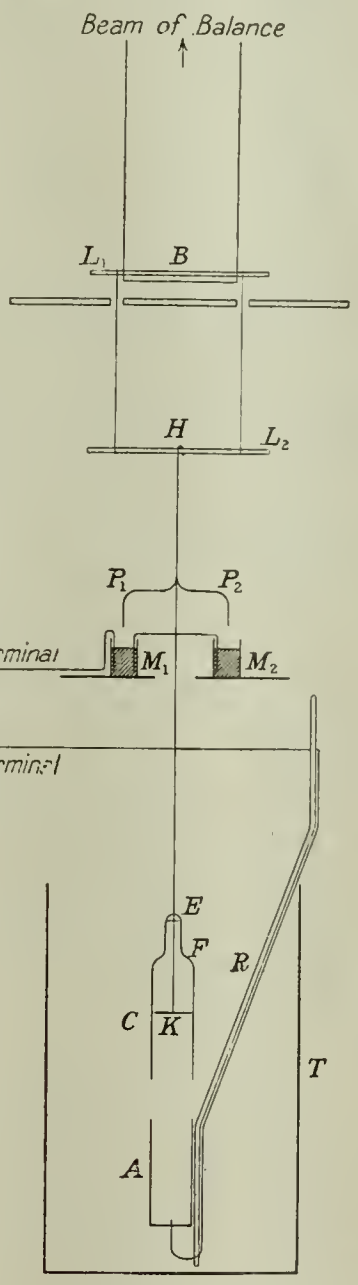


Fig. 2.

attached to the cathode at its lower end. The insulated wire passes vertically up from the cathode and through the 2 mm. bore tubing EF, into which it fits tightly, and is sealed. Thus, the cathode vessel is completely closed at the top. About 34 cm. above the cathode vessel the suspension wire terminates in a hook which passes over a glass rod suspended from a balance pan. Electrical connection with the cathode is effected by means of two platinum points attached to the suspension wire near the top.

Anode.—The anode consists of a spiral of thick copper wire with a lacing of thin wire across two diameters to hold the turns of the spiral in place. From the centre of the spiral and continuous with it, being part of the same wire from which the spiral was made, a wire passes down vertically till clear of the anode vessel, then bends round, and passes up through the liquid and out at the top of the tank. All this wire, after it leaves the anode spiral, is coated with gutta-percha insulation. The *anode vessel* consists of a piece of glass tubing 8 cm. long and 2·7 cm. diameter. The anode just fits inside it at the lower end.

Support Rod. The wire to the anode vessel and the anode vessel itself are bound tightly to a bent glass rod, R, which supports them and holds them in the required position. This rod is clamped above the level of the top of the tank by two firm clips which are carried by a vertical bar fixed in a strong stand.

The anode vessel is set vertically under the cathode vessel so that the distance apart of the two vessels is about 3 cm. This is done before the tank is placed in position.

Current Leads to Cathode. The suspension wire of the cathode is cleared of insulation at a point near the top, and round it at this point are tightly wrapped two pieces of copper wire. These are bent as in the diagram and terminate in two platinum points, dipping into two cups of mercury connected together by a thick copper wire. Into one of these cups dips a wire connected to the negative terminal of the cell. The mercury cups are supported by a shelf of wood fixed to a stand of adjustable height. By raising or lowering the stand the platinum points are immersed in the cups the current is allowed to pass, or they hang free in air, and weighings are made by the balance.

Balance.—The balance used was a Sartorius, and would weigh with accuracy to 0·0001 gramme.

The tank is a cylindrical glass jar, having a capacity of 8 litres, and contains the solution of copper sulphate used for the experiment. Over the surface of the solution is placed a layer of castor oil (about 100 cubic cm.), for it was found that the weighings taken by means of the balance were very inaccurate when the suspension wire passed straight into the copper sulphate solution from the air, but that when the layer of castor oil was placed over the surface the weighings were very consistent. The temperature of the solution in the tank is taken by means of a thermometer suspended in the solution, so that its bulb is close to the cathode vessel.

The foregoing apparatus—tank, balance, cathode, anode, &c.—are arranged in a room kept at constant temperature by means of a thermostat-regulated gas stove. The wires from the cathode and

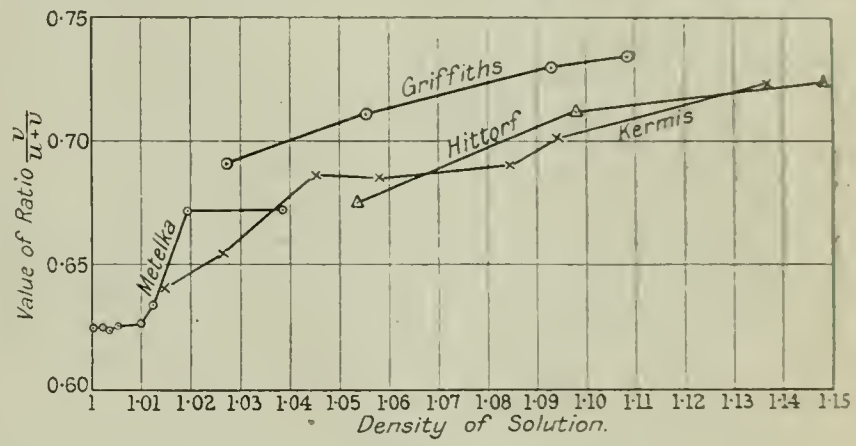


Fig. 4.

anode are connected to two terminals, and from these wires proceed to a table outside the thermostat room, and on this table is arranged the rest of the circuit, consisting of a 4-volt secondary cell, a key, an adjustable resistance, and a Paul millivoltmeter in parallel with 1 ohm.

A detailed description is given of the method of procedure and preliminary weighing.

After an interval of about one hour after the preliminary weighing *another weighing was taken* at a noted time. The temperature was also read. The *mercury cups* were then raised so as to make contact with the platinum points, and the current was put on at a definite time and rapidly adjusted to the desired value.

Readings of the current, time and temperature were then taken at intervals.

After a time, which varied from about two to four hours, the current was stopped. The mercury cups were lowered and the weight was rapidly taken. After about an hour another weighing was taken to get the rate of change of the weight after the experiment. The mean of this rate of change and the rate of change before the experiment was taken to be the average rate of change of weight during the course of the experiment.

The average current during the time of the experiment was found by taking the average current over the intervals between each two consecutive readings, multiplying each of these averages by the number of minutes in that interval, and finally obtaining the average current per minute from all the results so obtained.

A specimen experiment is given in the Paper, with full details of calculations.

The results obtained by the author are compared with those obtained by Hittorf, Metelka and Kirmis by means of curves. The comparison would appear to justify the method, but there is considerable divergence between the results of previous experimenters.

FLYWHEEL EFFECT.

Entitled "A Comparison of Motor Armatures of Different Diameters," Mr. E. A. Rew recently contributed an article to the "Electric Journal." After referring to the inertia of bodies and the "centre of gyration," the author proceeds to discuss "flywheel effect." If the weight of a cylinder per unit volume C is multiplied by the total volume, then $W = C\pi r^2 L$. The moment of inertia $WK^2 = \frac{1}{2}C\pi D^4 L$. Consequently, it is evident that while D varies while L remains constant, the so-called flywheel effect will vary with D^4.

Within certain limits, and excluding forced ventilation, the output of an armature varies as D^2L.

If we consider two armatures rated equally, say, $D^2L = 3{,}070$, and weight of each armature is 1,300 lb., then if the flywheel effect is calculated for an armature of $D = 16$ in. and $L = 12$ in., and $D = 22{\cdot}5$ and $L = 6$ in., we find in the one case $WK^2 = 290$ and for the other 572. While the diameter of one armature is only 40 per cent. greater than the other, its flywheel effect is practically double. In the one case, therefore, the stored energy is double that of the other. This is of importance when a motor is accelerating or decelerating, since when two armatures are to be used in this way it is seen that the stored energy is proportional to D^2 and the heating effect to D^4.

The time required to accelerate an armature from rest to full-speed or to decelerate the same from full-speed to rest under any given torque is

$$t = \frac{0{\cdot}0147NWK^2}{Tg} = \frac{0{\cdot}0147NWD^2}{8Tg},$$

in which t = time in seconds, N = revolutions per minute full-speed, g = gravitational acceleration, T = torque in foot-pounds, WK^2 = flywheel effect, W = weight of armature in pounds, D = diameter of armature in feet.

Consequently, for armatures of the same speed and torque rating, and the same weight, the time required to accelerate or decelerate $\propto D^2$. In the case of two armatures with an hour's rating, each armature having a torque of 875 lb. ft., $t = 0{\cdot}517$ second for one of them, and for the other $t = 1{\cdot}02$.

For heavy duty reversing service, entirely enclosed, the motors with a continuous loading, say, five hours, the normal torque is about 360 lb.ft. and the time for complete reversals are in the two cases considered 2·5 seconds, and 5 seconds respectively. Reversals every 10 seconds are common in steel-mill operations, so that while one motor would have its output available during 75 per cent. of the time the other would be available for useful work for only 50 per cent. of the time.

In the design of armatures the service to which it is going to be subjected is the primary consideration. Motors which are to be used for rapid reversing service or sudden starts and stops, such as motors used for roll tables, cranes, screw-downs in rolling mills, ore unloaders, and planers, where the motor reverses for each cutting stroke, the flywheel effect, and consequently the armature diameter, should be kept as low as possible. In other cases, such as that of punches, shears and rail straighteners a high flywheel effect is desirable in order that the energy stored in the rotating parts may force the tool through the material at the expense of a slight drop in speed. In practice it is customary to make up the necessary flywheel effect by installing a suitable flywheel.

Again, in the case of motors for continuous working, flywheel effect is of little importance, and other considerations govern the design of the armature.

PERFORMANCE OF DIESEL-ENGINE PLANTS.*

BY R. H. HURLOCK.

The author describes at some length the working of several Diesel-engine plants.

Eight Diesel engine installations in small electrical generating stations in the State of Texas are operated by the Texas Power & Light Co. Tests have been conducted at these plants and operating records kept which show results of performance and operating practice in modern plants of this type.

The Paris installation consists of an initial equipment of three McIntosh & Seymour Diesel engines rated at 500 h.p. each. These units are of the four-cylinder four-stroke-cycle design operating at 164 revs. per min., and directly connected to three 437 k.v.a. 2,300-volt three-phase 60-cycle alternators. Two 35 kw. induction motor driven sets and one 35 kw. belt driven exciter set are provided, the latter being driven from the generating unit. Compressors and water-circulating pumps are integral with engines. The apparatus is housed in a steel-framed plastered building 82 ft. 6 in. long by 52 ft. 6 in. wide and 33 ft. high to the eaves, with a flat concrete roof and concrete floor. Outside the station on a wooden pole switch and bus structure are installed three 250 k.v.a. 2,400 to 24,000-volt single-phase transformers and three 75 k.v.a. 2,200 to 6,600-volt single-phase transformers with air-break switches.

The station feeders at this plant are arranged to provide energy at 24,000-volt three-phase alternating current for a transmission line; 6,600-volt three-phase alternating current; 2,300-volt three-phase alternating current regulated; 2,300-volt three-phase alternating current unregulated: 2,300-volt single-phase alternating current are service, and 500-volt direct-current railway service.

An oil-storage tank of 360 barrels capacity and a cooling tower of the atmospheric type, exposing 5,100 sq. ft. of cooling surface, are provided for the equipment.

The Diesel-engine installations operated in central stations controlled by the Texas Power & Light Co. have a total rating of 5,545 h.p. The chief reasons influencing the utilisation of Diesel engines in preference to steam or other types of prime movers in these small isolated generating stations are summarised as follows: (1) Abundance of low-priced fuel oil: (2) efficiency of Diesel engines at low station factors: (3) comparatively low labour costs: (4) flexibility of plant—that is, the ability to meet unusual peak-load conditions without loss of time or operating economy: (5) absence of stand-by losses other than interest on investment when units are not in service: (6) ease of transfer of equipment from any isolated station which may be picked up by a transmission line extension to another isolated station whose increase in load warrants the installation of additional equipment.

While it is practically impossible to lay down definite general rules for the selection of Diesel engines in preference to steam or other types of prime movers for small central stations, or to prescribe the limitations as to the size of plant where Diesel engines are applicable over and above other types of equipment, because of the many varying considerations entering into each problem, among which are character of load, availability of proper fuels and labour, investment allowances and the like.

A table is given showing that the cost of a Diesel plant of 1,000 kw. is £4,590, as against £2,652 for steam; the annual saving for the former is, however, £1,776 over the steam plant.

The approximate cost of another representative Diesel station, erected by the Texas Power & Light Co. in the latter part of 1914 at Tyler, Texas, is given. This plant includes an initial installation of two second-hand Busch-Sulzer Diesel-engine sets built in 1907-1909, each consisting of two three-cylinder four-stroke cycle 225 h.p. engines, directly connected to one 300 kw. 164 revs. per min. three-phase 60-cycle 2,300-volt generator. One 17 kw. induction motor driven exciter set and one 20 kw. exciter belt-driven set operated from one of the engines were also provided. The necessary auxiliaries, such as air compressors, water and oil pump, cooling tower and the like were included.

Tests on Diesel-engine Equipment at the Paris Station.

The results of rigid tests conducted at the Paris plant are given. This station is considered the most modern type, and is representative of present-day construction and arrangement for the efficient operation of Diesel-engine installations. The apparatus tested consisted of three 437 k.v.a. Diesel engine driven alternators already described. Four tests were conducted on each unit, varying in length from one hour to four hours, each machine in turn being subjected to full-load, three-quarters-load, half-load and quarter-load tests, and these loads held as nearly constant as practicable. As the three generating sets were required for service almost continuously it was not feasible at times to secure the test loads exactly 100 per cent., 75 per cent., 50 per cent. and 25 per cent. of unit rating; but these loads were approximated and carried throughout each test with reasonable constancy. A table of results for one set of tests is given below.

The fuel oil is known as "desulphurised," and is employed in practically all of the Diesel engine stations operated by the Texas Power & Light Co. The oil was pumped from an outdoor storage tank, weighed in a barrel on a platform scale and re-pumped therefrom to small individual engine-supply tanks.

The curve of average fuel consumption for the tests as shown in the figure is given in "gross B.T.U. per kilowatt-hours generated." In using the term "gross B.T.U." reference is made to the possible allowance for any unavailable latent heat carried off as uncondensed water vapour in exhaust gases (representing the products of combustion of hydrogen and oxygen) for which no allowance has been made. It includes any such latent heat which may have existed for

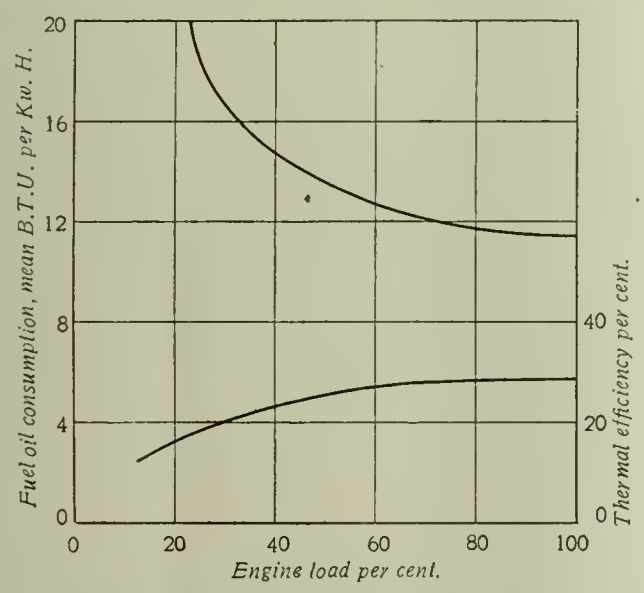
* Abstract of an article in the "Electrical World."

Table I.—*Summary of Tests on Paris (Tex.) Diesel Engine.*

	Unit No. 1.			
	1.	3.	2.	4.
Approximate load	Full.	3-fourths.	Half.	Quarter.
Kw. (average)	340·6	253·3	168·9	86·1
Load factor (kw.), %	97·5	72·5	48·2	24·6
K.v.a. (average)	400·7	301·5	211·1	117·9
Load factor (k.v.a.), %	91·7	69·0	48·2	27·0
B.-H.P. (average)	481·3	359·8	240·2	127·1
Kw.-hr. generated (total)	1,299·3	891·1	577·0	101·9
Time start	2:29	7:13	2:53	11:37
Time stop	6:18	10:49	6:18	12:48
Duration of test, hours	3·816	3·517	3·417	1·183
Power factor (average)	0·85	0·84	0·80	0·73
Kw. for excitation (av.)	8·1	6·91	7·64	7·42
Fuel oil consumed (gal.)	111·0	77·0	56·0	14·0
Fuel oil consumed (lb.)	783·0	543·0	396·0	98·5
Fuel oil consumed (B.T.U.)	15,321,744	10,621,080	7,789,616	1,923,803
Fuel oil per kw.-hr. (lb.)	0·603	0·609	0·686	0·966
B.T.U. per kw.-hr.	11,792·0	11,930·0	13,500·0	18,879·0
B.T.U. per b.-hp.-hr.	8,342·0	8,396·0	9,491·0	12,795·0
Generator efficiency, %	92·6	91·8	89·5	83·0
Thermal efficiency, %	28·9	28·6	25·3	18·0
Water for cooling (tot'l gal.)	14,653·0	11,606·0	...	4,436·0
Water per minute (gal.)	64·0	55·0	...	62·5
No. units in operation	3·0	3·0	3·0	2·0
Station load (average kw.)	635·0	697·0	660·0	370·0
Station factor (average)	60·5	64·2	62·8	35·2

the reason that in analysing fuel oils the usual type of calorimeter was used, in which such latent heat is surrendered and included in the results of analysis. The lower curve in the figure shows the curve referred to and shown above converted into thermal efficiency, in the determination of which allowance has been made for electric generator efficiencies. It actually represents the power delivered to the generator coupling in proportion to power supplied to the engine as fuel oil.

One of the chief faults with the guarantees made by Diesel-engine manufacturers and operators seems to be the tendency toward



Average Fuel Consumption per Kilowatt-hour and Thermal Efficiency of Paris (Tex.) Diesel Engines.

narrow specifications for fuel oils. Practically any crude or semi-refined oil having less than 1½ per cent. sulphur content, 2 per cent. water and 30 per cent. asphalt may be safely used in Diesel engines if filtered. This statement is qualified to the extent of setting the fluidity at a free-flowing and free-pumping point. Usually oils having a specific gravity below 16 deg. to 17 deg. Baumé, as below, require heating to aid their feeding to the engine pumps properly.

With the exception of the Diesel engines at Paris and Palestine, the splash or crank-case system of lubrication is employed with indifferent success. In some instances oil alone is used in the crank case, and in other cases the lubricating oil is floated on water. Neither system can be considered particularly efficient or satisfactory compared with the forced-feed lubrication used on the more modern engines at Paris and Palestine.

Labour Item in Diesel-engine Plants.

The question of labour has frequently been considered the "bugbear" of Diesel-engine operation. It has been the writer's experience, however, that any careful mechanic well versed in the theory of internal-combustion engine operation can handle any

Table II.—*Actual Unit Production Costs, Paris and Tyler Diesel Stations, September 1 to December 31, 1915.*

Article.	Paris.	Tyler.
Data—		
Station output (m. kw.-hr.)	1,565·0	499·0
Rating of plant (kw.)	1,050·0	600·0
Station factor, per cent.	51·0	28·5
Total fuel oil (gal.)	149,072·0	78,455·0
Pounds oil per kw.-hr. output	0·672	1·100
B.T.U. per kw.-hr. output	13,100·0	21,400·0
Production costs per kw.-hr.—		
All labour	0·298d.	0·816d.
Fuel oil		
Water		
Lubricants and waste		
Miscellaneous supplies and expense		
Maintenance of engines		
Maintenance of buildings		
All other maintenance		

Table III.—*Estimated Obtainable Operating Results and Production Costs in Diesel-engine Electric Stations of from 1,000 kw. to 2,000 kw.*

Data—	
Station factor, per cent.	50·0
Fuel oil—	
B.T.U. per kw.-hr. output	13,300·0
Gallons per kw.-hr. output	0·095
Cost per gallon, cents	3·0
Labour—	
Man-days per mean kw.-hr. output	0·46
Cost per man-day	2·80
Lubricating oil—	
Gallons per kw.-hr. output	0·0007
Cost per gallon, cents	30·0
Unit costs: Production costs per kw. hour—	
All labour	0·279d.
Fuel oil	
Water	
Lubricants and waste	
Miscellaneous supplies and expenses	
Maintenance of engines	
All other maintenance	

Diesel engine satisfactorily with a minimum of difficulty. In the Paris and Tyler stations the average cost per man-day is 10s. to 15s.

Engine Maintenance.

The wide diversity of maintenance costs between the stations, a ratio of 0·04 to 4·48, is accounted for by the facts that the Paris engines are of more modern design than the Tyler engines, the former having been operated but eight months, while the latter have done miscellaneous severe intermittent shop duty over a period of six to seven years.

It is of interest to note that upon close investigation of numerous accidents to Diesel engines practically all of them have been traceable to one of two causes—the neglect of mechanical features and faulty mechanical design. The chief cause of troubles seems to have been the former, which is the direct outcome of carelessness on the part of operators, and which, if practised in the operation of steam or other type of equipment, would have been fully as serious.

The length of life of the Diesel-engine parts has been estimated by those familiar with their operation as follows: Bed and frame, 20 years; crank shaft and governor, 10 years; cylinder linings, six years; wrist-pin brasses, five years; cylinder heads, four years; pistons, piston pins, valves and gears, three years; piston rings, one year.

Summarised, this information shows a life equivalent to 20 years with one-third of the original cost expended on maintenance during that period, which estimate may be considered conservative.

Actual Operating Costs.

In the determination of costs under this heading, the actual monthly records of the Texas Power & Light Co. for the periods noted have been consulted, and are practically standard in public-utility practice. The Paris and Tyler installations have been selected, and Table II. sets forth the production costs. This table shows "cost per kilowatt-hour" delivered at the switchboard for those plants, covering periods of four months each.

To summarise the foregoing data and statistics, Table III represents a fair estimate of operating results and costs which should result in a modern Diesel-engine electric generating station of 1,000 k.v.a. to 2,000 k.v.a.

The Electrician.

The Oldest Weekly Electrical Journal (established weekly 1861—1878).

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone : City 4698 & 4699. *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITOR. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed. Advertisement Rates, &c., forwarded on application to the Publisher.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by Wednesday. Renewals of expiring Advertisements, alterations to standing Advertisements and Wrapper Advertisements by Tuesday evening.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **12.30 P.M. THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRICAL MEASURING INSTRUMENTS : THEIR DESIGN, CONSTRUCTION AND APPLICATION. By C. V. Drysdale, D.Sc., and A. C. Jolley. *In preparation.*

ELECTRIC LIFTS AND HOISTS. By Gilbert Rowe, M.I.E.E., &c. *In preparation.*

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation.*

ELECTRIC TRACTION ON RAILWAYS. By Philip Dawson, M.I.C.E., M.I.E.E., &c. Handsomely bound ; fully illustrated. Price 25s. nett, postage 6d. U.K., abroad, 1s. 6d.

SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson, M.I.E.E. 15s. nett.

ELECTRICAL LABORATORY NOTES AND FORMS. Arranged by Dr. J. A. Fleming, M.A., F.R.S. Single copies 4d. nett, or in dozens at 3s. 6d. nett. Complete Sets of 50 Notes and Forms, 12s. 6d. nett, or in strong portfolio, 14s. nett ; or bound in strong cloth, 15s. nett. Spare Copies of Tabular Sheets, 1s. per dozen. Portfolios, 1s. 6d. each. Sectional paper, 1s. per dozen sheets. *Complete Prospectus post free on request.* These Notes and Forms are kept revised as new printings are required.

HANDBOOK OF THE ELECTRICAL LABORATORY & TESTING ROOM. Very fully illustrated. By Dr. J. A. Fleming. *Revised Editions now Ready.* Vol. I., 12s. 6d. nett. Vol. II., 14s. nett.

INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 8d. nett.

INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.

ELECTRICITY METERS : THEIR CONSTRUCTION AND MANAGEMENT. By C. H. W. Gerhardt. Profusely illustrated. Price 9s. nett. [Price 10s. 6d.

MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.

SIGNALLING ACROSS SPACE WITHOUT WIRES : THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.

BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By C. M. Baines. Price 7s. 6d. nett.

THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol. I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.

THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. *New Edition.* Bound cloth, 2s. 6d. nett, post free 2s. 9d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone. 9s. nett, post free 9s. 4d.

STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett.

ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S. Heather, M.I.E.E. 9s. nett.

AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec." Very fully illustrated. Price 2s. 6d. nett, postage 2d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.

WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.

ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.

LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.

Further portions of this list of "THE ELECTRICIAN" SERIES OF BOOKS appear each week

"THE ELECTRICIAN" TABLES OF ELECTRICITY SUPPLY.

These important Tables and Data relating to Electricity Supply in the United Kingdom in 1916 (which have been published annually since 1887) are now obtainable, price 3s. net, post free 3s. 3d.

The Tables of Colonial (and certain Foreign) Electricity Supply, Power and Traction Stations are also obtainable, price 2s. 6d. net., post free 2s. 9d.

The two sets of Tables are supplied, price 5s. net., post free 5s. 4d.

SPECIAL NOTICE.

With last week's number of "THE ELECTRICIAN" was issued (Gratis) the Index to Vol. LXXVI. This includes the Index to the "Commercial and Industrial Supplement."

Complaints of non-receipt should be promptly made to the Publisher.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

SPECIAL NOTICE.

In order that we may be able to supply the newspaper trade effectively and meet the requirements of the Post Office, we are sending THE ELECTRICIAN to press a few hours earlier every week. All editorial and news matter for the next current issue of THE ELECTRICIAN must reach us as much earlier as possible, but not later than WEDNESDAY MORNING, and advertisement text and blocks must reach the offices as much earlier as possible, but not later than TUESDAY EVENING, during the continuance of the War. Displayed Advertisements not for proof before first insertion can be taken until NOON ON WEDNESDAY, and Official Announcements, Auctions and "Smalls" of all kinds of which no proofs are required before insertion can be accepted up to FIRST POST THURSDAY MORNING.

ELECTRICITY SUPPLY IN GREAT BRITAIN.

We sometimes compliment ourselves upon the cheapness of electric power in this country. On the other hand we often reach the conclusion that the present state of affairs is very far from good. Actually the truth lies between these two extremes. There is no doubt that a great deal of very good work has been done, and that consequently the cost of electric power in this country is less than it is in many others. Nevertheless, it must be admitted that there is a great deal that is on the wrong lines. If we look at the problem as a whole we know, on the one hand, that the greatest economy is obtained by the use of large power stations interconnected so that the capital costs are reduced to a minimum, and when full advantage is taken of diversity factor and of refinements to give efficient production. By means of large stations instead of the many small ones, a very marked saving of coal—put at 30 to 60 per cent. by Mr. C. H. MERZ—can be effected, and this alone is an important matter from the national point of view. On the other hand, we find that progress has been hampered in many ways. For example, the cost of Parliamentary procedure has entailed great waste of money in an industry where money is by no means too plentiful. The Board of Trade, although nominally having the interests of trade at heart, adopts an attitude which is not in sympathy with present-day requirements, as was very evident from the fate suffered by the recent Bill of the Yorkshire Electric Power Co. Lastly, there is the opposition of small municipalities to any large scheme which may render it unnecessary for them to have small stations of their own, such stations having the supposed virtue of relieving the rates. These smaller municipalities, as a rule, have been unable to grasp the fact that it is far better to allow other people to produce the electric power if by so doing they can have it cheaper themselves. It is not merely the present advantage, which may for the moment be small, but the advantage some years

hence which should be considered. The net result of these influences has been much delay in the normal progress in electricity supply.

Last week an interesting discussion on this subject was held at the Institution of Electrical Engineers, and was opened by Mr. E. T. WILLIAMS, who put forward a scheme to remedy these defects. The scheme suggested by Mr. WILLIAMS is notable for the broadminded way in which he proposes to leave those people who are already engaged in the business more or less alone, but at the same time to create an Electricity Board with the object of co-ordinating the supply throughout the country. An abstract of this Paper was given in our last issue, and from this our readers will see that the proposed Board would have the power of dictating to all electricity undertakers, of connecting together large generating stations by means of transmission networks, and of operating and erecting power stations where desirable. Such a Board would prevent the extension of uneconomical generating stations, which would in due course tend to become sub-stations taking a supply from the high-tension network belonging to the Board.

In any such scheme there are two most important points to be considered. One of these is the human factor. It is an undoubted fact that if the engineers of smaller stations see their livelihood threatened thereby they will naturally do all they can to oppose any such scheme. This is only human nature, and we think that Mr. WILLIAMS has been wise in trying to safeguard the interests of these men. The second point is that any Board that is formed should not have the power of operating power stations. Mr. WILLIAMS suggests that this power should be given. In our opinion any such power would be a grave danger to existing concerns, against whom the Board would be free to compete, at an enormous advantage. It is obviously wrong that the Board should at the same time have judicial rights and the rights of competition. In this connection a warning was given by Mr. W. L. MADGEN, who stated that the results of the Hydro-Electric Commission of Ontario, which has such powers, has been very harmful.

As to what should now be done, we agree with Mr. C. H. MERZ that the first thing is for the engineers themselves to come together, and to decide what is wanted from the technical point of view. It will be hopeless for us, as engineers, to approach the Government unless we have a cut-and-dried scheme. It is impossible to look ahead for more than a certain number of years, but there should not be any great difficulty in preparing a scheme which would hold good for, say, the next 10 years. This would include linking up certain of the largest stations and a decision as to the desirable voltage to adopt. Having gone so far it appears to us that the natural course to follow would be to proceed with the scheme to a limited extent, dealing only with those portions which show a likelihood of giving a financial return in the near future. Any scheme of this kind should be run on sound financial lines, and not with the idea that we are free to dip into the public purse and to obtain money, the return on which is of no consequence. Having decided upon a scheme for some years ahead, and the initial links which should be laid down at once, the supply industry would be in a position to approach the Government for the creation of an Electricity Board of a purely judicial character, to supersede the Board of Trade and Parliamentary procedure.

Although the discussion at the Institution was comprehensive and to the point, the number of members attending was much smaller than the importance of the subject warranted. We should have liked to have seen the lecture theatre filled to overflowing. We only hope that now the subject has been raised the Council will not allow it to drop. It is a great opportunity for the Institution to take up a matter of national importance, and to see it through to a definite conclusion.

REVIEWS.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

The Electric Railway. By A. M. BUCK. (London: Hill Publishing Co.) Pp. xi.+390. 12s. 6d. net.

Although there are several excellent treatises dealing with electric traction, these are more for the specialist than for the student. It was to meet the need of an adequate text-book for the instruction of advanced students taking electric railway courses that the book under review was prepared. The author assumes an elementary knowledge of mechanics, and purposely limits the scope of the book by not dealing at any length with power plant and transmission line work. Car-house design and equipment are entirely omitted, for, while of prime importance in electric railway operation, they are topics of limited scope which have no direct bearing on the other factors which make up a railway system. Such points are already very fully covered by recent works on the subject.

Of the 18 chapters the first is introductory, and the second deals with the mechanics of traction. In this chapter the author presents his facts in such a way as to make them easily understood. The next three chapters are devoted to railway motors and control. In some respects it would have been better to give a broader treatment of these subjects. Chapter IV. on motor construction would be greatly improved by the inclusion of dimensioned sectional drawings of a number of typical railway motors, and by referring at greater length to ventilation and kindred subjects. In the chapter on control, a detailed description of the multiple-unit system and apparatus connected therewith would be appreciated by many of the students who are likely to use the book.

Power requirements and braking are discussed in Chapters VI. and VII., and it is evident that pains have been taken not to get students out of their depth. These sections are well written, and many useful curves are given. The next three chapters dealing with cars and equipment, electric locomotives, and self-propelled cars, call for no special comment. One would, however, like to see more references to British practice and many more detailed drawings. To track construction only nine pages are given, and these, in our opinion, could have been used to better advantage. Chapter XII. on the distributing circuit is good, but here again the work would be improved by the inclusion of selected examples, showing the practice in this country. Our engineers have set a high standard in these matters.

Sub-stations, transmission circuits, and power generation are briefly dealt with in the next three chapters, and as stated above the scope of these chapters has purposely been limited. Chapters XVI. to XVIII. cover respectively signals, systems of traction and matters connected with the engineering preliminaries. The student will find plenty to interest him, and the underlying principles of electric railway design and operation are clearly expressed. It is possible that by expanding certain of the sections the book would appeal to a wider circle of readers, but in a book intended primarily for students it is desirable not to give too full a treatment. To those desirous of obtaining a clear insight into the elements of the subject the book can be confidently recommended.

Principles of Dynamo-Electric Machinery. By B. F. BAILEY, Ph.D. (London: Hill Publishing Co.) Pp. xv.+314. 12s. 6d. net.

The purpose of this book is the presentation of a clear physical conception of the phenomena which take place in electrical machinery. An attempt is made to teach the student two things about each machine studied. These are: What

the machine will do, and why it does what it does. The author has made but sparing use of mathematical demonstrations because he is firmly convinced that a clear physical idea of the actions which take place should be obtained before an attempt is made to apply mathematical analysis.

We agree that physical conceptions are of fundamental importance, but, at the same time, we are of the opinion that it is desirable, in an engineering book, to give many numerical exercises so as to enable a student to gain an insight into the magnitudes of the quantities involved. This is recognised by the author and examples are given at the end of each of the important chapters. Many of these examples appear to have been framed with the object of determining whether a student has understood the text.

Of the 19 chapters, the first 10 are devoted to the consideration of continuous-current machinery and apparatus. This represents roughly one-third of the book. The author's treatment of the dynamo, motor and allied subjects leaves little to be desired. We think, however, that it would have been advantageous to include a number of scale drawings so as to give the reader some idea as to the arrangement and shape of parts. Such drawings are preferable to half-tone illustrations in a book intended for engineering students.

Chapters XI. to XIX. deal with alternating-current principles, apparatus and machinery. In addition to the matter usually given in elementary books on alternating currents the author departs from the beaten track. His treatment of the operation of alternating-current machines will be welcomed by many who have experienced difficulties on attempting to read more ambitious works. This applies equally to several of the chapters dealing with continuous-current machinery. The book can be recommended to those desirous of obtaining a thorough knowledge of the elementary principles of dynamo-electric machinery.

SIR J. J. THOMSON ON RADIATION FROM ATOMS AND ELECTRONS.

Last Friday Sir J. J. Thomson delivered the last of his six Royal Institution lectures on "Radiation from Atoms and Electrons," the first three of which we have already noticed. We publish to-day an account of the two succeeding lectures.

In the fourth lecture Sir J. J. Thomson dealt with the important question whether an atom or a molecule of a gas would be rendered luminous by any disturbance of appropriate kind, however small, or whether the disturbance had to exceed a certain minimum value before any luminosity would be given out. The atom might vibrate like a violin string, which gave out sound under the least disturbance; or it might behave like a bell with a heavy pendulum clapper, which would not emit sound unless the energy of the disturbance were sufficient to make the clapper strike the bell. The question was very important with respect to the quantum theory, according to which the energy of light was made up of definite units, so that it would be as impossible to excite light by less than one of these units as it would be to obtain a mass of matter of less than one atom. The early arguments had been based upon the comparative study of the luminosities of flame arc and spark spectra. In the arc spectrum certain lines were seen which were not observed in the flame spectrum, and in the spark spectrum, again, new lines flashed up. That seemed to indicate that certain lines only appeared when the energy of the disturbance exceeded a certain definite value. But these phenomena could not give a decisive answer to the question. Flames were gases; in gases some molecules moved with small, and some with large velocities; and the conditions were not suitable for making definite kinetic measurements. In arcs and sparks the conditions were not any more favourable.

Within the last few years, however, experiments had been devised in which precise, definite amounts of energy seemed to be necessary to produce definite effects. Spectra of the simplest kind possible, each consisting of a single line only, had been discovered by J. Franck and G. Hertz, and this light emission was excited, not by temperature nor by the electric discharge, but by kathode rays produced in a definite field of force, all moving at the same definite speed. The rays were derived from a Wehnelt kathode, consisting of a speck of lime or barium oxide on a strip of platinum which was heated by the current of a battery, this battery circuit being separate from the bulb circuit. Prof. Thomson remarked that he could not demonstrate the full experiment, but he could show that the colour of the light emitted varied with the speed of the rays. The negative particles would shoot out in straight lines from the speck S (Fig. 4) on the platinum strip, and their speed could be calculated; the particles knocked against the residual gas molecules in the bulb, and made the gas luminous along their path. Opposite S was fixed, obliquely to the rays, the plate P; when P was negatively electrified, the particles were deflected in a luminous parabola. Owing to this deflection, the particles would be slower at point 2 (nearest the plate) than at 1, and as a result the glow was blue at 1 and reddish at 2. In the experiments of Franck and Hertz the bulb contained mercury vapour, and the plate P was omitted, since they wanted rays all at the same speed, which they increased very slowly by raising the battery potential. They watched the spectrum. As long as the potential remained below 5 volts (4·9 exactly), nothing but an ill-defined continuous spectrum was seen. At 4·9 volts the ultra-violet mercury line of 2,536 Angström units (known to be the first number of a series) flashed up. Now the energy of the negative particles at that moment—*i.e.*, the energy which a negative particle (or elementary quantum of electricity) would acquire when falling through a potential of 4·9 volts—was exactly the energy necessary, according to the quantum-theory, to produce light of that frequency (corresponding to the $\lambda = 2{,}536$), the light energy being equal to $6{\cdot}6 \times 10^{-27} \times$ frequency (understanding by frequency, in the Continental sense, the number of vibrations per second), and the spectrum produced under these conditions was the simplest possible, since it consisted of one single line.

When, afterwards, the potential of the platinum strip S was raised above 5 volts, the spectrum still consisted of one line only, until 12·5 volts were reached. Then, according to J. C. McLennan, of Toronto, the spectrum suddenly became complex, showing, in fact, all the ordinary mercury lines, and some of these, it was peculiar to note, were on the red side of the λ 2,536, and hence of smaller frequency and smaller energy. One might have expected that the red lines, requiring less energy, would turn up first; but it resulted that more than twice the 5 volts which had brought out the single ultra-violet line were needed to cause the emission of lines in the red part of the spectrum. Something more than the mere energy equivalent seemed hence to be wanted to bring out the red lines of the spectrum: perhaps the atom had first to be altered in some way. Continuing those experiments with vapours of other metals, McLennan observed the following further single-line spectra:—

Zinc	3,075, Å.
Cadmium	3,260 ,,
Magnesium	2,852 ,,

And each of these lines, like the mercury line 2,536, formed the first number of a series of that particular spectrum. Thus the series of lines which spectroscopists distinguished in spectra had a physical meaning. So far as Prof. Thomson knew, these four vapours were the only ones which had yielded single-line spectra. The further search would be very interesting, and it would be still more interesting to determine the stages at which the lines made their appearance. If that were achieved, the sorting out of the series and the classification of the different spectra of one and the same element might become much clearer.

Qualitatively, the lecturer continued, the connection between the amount of energy supplied and the luminosity could further be illustrated with the aid of the experiments described at the end of the third lecture, in which a spherical bulb, charged with some residual gas, was brought near a primary coil of a few turns wound round a glass cylinder. When the bulb was filled with hydrogen at low pressure and slowly approached, a diffuse luminosity was first observed. At a certain distance a bright ring suddenly flashed up in the bulb, and that ring disappeared again when the distance was again increased. When spectroscopic observations were made during these experiments, it was found that the first diffuse glow was accompanied by the very complex secondary (banded) spectrum of hydrogen, whilst the bright ring glow emitted the well known primary (line) spectrum of hydrogen. Other gases gave similar phenomena. In each case the bright ring was observed at a certain distance between bulb and coil, the distance being characteristic for the gas. The glow, of course, marked the discharge through the gas, which acted as a secondary circuit. When the bright ring was seen the gas was a fairly good conductor, and much more energy was absorbed by the bulb (which then became hot) than during the first diffuse discharge; thus the connection between energy and luminosity was shown in this way also. These discharges (the diffuse and the ring discharges), the changes in the conductivity of the gas with the field strength, and the changes in the spectra had been studied by R. Wachsmuth. The lecturer showed some of Wachsmuth's spectra of hydrogen and mercury.

Another way of exemplifying the discontinuous character of the luminosity was to arrange discharge tubes in such a way that the

effects of either kathode ray bombardment or of positive ray bombardment, or of both together, could be observed in the same tube The kathode particles were of very small mass, but of high speed ; the positive particles (atoms of the gas) had larger masses, but smaller speeds. The effects need not be the same, even if the energies were the same in the two cases. Thus, a vertical helium tube was provided with a stricture in which the kathode was mounted ; this electrode consisted of a short tube with a horizontal perforated disc. In this tube the negative particles moved up towards the anode, and produced a bluish-green beam in the upper tube, whilst the positive particles moved down and gave a reddish beam in the lower part of the tube. Similarly, two different colours could be distinguished in a neon tube. Then a spherical bulb was shown in the centre of which a peculiar kathode was mounted (Fig. 5) ; it consisted of two small equilateral triangles of aluminium pinned together at their corners so as to leave a triangular space about 2 mm. in thickness between them. From such a kathode, negative as well as positive particles were shot out, the pinkish positive rays issuing in streams from the corners of the triangles (or the space between them), and the blue kathode rays from the middle of each side (Goldstein ; Kunz, 1908).

Another tube was of inverted T shape ; the anode was in the vertical limb above, the perforated kathode lower down, and in the horizontal limb (which was connected to a charcoal tube) was lying underneath the kathode a piece of platinum foil, on which some lithium chloride was fused (the salt is hygroscopic); struck by the negative particles the salt emitted a blue glow, struck by the positive particles (by reversing the poles) it gave a red glow. It was peculiar that in such experiments the spectra of the metals came out much better when a salt, than when the metal itself was being bombarded. Thus the liquid alloy of potassium-sodium showed specks of the (never missing) oxide in yellow glow, whilst the bright metallic surface appeared black under the bombardment.

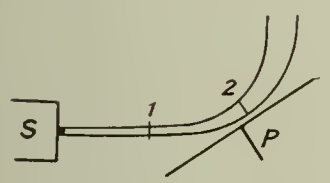


Fig. 4.

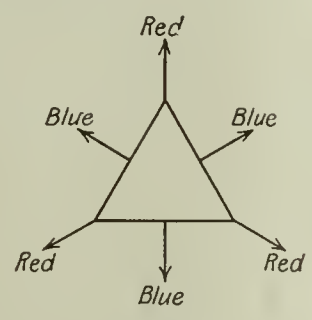


Fig. 5.

In all these bombardments the particles had to travel at a speed exceeding a minimum before luminosity was excited, which set in suddenly, and this speed or the corresponding voltage was rather high for salts of lithium and sodium, being of the order of 600 or 700 volts, whilst it was 4·9 volts only for mercury vapour, as stated. That fact confirmed the conclusion that the luminosity of the atom could only be excited by the communication of definite amounts of energy, and that the luminosity was discontinuous and not simply proportional to the disturbance. That was one point gained. Before we could go further we wanted more information on the nature of the luminous particles. Were they atoms or molecules or something more complex ? Doppler's principle enabled us to investigate that question. So far as the observer was concerned, the light given out by a body at rest was not the same as the light emitted by the body when itself moving. When the body approached the observer, the lines of the spectrum appeared displaced towards the violet ; when the body receded from him, the lines were displaced towards the red. From the displacement the velocity of the moving body could be deduced. Now in the discharge tubes the particles of the gas (neon, hydrogen, &c.), which emitted light and showed spectra, were moving at speeds of 10 or 100 cm./sec.; Stark had found that the lines in their spectra were displaced, and since atoms and molecules moved at different speeds, it was possible to gain some information as to the nature of the particles.

In these experiments, Sir Joseph continued in the fifth lecture, the positive particles passed through the openings (canals) in the kathode into the further part of the tube and then directly into the spectroscope. Some lines of a spectrum were then found displaced, others not. Thus, in the case of a hydrogen tube the spectrum of hydrogen changed as very roughly indicated in the diagram, Fig. 6. Instead of the original line of the "rest" spectrum R, a wider spectrum, R_1, was observed, almost completely separated from R by a dark gap, and having two peaks instead of one. The displacement and the broadening proved that the luminous particles were moving, and that they were the hydrogen particles shot through the canals. These particles were a mixed lot, moving at very different speeds ; hence the considerable broadening and the two intensity peaks; these latter marked velocities which were approximately in the ratio $\sqrt{2}$: 1, and it had been suggested that the respective particles giving rise to the two peaks were atoms and molecules of hydrogen, which should have this velocity ratio. The interpretation of those curves required very great caution, and Sir Joseph did not accept this view. Referring to his positive ray analysis* he pointed out that a stream of mixed positive particles striking a photographic plate would, in strong magnetic and electric fields, be sifted out according to mass and velocity of the particles into a series of parabolic traces, which at some distance from the origin would look like slightly curved lines. The lightest particles (hydrogen atoms) would settle in a trace far away from the abscissa, the heavier particles (*e.g.*, residual mercury vapour) close to the abscissa. If the particles of one trace had all the same velocity, the line would contract to a speck. Now the hydrogen-atom trace (as well as other traces) sometimes showed thick portions like beads ; and those beads seemed due to the molecules breaking up into atoms after passing through the opening in the kathode, but had continued to move with the smaller velocity of the molecule ; the velocity was at any point of the curve given by the ordinate, and the positions of two beads gave that ratio $\sqrt{2}$: 1 : but it was not necessary for this reason to assume that molecules gave out the same spectrum as atoms.

Now all the Balmer series lines of the primary spectrum of hydrogen were found to be displaced in these experiments, and all by about the same amount, whilst the also visible lines of the secondary (banded) spectrum of hydrogen were not displaced. Since positive ray analysis proved that various hydrogen particles, H (atoms), H_2 (molecules), and H_3 (the peculiar, otherwise unknown compound) all passed through the canals, and were all displaced, the secondary spectrum could not be due to any such particles. How did the secondary spectrum originate ? Ionisation by collision possibly came in, an atom or molecule losing an electron by the bombardment and acquiring a positive charge. That those atoms or molecules did not belong to the bombarding particles themselves, however,

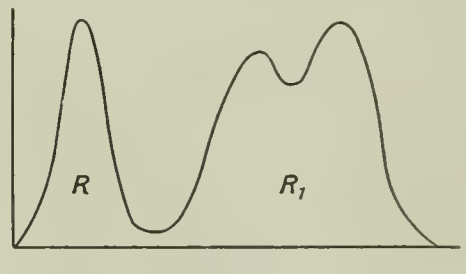


Fig. 6.

was shown by an experiment in which the tube contained two different gases on the two sides of the kathode, so that gas I. was shot through the canal into gas II. ; the spectroscopic observations conducted as before then showed that the lines of gas I. were displaced, but not those of gas II. But the interpretation of these phenomena was difficult, and there was no unanimity so far. There was acute controversy, in fact, as to the question, whether the particle which gave rise to the lines was the positively charged hydrogen particle or the particle which had become neutral again by the falling-in of an electron. Yet it would require very strong evidence to convince the lecturer that the positively-charged atom gave out the lines. For the Zeeman effect (presently to be discussed) showed that it was the vibrating electrons, and since they had various reasons to assume that the hydrogen atom contained one electron only, the positively charged atom of hydrogen could only be one which had lost its electron. His (Sir Joseph's) own view was that both opinions were in a certain sense right. The vibrating atom had first to lose its electron and thus to become positively charged, to emit a spectrum line ; but the light was really only given out while the electron was coming back, during the period of its collision with an atom or molecule. The mere expulsion of the electrons did not produce the luminosity. Strutt had driven the free electrons out of gas which was being bombarded, by placing the gas in a strong electric field, and he had hardly observed any diminution of the brightness. There was other evidence. In Fig. 6 a gap was noticed between the rest spectrum and the displaced spectrum. As the velocity of the particles was increased that gap became wider, but the increments became smaller and smaller, and finally a further increase in velocity had no more effect. Similarly there was a lower limit for the width of the gap. Those relation had an analogy in ionisation : ionisation by rays required a certain minimum speed of the rays, and it also failed when a maximum speed was exceeded : so the luminosity might be limited to the moment in which the electron returned.

A heroic application of Doppler's principle had recently been suggested by Fabry and Perot ; the idea was one of those which looked too simple until actually tried. They applied Doppler's principle to a gas luminous under ordinary conditions. The gas

* *See* The Electrician, Vol. LXXIII., page 26.

particles were in kinetic motion. When the spectrum of that gas was observed, some gas particles would move towards the observer, some away from him, and the breadth of a line would depend upon the relative velocities. In general the breadth corresponded to the average velocity (Rayleigh); if the vibrating particles were of light mass, they would move faster, and the line should be broader: if the particles were heavy, they would move less rapidly, and the broadening should be smaller; and from the breadth of the line the mass of the particles could be deduced. But too many conditions affected the velocity in a gas carrying electric discharges: if the method really proved reliable it would be more generally applicable than Stark's method; it would be advisable to compare the results of the two methods.

(*To be concluded.*)

"SPEEDING UP" IN AN ENGINEERING FACTORY *

BY R. RANKIN, B.SC.

Summary.—The author discusses the logical basis of bonus systems of payment. The results obtained with the system adopted and the difficulties encountered are described.

At the outbreak of war in 1914 the writer, like many other engineers, found himself in the position of having to deal with large contracts, completion of which was necessary at the earliest possible moment. To deal with such contracts, in the face of the rapidly decreasing supply of labour, was a task requiring careful consideration and speedy action.

At first sight it might appear that work of this nature belongs more to the commercial side of a business than to the technical side; actually, however, the work is, for the most part, technical, as these notes will show. In the case dealt with what was done, on the whole, was that laboratory methods were applied, not to the carrying out of scientific experiments of the usual kind, but to experiments with that somewhat refractory material the workman and his ways. Such methods have been adopted in America to a considerable extent with good results, and it is being realised here also that the development of scientific workshop production is one of the most important problems in the province of the engineer.

The first step which had to be taken was to devise a special method of payment by results, or to adapt some of the existing methods: the next and more difficult steps were to find out the amount of work which could be done in a given time, and to get the workmen to accept the system decided upon.

The unrest prevailing in the labour market at the period in question made it particularly difficult to carry out reforms. The result was that most firms were taking on as many men as they could possibly get, and, in such instances, paying them all they asked for. As more men became necessary for the Army, and as more men enlisted, it became increasingly evident that some other steps would have to be taken to increase output and at the same time allow the maximum number of men to enlist. Before the steps described hereafter were taken in the works with which the writer was connected, a large number of extra men were employed; in fact, to such an extent was this so that the accommodation in the works was utilised practically to the full both night and day, and yet it was found impossible to deliver orders by the dates specified and anticipated when promised. The works being full, in due course a demand was made all round for more money. The demand in this instance was for increased rates of pay, the main reason for this being that, in former years, higher rates of pay had been in force. Although this was not in accordance with the prevailing custom of paying a fixed "War bonus," it was decided to increase the rates to some extent after preliminary investigation showed that considerably increased outputs were possible all round and after such increased outputs had actually been obtained in some departments.

In the former years referred to above, when higher rates of pay were in force, a good deal of work was done on the piece work system. Under this system the maximum wages earned were 33⅓ per cent. more than would have been earned by men working at the flat, base rates. As is almost invariably the case, working on this system led to limitation of output, and some remarks may be permissible here regarding the straight piece work system. It would indeed be remarkable if limitation of earnings did not lead to limitation of output. Limitation of earnings on piece work has little to commend it, in the writer's opinion. On straight piece work a man's earnings are directly proportional to the amount of work he turns out. He gets paid a certain sum per piece of work done, and, if the piece cost fixed by the employer is considered satisfactory for a given output, it seems necessarily to follow that it must be even more satisfactory for a larger output, for the more quickly the work is turned out the smaller are the overhead charges against it. Limitation inevitably also leads to faking of time records where money is easily made on some kinds of work but with difficulty on others.

Straight piece-work is not a great success. It possesses simplicity, but this is not altogether an advantage. In fixing the price for a piece of work the employer, so to speak, tells the men what he thinks he can afford to pay for it, and this puts a weapon in the men's hands at once. It fosters the habit among them of calculating to their own satisfaction what a piece of work should cost their employer, and working accordingly. In fact, instead of selling their ability to work to their employer, they very soon practically sell pieces of work to him, which, to the author's way of thinking, is absolutely wrong in principle. The employer who bases piece-work prices on what he can afford to pay for labour is only looking for trouble. It does not follow that what he can afford to pay to-day is what he will be able to afford to pay tomorrow.

Satisfactory fixing of piece rates is not an easy matter. If the price is set high, the employer usually cuts it sooner or later; if it is set low by guesswork, or estimation not fully backed up by data, the men will not accept it. It is extremely difficult to get them to work in earnest on work for which a price has not been fixed. They will not work hard, and so find out what can be done, before the price is fixed; and after it is fixed they will not work hard in order that cutting may be avoided, or at least postponed. It is very easy for them to linger over their work, particularly over the intervals between the component parts of a complete operation, and observation by ordinary means, or by anyone other than a thoroughly practical observer, is in most cases of no use in detecting the extent of this. The analytical method of rate fixing is the only one to be relied upon.

To ensure a minimum wage and to level up discrepancies due to faulty rate-fixing or other causes, the men are sometimes paid at the standard base rates when the amount earned per hour on piece-work falls short of this rate. In such cases a workman is usually compelled to make up for lost time or shortage of output by turning out a larger output per hour on his succeeding work. He can earn nothing higher than the base rate until his lost time or shortage is made up. If necessary, the time to be made up can be spread over several succeeding jobs, but only when it has been wiped out or compensated for can a higher rate than the standard base rate be earned. This method of working does not appear to be conducive to honesty in the making out of time records, and faking of these records may give the cost clerk, or rate-fixer who estimates, very wrong impressions of what labour costs should be.

After consideration, it was decided that the system of payment devised by Harrington Emerson could be adapted so as to meet the conditions obtaining. Only the skeleton of the system was available, but this was worked out in some detail, and it will be shown that it is a much simpler affair than it appears to be when presented in the usual form in which the writer first encountered it.

In order that an accurate knowledge might be obtained as to the amount of work possible per hour, recourse was had to the services of a stop-watch. This was employed as in Taylor's System of Scientific Management, but without excessive attention being paid to small details on account of the urgency of the matter. In the production of any piece of work, each subsidiary operation going to make up the complete operation was timed. An analysis was then made so as to show which of those subsidiary operations (*a*) were taking too long, (*b*) were unnecessary, (*c*) could be done by boys or unskilled labour.

Upon the results of the analysis of the work a rearrangement of the method of working was made where possible and necessary, and it was then that the greatest difficulties were experienced, for although it could be proved to the workmen that they would be much better off financially, they went on strike on several occasions. A firm attitude, however, and the voice of reason prevailed in the end, and the system was got under way, and in operation proved most beneficial to all concerned.

The following points were laid down as essential for the success of the scheme:—

1. A proper idea had to be obtained of the amount of work that could be done in an hour;
2. A reasonable advance on prevailing rates of pay should be made if the amount of work was done which was shown to be reasonably possible;
3. A reasonable minimum rate of pay should be guaranteed;
4. There should be no cutting of wages or increase in the amount of work set as a task unless working methods or appliances were altered;
5. The method of payment should encourage the men to do their

* Abstract of a Paper read before the Junior Institution of Engineers.

best, and at the same time, by resulting in a decrease in labour cost with increase in work done, render it undesirable that alterations should be made in the rates of pay ;

6. Untrained men just starting should not be considered equal to the more skilled workers, and yet should be paid at a reasonable rate, rewarded according to industry and encouraged to improve their efficiency ;

7. Owing to the nature of the work, a time allowance should be made for washing, &c., before meals ; an allowance should also be made for the worker's personal requirements.

Briefly, the system adopted to the requirements of the works is as follows : The amount of work which can be done per hour by a good worker, working at a good pace, is ascertained and taken as a base to work on. The amount he does in one hour is set as the task which it is expected will be done, and a definite rate of pay is decided upon for this rate of working, this rate of pay being a certain percentage higher than the prevailing base rate. This percentage was fixed at 20 per cent. If the task is done in less than an hour the workman gets one hour's wage at the base rate plus an amount, at the base rate, corresponding to 20 per cent. of the actual time taken to do the task. If the task takes longer than an hour the man is paid at the base rate for the time actually taken plus a bonus equal to an amount, at the base rate, corresponding to a fraction of the time actually taken, this fraction being 20 per cent., when exactly one hour is taken for the task, and vanishing when the time taken reaches some predetermined period in excess of an hour. The point at which the bonus becomes zero was fixed at an hour and 20 minutes. If more than one hour and 20 minutes is taken, the base rate alone becomes operative, no bonus being payable.

Basing the bonus on the time taken, not on the time saved, may not seem to be rational, but what follows shows that it is quite sound. It should be observed that, when the task is done in less than an hour the full hour's wage plus the bonus is paid for the task. In systems in which the bonus is based on the time saved the wages paid consist of the amount corresponding to the period taken only

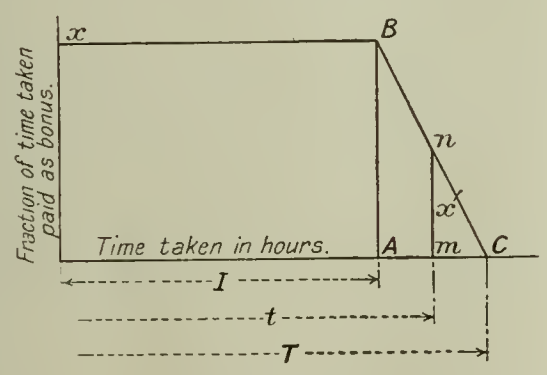


FIG. 1.

plus the bonus. This is what constitutes the difference between the two principles. If in the latter case payment were made for a full hour plus a fraction of the time saved the labour cost per piece of work would increase instead of diminish, with increase in the rate of production.

Let a=Prevailing rate of pay per hour before introduction of system.
,, n=Number of pieces set as one hour's task.
,, N=Number of pieces actually done per hour.
,, x=Fraction of time taken paid as bonus if time taken $\leqslant$ one hour.
,, x'=Fraction of time taken paid as bonus if time taken $>$ one hour.
,, t=Time actually taken to do one hour's task=n/N hours.
,, T=Time taken to do one hour's task at which bonus vanishes.
,, P=Actual pay per task under bonus system.
,, p=Actual pay per hour under bonus system.
,, c=Actual cost per piece under bonus system.

It is postulated that x' shall vary from x when the time taken to do one hour's task is exactly one hour, to zero when the time taken is $1\frac{1}{3}$ hours, the variation following a straight-line law when plotted on a time base ; x is constant. Exactly what is postulated is shown diagrammatically in Fig. 1.

If $t =$ one hour bonus fraction=x=constant.

If $t =$ one hour bonus fraction=$x'=mn$ in diagram

$$=AB\times\frac{mC}{AC}=x\frac{T-t}{T-1}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Case I. : $t \leqslant$ one hour—

$$P=a(1+xt), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$
$$p=P/t=a(x+1/t), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$
$$c=pt/n=P/n=a/n(1+xt). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Case II. : $t >$ one hour—

$$P=a\left\{t-\frac{x(T-t)}{T-1}t\right\}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$
$$p=P/t=a\left\{1-\frac{x(T-t)}{T-1}\right\}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$
$$c=p/N=pt/n=P/n=at/n\left\{1-\frac{x(T-t)}{T-1}\right\}, \quad . \quad (7)$$

x being taken as 0·2 and T as $\frac{4}{3}$ hours the equations become

Case I. :

$$P=a(1+0\cdot2t), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2^1)$$
$$p=a\left(0\cdot2+\frac{1}{t}\right), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3^1)$$
$$c=a/n\,(1+0\cdot2t). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4^1)$$

From (4^1) it is seen that c clearly diminishes as t diminishes.

Case II. :

$$P=at(1\cdot8-0\cdot6t), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5^1)$$
$$p=a(1\cdot8-0\cdot6t), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6^1)$$
$$c=\frac{a}{n}(1\cdot8t-0\cdot6t^2). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7^1)$$

From (7^1) $$\frac{dc}{dt}=\frac{a}{n}(1\cdot8-1\cdot2t).$$

Since the range of values of t for which equation (7^1) holds is from $t=1$ to $t=\frac{4}{3}$, the value of dc/dt is positive, and hence, for increasing values of t, the piece cost increases, or, what is the same thing, for decreasing values of t the piece cost decreases.

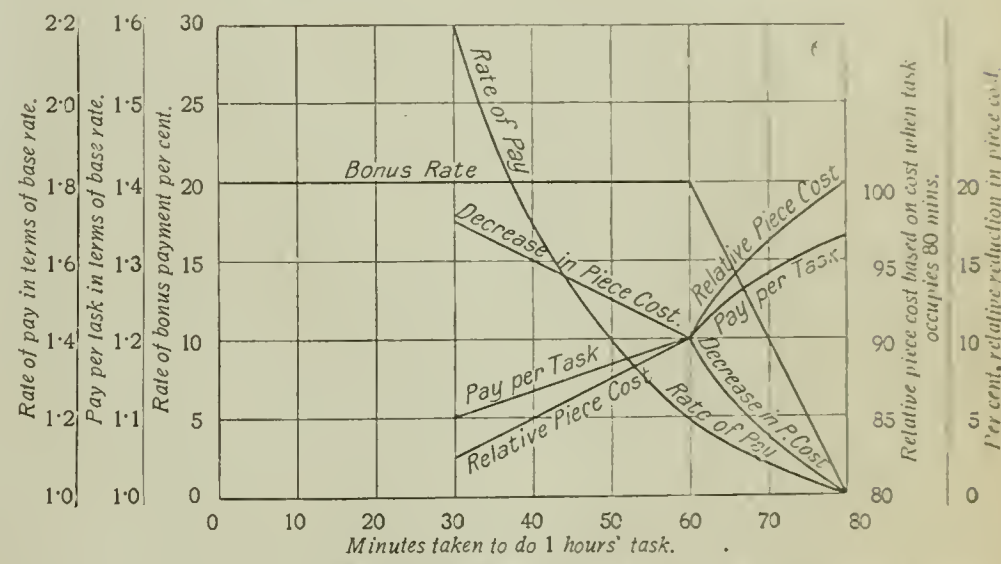


FIG. 2.—BONUS SYSTEM OF PAYMENT. CURVES SHOWING PARTICULARS OF WAGES AND COSTS.

Fig. 2 shows the effect of this scale. Actually, the prevailing rate a varied with the experience of the men and the nature of the work. In each case the prevailing rate was taken as a basis, and a curve plotted showing actual rate of pay as a function of time per task or number of pieces done per hour. By means of those curves and a slide rule the wages of the men were calculated.

The system of payment amounts to paying a certain figure for a fixed number per hour and so much per piece when the fixed number is exceeded. This aspect of the system was not enlarged upon to the workmen, but stress was laid on the fact that the more they did per hour the greater was the rate of pay per hour, and, not only so, but the more quickly they worked the more rapid was their rate of increase of pay. This appealed to them forcibly after they grasped it to some extent, and the writer believes that the system was far more successful in operation than any system would have been which they could have understood thoroughly. With the latter the temptation to " play up " the system might have been too strong.

It may also be observed from the foregoing considerations that the more work the men do per hour the more nearly the piece cost approaches a/n, which is the limit. This fact may be useful in starting such a system of payment in cases where the stop-watch leads to mutiny, provided a fair approximation can be made to the permissible cost or the possible rate of working : but in such cases it is well to leave an opportunity for alteration in the task by arranging that methods of working may be altered. No alterations in methods of working should be effected in those cases until the system of payment has been established.

(To be concluded.)

CORRESPONDENCE.

"METHODS FOR DETERMINING THE GRADING OF STARTING AND BRAKE RESISTANCES FOR SERIES-MOTORS."

TO THE EDITORS OF THE ELECTRICIAN.

Mr. F. Erens is in error when stating that the graphical method for determining the grading of the starting resistance for a series motor contained in my article in your issue for March 3rd "starts from the supposition that the back E.M.F. remains constant at the moment of changing over from contact to contact." The method involves no such supposition, and I said so in my article. When dealing with the shunt motor this assumption is made, which is, of course, perfectly allowable. When dealing with the series motor, however, I said (page 773, middle of left-hand column) "With the series motor the back E.M.F. may increase when changing over from one contact to the next." I then went on to say that if the field magnets are near saturation the same assumption as for a shunt motor may be made with a series one. As, however, it is not always correct to do so, I gave the method originated by Bragstad which is quite independent of any such assumption and may be used for determining the grading for any maximum and minimum values of the starting current that may be fixed upon.

The method likewise does not depend, as Mr. Erens would seem to suggest, upon the operator waiting until the starting current drops to I_c (the current at which the torque is equal to the opposing torque.) If it be not desired to wait so long on each contact then, if the maximum current is not to be exceeded, it will be necessary to have a larger number of steps. This follows directly from the diagram (Fig. 2 in the article). It will be seen in this case that the two sloping lines in the left half of the diagram come closer together, and in order to get from the bottom to the top there will be a larger number of steps in the zig-zag line. It will thus be seen that the method is quite general in character. One first of all settles what are the limits of current one wishes to work between and from the diagram the necessary number of steps is determined. By taking I_c equal to the current at which the torque is equal to the opposing torque one obtains the minimum possible number of steps one must have if a larger starting current than I_b is not to be used. The statement, therefore, of Mr. Erens that "The method gives a rough approximation" is wrong and if Mr. Erens will be so good as to look into the matter again I think he will agree with me.

Sutton Coldfield, April 17. CHARLES C. GARRARD.

PHYSICAL SOCIETY.

At a meeting held on March 24, 1916, at the Imperial College of Science, Mr. F. E. SMITH, A.R.C.S., Vice-President, in the Chair, a Paper entitled

"A New Method of Determining Ionic Velocities"

was read by Mrs. C. H. GRIFFITHS, B.Sc.

In the experiments described the cathode, which consists of a horizontal copper disc perforated with two holes is mounted in a cylindrical glass tube open at the lower end. The whole is suspended from the beam of a balance, and is immersed in a vessel of copper sulphate. The anode is a copper spiral fixed in the electrolyte some distance below the mouth of the cathode vessel. From the rate of change of weight of the suspended system during the passage of a current the ionic velocities can be determined.*

Dr. S. W. J. SMITH discussed the Paper at some length. His remarks will appear in the "Proceedings."

Mr. F. E. SMITH admired the manner in which small difficulties had been overcome. Some years ago he had determined the electrochemical equivalent of silver with the anode suspended from the beam of a balance. If Mrs. Griffiths intended continuing these experiments, he would suggest the use of such salts as silver nitrate rather than copper sulphate.

Mr. J. H. SHAXBY communicated the following remarks: It may be noted that the use of a relation, implicit in the reasoning but not actually employed, leads to a simple formula for calculating t without the necessity of separate determinations of m_1 and m_2. This gives a rather lengthy calculation, and incidentally avoids the necessity for relying on data in Landolt obtained by other workers. The relation is that the current $Ne(U+V)$ is also equal to $m_1q(U+V)$. (In fact, from the values given, $Ne=34{\cdot}36$ and $m_1q=34{\cdot}12$.) If, then, we substitute $\frac{c}{m_1q}-V$ for U in the equation

$$m_2V-m_1U-n\delta\rho V+\frac{c\rho}{qd}=W \text{ (loss in weight observed)},$$

we have

$$m_2V-m\left(\frac{c}{m_1q}-V\right)-n\delta\rho V+\frac{c\rho}{qd}=W,$$

or

$$V(m_1+m_2-n\delta\rho)=W+\frac{c}{q}-\frac{c\rho}{qd};$$

i.e.,

$$Vn(1-\delta\rho)=W+\frac{c}{q}\left(1-\frac{\rho}{d}\right).$$

The quantity δ is derived from the statement that "total mass of salt in cathode vessel diminishes at the rate of $(m_1+m_2)Av$ gms./sec." Now this diminution is not by the elimination of salt *qua* salt, but in the form of already dissociated ions. The calculation of δ, from the variation of density of a solution with concentration, lumps together undissociated and dissociated salt. If we may suppose the ions to be of great density, the value of δ would be very small. If we neglect δ and re-calculate V, we find for experiments (12), (9), (3) and (6) respectively the values 6·339, 3·138, 4·011 and 1·561 ($\times 10^{-4}$), leading to the values for $\frac{v}{u+v}$ 0·6584, 0·6561, 0·6627 and 0·6634. For the lowest concentrations these agree with other workers' figures. Metelka's results for densities 1·019 and 1·038 suggest similarly constant values of $\frac{v}{u+v}$ for various concentrations, and are also in good agreement with Mrs. Griffiths' figures (as thus re-calculated).

Dr. GRIFFITHS, replying on behalf of Mrs. Griffiths, expressed thanks for the interest taken in the Paper by Dr. Smith and for his rational criticism. He agreed that further research was advisable on the density of electrolytically deposited copper, and thought that Mrs. Griffiths might be able to measure experimentally the integral volume changes calculated in the Paper. She had already given some thought to these subjects. He was of the opinion that the space above the cathode was ample, and that the value of δ, in so far as its value depended on changes in the concentration of the solution of copper sulphate was correct. If the variations in concentration had been so great as to vitiate the value of δ, then, owing to the equalising effect of diffusion, an appreciable change would have taken place in the weight of the cathode vessel and contents after the conclusion of an experiment.

Mrs. GRIFFITHS has communicated the following comments on Mr. Shaxby's remarks: The mathematics in the second and third paragraphs appears to be correct and is interesting, but the first paragraph would seem to be somewhat misleading in that the necessity is not avoided for relying on data (dealing with concentrations) obtained by other workers. Mr. Shaxby avoids the necessity by making an hypothesis in the last paragraph which is not justifiable, for when the current has ceased the value of δ cannot depend on the process whereby the salt has been eliminated. Even during the passage of the current the process can have only an inappreciable effect on the value of δ.

A Paper entitled

"Note on an Explanation of the Migration of the Ions"

was read by Dr. S. W. J. SMITH, M.A., F.R.S.

The object of this Note is to show how a familiar diagram, appearing in many text-books, can be improved in a way which makes it easier to appreciate what happens at the electrodes in the simpler examples of Hittorf's method of determining the migration constant. An attempt is made to give precision to an idea which is sometimes vaguely expressed and frequently ignored.

Mr. D. OWEN considered that the usual graphical method expressed the integral effect simply and satisfactorily unless pressed in detail. The analysis of paragraph three of the Paper, whilst adding precision to the conclusions, did not modify them or "explain" them. The fact of the existence of a volume distribution of electricity near to the electrodes implied an increased potential gradient which played a part in the actions occurring in those regions.

Dr. WILLOWS suggested that, if Mr. Owen's view were correct, it should be possible to detect the potential gradients to which he referred.

Mr. F. E. SMITH remarked that Dr. Smith's Paper dealt with a real difficulty, and one which teachers of electricity had to face. He remembered giving lectures on the subject to very elementary students, and, feeling dissatisfied with the explanatory diagrams in text-books, had adopted another form of explanation. In dealing with the phenomenon the negative ions were never said to be discharged. The general argument followed was to regard matter as being in four states—solid, liquid, gaseous and ionic. It was already conceded from analogies that copper ions and metallic copper differed because of a difference of electrical energies. Conversion from one into another could be brought about by adding or subtracting electrical energy. Thus, in the electrolysis of copper sulphate solution with copper electrodes, the electrode at high potential lost energy by conversion of a part of itself into positive ions, and the negative electrode gained energy from the solution due to

*An extended abstract of this Paper appears on an earlier page of our present issue.—Eds. *E.*

positive ions giving up their charge and being converted into the metallic form.

Dr. SMITH, in reply, said: In the original draft of the Note, as submitted to the Society, he had hazarded the opinion that perhaps the Authors, who used the diagram, wished it to be understood that the excess ions shown at the ends of the chains were removed by excess potential gradients. He had deleted this conjecture, and had substituted a footnote (which was, in fact, a quotation), because he had been unable to find any proof that this was the view taken. In any case it was unsatisfactory. Mr. Owen seemed to imagine that there was some virtue of simplicity about this view which made the analysis unnecessary. This was not the case. The problem was not merely to state how a Hittorf migration experiment might be supposed to begin. It was as necessary to show clearly what occurred while it continued. This was the object of the Note. The analysis was the simplest general method of expressing the fact that some of the ions which take part in the electrolytic process are fed into the circuit near the electrodes, and are not brought there by the potential gradients. Views which "explain" the facts, while ignoring this, have been the cause of needless confusion in the minds of students. The analysis showed, for example, that conduction could not proceed as it began unless for every $(u+v)$ cations deposited v cations and v anions were fed into the circuit at the cathode. If the cathode region had to draw upon itself for this supply of ions, the concentration near it would rapidly fall and the "polarisation" at the cathode would rise in accordance with the well-known relation connecting the contact potential difference with the concentration. Diffusion, however, always played an essential part. When it was promoted by convection, a slight reduction in the concentration of the solution round the cathode would be enough to set up an appreciable diffusion current which would be maintained in the way described in the Note. This was the current which supplied the necessary molecules to the cathode space. The relation between this diffusion current and the electric current could be represented by the equation $kn=vi/(u+v)e$, where k is a diffusion constant, n is the concentration gradient at the cathode, i is the electric current density, and e is the ionic charge.

If notwithstanding this re-expression of his views, which he had thought were adequately conveyed in the Note, Mr. Owen still insisted that the usual graphical method was satisfactory, he could think of no better method of convincing him that it was not than to ask him to examine more closely the consequences of his own view as expressed at the meeting. He would then be led to the conclusions stated in the Note. Since the point had been raised, it should, perhaps, be noted that there was an obvious clerical error in the proofs of the Paper whereby N, N' and N'' had been printed throughout instead of SN, $S'N'$ and $S''N''$ respectively. With regard to the question raised by Dr. Willows, he was of the opinion that measurable potential differences of the kind described did not exist. He was glad that the Chairman was of the same opinion as himself with respect to the diagrams and descriptions usually given.

A Paper, by Dr. S. W. J. SMITH, entitled

"A Method of Exhibiting the Velocity of Iodine Ions in Solution,"

was taken as read. The method was shown.

Dilute solutions of potassium iodide and potassium chloride of equi-molecular concentration have almost the same electric conductivity. They are, therefore, of interest in connection with the direct measurement of ionic velocities. The Paper describes a simple method of observing their common boundary. It is only necessary to add a little mercuric chloride to the potassium chloride solution. An extremely thin layer of mercuric iodide then forms where the two solutions meet. The method is particularly convenient for lecture purposes, and an approximate value of the ionic velocity can be obtained in a few minutes.

The Paper gives examples of the use of the method. The current is first passed in the direction which causes the iodine ions to travel towards the chloride. The chlorine liberated at the anode in this case supplies a means of re-determining the velocity of the ions when, the current being reversed, they move in the opposite direction.

LEGAL INTELLIGENCE.

Krupp Magnetic Separator Patents.

On Thursday last Messrs. Edgar Allen & Co. (Ltd.) applied to the Patents Court for a licence to use nine patents—viz., 14,082 of 1908 and 29,230 of 1911 granted to Herr Ullrich, and the following in the name of Krupp—17,459 of 1909, 29,201 of 1911, 29,224 of 1911 and 4,595, 14,426, 14,427 and 24,355 all of 1913.

For the applicants, Sir Geo. Croydon Marks, M.P., said his clients had in hand an order for three Ullrich magnetic separators which were urgently required for the manufacture of tungsten for use in the production of high-speed steel, the machines to be similar to the Ullrich separator in the Bessemer Laboratory at the Imperial College of Science. Messrs. Allen were desirous of executing the order and also of developing the manufacture of those machines for general commercial purposes He offered a royalty of 5 per cent. on the net selling price.

Mr. TEMPLE FRANKS, the Controller of Patents, asked whether Ullrich's patents were owned by Krupps.

On Krupps' behalf, Mr. RUSHEN (Messrs. Hasletine, Lake & Co.) said he understood that Ullrich's patents were not the property of Krupps. He was not able to say there was any partnership between them. His firm had received separate instructions from both Ullrich and Krupps to oppose. He believed there was some sort of agreement between Krupp and Ullrich, but Ullrich was not in their employ.

The CONTROLLER: I think we must fix one royalty and let them fight it out between them as to what proportion each is to get.

Mr. RUSHEN recommended 15 per cent. as a fair royalty, considering all Krupps had done in the matter in this country and the market that had been made. It was little enough return.

Sir GEO. CROYDON MARKS: But there has been no sale yet. Probably all the large steel makers in the country are interested in developing the high speed steel and tungsten being employed: they want, if they can, to command the process set out by Krupps. Only through their agents had Krupps tried to licence those machines before. The machines had not been sold.

The CONTROLLER: There is an interesting point in connection with the machine in the Imperial College of Mines. Just after the war broke out Krupps' agent tried to get the machine out, but the authorities knew what they were about, and did not let him. Krupps' agent over here was the only person concerned in the utilisation of the machine the authorities had on exhibition there. The Rapid Co. claim that already they manufacture a British magnetic machine that will do all that is claimed for the German—"as good as, or better than" is the claim—and in view of that fact, it would not be right to treat Krupps' machine for purposes of royalty as something unique. It is hardly epoch making if there is another machine quite as good. The Rapid Co. had asked for three patents. I think they had better follow the example of the Edgar Allen Co., and take the lot.

The Rapid Co.'s managing director, Mr. H. Hubard Thompson, who was present in Court, said he would do so.

The CONTROLLER: There would be only one 5 per cent. royalty paid for each machine, and that would not go to Krupps. It would be paid to the Public Trustee, and the Government or the Board of Trade would decide what was to be done with it after the war. He thought a good case had been made out, and should recommend the Board of Trade to grant each applicant a licence to manufacture the Ullrich machine at a total royalty, as offered, of 5 per cent. That was the royalty most usually adopted by the Court.

Lion Spring Co. v. Carleon Electrical Co.

In the City of London Court last week, before his Honour Judge Atherley-Jones, K.C., plaintiffs sought to recover £39. 1s. 4d. for 25,000 percussion springs and 25,000 detent springs, supplied to their specification, at 1s. 6d. per gross, for the Government. Defendants had a contract to supply the springs to the Government in May last year. The work was carried out, and defendants refused to pay, as the springs were not made in accordance with the specification, as they were too weak, and some of them were returned. Plaintiffs said the Government inspector agreed to pay for the springs because they were made before the specification drawing was altered.

The defence was that the springs had not been accepted by the Government, and therefore plaintiffs could not expect to be paid.

Plaintiffs' WORKS MANAGER said the springs were inspected by a Government official at their works, sealed up by him, and forwarded to the Government premises in London.

The official, however, when called, admitted that his inspection was not final.

Judge ATHERLEY-JONES said that being so, plaintiffs could not recover, and must be non-suited, with costs.

Workmen's Compensation.

Last week Judge Mellor, of the Manchester County Court, gave his reserved decision in an arbitration in which Mrs. H. Robinson claimed £300 as compensation for the death of her husband, resulting from injuries sustained in July while working for Messrs. Wm. Sutcliffe & Son. The Judge said the question he had to decide was whether the £150 paid into court by respondents was or was not adequate. For claimant it had been argued that the grade and wages of the workman should be the basis of compensation whether the workman regularly followed his own employment or not, and whether he earned £1 a week or £3 a week or whatever sum was the average wage of an engineer. The objection to such a contention was that a hard-working man might get less compensation in case of injury than the lazy man who only worked a few months in the year, because in the first case holidays and stoppages would have to be considered, while in the second only the number of weeks worked would be considered. The workman in that case was 63 years of age, and having a comfortable home and money coming in from a shop managed by his wife and daughter he only worked at his trade when the fancy took him to do so, and for three or four years had only averaged about 11s. 8d. a week. Citing opinions of judges to the effect that regard could be had to the particular circumstances of each case, he held that the £150 paid into court was adequate and made an award accordingly.

Read v. Stella Conduit Corpn.

On Friday the Court of Appeal (the Master of the Rolls, Lord Justice Phillimore and Mr. Justice Sargant) delivered a considered judgment in this case upon the appeal of plaintiffs from a judgment of Mr. Justice Joyce. The facts were stated in our issue of the 7th inst. (p. 26).

Mr. Justice SARGANT delivered the judgment of the Court. He said that apart from one small variation plaintiff's appliance was the same

whether it was used for connecting a tube and a fitting or for connecting two tubes, and in the latter case whether the two tubes were of equal or unequal diameter. What was the invention as claimed by plaintiffs? So far as each junction taken by itself was concerned the method described in plaintiffs' specification was undoubtedly old. It was in substance the arrangement used for clamping or locking the adjustable steering handle post of the ordinary safety bicycle shown in Whitehouse's patent. No doubt in view of this refreshingly short and intelligible claim, in plaintiffs' specification it was not for a method or appliance for effecting a single junction or connection of this nature with one tube, but for an appliance for connecting together the ends of two tubular electrical conduits or fittings in the manner described. Did that double connection as distinguished from a single connection disclose sufficient subject matter or sufficient invention to support the letters patent. In the Court's judgment they did not, and the appeal would be dismissed, with costs.

American Radio-Telegraph Patent Case.

We are informed that in the Marconi-Simon radio-telegraph patent case the American Court of Appeal decided, on March 15th last, that owners of patents alleging infringement of rights by contractors to the United States cannot interfere with the execution and delivery of apparatus by suing the contractors, but they may obtain relief only from the Government. In the case in question the Marconi Company sought an injunction to prevent Emil J. Simon from producing 25 wireless sets for submarines of the United States Navy on a contract awarded him for delivery by Jan. 1, 1916. Plaintiff company alleged infringement of the basic Marconi patent, while defendant maintained that any action should be brought against the Government itself for demanding the precise arrangement in its specifications.

Mr. WALTER H. HUMPHREY (acting for defendant and also for the Secretary of the Navy) urged that the court action was a menace to national safety, as it threatened to prevent delivery of apparatus necessary to the Navy and would force disclosure of valuable secrets of adjustment and operation discovered by Government experts. In a letter from the Secretary of the Navy, which was submitted to the court, it was stated that the Government desired that its work should not be interfered with.

Judge Hough, of the United States District Court, based his decision on a previous ruling of the United States Supreme Court in the case of Crozier v. Krupp, and was affirmed by the United States Court of Appeals, to the effect that no cause for action of any kind arises against a contractor to the United States Government through the use of a patented invention in carrying out such contracts. The use of a patented invention by or for the Government was a use by the Government as a licensee (under an Act of Congress of June 25, 1910), and the only recourse plaintiff had owing to such use was by action in the Court of Claims against the Government for royalties, as was provided by the Act of 1910, which made the Government a licensee by law whenever it made use of a patented invention, and provides for full compensation in all cases.

Re Cedes Electric Traction (Ltd.)—Upon the petition of the Tudor Accumulator Co. (Ltd.) Mr. Justice Neville made an order on Tuesday for the compulsory winding-up of the Cedes Electric Traction (Ltd.).

PARLIAMENTARY INTELLIGENCE.

THE RECENT TELEGRAPH BREAKDOWN.

In the House of Commons last week the Postmaster-General (Mr. J. A. Pease) stated, in reply to a question, that the importance of securing uninterrupted telegraphic communication by means of underground lines had been kept in view by successive Postmasters General, and an underground telegraph system, which cost about £2,000,000, was now in use. Taking the telegraph and telephone systems together, the total length of aerial wire in use was not less than one million miles, compared with over two million miles of underground wire. The cost of putting the remaining trunk telegraph lines underground would probably exceed £3,000,000, and the annual charge for interest and depreciation (taken at 6 per cent. only) would be £180,000 a year, compared with an average annual cost for storm repairs for the past 10 years of £25,190, of which £6,700 has been in respect of the main trunk telegraph lines. It would, moreover, be impossible to carry out that work at present owing to the shortage of labour and other circumstances connected with the war. It had been necessary to suspend the schemes in progress for the construction of additional telegraph and telephone underground lines. Communication with Ireland was not wholy interrupted by the recent storm, although some of the land lines connecting the Irish cables were broken down.

PROPOSED LIMITATION OF ELECTRICITY AND GAS SUPPLY.

In reply to a question, it was stated in the House of Commons on the 13th inst. that it was not proposed to limit the use of electricity and gas for lighting purposes after a stated hour.

Dr. ADDISON (for the Ministry of Munitions) also added that care had already been taken that the requirements of munition factories should rank before all other considerations.

PATENT RECORD.

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

March 11, 1916.

3,629 TAYLOR. Changing frequency of alternating currents.
3,631 SANDERSON. Wave motors.
3,657 McBERTY & WESTERN ELECTRIC Co. Impulse-control systems for automatic telephone exchanges.
3,658 BRITISH WESTINGHOUSE ELECTRIC & MFG. Co. Starting mechanism for automobiles (6/4/15, U.S.)
3,659 BRITISH WESTINGHOUSE ELECTRIC & MFG. Co. Starting mechanism for automobiles. (24/3/15, U.S.)

March 13, 1916.

3,680 WESTWOOD. Electric lamps.
3,707 BEAVER & CLAREMONT. Leakage protection device for electric cables.
3,726 GREEN. Manufacture of electrically-welded link chains and cables.
3,736 & 3,737 HERINK & RELAY AUTOMATIC TELEPHONE Co. Automatic and semi-automatic telephone systems.
3,739 B.T.-H. Co. (G.E. Co.) Coil supports for electrical apparatus.
3,743 COMPARE & COMPARRI WIRELESS CONTROL SYND. Oscillators or vibrators for wireless telegraphy, &c.
3,745 SOC. FRANCAISE RADIO-ELECTRIQUE. Alternators for production of high-frequency electric oscillations. (13/3/15, France.)

March 14, 1916.

1,795 SALMSON. Contact apparatus for electrical connection of magnetos.
3,758 LUNDELL. Telephone exchange systems. (19/3/15, U.S.)
3,767 DAVIES. Projectile ignition devices.
3,769 HOBLEY & HOOPER. Electrical indicators, &c.
3,777 KINGSLAND. Apparatus for obtaining synchronous motions at a distance.
3,760 DOULTON & PODMORE. Tools for internally shaping telegraph insulators, &c.
3,789 MARCONI'S WIRELESS TELEGRAPH Co. Measuring instruments, relays, &c.
3,796 SALMSON. Interruption device and method of mounting cams for magnetos.
3,797 SALMSON. Mount for magneto distributors.
3,798 SALMSON. One-piece framing for magnetos.
3,817 SOC. ANON. DES ETABLISSEMENTS L. BLERIOT. Explosion engines coupled to dynamo-electric machines. (10/4/15, France.)

March 15, 1916.

3,835 CLAY. Electric lamps.
3,859 JOEL & MAWDSLEY. Dynamo-electric machinery.
3,869 HOLT. Stationary contacts for electric switches or circuit-breakers.

March 16, 1916.

3,896 CONNER & KAHL. Magneto-electric machines for ignition in internal-combustion engines.
3,919 SOC. L'ECLAIRAGE ELECTRIQUE. Machine for cutting bars or tubes. 8/9/15, France.)
3,922 HACKLEY & WESTERN ELECTRIC Co. Automatically-operating switch for machine switching telephone systems, &c.

March 17, 1916.

3,938 HALL. Electric flash-lamps.
3,948 TITTERTON. Apparatus for transmitting signals or messages.
3,954 HAILWOOD. Miners' safety lamps.
3,969 HENSMAN. Grapnels for raising submarine telegraph cables, &c.
3,976 BAYLES & BRITISH INSULATED & HELSBY CABLES. Electric cables.
4,006 PROKSCH. Apparatus for testing electric circuits. (22/3/15, Austria.)
4,019 MILLERSH-JACKSON. Starting and generating systems for automobiles.
4,026 RANDALL. Deflector for deflecting light in electric fittings.

March 18, 1916.

4,035 HONEYMAN & LANE. Treating articles electrolytically.
4,049 BRITISH EVER READY Co. & SHEPPARD. Casings for electric batteries.
4,067 LE NOIR & SIMPSON. Magnetos.

March 20, 1916.

4,096 ROTTENBURG. Electric contact keys, electric buzzers, &c.
4,104 BERRY. Route indicating and signalling devices for railways, &c.
4,109 CLAREMONT & TANNER. Joint for electric cable.
4,110 B.T.-H. Co. (G.E. Co.) Manufacture of incandescent lamps.
4,111 SIGNAL GES. Submarine sound-producers.
4,115 JONES. Electric-arc soldering.
4,136 BROWN. Securing electric lamps, &c., in sockets.
4,143 LYON. Searchlights, &c.

March 21, 1916.

4,180 SOC. L'ECLAIRAGE ELECTRIQUE. Machine for cutting bars or tubes.
4,182 B.T.-H. Co. (G.E. Co.) Shaping wire.
4,184 CLARK, LONGFORD, LONGFORD, MORRIS & SPHINX MANFG. Co. Electrical condensers and condenser systems.
4,186 GLENN & O'DONNELL. Railway signalling.
4,190 HASSELT. Process for electrolysis of alkali chlorides.
4,192 GILBART, GRIFFITHS, GILBART & Co., & GRIFFITHS. Sparking-plugs for internal combustion engines.
4,196 STONE & Co. Indicating state of adjustment or output of dynamo-electric machines.

March 22, 1916.

4,240 BLOOM. Electrical treatment of liquids and fluids, and products resulting therefrom.
4,247 B.T.-H. Co. (G.E. Co.) Electric transformers.
4,254 BAILY. Electric signalling-apparatus.
4,279 BRASS FLASK & CARSULE Co. & PERLOW. Electric flash-lamps.
4,288 ALLEN & NORTH. Interrupters for magneto-electric machines.

March 23, 1916.

4,295 CLARKE. Indicators for wireless telegraphy, &c., and manufacture thereof.
4,320 McCOLL. Protective gear for electrical circuits.
4,321 McCOLL. Protecting alternating-current generators and transformers.
4,337 NATIONAL SAFETY APPLIANCE Co. Automatic block-signal systems. (30/6/15, U.S.)
4,338 KRUPP AKT.-GES GRUSONWERK. Magnetic separators. (22/10/15, Germany.)
4,342 PITMAN & RAILING. Electric-light reflectors.
4,343 CURTIS. Controlling electric lighting of motor-vehicles.
4,347 PETTIGREW. Telephone systems.
4,348 BROOKIE. Arc projector lamps.
4,351 QUARZLAMPEN-GES. Radium-quartz lamp provided with a reflector. (12/2/15, Germany.)

March 24, 1916.

4,363 THYNNE. Application of [illegible] to walls, &c.
4,373 HENSHAW. Trailer head for trams, &c.
4,376 CHAMBERLAIN & HOOKHAM & JAMES. Maximum-demand indicators for electric supply and other recording apparatus.
4,399 B.T.-H. Co. & WISE. Connecting-up arrangements for electric circuits.
4,402 PRICE. Telegraph machines.
4,427 MEIKLEHAM & Co. & SONS. Telegraphy.
4,413 BRITISH EVER READY Co. & UNWIN. Electric flash-lamp attachments.

March 25, 1916.

4,453 B.T.-H. Co. (G.E. Co.) Lamp-holder connectors.
4,467 GHEKATARIAN. Magnetos.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	95	A.C. and D.C. Small Power Motors. Illustrated	17
Imports and Exports of Electrical Manufactures	96	"Preparedness"	18
Business Notices	96	A New Cord Absorber. Illustrated	19
Liquidations, &c.	96	Engineering Work in China. By Prof. Middleton Smith.	20
Electricity Supply	96		
Lighting and Power Notes	97	Tenders Invited	99
Traction Notes	97	Tenders Received & Accepted	100
Empire Notes	97	Companies' Meetings and Reports	100
Foreign Notes	98	City Notes	101
Miscellaneous Notes	98	Electrical Companies' Share List	102
The Round Table	15		
Electric Self-Charger Vehicle. Illustrated	16		

COMMERCIAL TOPICS.

Contraband of War. A Royal Proclamation was issued on the 12th inst. making certain additions to and amendments in the list of articles to be treated as contraband of war.

The following are now to be treated as absolute contraband :—

Gold, silver, paper money and all negotiable instruments and realisable securities ; metallic chlorides (except chloride of sodium), metalloidic chlorides, halogen compounds of carbon ; starch. borax, boric acid and other boron compounds.

It is further ordered that no gold, silver and paper money henceforth captured shall be treated as conditional contraband.

* * * *

Restrictions Upon Exports. By an Order in Council further restrictions are imposed upon exports and the exportation of the following is prohibited to all destinations :—

Pig-iron of all descriptions. The following railway material : Steel rails, steel sleepers, steel springs, steel wheels and axles. The following shipbuilding material : Boiler tubes, condenser tubes, steel plates and sectional materials for shipbuilding. Soap containing more than 1 per cent. of glycerine. Steel in bars, angles, rods and shapes or sections ; steel blooms, billets and slabs ; steel bridge, boiler and other plates not under $\frac{1}{8}$ in. thick ; steel girders, beams, joists and pillars ; steel ingots, steel tubes of all descriptions ; steel wire, except barbed and galvanised wire (the exportation of which remains prohibited to all destinations abroad other than British possessions and protectorates).

The exporation of the following is prohibited to all destinations abroad other than British possessions and protectorates :—

Aluminium sulphate and alumino-ferric ; files ; lacs, not including lac dye ; soap (soft) containing 1 per cent. and less of glycerine.

The exportation is prohibited to all foreign countries in Europe and on the Mediterranean and Black Seas, other than France, Russia (except through Baltic ports), Italy, Spain and Portugal) : Asphalt and solid or liquid bitumen ; petroleum and its products not already specifically prohibited ; soap (hard) containing 1 per cent. and less of glycerine.

* * * *

Brush Company's Progress. We are pleased to notice that the Brush Electrical Co., whose career in recent years has been a somewhat chequered one, has made progress during the past year. Though the trading profit only increased from £60,600 to £61,400, and the net profit from £7,100 to £7,300, these figures (we are told) do not give an adequate idea of the volume of orders or of the year's turnover. High wages, the shortage of skilled labour and the heavy increases in the cost of fuel and materials have affected the company like all engineering and manufacturing firms, and their natural effect has been to keep down profits. The company should, however, benefit from the trading expansion, and in view of the recent reorganisation of capital the shareholders, who have not had a dividend for 10 years, will now reap whatever advantages may arise from the improved business position.

* * * *

Electricity Supply Publicity. There are no signs at the present time of any activity whatever on the part of electricity supply interests in the country in giving publicity to the electric service. So far as we can gather, the operations of the newly formed Development Committee of the I.M.E.A. have temporarily ceased. Beyond the advertising of metal lamp makers and a certain number of small display announcements of vacuum cleaner makers and dealers, the merits of the electric service are not being pressed before the notice of the public. In strong contrast is the campaign of the British Commercial Gas Association. This body has probably never been so active as now in taking space in every form of daily, weekly and trade newspaper, which it considers to be of value in furthering its interests. The wording of many of these advertisements is such as to give the impression that certain domestic operations are only conveniently possible with gas, and certain definite effects and results can only be produced by this agency. The phrasing is cleverly designed to create a mental atmosphere amongst the public, which we think must be highly detrimental to electricity supply interests. If this kind of thing goes on long enough it will produce the effect which those who are responsible for it are desirous of obtaining. It is high time that the publicity work in connection with electricity supply were taken in hand, and promulgated on at least as extensive a scale as that undertaken by the British Commercial Gas Association. If the gas interests, both Company and Municipal, are able to find money in war time to trumpet the merits of their wares throughout the land, the electricity supply undertakings should be able to follow suit. There are some minds in electricity supply which hold the view that because the gas advocates make use of the daily papers it would be unprofessional, or even infra dig, to do the same. On no occasion has any agreed programme for lay press advertising been put forward, much less undertaken, in the interests of electricity supply. It is not sufficient to presume that the electric service is in no need of advertising at a time when the charges for electrical energy are being consistently increased throughout the country, and side by side with that increase there is a very energetic propaganda for increasing the uses of gas. At the outbreak of war there were indications of rapid progress in the department of the domestic electric service, and none recognised this more clearly than the gas undertakings. Central station engineers must see to it that the gas men, who are better organised and more commercially-minded than themselves, should not deprive them of the fruits of the labours in which they displayed considerable vigour before the war broke out. The present campaign in the interests of gas is the largest hitherto attempted, and this fact should bring the electricity supply industry sharply to its senses.

* * * *

United Kingdom Trade with Australia. In accordance with the practice for H.M. Trade Commissioners in the British Self-Governing Dominions to visit the United Kingdom officially from time to time, so that manufacturers and merchants may have the opportunity of consulting them on any matters connected with their business, or of obtaining information as to the possibilities of extending their trade, H.M. Trade Commissioner for Australia (Mr. G. T. Milne) is now in this country, and on the 17th, 18th and 19th inst. he interviewed by appointment representatives of firms who expressed a desire to see him in London.

Immediately after Easter Mr. Milne will commence to visit those trade and industrial centres in the provinces which have been decided upon as most advantageous to visit in view of the applications that have been received from firms in or near those centres, and from Chambers of Commerce. The itinerary includes Bristol, Newport (Mon.), Cardiff, Birmingham, Wolverhampton, Walsall, Coventry, Leicester, Nottingham, Derby, Stoke-on-Trent, Dublin, Liverpool, Manchester, Sheffield, Huddersfield, Bradford, Leeds, Newcastle, Edinburgh, Dundee, Dunfermline and Glasgow in the order named.

* * * *

U.S.A. and the South American Market. The "Electrical World" announces that Mr. P. S. Smith has been appointed by the Bureau of Foreign and Domestic Commerce as special agent to investigate the markets for electrical goods in South America.

Mr. Smith will report both on the present conditions as well as the future prospects in the South American market for electrical goods of all character. His reports will (it is hoped) enable the American manufacturer to cultivate intelligently the South American market. At present Mr. Smith is visiting a number of American cities in order to interview manufacturers and to ascertain what ground American firms interested in foreign trade would like to have him to cover in his investigation.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From April 10, 1916, *to* April 15, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

GOOLE.—*Holland:* Elec. lamps, 25 pkgs.
HULL.—*Holland:* Electrodes, 32 pkgs.
LIVERPOOL.—*U.S.A.:* Unenumerated, 5 pkgs. *Spain:* Elec. carbons, 67 pkgs.; unenumerated, 5 pkgs.
LONDON.—*U.S.A.:* Elec. machinery, £2,380; elec. lamps, £90; carbon candles, £970; telephone material, £8,745; unenumerated, £3,193—639 pkgs. *Holland:* Elec. lamps, £9,659—522 pkgs.; incandescent elec. lamps, 103 pkgs.; threaded electrodes and pins, 255 pkgs.; unenumerated, £30. *France:* Unenumerated, £1,572. *Switzerland:* Elec. machinery, £178; elec. lamps, £1,000; unenumerated, £1,017. *Italy:* Wire and cable £1,244; elec. wire, 73 pkgs. *Japan:* Unenumerated, £211. *Denmark:* Unenumerated, £195.

EXPORTS.

TO AUSTRALASIA.—*Melbourne:* Elec. machinery, £1,315; wire and cable, £45, unenumerated, £1,547. *Sydney:* Wire and cable, £1,065; elec. machinery, £1,641; elec-power transformers, £1,030; unenumerated, £3,147. *Christchurch:* Unenumerated, £36. *Dunedin:* Elec. machinery, £165; unenumerated, £125. *Lyttelton:* Elec. machinery, £107; wire and cable, £98; unenumerated, £117. *Brisbane:* Elec. machinery, £123; unenumerated, £100. *Adelaide:* Unenumerated, £109. *Napier:* Unenumerated, £79. *Newcastle:* Elec. machinery, £931. *Wellington:* Wire and cable, £219; elec. machinery £241; unenumerated, £2,249
AFRICA.—*Durban:* Elec. machinery, £763; wire and cable, £156; unenumerated, £356. *Cape Town:* Wire and cable, £241; unenumerated, £367. *East London:* Unenumerated £153. *Port Elizabeth:* Elec. machinery, £790; unenumerated, £142. *Beira:* Elec. machinery, £100.
SOUTH AND CENTRAL AMERICA.—*Buenos Ayres:* Wire and cable, £26; unenumerated, £1,609. *Rio de Janeiro:* Wire and cable, £27; telegraph material, £118; unenumerated £406. *Santos:* Unenumerated, £514. *Bahia:* Unenumerated, £31.
U.S.A.—*New York:* Elec. machinery, £91; telegraph material, £202; unenumerated, £318.
MALTA.—Wire and cable, £101; unenumerated, £188.
GIBRALTAR.—Unenumerated, £59.
WEST INDIES.—*Barbadoes:* Unenumerated, £31.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Wire and cable, £324; elec. machinery, £93; unenumerated, £1,629. *Calcutta:* Unenumerated, £673. *Ceylon:* Unenumerated, £184. *Karachi:* Unenumerated, £122. *Singapore:* Wire and cable, £349; elec. machinery, £78; unenumerated, £746. *Port Swetenham:* Telegraph £28; unenumerated, £110. *Penang:* Unenumerated, £14.
CHINA.—*Shanghai:* Wire and cable, £63; unenumerated, £28. *Hongkong:* Wire and cable, £2,056; unenumerated, £492.
HOLLAND.—*Amsterdam:* Unenumerated, £2,037. *Rotterdam:* Unenumerated, £146.
FRANCE.—*Treport:* Unenumerated, £139. *Dieppe:* Elec. machinery, £86; unenumerated, £165. *Dunkirk:* Elec. Machinery, £1,040. *Calais:* Unenumerated, £21. *Bordeaux:* Wire and cable, £1,420; unenumerated, £4,333. *Havre:* Elec. machinery, £82; unenumerated, £33
DENMARK. *Copenhagen:* Wire and cable, £2,995; unenumerated, £320.
RUSSIA. *Petrograd:* Elec. machinery, £603. *Vladivostock:* Wire and cable, £808.
SPAIN.—*Cadiz:* Unenumerated, £97.
PORTUGAL.—*Lisbon:* Wire and cable, £109; unenumerated, £453.
EGYPT. *Port Said:* Elec. machinery, £58; unenumerated, £343. *Port Sudan:* Elec. machinery, £55.
SWEDEN.—*Stockholm:* Wire and cable, £150. *Gothenburg:* Wire and cable, £130.
CANADA.—*St. John's:* Unenumerated, £99. *Nova Scotia:* Telegraph paper, 82 cwt.
JAPAN.—*Yokohama:* Telegraph material, £274; unenumerated, £850. *Tokio:* Wire and cable, £215.

FOREIGN GOODS (duty paid and free).

Bombay: Unenumerated, £14. *Adelaide:* Unenumerated, £302. *Rotterdam:* Unenumerated, £16. *Amsterdam:* Unenumerated, £227. *Cape Town:* Unenumerated, £85. *Dieppe:* Unenumerated, £35. *Christiana:* Unenumerated, £240. *Durban:* Unenumerated, £589. *Copenhagen:* Unenumerated, £93. *E. London:* Unenumerated, £80. *Port Elizabeth:* Unenumerated, £42. *Melbourne:* Unenumerated, £65. *Sydney:* Unenumerated, £77. *Singapore:* Unenumerated, £201. *New York:* Elec. machinery, £268; unenumerated, £284. *Gothenburg:* Unenumerated, £1,070.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

A firm of engineering merchants in Western Australia advertise that they are desirous of adding a first-class electrical agency to their business. Applications to Messrs. Hopcraft & Broadwater, 4, Fenchurch-avenue, London, E.C. *See an advertisement.*

Mr. Claude W. Hill has removed to 19, Old Queen-street, Westminster, London, S.W.

Messrs. José Ferreira & Filho, 15, Rua Nova, Recife, Brazil, advertise that they desire to represent British manufacturers of electrical apparatus, machinery, tools and materials.

Plant Wanted. Messrs. Head, Wrightson & Co. (Ltd.), Teesdale Iron Works, Thornaby-on-Tees, advertise for generating plant of 250 B.T.U. to 500 B.T.U. for 460/500 volts, d.c.

An advertiser requires two or three d.c. motors, 1 B.T.U. to 3 B.T.U., for 100-volt circuits.

LIQUIDATIONS, &c.

A meeting of creditors of Norman & Beard (Ltd.) (in vol. liq.) will be held at Cannon-street Hotel, London, E.C., on April 26.

A petition has been presented to the Court of Session (First Division), Edinburgh, for the appointment of Mr. Wm. B. Galbraith, C.A., Glasgow, as voluntary liquidator of the Light Electric Motor Co. (Ltd.) along with Mr. David B. Laurie, 130, St. George's street, Glasgow, the present voluntary liquidator. An interlocutor by the Lord Ordinary on April 14 ordered that answers to the petition must be lodged within eight days from that date.

Composition.—A composition of 5s. in the £ payable to the creditors of John Taylor Peddie, mechanical engineer, Exhibition-buildings, Aldwych Site, London, W.C., at the offices of Messrs. Elles, Salaman, Coates & Co., 1 and 2, Bucklersbury, London, E.C., has been approved.

ELECTRICITY SUPPLY.

EXTENSIONS.

Accrington.—The L.G. Board have sanctioned the scheme for the extension of the electric generating plant and the erection of a new chimney and flues at the destructor works. The new generating plant will cost £14,000, and the boiler, chimney and flues £7,000.

Altrincham.—The Altrincham Electric Supply (Ltd.) has successfully put into commission its first turbo-alternator set, which is one of 1,850 k.v.a., by the British Thomson-Houston Co., with Cole, Marchent & Morley surface condenser and Rees-Roturbo pumps.

Barnes.—Electric supply mains are to be extended to the Beverley works of Dehon, Godar & Co.

The firm will pay the cost of the work, provided the Council refunds 50 per cent. of the then market price of the cable if the firm vacates the factory in the next 18 months, the cable then becoming the property of the Council.

Birkenhead.—The L.G. Board have refused to sanction a loan of £6,400 for additional electrical plant, mains, extensions, &c.

Bolton.—The Corporation have received sanction to a loan of £2,281 for the electric supply department.

Cardiff.—The Electric Lighting Committee have decided to extend the Hayes sub-station, at a cost of £1,200.

Swansea.—Mains are to be extended to Morgan-street, Hafod, at an estimated cost of £150.

Wolverhampton.—Last week the Corporation sanctioned the expenditure of £17,160 on extensions of the generating plant to cope with the load required during the winter of 1917.

Councillor GIBSON said the demand for electricity had been so rapid of late that it was absolutely necessary to take steps to secure an ample supply as soon as possible.

It was also decided to make a general increase of 10 per cent. on all electricity accounts where it may be legally made, such increase to date from the quarterly reading of the meters taken in June next.

GENERAL.

Bridlington.—A revised scale of charges for the supply of electrical energy will come into force after June 24.

For lighting, the charge will be 5½d. per unit up to 500 units per quarter, 5d. per unit up to 1,000 units, 4½d. up to 1,500 units, and 4d. per unit exceeding 1,500 units per quarter. For heating and cooking, 2d. per unit will be charged up to 100 units per quarter, and 1½d. per unit exceeding 100 units per quarter.

Brighton.—It was reported to the Council last week that the engineer and manager (Mr. John Christie) had advised the acceptance of an offer by a firm acting on behalf of the Government authorities to purchase four boilers (with the option of a fifth) and two Willans engines and generators, with a section of piping and the old feed pumps at North-road works.

The offer was £550 per boiler and £1,250 per engine, making a total of £4,700. This machinery was originally purchased between 1897 and 1899 at a cost of £14,000, and as the loans were obtained over a period of 21 years they were now nearly extinguished. The plant would never again be required at North-road, and in Mr. Christie's opinion the offer was an exceptionally good one for second-hand plant of that class.

The Council therefore decided to accept same. The purchaser is to dismantle and remove the machinery at his own expense; payment is to be made at rate of 10 per cent. of the purchase price on acceptance, and the balance within 14 days after the plant has been handed over to the Railway Company.

The Lighting Committee have elected their Chairman (Councillor Lintott) and the Engineer (Mr. John Christie) to represent the Corporation at the business meetings of the Incorporated Municipal Electrical Association, to be held in London on June 22 and 23 next.

Islington (London).—The Lighting Committee has adopted the Electrical Engineer's suggestion that for certain arc lamps high candle-power metallic filament lamps should be substituted in the globes. The annual saving (exclusive of energy) is estimated at a minimum of £85.

Municipal Loans.—We are informed that the Local Government Board has, on an application made by the B.E.A.M.A., extended the period for the repayment of loans in respect of storage batteries from seven years to 10 years, satisfactory guarantees being given.

Poplar (London).—The Electricity Committee is of opinion that a temporary increase of 10 per cent. for current for power and public lighting is necessary.

It would be possible to carry on the undertaking at the present rates of charge without incurring any loss on the year's working, but it would then become necessary for the Committee to decline to supply intending consumers, as funds would not be available for laying services (for which loans cannot now be raised) and installing meters and wiring. It is estimated that the proposed increase, after making allowance for probable decreased demand, would enable a surplus of not less than £5,000 to be earned, while if coal is obtained at 2s. 6d. per ton less than estimated, the estimated surplus would be £10,000 for the ensuing year. An annual surplus of not less than the latter sum is required to meet all demands upon the undertaking and maintain the policy of providing for new services, meters, &c., and the writing down of plant out of revenue. It is not considered desirable to increase the charges for private lighting.

The Committee proposes to instal, experimentally, a Cumberland electrolytic process on a Babcock boiler and economiser at the works at a cost of £200. Should the process achieve the results claimed for it, the Committee anticipates that the cost of installation can be met in a year.

The Council are recommended to grant a war bonus to their staff of 10 per cent. on present normal salaries and wages (including emoluments) under £200 per annum ; 7½ per cent. on £200 and under £300 ; and 5 per cent. on £300 and upwards. In the case of the electricity department it is proposed that those who have received war bonus or increase due to the war should have the amount made up to 10 per cent., and should a profit bonus be available at the end of the ensuing year the aggregate amount paid as war bonus during the year, as proposed, to be deducted from each individual share in profits.

Rhyl.—The Council have empowered the electricity committee to carry out, at a cost of about £200, certain alterations of the Diesel engines to enable them to use tar oil fuel instead of crude paraffin.

Southend-on-Sea.—Owing to the increase in the price of materials, the Electric Light Committee has agreed to pay the contractors for the supply of joint boxes, an extra sum of 2½d. per box in respect of 250 boxes recently ordered by the Electrical Engineer.

Subsequent to the decision of the Council in January last to pay £1,680. 15s. 3d. to Callender's Cable & Construction Co. for cable ordered in December, 1914, in connection with the proposed supply of current in Leigh (payment for which had been delayed in consequence of the L.G. Board withholding sanction to a loan) a portion of the cable had been commandeered by the Government. The company has offered either to replace such cable now, undertake to replace it at the termination of the war at the original contract price, or credit the Corporation with the value (£480), plus £210, being the increased value of the copper at the existing market price, thus reducing the amount payable to the firm to £990. 15s. 3d. The Committee has decided to accept the last-named offer.

Watford.—The Urban Council is applying to the L.G. Board for sanction to the borrowing of £3,300 for the electric supply department.

West Ham.—The electrical engineer (Mr. J. W. Beauchamp) reports having obtained quotations for further automatic protective devices to be used in connection with the three main generators, and that he proposes to put these on order immediately.

The Council's contract with the Fuller Electrical & Mfg. Co. for the supply of motors for the sales department terminated at the end of March. Mr. Beauchamp invited nine leading firms to send in quotations, but only four replied. Out of these the Fuller Co. was the only complete one, their prices (although much higher than last year) being slightly lower than any one of the other three on most of the items, and slightly higher on two or three other items. The firm intimated, however, that they would not enter into a contract, and reserved the right to increase prices by a month's notice. Under the circumstances the engineer proposes to continue to buy from the company until such time as it seems desirable to make another contract.

LIGHTING & POWER NOTES.

Electricity in Quarries.—The report of the Inspector under the Metalliferous Mines Act (Mr. Hugh Johnstone) for the Midland & Southern Division of England for 1914, was recently issued.

It states that the total output of minerals during the year showed a decrease of 30,312 tons. Electrical plant of a total of 5,835½ H.P. was employed, 4,422½ H.P. above ground (for winding, ventilation, haulage and miscellaneous purposes), and 1,413 H.P. below ground (for haulage, pumping and miscellaneous work).

Electrolytic Treatment of Zinc.—In a statement issued by Amalgamated Zinc (de Bavay's) (Ltd.), the directors report that investigations are proceeding in America regarding electrolytic treatment of zinc concentrates. Commercial possibilities of the process contemplated depend to a large extent on cheap power, and the chairman has obtained from the Tasmanian Government a satisfactory offer under which all power required will be supplied by the hydro-electric department.

Emergency Lighting of Passenger Vessels.—It is reported that the United States Steamboat Inspection Service has introduced new regulations as to emergency lights on passenger ships.

The emergency radio-telegraph storage battery is utilised as an auxiliary source of power to operate their emergency lights. In order that the storage battery shall be properly charged, a special charging panel board has been designed, and it is so equipped as to disconnect automatically the charging circuit when the battery has been charged. The board is equipped with overload and underload automatic switches to prevent excessive charging. Should an accident require the use of emergency lights, an officer or wheelman on the bridge throws one switch or presses a push button on the steering head of the wheel. The emergency lights are placed in the main passageways, in the passageways leading to the staterooms, over the doors leading to the decks, on the stairways leading to the lifeboat decks, on the boat deck in immediate vicinity of lifeboats and rafts, and the auxiliary current circuits are also connected with the signal lights. These lights are arranged on three circuits, one for each deck, leading to the charging panel. On the freight deck 3-ampere fuses are used, on the passenger deck 5-ampere fuses, and on the boat deck 10-ampere fuses. In the event of an accident, should the water reach the freight-deck circuit, the lower fuses will blow, allowing the lights on the upper decks to remain lighted. The auxiliary lights can be so placed as to illuminate the lifeboats, so that in case of accident.

Ilford.—The public lighting estimate for the ensuing six months shows an allowance of £1,000 for reduced lighting.

TRACTION NOTES.

Plymouth.—The Board of Trade have sanctioned the borrowing of £111,706 in respect of the purchase of the Devonport & District Tramways Co.'s undertaking, the term for repayment being 30 years.

The cost incurred by the Corporation, in connection with the tramways arbitration was £7,735.

Croydon Tramway Strike.—This strike still continues, the Corporation having declined to submit the dispute to arbitration. Over 20 cars are running at present.

Manchester-Bury Electric Railway.—On Monday the electric service between Victoria Station, Manchester, and Bury, on the Lancashire & Yorkshire Railway was inaugurated.

Women Tramcar Drivers.—Southend Light Railways Committee has decided to endeavour to find suitable women and girls with a view to employing them as temporary tramcar drivers.

EMPIRE NOTES.

Australasia.—The 18th half-yearly accounts of the Adelaide Municipal Tramways Trust (for the six months ended Jan. 31 last) have been handed to the Commissioner of Public Works, Adelaide, for submission to the Governor

The total amount of the advances from H.M. Government on account of construction of electric tramways is £1,532,267, of which £1,352,834 is outstanding, and the amount of capital expenditure over balance of advances by H.M. Government is £290,809. The total revenue for the half-year was £160,463 (compared with £157,149 in the six months ended Jan. 31, 1915), operating expenses were £97,206 (against £96,581), and total appropriation £64,579 (against £62,431), including interest, sinking fund and £9,121 (against £8,686) reserve for renewals, making the total expenditure £161,786 (£159,012). Revenue per car mile was 16·008d. (15·020d.) and operating expenses were 9·681d. (9·220d.).

The chief engineer and general manager (Mr. W. G. T. Goodman) states that reserves amount to £287,949 (including sinking fund £179,452). Reserve for renewals amounts to £97,426, and the only charges which have been made against this reserve amount to £1,813, while the reserves for insurance amount to £7,926. The net deficit for the half-year after meeting all statutory charges was £1,322, but wages paid to dependants of employés who have enlisted for active service amounted to £2,073. Surplus revenue over operating expenses was 8·758 per cent. on the capital cost. After meeting all obligations to date the whole of the interest on purchase money (£87,539) has been paid. Under normal conditions the revenue would have been at least £16,540 more, but there has been no retrenchment, and no men have been put on short time. During the Trust's nine years' ownership of the system the revenue has been £2,120,026, and expenditure, including statutory charges, £2,116,862, leaving balance of appropriation account available £3,164.

The last half-yearly report of the Broken Hill Pty. Co. states that it was recently decided to add four more open hearth furnaces to the three already in operation to increase the output of steel, and also to erect four more rolling mills, and to add a further 1,000-kw. generating plant at the power station.

The Wollongong (N.S.W.) correspondent of the "Australian Mining Standard" states that the electric safety lamp made by the Wolf Safety Lamp Co. and adopted by the South Bulli colliery, is found to be satisfactory, giving a better light than the oil lamp, while the work of keeping

it in going order is less. The majority of the employees express appreciation of these lamps, of which there are between 500 and 600 in the mine.

At a recent meeting Sydney (N.S.W.) Council decided not to accept any tender for annual supplies of electrical accessories, wires or cables. It was announced that the electrical engineer would shortly recommend that no further extensions of overhead mains be made until bare copper conductor is purchased at a price more near the normal than is possible at present.

Electric Smelting in Newfoundland.—It is stated that an electric smelter was recently installed at St. Johns, Newfoundland, and in the initial test on copper ore from the Little Bay Copper Mines the plant worked admirably and a high grade of copper was produced. The plant will smelt about 1,000 lb. of ore per hour, and is owned by the Hydro Electric Smelting Co. (Ltd.).

India.—"Indian Engineering" says Ootacamund Municipal Council has resolved that the question of electric lighting of that town with suction gas-driven plant must stand over in consequence of the high price of suction gas engines and the probability that they might not be obtainable at all at present. Nevertheless, Mr. Jackson, of Messrs. Siemens Brothers, will visit the station and investigations will be carried on.

FOREIGN NOTES.

Argentina.—The "Review of the River Plate" says a public electric light service has been inaugurated at Diamante (Entre Rios).

The Ministry of Finance has authorised the Direccion General of the Port of Buenos Ayres to arrange with the Compañia Italo-Argentina de Electricidad for the suspension of the works of renewal of lighting material for three years, the executive power reserving the right to remove the suspension at any time in which case the company would be required to resume the works within seven months from date of notification. This decision represents a saving of $23,000 gold per annum, so long as the arrangement subsists.

China.—It is desired to obtain samples and models of engineering products of United Kingdom manufacture for the engineering school of Peking University. The consulting engineers (whose name can be obtained from the Board of Trade, 73, Basinghall-street, London, E.C.) desire to get into communication with United Kingdom manufacturers who would be willing to present the necessary apparatus either free of charge or on specially favourable terms.

Chosen.—*Seoul Mining Co.*—The following extracts from the report of the Directors of the Seoul Mining Co. for 1914 are taken from the "Far Eastern Review":—

The erection of the electric power plant has been completed under the direction of the managing engineer of the electrical department, Mr. H. Maki, and is performing its full expected service with complete regularity. In the report on the Company's Suan Concession at Holkol it is stated that the change from steam to electric motive power has been made at the Suan mine and mill, and the plant is working satisfactorily. In his report on the power plant Mr. Maki says the early part of the year was not suitable for outdoor work on account of the weather, but the erection of the steelwork for the power-house building was completed during May. The transmission line from the generating station to the half-way house was completed in May, but a flood in July washed away 4 miles of the transmission line, which has since been re-erected upon higher ground. At the time of the flood some of the equipment was being transported up the river to Tam Bowie and the heaviest transformers were under water when placed 15 ft. above the usual water level of the river. These were dried out and no injury was done. The transmission line was completed and ready for use in October. The generating station equipment consists of three batteries of water-tube boilers with superheaters and chain-grate stokers, two feed-water pumps, two steam-feed water heaters and two stoker engines; two 1,000 kw. turbo-generating sets with direct-connected exciters, five switchboard panels, four 400 k.v.a. power transformers, four 30 k.v.a. auxiliary motor transformers, two electric motor-driven surface condensers and two intake pumps, one 5-ton electric wharf crane and one 12 ton travelling crane.

One wooden pole line was erected for the transmission of 44,000 volts, three-phase current from generating station to Pami Chung, a distance of 34 miles, from which point the lines diverge to the Soctarie and the Tul Mi Chung sub-stations, where the voltage is stepped down to 440 volts. At the Soctarie sub-station there are four 150 k.v.a. transformers, four 150 k.v.a. step-down transformers, three switchboard panels with instruments to control incoming and outgoing power and measuring instruments, and 16 different sized mill motors with panels.

The Holkol sub-station is equipped with four 75 k.v.a. air compressor motor transformers, two panels with instruments for controlling incoming power from the Soctarie sub station and synchronous motor of 240 h.p. for air compressor. The Tul Mi Chung sub-stations are in course of construction. At the generating station one 1,000 kw. generating set was ready to operate in October last.

Chosen Railways.—In the report on the Chosen Railways for the year ended March, 1914, the Director of the Railway Bureau states that amongst the improvements during the year was the equipping of three carriages with electric lights and fans. The telegraphic apparatus installed numbered 137, telephonic 934, and blocks 267. Railway telegraphic stations numbered 144; railway messages dealt with were 3,702,410, and public messages 247,777. There are two generating stations with engines of 830 H.P. and generators of 466 kw. There are 34 arc and 6,297 incandescent lamps. Besides, those installed in carriages numbered 1,975 in all.

Light railways and tramways in Chosen in operation at the end of the year were five, namely, the system operated by the Nikkan Gas & Electric Co. and four others operated as private concerns. The aggregate capital of these light railways and tramways totalled 10,426,600 yen, of which 5,748,695 yen was paid up. The mileage open to traffic was 23·7 miles, of which 16 miles were worked electrically (in Keijyo). The mileage to be opened hereafter amounts to 181·2 miles, including 7 miles of electric tramway in Fusan. At Ryuzan workshops, on completion of air compressor station newly built, three sets of boilers and two sets of compressors were erected and set to work, and in the erecting shop a set of goliath cranes was fixed up. The motive power was supplied by two sets of dynamos of 224 kw. (one as standby), and there were 15 sets of motors (649 H.P. in all) and two sets of air compressors of 196 H.P.

In all 130 carriages were equipped with 1,975 electric lights and 130 with motor fans, their motors being 59 and batteries 1,416 in number respectively, increases of 40 in carriages, 710 in lights, 69 in motor fans, 18 in generators and 432 in batteries. The total amount of current generated was 1,184,068 units, while the total expenditure was 29,317·85 yen, of which 59·2 per cent. was for fuel.

Electric Zinc Refining in Norway.—H.M. Minister at Christiania states that the electric refining of zinc, which has been developing on a gradually increased scale at Trollhattan for some years, has now reached an output of over 6,000 tons of refined zinc per annum.

Refining is also being carried on at Sundlokken. Increased facilities are required for smelting the ore, and it has now been decided to secure the necessary water-power from the Glomfjord waterfalls, in Nordre Helgeland, Nordland. These falls have been purchased by a company formed for the purpose, and are expected to yield 125,000 H.P. The works are expected to be completed by 1918.

Portugal.—A Bill was recently presented to the Portuguese Chamber of Deputies to authorise the municipality of Amarante to borrow 120,000 escudos (about £17,500) for a hydro-electric installation for the production of power for lighting and other purposes, the construction of a market, water supply, &c.

MISCELLANEOUS NOTES.

British Industries Fair.—The Board of Trade have decided to hold this fair in London next year from Feb. 26 to March 9 inclusive. Having regard to the satisfactory results of the two British industries fairs already held, it is proposed to organise the 1917 fair on similar lines; participation will, therefore, be confined to manufacturers and admission restricted to wholesale buyers.

City of London Fires in 1915.—The Coroner for the City of London and Southwark (Dr. F. J. Waldo) has submitted his annual return to the City Corporation for 1915.

Dr. Waldo states that with respect to his duties under the City of London Fire Inquests Act, 165 fires (compared with 139 in 1914) had been officially notified to him. In 148 cases the cause of the fires was determined and in only 17 fires did the cause remain unknown. In the case of 26 fires (against 11 in 1914), Dr. Waldo states that, with the expert assistance of the City Electrical Engineer, he had been able to decide that those fires were due to defective electrical arrangements. In more than one instance during the present war suspicion had fallen on alien enemies, but inquiry had fortunately cleared up the matter satisfactorily. The coroner is of opinion that the City of London Fire Act (1888) should be extended to the whole of the country, as suggested by the Home Office Departmental Committee in 1909.

Defence of Realm Regulations.—A new regulation, which has been made under the Defence of the Realm Acts, states that:—

Any person charged with having in his possession or control any tungsten ore or products therefrom, high-speed steel, or scrap therefrom, molybdenum, vanadium, cobalt, nickel, or any alloy used in the manufacture of high-speed steel or any other metal required for the production of war material, which may reasonably be suspected of being stolen or unlawfully obtained, who does not give an account satisfactory to the Court, shall be guilty of a summary offence against the regulations.

Inquest.—An inquest was held on Friday at Pool (Cornwall) on Thos. Symons, who was recently killed at East Pool Mine.

A witness said that on the morning of the 12th inst. a stay wire had become loose, and Symons, who took hold of the wire, immediately fell to the ground. The stay wire was swaying with the wind and when it touched the electric wires it transmitted sparks. Deceased was fetched to it because he knew something was wrong.

Mr. R. H. BERRIMAN, mill superintendent, said the man had been evidently "electrocuted." It was a wound wire stay, and it had not

been treated to be non-conductive. Of course, it was never intended that it should come into contact with live wires. It would not be deceased's duty to touch the wire, but witness believed he went to put the wire so that nobody should be hurt. Symons should have reported it to the electrical engineer. There was a pair of rubber gloves on the premises which deceased could have obtained to handle the wire with safety. One of the employés used the gloves to remove deceased from the wire. He also tried to revive him by resuscitation.

Mr. D. D. BELCHAM, electrical engineer, said other than by outside covering, there was no method of making stays non-conductive. Covering was impracticable for wire stays. Symons had no right to touch the wire. It should have been reported to the electrical staff.

A verdict of "Accidental death" was returned, and no blame imputed to anyone.

More Alien Enemy Firms Wound-up.—Up to date the Board of Trade have ordered the winding-up of 103 businesses controlled by alien enemies. The two latest are the Rhineland Mfg. Co. (Ltd.), importers of ball bearings, 69, Wells-street, London, W. (controller, Mr. L. F. Goodricke, 10, Coleman-street, E.C.); and Nitsche & Gunther Optical Co. (Ltd.), manufacturers of optical instruments, &c., 66, Hatton-garden, London, E.C. (controller, Mr. B. E. Mayhew, Alderman's House, Bishopsgate, E.C.).

Mr. W. G. Jefferys, 56, Coleman-street, London, E.C., has been appointed to supervise the winding-up of Ferrum (Ltd.), 198 and 199, Winchester House, London, E.C.

Trading with Enemy Firms in Neutral Countries.—The "London Gazette" of April 14 contains further lists of firms and persons in neutral countries with whom persons in the United Kingdom are prohibited from trading.

Amongst the firms mentioned are: *Argentina and Uruguay.*—Siemens Schuckert (Ltd.) (Compania de Maquinaria e Instalaciones Electricas), and Sociedad Anonima Argentina Hidraulico Agricola.

Tribunal Cases.—At the Lancashire County Tribunal last week, an electrical engineer, aged 26, appealed on the grounds that his technical skill would be of more service to his country than his service in the army would be. The appeal was dismissed, and the military representative was instructed to recommend the man for the Royal Engineers.

At Worksop last week the electrical engineer of the Urban Council, Mr. J. P. Crowther, withdrew his application for exemption, and said he had enlisted in the Electrical Corps of the Royal Engineers. The application was granted, and the Tribunal granted temporary exemption to the station superintendent and also to two stokers, the cable jointer, and the fitter. The only single employee (the meter tester) was put back to Sept. 1.

"Manchester Guardian" Chinese Supplement.—With the issue of our contemporary for the 18th inst. was published a well-illustrated and interesting supplement dealing with China and its commercial possibilities.

It contains special articles dealing with (inter alia) The New Outlook in China, The Possibilities for British Commerce, British Engineering Opportunities in China, The Enemy Trading Question, English Dyes in China, The General Economic Position in China, Government Railways, The Civil Service, &c. The articles, which have been written by experts, contain much interesting information concerning the commercial and industrial position of China. The article on British Engineering Opportunities in China [illegible] field and lay stress upon the need of [illegible] permanent footing in the country and to [illegible]

Imports.—The following are [illegible] material and apparatus imported into this country (*a*) during March, 1916, and (*b*) the aggregate figures from Jan. 1 to March 31, with increase or decrease compared with corresponding periods of 1915:—

Electrical machinery, (*a*) £80,970 (decrease £74,264), (*b*) £264,209 (decrease £176,952); including generators and motors other than for aeroplanes, motor cars and cycles, (*a*) £14,372 (decrease £27,572), (*b*) £45,040 (decrease £19,529); and electrical machinery unenumerated, (*a*) £66,598 (decrease £26,932), (*b*) £219,163 (decrease £107,420); telegraph and telephone cables other than submarine, (*a*) £1,246 (decrease £462), (*b*, £22,689 (increase £17,462); telegraph and telephone apparatus, (*a*) £24,137 (increase £20,980), (*b*) £46,[illegible] (decrease £[illegible]), other electrical wires and cables, rubber insulated, (*a*) £12,[illegible] (decrease £2,068), (*b*) £29,945 (increase £13,615); with other insulation, (*a*) £[illegible] (decrease £2,001), (*b*) £1,404 (decrease £4,032); carbons, (*a*) £7,247 (increase £1,520), (*b*) £26,561 (increase £5,832); glow lamps, (*a*) £22,[illegible] (increase £9,545), (*b*) £49,261 (increase £14,904); arc lamps and electric searchlights, (*a*) nil (decrease £364), (*b*) nil (decrease £[illegible]); parts of arc lamps and searchlights (other than carbons), (*a*) £8,574 (increase £4,[illegible]), (*b*) £19,599 (increase £773); primary and secondary batteries, (*a*) £10,443 (decrease £2,895), (*b*) £53,144 (increase £17,933); meters and measuring instruments, (*a*) £2,493 (increase £488), (*b*) £8,940 (increase £2,[illegible]); switchboards, (*a*) nil (decrease £545), (*b*) £248 (decrease £2,[illegible]); electrical goods and apparatus unenumerated, (*a*) £26,380 (increase £[illegible]), (*b*) £72,025 (increase £36,437). Total of electrical goods and apparatus other than machinery and uninsulated wire, (*a*) £115,[illegible] (increase £48,783), (*b*) £330,805 (increase £137,236).

Exports.—The exports of electrical machinery, material, &c., (*a*) during March, 1916, and (*b*) from Jan. 1 to March 31, with increase or decrease compared with corresponding periods of 1915, were as follows:

Electrical machinery, (*a*) £104,277 (decrease £11,687), (*b*) £308,257 (increase £9,337); including railway and tramway motors, (*a*) £5,475 (decrease £4,624), (*b*) £11,917 (decrease £6,659); other generators and motors except for aeroplanes, motor cars and cycles, (*a*) £59,991 (increase £46), (*b*) £168,227 (increase £37,891); and electrical machinery unenumerated, (*a*) £40,811 (decrease £7,109), (*b*) £128,113 (decrease £21,897); telegraph and telephone cables, submarine, (*a*) £42,876 (decrease £12,737), (*b*) £68,670 (decrease £61,805); other than submarine, (*a*) £58,043 (increase £18,560), (*b*) £159,156 (increase £71,208); telegraph and telephone apparatus, (*a*) £22,509 (increase £9,026), (*b*) £69,922 (increase £27,720); other electrical wires and cables, rubber insulated, (*a*) £40,974 (increase £19,718, (*b*) £111,521 (increase £46,831); with other insulation, (*a*) £62,404 (increase £34,852), (*b*) £175,687 (increase £84,078); carbons, (*a*) £1,198 (increase £674), (*b*) £2,262 (increase £743); glow lamps, (*a*) £15,390 (increase £4,772), (*b*) £39,375 (increase £9,453); arc lamps and searchlights, (*a*) £1,832 (increase £1,623), (*b*) £4,141 (increase £3,518); parts of arc lamps and searchlights (other than carbons), (*a*) £545 (decrease £67), (*b*) £2,955 (increase £635); primary and secondary batteries, (*a*) £19,609 (decrease £2,431), (*b*) £57,982 (increase £2,408); meters and measuring implements, (*a*) £14,591 (decrease £432), (*b*) £44,643 (increase £4,035); transformers, (*a*) £1,206 (decrease £3,901), (*b*) £13,826 (increase £3,968); switchboards, (*a*) £2,114 (decrease £4,493), (*b*) £15,225 (increase £1,183); electrical goods and apparatus unenumerated, (*a*) £44,282 (increase £13,963), (*b*) £141,379 (decrease £7,861). Total of electrical goods and apparatus, other than machinery and uninsulated wire, (*a*) £328,173 (increase £51,203), (*b*) £906,744 (increase £186,011).

TENDERS INVITED.

Boilers and Economisers.

Tenders are invited by the electricity department of the County Borough of WEST HARTLEPOOL for the supply and erection of two Water-tube Boilers, Superheaters and Mechanical Stokers. Specifications from borough electrical engineer (Mr. J. W. Spark) and tenders to Town Clerk by April 28.

WARRINGTON Electricity and Tramways Committee require tenders by noon April 26 for supply of Boiler Plant and Economiser. Specification from Borough Electrical Engineer.

Turbo-Alternator, Gas Producer Plant, &c.

The NEW SOUTH WALES GOVERNMENT Railways and Tramways Department invite tenders for the supply and erection of a 2,500 kw. Turbo-Alternator for the Zarra-street (Newcastle, N.S.W.) power house. Specification (No. 470) from the Electrical Engineer, and tenders to Chief Commissioner for Railways and Tramways, Phillip-street, Sydney, by noon May 3.

WANGANUI (N.Z.) Borough Council require tenders by noon May 9 for the supply and erection of Additional Plant at their tramway power house, including Pressure-type Gas Producer Plant, Gas Engine, Electric Generator and Switchgear. Specification, &c., from the Town Clerk.

Tramway Construction, Tramcars, &c.

The Dirección General de Obras Publicas, Ministerio de Fomento, Madrid, require tenders by May 19 for the construction and working, for 60 years, of an electric Tramway in BILBAO, connecting the existing system with the Irala-Barri district. Minimum rolling stock required to commence is one motor and one trailer coach for passengers, and one motor goods coach and two trailer goods wagons. An option on the concession is held by the Sociedad Tranvia Urbano de Bilbao.

DUNEDIN (N.Z.) City Council require tenders by 5 p.m. May 17 for six Electric Tramcars and sections of Cars (Bodies, Electrical Equipments and Trucks). Specifications, &c., from the Town Hall, Dunedin.

JOHANNESBURG (Transvaal) Council require tenders by noon June 6 for supply of two Manganese Steel Crossings. Specification, &c., from the Municipal Offices, Johannesburg.

The Public Works Dept., Madrid, will receive tenders until noon May 30 for the Construction and Working, for 60 years, of an Electric Tramway in MELILLA (North Africa). The minimum rolling stock required is 16 coaches, with motors and accessories. An option is held by Don Felipe Ezquerro.

Sub-Station Equipment.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. April 26, for the supply of Electrical Equipment and Accessories for sub-station for the Sandringham–Black Rock tramway (contract No. 29,762).

Motor Generator, &c.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. May 10 for Motor Generator and Accessories for Battery Charging of Baggage Trucks, also Switchboard and Connections (contract No. 29,796).

Water Softening Plant.

WALTHAMSTOW Urban Council require tenders by 5 p.m. April 26 for the supply and erection of a Water-softening Plant, to deal with 5,000 gallons of water per hour, for the electricity department. Specification, &c., from the Engineer, electricity department, Priory-avenue, Walthamstow.

Generating Plant, Mains, Transformers, &c.

WIGAN Electricity Committee require tenders by April 26 for h.t. Three-core Cable, Transformers and Switchgear. Specifications, &c., from the Borough Electrical Engineer.

OAMARU (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1. 1s. for each contract.

Joint Boxes, &c.

The Town Clerk, municipal offices, JOHANNESBURG, will receive tenders until noon June 6 for the supply of 500 c.i. Joint Boxes and 200 Hanks of Trolley Rope (contract No. 112). Specifications, &c., from the municipal offices, Johannesburg.

Steam Pipes, &c.

SALFORD Corporation want tenders by noon May 8 for high pressure Steel Steam Pipes and Separator; and c.i. Pipes and Valves. Specifications from the Borough Electrical Engineer.

Electric Cable, Cranes, &c.

The SOUTH AFRICAN RAILWAYS ADMINISTRATION require tenders by noon May 1 for the Supply of 1 Mile of 0·9 sq. in. Single-stranded Copper Conductor of Armoured and Lead-sheathed Paper-insulated Cable, suitable for 660 volts d.c. (contract No. 700); and until noon May 15 for the supply of two 50-ton Electric Overhead Travelling Cranes for new erecting shop at Salt River workshops (contract No. 701). Specifications and forms of tender from the Secretary, Tender Board, South African Railways Headquarters Offices, Johannesburg. Tenders for the cranes will also be received up to May 15 by the High Commissioner for South Africa, 32, Victoria-street, London, S.W., at whose office also specifications may be obtained.

TENDERS RECEIVED AND ACCEPTED.

BARROW-IN-FURNESS.—The Corporation have accepted the following tenders:—

General Electric Co., switches, &c.; British Insulated & Helsby Cables, joint boxes and cut-outs; Chamberlain & Hookham, meters; Ferranti (Ltd.), prepayment meters; Drake & Gorham, metal filament lamps; Pope's Electric Lamp Co., carbon filament lamps; Verity's (Ltd.), motors; A. F. Goodwin & Co., wire, &c.; Dussek Bitumen Co., insulating compound and bitumen; New Conveyor Co., ash conveyor.

BURNLEY.—The Guardians have accepted the tender of F. Thornton & Co. for the supply of electrical goods.

MANCHESTER.—The Tramways Committee have accepted the following tenders for stores, &c., for the year ending March next:—

General Electric Co., metal and carbon filament lamps, switches, bells, cells, telephones, &c.; Drake & Gorham, metal filament lamps; L. Andrew & Co., mica segments, tapes, soldering fluid, &c.; British Westinghouse Electric Co., motor and controller parts, coils, bushes, lightning arresters, gear and pinion wheels, &c.; Electro Mechanical Brake Co., resistances and parts; H. Wallwork & Co., grids; Dyer & Young, commutator segments and controller fingers; P. R. Jackson & Co., coils; Kay & Co., brush holders, worm bushes, bolts, &c.; Engineering Supplies Co., controller fingers; S. Gratrix & Brother, bell pushes, globes, &c.; Mason & Brown, bells and parts; Micanite & Insulators Co., mica cones, commutator sleeves, &c.; G. Schultz & Co., mica tubes, washers, &c.; Pinchin, Johnson & Co., varnish, &c.; Morgan Crucible Co., carbon brushes, crucibles, &c.; E. A. Longrish & Co., carbons; A. Wiseman (Ltd.), overhead equipment insulating material, &c.; Fleming, Birkby & Goodall, trolley wheel bushes, &c.; Connolly Bros., cable; F. Smith & Co., copper cable and strip and steel wire and cable; British Insulated & Helsby Cables, copper wire.

The tender of the British Thomson-Houston Co. has also been accepted for three months' supply of motor and controller parts, motor cases, field coils, brush holders, &c.

RATHMINES.—The Urban Council have accepted for 12 months' supply of house service cable, house service and fuse boxes and meters: British Insulated & Helsby Cables, cables at schedule prices; and Reason Mfg. Co., electrolytic meters, at schedule prices. The tenders for house service and fuse boxes have not been settled yet.

ST. HELENS.—The Council have entered into a contract with the Tudor Accumulator Co. for renewing and maintaining the storage battery at the electricity works.

SWANSEA.—The Electric Lighting Committee has accepted the tender of Ferranti (Ltd.) (at £66) for the supply of a three-phase transformer, and that of Thomas & Evans (at £530) for wiring the Brynmill and Cwmbwrla schools.

TYNEMOUTH.—The Electricity Committee recommends the acceptance of the tender of the Macintosh Cable Co. for the supply of 110 yds. three-core armoured cable 7/18 conductors, and for 110 yds. 7/18 twin cable.

BARNES.—The tender of the Pirelli General Cable Works (at £187. 5s.) has been accepted by the Council for the supply of 440 yds. of three-core distributing cable.

WESTMINSTER.—The Guardians have accepted the tenders of Pope's Electric Lamp Co. for lamps; and the General Electric Co. for electric fittings, &c.

SOUTHEND-ON-SEA.—The Corporation are recommended to accept the tender of the British Insulated & Helsby Cables for the supply of 6 miles of overhead trolley cable at 1s. 4 d. per pound.

SYDNEY (N.S.W.)—The Council recently decided to purchase from Standard Waygood, Ltd., six current transformers for Westinghouse 10,000-volt switchboard; from the Australian General Electric Co., six ditto, for B.T.-H. 10,000-volt switchboard; from Noyes Bros., six ditto, for Ferranti 5,000-volt switchboard; and six ditto, for Ferranti 10,000-volt switchboard; also a complete spare exhauster for the suction ash-removing plant at the power house from Babcock & Wilcox, the contractors who supplied the plant, at £845, f.o.b. Glasgow, and to pay the firm the cost of shipping to Sydney and delivery to site, including duty and insurance, amounting to about £368.

FINANCIAL MATTERS.

COMPANIES' MEETINGS AND REPORTS.

CANADIAN GENERAL CO. (LTD.) The gross profit for 1915 is $1,219,513, and after deducting interest and $440,222 for depreciation, the net profit is $764,378. Dividends of 7 per cent. have been paid on both the preference and ordinary shares, leaving $66,356, and increasing the undivided profit to $1,007,119, out of which $300,000 goes to reserve, raising that fund to $3,000,000, and $707,119 remains to be carried forward.

HOLSWORTHY GAS & ELECTRICITY CO.—At the recent meeting it was reported that the total receipts from the gas undertaking were £1,095 and from electricity supply £295. A dividend of 2 per cent. was declared, and the chairman (Mr. J. M'T. Dickson) said the increase in the price of coal, the reduction of public lighting and economy by private consumers had greatly affected them.

MARCONI WIRELESS TELEGRAPH CO. OF AMERICA—The report states that for the year 1915 (before allowing for reserves) the net income is $288,994, compared with $271,888 for 1914. While progress has been hampered by the restriction of ocean travel, and the postponement of the Marconi Transatlantic wireless service owing to the European war, nevertheless substantial improvements have been made. The new policies of standardising wireless equipment and contracting for its use on a basis which provides a fair return for the service rendered are now well established with shipowners. Important economies in operation have been effected and have resulted in a substantial saving. There are nearly 500 ships equipped with Marconi apparatus, the majority of such equipments being leased at the company's new rental rates for a term of

years. A considerable increase in the number of contracts had been made, and among the largest may be mentioned the equipment of 30 ships of the Standard Oil Co., and a contract for standard installations on 36 large power barges about to be operated on the Mississippi River. That large equipment of Marconi apparatus on inland river barges (the largest of which approximates 5,000 tons) is the most interesting and promising development of the company's marine service during the year. Since the beginning of 1916 35 ships have been equipped with Marconi apparatus. Notwithstanding that practically all passenger traffic to and from European countries has been suspended, and that American shipping has been withdrawn from the Pacific, the receipts from message traffic during 1915 were only about 8 per cent. less than for 1914. There has been no change in the commercial status of the trans-Atlantic stations, the high power equipments remaining closed to business on account of the war. The British Admiralty still holds for Imperial Government use the English plants constructed to operate with the company's Belmar and New Brunswick duplex stations, and thus far, because of the war, it has been impossible to open similar direct service with Norway and Northern Europe through the newly completed high power stations at Marion (Mass.) and Chatham (Mass.) Reliable and rapid service has been maintained between stations in California and Hawaii, and the volumo of traffic shows steady improvement. The Hawaiian stations are two-way stations, being constructed so as to work with California and Japan simultaneously. The Japanese Government recently notified that its new wireless stations at Funabashi and Otchisi, near Tokyo, are complete, and tests are now being made daily with a view to early inauguration of a public service, spanning 5,600 miles of tho Pacific. Negotiations on traffic regulations are now in progress with the Japanese Government Department of Communications, and it is expected that by means of the Japanese Government cables the service will be extended to China, Manchuria and other Far Eastern countries. The new circuit connecting the United States with Alaska was opened in August, 1915. All of the year's production of the factory at Aldene (N.J.) has been rented, sold to patrons, or installed on steamships, in addition to which a number of sets have been manufactured on special order for the U.S. Government. The management of the company has effected a substantial reduction in expenses of $111,054. The income derived from investment of surplus funds amounted to $87,010, and adding $17,922 interest on stock subscription, the total income from these sources was $104,932, against $150,274. The reduction is explained by the liquidation of investments necessitated by capital expenditures. The reserves set aside out of the 1915 profits for depreciation have been determined on practically the same basis as in 1914. After setting aside all reserves, the net profits amounted to $177,316, an increase of 18·30 per cent. This amount has been added to the surplus, increasing that account to $541,887.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—The gross earnings during 1915 (including dividends and interest from subsidiary companies) amounted to £90,630. 17s. 6d., to which should be added certain payments made under the deed of compromise dated June 9, 1915, amounting to £15,481. 3s. 1d., and with balance from 1914 (£56,136. 8s. 2d.) the total is £162,248. 8s. 9d. Deducting working expenses, maintenance, &c. (£38,654. 12s. 9d.), depreciation of securities (£5,500), interim dividends, debenture interest and redemption charges (£18,367. 15s. 6d.), leaves £99,726. 0s. 6d. The directors recommend payment of a final dividend of 3 per cent. (less tax) for the year on the preference shares (£1,500), and of 6 per cent. (tax free) on the ordinary shares, making 10 per cent. for the year (£10,758. 15s. 7d.), the transfer to reserve account of £70,000, and to staff pension fund of £2,000, leaving to carry forward £15,467. 4s. 11d. The company's exchanges continue to expand and show improved revenues. Underground cabling extensions are in progress at Singapore and Madras, from the operation of which additional revenue will accrue to the company. The Indian local companies show considerably increased revenues. The Bengal Telephone Co. has paid the same dividend as for 1914 (7 per cent.) and its directors have decided to purchase a central site in Calcutta for erecting a suitable building thereon, in which will be installed a new switchboard equipment. The Bombay Co. has paid a dividend of 20 per cent., against 16 per cent. for 1914. Both the Telephone Co. of Egypt and the China and Japan Telephone & Electric Co. have had a satisfactory year ; the former continues to pay the previous rate of dividend of 10 per cent., and the latter 10 per cent., against 5 per cent. for 1914.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—The revenue for 1915 was £136,167. 1s. 2d., the traffic receipts (£119,872) showing an increase of £4,789, compared with 1914. After deducting all expenses, including £11,269 for debenture and other interest, the balance is £40,872, compared with £35,825. Adding £1,698. 15s. 10d. brought forward the available balance is £42,570. The directors recommend that £8,036 be placed to reserve and £10,000 to renewals account, that a dividend at rate of 5 per cent. per annum be paid on the preference shares (£12,250), and a dividend on the ordinary shares at rate of 3 per cent. per annum (£7,350), leaving to be carried forward £4,935. The receipts from the operation of the tramways and omnibus services showed satisfactory increases during the second half of the year. Owing to the shortage of labour working conditions were exceedingly difficult. The negotiations with Stoke-on-Trent Corporation for the postponement by the Corporation for a definite period of their rights to purchase certain portions of the company's undertaking, have not so far resulted in agreement.

SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO.—Under the working arrangement with the Treforest Electrical Consumers Co. (Ltd.) the working expenses in connection with this undertaking are now borne by that company, there is no revenue account to be submitted for 1915. The directors, however, report that the business of the company shows a material increase during the year, the units sold amounting to 28,967,656 compared with 26,510,198 in 1914, an increase of 2,457,458 units. After payment of all working expenses and interest on preference debenture stock and making provision for depreciation of new plant, the surplus amounts to £6,756. 3s. 8d., compared with £5,347. 7s. 5d. The indebtedness of £13,500 to certain members of the Treforest Company for extra charges having been provided for, this surplus has enabled payment to be made of the interest on the old debenture stock for the half-year ending December 31 last (£5,000), leaving £1,756 to be carried to suspense account, and making, with balance to credit of the account a total of £3,999. Sanction was obtained during the year from the Treasury for the issue of an additional £80,000 of 5 per cent. preference debenture stock, and this stock has been duly placed.

WESTERN UNION TELEGRAPH CO.—The report for the year ended Dec. 31 last shows operating revenues, $51,171,795 ; and operating expenses, including reserve, rents, &c., $40,972,541 ; leaving $10,199,254, to which is added $1,303,925 income from loans and investments, making $11,503,179. Interest on bonds absorbed $1,335,588, leaving balance $10,167,591, which, with surplus at December, 1914, $13,731,021, and adjustment of surplus, $169,819, makes $23,869,331. Dividends require $4,986,364, leaving surplus at December, 1915, $18,882,967. Operating revenues increased by $4,907,019. Income from loans and investments increased 27½ per cent., and net income increased $4,736,197, or 89·3 per cent.

WOLSELEY MOTORS (LTD.)—The report for 1915 states that, after providing for all expenses, contingencies and depreciation of buildings, &c., and after charging repairs and maintenance to revenue, the trading for the year has resulted in a net profit of £172,893. The directors recommend payment of dividend of 7 per cent. on the preference shares, and a dividend of 20 per cent. on 300,000 ordinary shares (tax free), placing £30,000 to reserve, and carrying forward £6,513.

CITY NOTES.

MEMORANDA (April 18).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 57 5/16. Consols Pay Day, May 4. Stocks and Shares Ticket Days, April 27 and May 11. Pay Days, April 28 and May 12. Price of silver, 30 7/16d.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The directors have declared an interim dividend for the quarter ended March 31 of 1s. per cent. on the ordinary stock and £1. 10s. per cent. on the preferred stock (less tax at 3s. 2d.), payable on May 1.

BRAZILIAN TRACTION, LIGHT & POWER CO. (LTD.)—A quarterly dividend of 1 per cent. has been declared on the ordinary stock.

CEDARS RAPIDS MFG. & POWER CO.—The gross earnings for 1915 were $685,593. Operating expenses, including rentals, general expenses and taxes, absorbed $48,295, and fixed charges $392,246, leaving a surplus of $245,052.

EASTERN TELEGRAPH CO. (LTD.)—The company announce the payment by warrants on May 1 of interest for the half-year ending April 30 on their 4 per cent. mortgage debenture stock. The transfer books of the debenture stock will be closed from the 26th to 29th inst., inclusive.

GREAT NORTHERN TELEGRAPH CO. (LTD.)—At the general meeting, which will be held at Copenhagen on May 6, the board will propose to pay a total dividend and bonus of 12 per cent. for the year 1915, including the 5 per cent. already paid, and to transfer to reserve and renewal fund (reduced by £233,202. 10s. 9d. on account of depreciation of securities), and to the pension fund £138,888. 17s. 9d., and £22,222. 4s. 9d. respectively. It is also proposed to transfer £27,777. 15s. 7d. to renewal fund for cable steamers and to set aside £83,333. 6s. 9d. for extraordinary income taxes.

INDO-EUROPEAN TELEGRAPH CO. (LTD.)—The directors have declared an interim dividend in respect of the year ending Dec. 31, 1915, at the rate of £2. 12s. 6d. per share, tax free.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. LTD.—The directors have declared a dividend on the preference shares at the rate of 4 per cent. per annum for the six months ended March 31.

LA PLATA ELECTRIC TRAMWAYS CO. (LTD.)—The accounts for 1915, after including £6,614 brought forward and providing for debenture stock and other interest, show a balance of £12,142, which the directors recommend to be carried forward.

LYMINGTON ELECTRIC LIGHT & POWER CO. (LTD.)—Including £807 from 1914, the profit for 1915 is £2,447, and after paying debenture interest, &c., placing £800 to reserve and paying the dividend on the 5 per cent. preference shares, the balance (£704) has been carried forward.

READING ELECTRIC SUPPLY CO. (LTD.)—The accounts for 1915 show that, after paying debenture interest, &c., and setting aside £3,500 for depreciation, a credit balance of £1,262 brought in was reduced to £453.

SUBMARINE CABLES' TRUST.—Notice is given that in accordance with the terms of the trust deed, tenders are invited from the certificate-holders of certificates to be redeemed out of surplus income, accrued to

15th inst., at a price not to exceed £120 per certificate. Certificate-holders desirous of surrendering their certificates on these terms, should communicate at once with the secretary (Sidney Collett), Electra House, Finsbury-pavement, London, E.C.

TELEPHONE CO. OF EGYPT (LTD.)—A dividend of 6 per cent. (tax free) has been declared on the preferred and deferred shares, making 10 per cent. for the year; £7,965 has been voted for directors' additional remuneration, and £193,469 forward.

VICKERS (LTD.)—A circular has been issued to the shareholders stating that it has been impossible to complete the accounts for submission at the usual time to the ordinary general meeting, which the articles of association provide should be held not later than in the month of April. The directors are, therefore, compelled to postpone the meeting to a later date, when the accounts will be submitted. Recognising, however, the inconvenience which would be caused if payment of the final dividend for the year were also postponed, the directors feel justified in declaring a further dividend of 1s. 6d. per share (equal to 7½ per cent., tax free) on the ordinary share capital in anticipation of the dividend payable for 1915. This, with the interim dividend already paid, will make a total distribution of 2s. 6d. per share, equal to 12½ per cent. for the year.

WINNIPEG ELECTRIC RAILWAY CO.—The net earnings for 1915 were $1,331,737, compared with $1,685,093 for 1914. After providing for fixed charges and dividends amounting to 9½ per cent., the net result was a deficiency of $388,898, reducing balance brought forward to $782,598.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date, April 18, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17d.
Solid Drawn Copper Tubes	18½d.
Brazed Copper Tubes	18½d.
Brazed Brass Tubes	19d.
Brass Wire	16½d.
Copper Wire	18d.
Rolled Brass	16½d.
Brass Sheets	16½d.

	per ton.
Copper Sheets	£150 0 0
Spelter	£97 0 0
English Lead	£35 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£100 0 0
Clean Brass Scrap	£66 0 0
Braziery Copper Scrap	£92 0 0
Old Lead	£27 10 0
Old Zinc	£60 0 0
Hollow Pewter	£120 0 0
Black Pewter	£85 0 0
Gun Metal	£82 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date April 17, the following approximate prices of Scrap Metals:—

	per ton.		per ton.
Aluminium Cuttings	£100 0 0	Old Lead	£30 0 0
Clean Mixed Brass	£72 0 0	Tea Lead	£28 0 0
Clean Cooper	£108 0 0	Old Zinc	£76 0 0
Braziery Copper	£98 0 0	Hollow Pewter	£135 0 0
Gun Metal	£86 0 0	Shaped Black Pewter	£95 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £115; Blowpipe Solder, £120.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Monday, April 17. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Mon., April 17.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	†Do. 4½% Cum. Pref.	10	4 10 0	Feb, Aug
10	6%	†Do. 6% Cum. 2nd Pref.	9½	6 3 1	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅛	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	5 0 0	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	80	5 0 0	Jan, July
5	2/3	Do. 4½% Pref.	3½	7 0 4	..
5	5%	Do. Ord.	3	7 15 4	Aug, Feb
5	4½%	Do. City Pref.	2½	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	4½	4 6 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	11½†	6 16 2	Feb, Aug
10	6/0	Do. 6% Pref.	10	6 0 0	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10⅛†	6 15 9	Mar, Sept
10	6%	Do. 6% Pref.	10½	5 17 1	Feb, Aug
St.	4½%	Do. 1st Deb.	86½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	97	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	75	6 0 0	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6/	London Elec. Supp. 6% Pref.	4½	7 1 2	..
St.	4%	Do. 4% Mort. Debs.	80	5 0 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2 1/16†	6 3 1	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-'on-Tyne E.S. 5%2d Mt. Db. St.	91½	5 9 3	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	3⅛	6 10 7	Mar, Sept
		Electricity Supply—*cont.*			
5	8%	St. James' & Pall Mall Ord.	5 11/16	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5 11/16	6 0 3	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	83	5 8 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅛	7 10 7	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅛	6 1 9	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4 13/16	5 11 7	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	78½	6 4 4	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	71	8 9 0	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	66	6 1 3	..
St.	4%	Do. do. Assented Def. Ord.	64½	6 4 0	..
St.	4½%	Do. 4½% Pref.	99½	4 10 3	Jan, July
St.	4%	Do. 4% Deb. St.	93¼	4 5 9	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	62½	8 0 0	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅛	6 1 3	Jan, July
St.	4%	Do. 4% Pref.	64	6 5 0	Mar, Sept.
St.	4%	Do. 4% Debs.	65	4 14 4	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	26¾	3 16 11	Feb, Aug
St.	3½%	Do. 3½% Pref.	77½	4 10 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	74½	4 13 9	Feb, Aug
St.	3½%	Do. 3½% A Debs.	82½	4 4 6	Jan, July
St.	3½%	Do. 3½% Debs.	83½	4 4 1	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	92	4 7 0	May, Nov
St.	4½%	Do. 4½% First Pref.	70¾	6 7 4	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 4	Jan, July
St.	4%	Do. 4% Debs.	71½	5 12 1	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	70½	5 13 6	Jan, July
St.	4%	Do. 4% Guar. Stock	68	5 17 7	Mar, Sept
		Electric Manufacturing, &c.			
1	14%	Babcock & Wilcox Ord.	2 11/16	4 15 4	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	5%	Brit. Aluminium Ord.	1⅜†	4 11 5	Mar
100	5%	Do. Prior Lien Debs.	89	5 12 4	Jan, July
1	6%	Do. 6% Pref.	⅞	6 12 5	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10⅞	7 3 9	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	⅝	6 17 2	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛†	7 5 5	April
100	6%	Do. 6% Prior Lien Debs.	100	6 0 0	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65¾	6 1 8	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	11⅛	6 9 0	Jan, July
5	2/6	Do. 5% Pref	4⅛	6 10 9	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅝	7 13 8	Sept
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	1⅛	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	11/16	7 7 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs	72	5 11 1	Jan, July
10	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9⅝	6 10 4	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14½†	6 17 1	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4½	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	9⅛	10 1 3	Feb, Aug
10	5%	Do. Pref.	7½	6 15 7	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	35	6 18 0	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1⅝	4 4 3	May, Aug
1	6d.	Do. 5% Pref.	⅞	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	80	5 0 0	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jun, Dec
St.	4%	Willans & Robinson B. Cum. Pref.	41½	9 12 9	..
St.	4%	Do. 1st Mt. Deb. St.	50½	7 18 5	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	98½	6 1 10	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	21⅛	7 2 0	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69	5 15 11	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7⅛	6 1 8	May, Nov
10	10%	Do. 10% Pref.	13⅝	7 5 1	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	5½	6 18 8	Ja,Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	141	4 19 3	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	63½	5 10 8	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	79	5 1 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77½	5 2 10	Feb, Aug
10	7%	Do. Ord.	14⅛	5 5 8	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co.	35½	6 3 11	Ja, My, Jly
25	13%	Indo-European	49½	6 10 4	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2⅞	4 10 2	April
1	7%	Do. 7% Pref.	1⅞	3 14 8	July
10	1%	West India & Panama Ord.	1⅛	8 18 10	May, Nov
10	6%	Do. 1st Pref.	7⅞	7 12 11	May, Nov
10	7%	Western Telegh. Co.	14½	5 0 0	Mr,Jly,O,Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½†	4 10 3	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅞	6 12 5	Nov.
1	10%	*Oriental Telephone Ord.	1⅞	5 8 6	Apl, Oct
St.	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6	6 13 4	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅞	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	84½	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	10⅜	5 11 0	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10⅛†	5 19 4	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	82½	6 1 9	Ja,Apl,Jly,O
..	4%	Do. $100 Pref	70	5 14 3	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	124	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅜	6 10 8	Mar, Sept
St.	5%	Do. 5% Debs.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10½	5 18 6	..
St.	4½%	Do. 4½% Debs.	87½	5 2 10	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6⅛	7 5 5	May, Nov
5	5%	Do. 5% Pref	4½	5 14 3	Mar, Sept

† Ex dividend or interest

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

* And 13⅓% bonus. † Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,980. [Vol. LXXVII. No. 4.] **FRIDAY, APRIL 28, 1916.** PRICE SIXPENCE (by post, 7d.)
Abroad 9d., or 20 cents. or 1/-., or 90st.

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 103
Arrangements for the Week. 105
A Mode of Studying Damped Oscillations by the Aid of Shrinking Vectors. By Prof. David Robertson, D.Sc. Illustrated..... 106
Tests on a Polyphase Continuous-Current Converter of 3,000 kw. Capacity. By C. F. Holmboe. Illustrated 108
"Speeding Up" in an Engineering Factory. By R. Rankin, B.Sc.—*Concluded*.. 110
Transformer Design. By F. M. Denton, A.C.G.I.—*Continued* 113
Service Branches from Extra High-Tension Circuits. By D. M. MacLeod..... 116
Sir J. J. Thomson on Radiation from Atoms and Electrons. Illus.—*Concluded* .. 118
AN EXTRAORDINARY BILL 120
REVIEWS..... 121
Experimental Wireless Stations: Their Theory, Design, Construction and Operation [Edelman].
Elements of Heat-Power Engineering [Hirshfeld and Barnard].
REVIEWS—*Continued.*
Machine Design [Smith and Marx].
An Unusual Foundation for a Turbo-Alternator. By G. L. Knight. Illustrated..... 122
On a General Bridge Method for Comparing the Mutual-Inductance Between Two Coils with the Self-Inductance of One of Them. By Charles H. Lees, D.Sc., F.R.S. Illustrated..... 123
Depolarisation in Leclanché Cells. By M. De Kay Thompson and Ernest C. Crocker..... 124
The Variation of the Resistance of Iron Wires with the Temperature on Alternate Current Circuits. By Prof. W. Peukert. Illustrated.. 125
Modern Practice in the Construction and Maintenance of Rail Joints and Bonds in Electric Railways. By E. R. Shepard..... 126
LEGAL INTELLIGENCE 127
PARLIAMENTARY INTELLIGENCE 128
The "Electrician" Commercial and Industrial Section .. 129-136

NOTES.

The Wage and the Output.

NOT merely at the present time, but also in the future when Peace once more returns to us, is the efficient working of our factories of supreme importance. The employer is often faced with the trouble of rising wages, so that the margin of profit becomes less and less. Generally, however, it may be taken as a principle that high wages are comparatively unimportant provided the output can be sufficiently large for given fixed charges. It is the cost of the unit product that is all important, and if the fixed charges or the labour form a large proportion of this, the only remedy for high cost is an increase in output. For any given worker the wage should vary both with the quality and with the quantity of the product produced by the individual. It is far from easy, however, to introduce a system giving effect to this principle, even if Trade Unions were not unfavourable. A flat-rate of payment is liable not to give the desired incentive. Piece-work, however, lends itself to better treatment in this respect, though it is by no means free from difficulties. Straight piece-work brings to the worker a larger wage automatically if he works more quickly, but, on the other hand, he is always troubled by the idea that if he works fast, and consequently obtains a wage above a certain amount, the rate will be cut down by the employer. Moreover, the employer will not necessarily be able to pay the same rate to-morrow that he pays to-day, owing to competition, and in the long run he may have to resort to automatic machinery to produce the desired result. For a satisfactory business system it is necessary to secure, not merely increased pay by increased output, but also an increased rate of pay.

MANY of these points are considered in a Paper by Mr. R. RANKIN, of which we conclude an abstract in our present issue. The method that has been evolved by Mr. RANKIN assumes a certain normal rate of working at a rate of pay above the average, and the worker obtains some advance on this rate if the time taken by him does not exceed the normal by more than one-third. If less time is taken, then the rate of pay increases. One important feature is that the worker who does his work in less time than the one hour that is assumed, nevertheless gets payment for one hour and, further, a certain percentage; thus, the rate of pay increases considerably with more rapid working. One of the most interesting parts of the Paper is that giving some account of the troubles which arose in introducing the system. Strikes were the natural outcome. The results obtained, however, have thoroughly justified the change that has been made. For example, the number of pieces done per hour increased in some cases more than three times and in one case nine times, and the reduction in labour-cost per piece varied from 15 per cent. up to 66 per cent. These results were not due merely to higher speed of working on the part of the skilled worker, but were partly due to re-arrangements, so that skilled workmen were assisted systematically by unskilled labour and, therefore, did not find it necessary to spend their time on unskilled work. It is interesting to note that once the men appreciated the benefits trouble came to an end, and, finally, thoroughly amicable working was secured. It would be well if employers would read Mr. RANKIN'S Paper carefully with a view to the future. There is only one criticism we would make on the Paper, and that is with regard to the title. It is called "Speeding-up." But it is generally recognised that "a rose by any other name would smell as sweet," and we would suggest that some other term would be received better by the workers themselves, and would not give the idea that they are to do work much more rapidly for the benefit of the employer, irrespective of any benefit to themselves. There is no doubt that this subject will become increasingly important in the future if we are to maintain our industrial position.

Motor Omnibuses and the Upkeep of Roads.

FOR long enough it has been a sore point with those who are responsible for the running of electric tramways that motor omnibuses should have the right of running on streets without bearing some proportion of the cost of upkeep, which is necessarily rendered more heavy by this form of traffic. It does indeed seem like adding insult to injury that these vehicles should have the privilege of running on paving for the upkeep of which the tramway undertakings are responsible. It now appears that a new clause has been inserted by the House of Lords in the Local Government Emergency Provisions Bill.

prohibiting the use of any new route by omnibuses, except with the consent of the local authority or the Local Government Board. This, of course, will enable the local authority to obtain contributions to the upkeep as the price of their consent. As a general principle, we do not think that it is wise that any branch of industry should be placed at the mercy of a competitor and, therefore, we feel that it would be much more satisfactory if some regulations could be adopted by means of which this class of traffic contributed a suitable amount to the upkeep of the roads, or alternatively that the tramways were relieved from such contributions.

Unusual Foundations.

American power-station engineers are now tackling problems with which, sooner or later, many engineers in this country will be faced. In substituting turbines for steam engines and in building new stations, up to a few years ago at any rate, it was customary to provide foundations for turbo-generators of the same size as those which were being installed at that time. The rapid development of the steam turbine, resulting in greater economy and decreased cost per kilowatt, has led to the introduction of units of much greater outputs than those originally contemplated, and the problem has been so to modify existing and unused foundations as to make them suitable for carrying the larger units. Elsewhere in this issue will be found a detailed account of altering an unused foundation, originally planned for a 12,000 kw. vertical unit, so as to carry a 22,000 kw. unit, which it was found could be installed in the space required for the smaller unit. Limitations necessitated the use of a structural steel foundation, consisting of cantilever girders bearing upon cross girders, which are supported by concrete-filled steel piles. The engineers responsible for the work are to be complimented upon the design and its workmanlike execution.

Applied Science (?).—In a recent issue of "Elettroteenica," Carlo Velardi advocates the use of hydrogen gas, obtained by electrolysis, for lighting and heating in substitution for, or mixed with, coal gas. The difficulties attending its use, the chief of which is its distribution, are easily surmounted, while the advantages from its employment, especially in a country like Italy, are great. Its utilisation for heating and cooking purposes, he contends, is easier of realisation than the replacement of coal gas by electricity.

Government Committee on Trade after the War.—The President of the Board of Trade has appointed two further Committees to consider the position of British Trade after the War, with Special Reference to International Competition. The following are the names of those selected to represent the Electrical Trades: Hon. Sir Charles A. Parsons, K.C.B., F.R.S. (chairman), Mr. J. Annan Bryce, M.P., Mr. T. O. Callender, Mr. James Devonshire, Mr. B. M. Drake, Sir John Snell. All communications should be addressed to the Secretary, Electrical Trades Committee, at 7, Whitehall-gardens, S.W.

"Beama" Journal. The current issue just to hand contains a number of articles likely to be of interest to those who are taking thought for the morrow. Prof. A. W. Kirkaldy contributes an article entitled "A Policy for the Future of British Industry," and Mr. F. Broadbent writes on "The Board of Trade and British Trade After the War." Of the other articles may be mentioned: "Swiss Industrial and Commercial Organisations," "Confused Issues and Popular Fallacies," and "The Neglect of Business by Science," by Mr. T. C. Elder. Technical articles on "Electricity in Italy," and "Rotary Converters," are contributed by Lieut. F. E. M. Thrupp and Mr. F. R. Whitaker.

Magnetic Testing. During the week we have received from the Bureau of Standards a copy of Circular No. 17 on "Magnetic Testing," the third edition of which is just being issued by the Bureau. Since the operation of motors, magnetos, transformers and generators depends upon the magnetic properties of iron and steel, the magnetic testing of these materials is of the greatest importance to the electrical industry. The design and efficiency of such apparatus depends upon a thorough knowledge of the magnitude of those magnetic properties which can only be ascertained by careful tests. The scope of the work of the Bureau in magnetic testing is set out at some length and the methods of measurement employed are described in considerable detail. Typical data and curves are given for representative materials in common use and, in addition, the more important empirical formulæ which express the relations between the various magnetic quantities are analysed. A list of references to 11 Papers on magnetic subjects published by the Bureau is given in conclusion. This publication should be invaluable in the test-room and laboratory, and the matter compressed into 50 pages is well found. Our readers would do well to make themselves familiar with the great work that is being done by the Bureau, and to students of engineering the publications issued from time to time by the Bureau, and sold by them at a price which covers merely the cost of paper and printing, are invaluable.

Magnetic Amplifier for Radiotelephony.—Messrs. E. F. W. Alexanderson and S. P. Nixdorff recently read an informative Paper on this subject before the Institute of Radio Engineers of New York. The authors describe a magnetic amplifying device for permitting the control of radio-frequency currents by varying the saturation of the iron-core of an inductance included in the radio-frequency circuit. The arrangement of windings of the amplifier is such that the controlling winding has no radio-frequency E.M.F. induced in it, nor does it induce currents in the radio-frequency coils. Various arrangements of this amplifier in connection with a solid steel rotor, radio-frequency alternator are shown, notably those in series with the alternator and those in parallel. "Short-circuiting" condensers are connected to each of the radio-frequency coils. A shunt condenser across both coils and their "short-circuiting" condensers increases the sensitiveness for reasons which are given. Another condenser inserted in series with the entire amplifier is employed to obtain linear proportionality of amplification and increased sensitiveness. The ratio of amplification is found to be proportional to the ratio of the frequency of the radio current to that of the controlling current. The control of the output of a 75 kw. alternator of radio-frequency for telephonic purposes is then shown by oscillograms to be accurate, and the numerical characteristics of alternator and amplifier separately, and in combination, are given.

Lubrication in Practice.—An instructive Paper on this subject was read by Mr. H. W. Petty before the Association of Engineers in Charge at their last meeting.

It is pointed out that in a modern factory the friction losses do not exceed 20 per cent., and may be as low as 13·5 per cent. A saving in friction losses by the use of suitable lubricants may reduce a coal bill by 5 per cent., and in addition the wear and tear on the bearings is greatly reduced. He classifies the lubricants as solid such as graphite, or sulphur, semi-solid, as grease or tallow, and liquid oils. Solid lubricants do not offer great advantages, as they merely transfer the friction surface to the material which coats the bearing surface. Regarding semi-solids, tallow is preferable to suet or grease. Greater efficiency can sometimes be obtained, however, by using grease instead of oil. So far as oils are concerned, they may be either animal, vegetable or mineral. The use of ball and roller bearings reduces friction, and so acts like a lubricant. Many lubricators are faulty, running too fast when full and *vice versa*, but ring lubricators have the great advantages of constant supply of oil, automatic feed, and little or no waste. Grease put in an oblong slot in a plummer block may only require attention once in six months. In the case of cylinder lubrication for gas or oil engines the oil used should have a flash point not below 420 F., and not too great viscosity; also in the larger sizes of engines it is preferable to use a high grade oil for the cylinders and a heavy viscous oil for the bearings. Filtered oil from the cylinders should be used for general lubrication purposes only, and never for the cylinders. The lubrication of Diesel engines and turbines is next dealt with, and steam cylinder lubrication is stated to be controlled to some extent by the method of introducing the lubricant. Mechanical lubrication in this case is preferable to sight feed, and some form of atomiser should be used to prevent the oil going in *en masse*. For low-pressure cylinders the flash-point should be 550 F., high-pressure superheat 595 F., and have Redwood viscosity at 250 F. of 65 in. and 80 in. respectively. The oils should be hydro-carbon, and fluid at 60 F., and entirely free from acid or alkali. Tests of mixtures of graphite with oil

did not appear to reduce the oil consumption. Using superheated steam there was more carbonising with the oil plus graphite than with oil only. Various curves are given in the Paper, and it is shown that the friction with different oils does not vary with their viscosity. Tests were also made to see to what extent the various oils mixed with steam. Altogether the Paper contains a considerable amount of valuable practical information.

OBITUARY.

Arthur C. Saw.—Flight Sub-Lieutenant Arthur Connorton Saw, R.N., who was killed on Good Friday in a seaplane accident, was a son of Mr. and Mrs. Saw, of Blackheath. Before the war he was a navigating officer (first officer) in the Eastern Telegraph Company's service and held a master's certificate. After the outbreak of war he obtained a commission in the R.N.R. and was present at the bombardment and taking of Duala. At the beginning of 1915 he joined the Royal Naval Air Service and became an experienced pilot.

PERSONAL.

An agreement has been concluded with Mr. Clifford C. Paterson, M.I.E.E., A.M.I.C.E., principal assistant in charge of electrotechnical and photometric buildings at the National Physical Laboratory, to join the Osram-Robertson Lamp Works (Ltd.), as director of laboratories for research and technical manufacturing purposes. The arrangement will date from the conclusion of the war or before then, if possible.

Mr. C. A. Unbehaun, electrical engineer, G.P.O., Adelaide, retired recently after 39 years' service.

Royal Engineers (T.F.)—Major (temporary Lieut.-Col.) Chas. R. Toomer has been gazetted Lieut.-Colonel.

APPOINTMENTS VACANT AND FILLED.

A firm of electrical engineers advertises for two engineers, with good commercial training, to manage branch offices in South Africa and Australia.

Belfast Corporation invite applications for the appointment of general manager of their tramways Salary £800, rising to £1,000. Applications to the Town Clerk (on forms supplied) by May 13.

A working foreman engineer to take charge of pumping plant, electrical appliances, &c., is required (for the period of the war) at the L.C.C. Cane Hill Asylum. Salary £150, with house. Applications to the Clerk of the Asylums Committee, 2, Savoy-hill, W.C.

Mr. R. Lawson has been appointed electrical engineer of the telephone branch of the Commonwealth Postmaster-General's Department, at Adelaide.

In consequence of a protest by the Professional Officers Association of the Commonwealth Postmaster-General's Department against the appointment of imported officers over the heads of Australians, a competitive examination was held with the result that Mr. R. Lawson, formerly assistant engineer on the staff of the chief electrical engineer, and who was one of the imported officers, was appointed. The salary is £528 per annum.

INSTITUTIONS AND SOCIETIES.

Institution of Civil Engineers.—The Council of the Institution have made the following awards for Papers read and discussed during the Session 1915-1916: A Telford Gold Medal to Sir John Benton, K.C.I.E. (Eastbourne); A Watt Gold Medal to Sir George Buchanan, C.I.E. (Rangoon); a George Stephenson Gold Medal to Mr. F. W. Carter, M.A. (Rugby); and Telford Premiums to Mr. C. Carkeet James (London), Mr. D. E. Lloyd-Davies (Cape Town), and Mr. W. T. Lucy (Oxford). The awards for Papers published in the "Proceedings" without discussion will be announced later.

Diesel Engine Users' Association.—At the April meeting of this association, the accident to an air compressor attached to a Diesel engine at the Smithfield Markets' Electric Supply Co. (Ltd.) was further discussed. (An abstract of the previous proceedings was given in our issue of the 7th inst., p. 9.)

Mr. P. H. Smith, of Messrs. Banks, Warner & Co. (Ltd.), who had reported on the breakdown to Lloyd's underwriters with whom the engine was insured, was present at the meeting, and he gave some further information on certain points which arose in connection with his report. Mr. W. Fennell suggested that it might be advantageous to fit some suitable form of coil instead of the usual purge-pot. Mr. R. Lyle referred to an accident of a similar nature which had occurred on an air compressor attached to a 300 B.H.P. Diesel engine at the works of Messrs. Hoffman Mfg. Co. (Ltd.), in 1913. On this occasion, fortunately, no personal injuries resulted from the accident. The engine had been at work continuously for 24 hours before the accident occurred, whereas in the Smithfield case, the accident occurred on starting up the engine. It was found that the high-pressure suction and delivery valves of the compressor were somewhat worn and fouled with the carbon deposit. An exhaustive inquiry was held, but no very definite conclusion was arrived at. Two theories were advanced to account for it. In the first place it was suggested that the bursting of the purge-pot was caused either by the high pressure getting back from the blast vessel or being built up, or, secondly, by high pressure due to combustion or explosion of oil vapour. Mr. Lyle did not think that the first theory was tenable as the calculated bursting pressure of the purge-pot was over 2,000 lb. per square inch, and the pressure in the blast vessel did not exceed 870 lb. at the time of the accident: the necessary pressure could not either be built up, as a test by the makers, which consisted in blanking off the delivery pipe, and running the compressor up to full speed, proved that the relief valves dealt efficiently with the air. He considered the trouble was undoubtedly caused by explosion, and that this was brought about by high compound pressure and temperature in the intermediate pressure cylinder, which might have been caused by the high-pressure valves sticking up, as was suggested in the case of the Smithfield accident. There was, however, another probable cause of the accident which his experience suggested. He had been able to satisfy himself that one cause of a rise in temperature in the indicated pressure purge-pot is from a choking of the indicated pressure cooling coil, due to a carbon deposit taking place at the sharp gunmetal bend which couples the indicated pressure delivery pipe to the cylinder. This might lead to the generation of an ignition pressure and temperature at this particular spot, and this pressure *would not be recorded by a gauge on the ignition pressure purge-pot.* Some measurements of the temperatures and pressures before and after cleaning the ignition pressure coil on the air compressor of one of the Diesel engines at Messrs. Hoffman's works, were then given. The precautionary measures taken as a result of the accident were as follows: A check valve was fitted on the high-pressure delivery pipe as close as possible to the air compressor casing; pressures gauges were fitted to the ignition pressure and low pressure stages, so as to give timely warning when the valves needed attention: instructions were given for the valves to be cleaned at more frequent intervals, and it was recommended that this should be done every six weeks.

Referring to Mr. P. H. Smith's recommendations in connection with the Smithfield accident, Mr. R. Lyle stated that his experience led him to suggest that the provision of anti-vibrators in connection with the gauges was better than throttle valves, as being more reliable in damping the oscillations and in providing freedom from choking. He considered that large relief valves provided no proper safeguard against explosions, though he quite agreed that valve wings choked the area. He thought that a non-return valve should certainly be fitted between the high-pressure delivery and the blast bottle. With regard to Mr. P. H. Smith's statement that the low-pressure purge-pot is always the better when the machine is in good order, Mr. Lyle contended that this would depend on the type of the compressor, and that when fitted with the low-pressure condenser type of cooler the reverse would be the case.

ARRANGEMENTS FOR THE WEEK.

MONDAY, May 1st.

Society of Arts.

4.30 p.m. At St. John-street, Adelphi, W.C. Fothergill Lecture on "Vibrations, Waves and Resonance" (Lecture I.), by Dr. J. Erskine Murray.

Society of Engineers.

5 p.m. At Caxton Hall, Westminster. A Conference on "Engineering and Scientific Research" will be opened by Prof. J. A. Fleming, M.A., D.Sc., F.R.S.

THURSDAY, May 4th.

Iron and Steel Institute.

10.30 a.m. At Great George-street, Westminster. Annual Meeting. A number of Papers will be read.

FRIDAY, May 5th.

Iron and Steel Institute.

10 a.m. At Great George-street, Westminster. Continuation of Annual Meeting. A number of Papers will be read.

ENGINEERING INSTITUTIONS' VOLUNTEER TRAINING CORPS

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

The following orders have been issued for the week commencing May 1, 1916:—

Drills, 6.25 to 7.25; 7.25 to 8.25 p.m.

Monday, May 1st.—Sections 1 and 2, Technical: Sections 3 and 4, squad and platoon, Signalling Class.

Tuesday, May 2nd.—6 to 7 p.m., School of Arms: 7.15 to 8.15 p.m., Recruit Drill.

Thursday, May 4th.—Shooting for Sections 1 and 2 and Signalling Class. Recruits, 5.45 to 7.45 p.m.

Friday, May 5th.—Sections 3 and 4, Technical: Sections 1 and 2, squad and platoon.

Sections for Technical parade at Headquarters, London Electrical Engineers, 46, Regency-street, S.W.

Unless otherwise ordered, all parades at Chester House.

A MODE OF STUDYING DAMPED OSCILLATIONS BY THE AID OF SHRINKING VECTORS.*

BY PROF. DAVID ROBERTSON, D.SC.

Summary.—It is shown that the method gives a means of integrating or differentiating shrinking sine functions, which can be applied to damped oscillations.

Shrinking Sine Functions.

When a vibration is damped, its amplitude gradually dies away and finally vanishes. The most important case of this kind, and also the one most easily dealt with, is that in which the rate of shrinkage is proportional to the amplitude. We shall term this type a "shrinking sine function" of the time.

In Fig. 1 let OP represent the amplitude at a particular instant, so that OQ, its projection on a vertical line, gives the instantaneous value of the function at the same instant. OP rotates with the

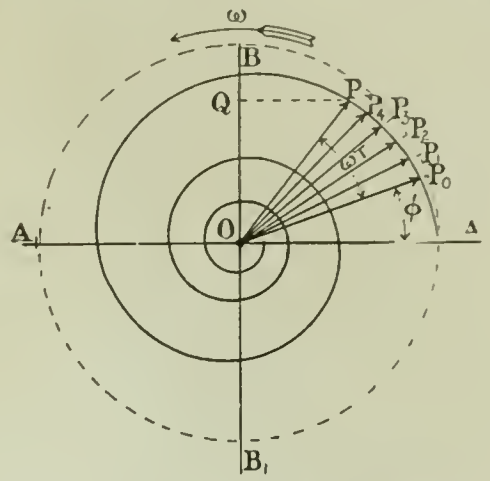


Fig. 1.—Shrinking Rotating Vector.

angular velocity $\omega=2\pi f$, but at the same time it shrinks at the rate $a\times OP$, where a is a constant, also of the nature of an angular velocity, termed the damping velocity or exponential decrement. P thus moves round a spiral instead of a circle as with a sine function; this particular type of spiral is known variously as the exponential, logarithmic, or equi-angular spiral.

Let P_1, P_2, P_3, &c., be a number of successive positions of P, so that the total time from P_0 to P is divided into a large number of equal parts. Let the parts be so very small that the length of OP only changes by an insignificant fraction during each; no appreciable error is then made by assuming that the rate of shrinkage remains constant during each interval and then drops suddenly to the value applicable to the next interval which corresponds to the reduced amplitude. If the total time be T and the number of parts n, each interval is T/n and the change during each interval is $a\times T/n$ times

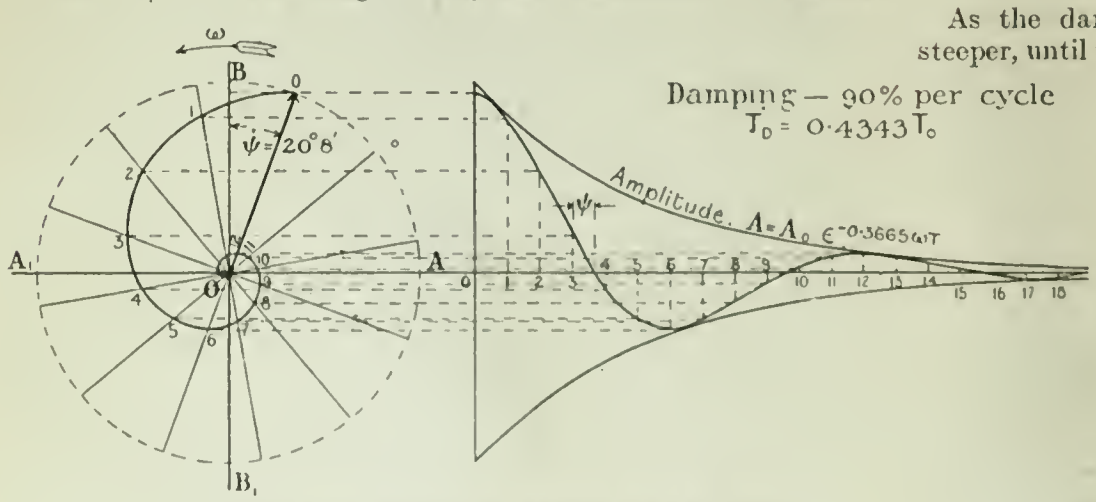


Fig. 2.—Oscillation Damped 90 per Cent.

the mean amplitude during the interval, which is practically the same as that at its commencement. We thus have

$$OP_1=OP_0(1-aT/n),$$
$$OP_2=OP_1(1-aT/n)=OP_0(1-aT/n)^2,$$
$$OP_3=OP_2(1-aT/n)=OP_0(1-aT/n)^3,$$
$$OP=\qquad\qquad\qquad OP_0(1-aT/n)^n.$$

When the number of intervals is made very great, each becomes exceedingly small and $(1-aT/n)^n$ takes the limiting value denoted by ϵ^{-aT}. We thus see that a quantity (in this case the amplitude of the shrinking sine function) which decreases, or increases, at a rate proportional to itself is an exponential function of the time. Conversely, the rate of change of the exponential function ϵ^{aT} is a times, and its time-integral $1/a$ times itself. The amplitude at any time T after it has the value OP_0 is thus

$$OP=OP_0\times\epsilon^{-aT} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Hence the equation to the shrinking sine function is

$$OQ=OP_0\times\epsilon^{-aT}\sin(\omega T+\varphi) \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where φ is a phase angle to take account of the initial conditions.

OP makes a complete revolution in the time $2\pi/\omega$, during which the amplitude is reduced to the fraction $\epsilon^{-2\pi a/\omega}$ of its original value. If we divide the revolution into n equal parts (12 is a good number, but 8 will suffice), the ratio of successive values of OP is $\epsilon^{-2\pi a/(n\omega)}$. The natural logarithm (to the base ϵ) of this fraction is $-2\pi a/(n\omega)$, and its common logarithm (to the base 10) is $-0{\cdot}4343\times 2\pi a/(n\omega)$, from which we can easily calculate it.

Multiplying OP_0 by this fraction we get OP_1, the amplitude at the end of the first interval; multiplying OP_1 by the same fraction we get OP_2; and OP_2 by it we get OP_3; and so on. This process is very easily carried out by the slide-rule, the accuracy of which is amply sufficient for any graphical process. In this way a number of points can be obtained and the spiral drawn through them.

The wave curve may be plotted in a manner exactly similar to that employed for the sine wave. Equidistant radial lines are drawn (12 is an excellent number, and it is convenient to use the same number for this purpose as for drawing the spiral) and their intersections with the spiral are projected on the corresponding ordinates of the wave curve. Fig. 2 shows such a curve with 90 per cent. degrees of damping.

From Fig. 3 it will be seen that the maximum instantaneous value of the function during any half-cycle occurs a little before the vector reaches the vertical position, at the point where the spiral is horizontal. OP then makes a constant angle, ψ, with the vertical, which is characteristic of the spiral, and from which it gets one of its names. We thus have the important result that although successive zero points, or successive maximum points, are separated by half a cycle, as in a sine function, the crests and hollows of the wave do not occur midway between the zero points. Instead, the phase difference between a zero point and the next maximum is $(\pi/2-\psi)$, while that between a maximum and the following zero is $(\pi/2+\psi)$ The diagram also shows that the amplitude at any crest exceeds the crest value in the ratio of $1:\cos\psi$. The point at which the amplitude curves touches the wave curve corresponds to the vertical position of the vector.

If we count time from the instant when the function is at a crest, and denote that crest value by OQ_0, we see from the diagram that

$$OP_0=OQ_0/\cos\psi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and

$$\varphi=90^\circ-\psi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Hence the equation to the shrinking sine function may be written:

$$OQ=\frac{OQ_0}{\cos\psi}\epsilon^{-aT}\sin(\omega T+90^\circ-\psi). \quad . \quad . \quad . \quad . \quad . \quad (5)$$

As the damping is increased, the spiral becomes steeper and steeper, until finally, when a is very great compared with ω the spiral

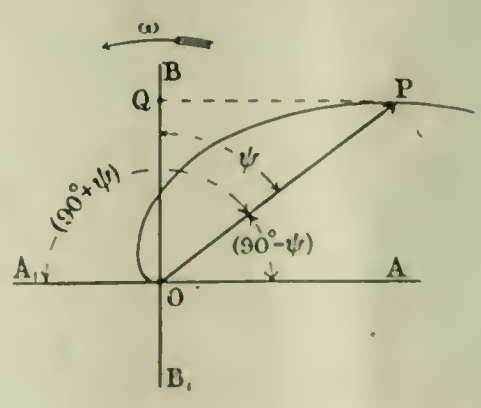


Fig. 3.—Conditions at Crest of Wave.

degenerates into a radial straight line, so that OP shrinks to zero before it has rotated to any appreciable extent. The function has thus ceased to be periodic. This particular amount of damping is known as "critical damping." For it, the equation and construction fail; it is treated by itself in the original Paper.

Rate of Change and Time-integral of a Shrinking Sine Function.

Just as with a sine function, the rate of change of OQ is equal to the component of P's velocity parallel to OQ, and is therefore given by the vertical projection of that velocity. But P now moves along the tangent to the spiral instead of at right angles to the vector (*see*

* Abstract of a communication to the "Journal" of the Institution of Electrical Engineers.

Fig. 4). Its velocity is made up of two components, one $\omega\times OP$ at right angles to OP due to the rotation, and another $a\times OP$ along PO due to the shrinkage. Hence the total velocity of P is

$$\sqrt{[(\omega\times OP)^2+(a\times OP)^2]}=\sqrt{(\omega^2+a^2)}\times OP=\omega_0\times OP \quad . \quad . \quad (6)$$

and it lies ahead of the perpendicular to the vector by the angle ψ, where

$$\tan\psi=a/\omega \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$
$$\sin\psi=a/\sqrt{(\omega^2+a^2)}=a/\omega_0 \quad . \quad . \quad . \quad . \quad . \quad (8)$$
$$\cos\psi=\omega/\sqrt{(\omega^2+a^2)}=\omega/\omega_0 \quad . \quad . \quad . \quad . \quad . \quad (9)$$

We can thus draw OP' at an angle $(90°+\psi)$ ahead of OP to represent the velocity of P. It therefore represents the amplitude of the rate of change of OQ, and its projection on the vertical gives the instantaneous value of that rate of change. Since OP' is proportional to OP, it shrinks at the same proportional rate, and thus P' traces out a similar spiral to P. By a suitable choice of scales, the same spiral can be made to serve for both. We thus see that :—

The rate of change of a shrinking sine function is another shrinking sine function of the same frequency, shrinking at the same proportional rate, of $\sqrt{(\omega^2+a^2)}$ $(=\omega_0)$ or $\omega/\cos\psi$ times the amplitude, and $(90°+\psi)$ ahead in phase, where $\tan\psi=a/\omega$.

Since the function represented by OP' is the rate of change of that given by OP, the latter is the time-integral of the former. Consequently, we have the converse statement :—

The time-integral of a shrinking sine function is another shrinking sine function of the same frequency, shrinking at the same proportional rate, of $1/\sqrt{(\omega^2+a^2)}$ $(=1/\omega_0)$ or $(\cos\psi)/\omega$ times the amplitude, and $(90°+\varphi)$ behind it in phase.

Thus, if the initial conditions correspond to Fig. 3 and equations 3-5 the rate of change of the shrinking sine function may be written :

$$(OQ)'=\frac{OQ_0\times\sqrt{(\omega^2+a^2)}}{\cos\psi}\cdot\epsilon^{-aT}\sin(\omega T+180°) \quad . \quad . \quad . \quad . \quad (10)$$
$$=-OQ_0\times(\omega^2+a^2)/\omega\times\epsilon^{-aT}\sin\omega T \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Differential Equations for a Shrinking Sine Function.

OP (Fig. 5) represents a shrinking sine function, and OP' is its rate of change of $\sqrt{(\omega^2+a^2)}$ times the amplitude and $(90°+\psi)$

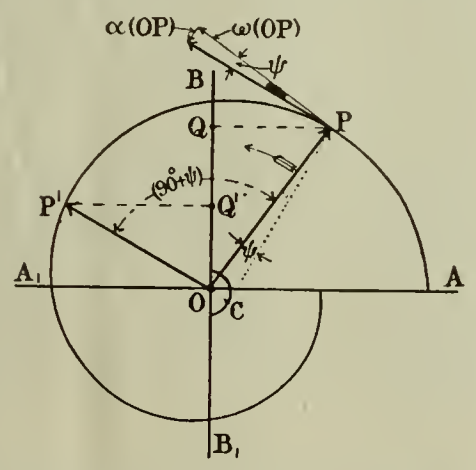


Fig. 4.—Rate of Change of a Shrinking Sine Function.

ahead in phase. OP'' is the rate of change of OP', and is a further $(90°+\psi)$ ahead in phase and has an amplitude $\sqrt{(\omega^2+a^2)}$ times that of OP' or (ω^2+a^2) times that of OP.

OR and OS are two vectors along OP and OP'' respectively, which together balance OP'. Since they make equal angles with OP', they must be equal to one another and the line SR is perpendicular to OP'. The relation between the lengths of these lines follows at once from the diagram. Using also the relations between the amplitudes, we get what is required ; for

$$OR=\frac{OP'}{2\sin\psi}=\frac{OP\times\sqrt{(\omega^2+a^2)}}{2a/\sqrt{(\omega^2+a^2)}}=\frac{(\omega^2+a^2)}{2a}\times OP \quad . \quad . \quad . \quad . \quad (12)$$

$$OS=\frac{OP'}{2\sin\psi}=\frac{OP''/\sqrt{(\omega^2+a^2)}}{2a/\sqrt{(\omega^2+a^2)}}=\frac{1}{2a}\times OP'' \quad . \quad . \quad . \quad . \quad (13)$$

But $O=OR+OP'+OS$ vectorially for the amplitudes . . . (14)

Or $O=\dfrac{(\omega^2+a^2)}{2a}\times OP+OP'+\dfrac{1}{2a}\times OP''$

vectorially for the amplitudes. (15)

That is, $O=(\omega^2+a^2)\times OQ+2a\times OQ'+OQ''$

algebraically for the instantaneous values. (16)

An equation such as this, which includes a function, its rate of change, the rate of change of its rate of change, and so on, or any two of them, is known as a differential equation. This, then, is the characteristic differential equation for a shrinking sine function. Conversely, if the equations derived from first principles for some particular problem are of this type, a shrinking sine function gives one solution of the problem.

When the differential equation is converted into the form (16), in which the coefficient of the last term (second rate of change) is unity, we see that that of the middle term (rate of change) is twice the damping velocity. Consequently the damping is determined by those constants of the vibration which give rise to this term. For fixed values of the constants which determine the coefficient of the first term (the function), (ω^2-a^2) must be constant, and so we may write

$$(\omega^2-a^2)=\omega_0^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

or

$$\omega=\sqrt{(\omega_0^2-a^2)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

where ω_0 is the rotation which the vector would have if the damping were zero. We note also that

$$\cos\psi=\omega/\sqrt{(\omega^2+a^2)}=\omega/\omega_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

We thus see that as the damping is increased—but the other factors characterising the vibration are fixed—the rotation of the vector, and hence also the frequency of the vibration, get less and less until they become zero with critical damping, when $a=\omega_0$. When the damping is still further increased, the quantity under the square-root sign becomes negative and its square root is then imaginary. Thus, the rotation of the vector for an overdamped vibration is an imaginary one. The function is no longer periodic.

Oscillatory Discharge of a Condenser.

When oscillations are started in an oscillatory circuit by suddenly closing it while the condenser is charged, the total E.M.F. is zero, and consequently its three components—resistance, inductance and dielectric E.M.F.s—must balance one another. That is, at every instant

$$O=E_R+E_L+E_D \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$
$$=RI+L\cdot I'+\frac{1}{C}\cdot Q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

Remembering that the charging current is the rate of growth of the charge, and that the rate of change of the current is consequently

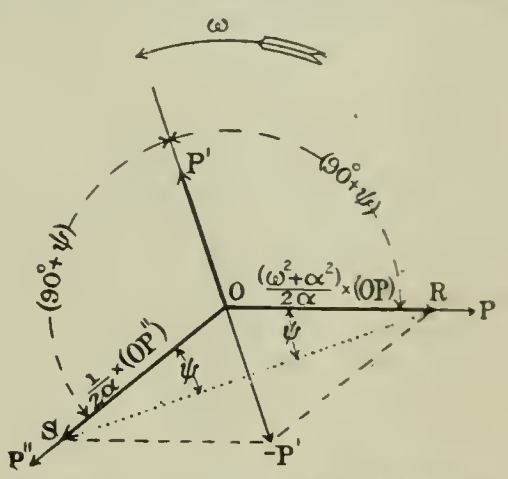


Fig. 5.—Vector Representation of the Differential Equation for a Shrinking Sine Function.

the second rate of change of the charge, we can put the equation into the form :—

$$O=Q+CR\cdot Q'+LC\cdot Q'' \quad . \quad . \quad . \quad . \quad . \quad (22)$$
$$=\frac{1}{LC}Q+\frac{R}{L}\cdot Q'+Q'' \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

We at once recognise this as the typical differential equation for a shrinking sine function. Certain relations between the constants may be noted before proceeding further. Both the ratio L/R and the product CR are periods of time which have a well-known signification with reference to the circuit. If the condenser be replaced by a battery of negligible resistance and the circuit be suddenly closed, the current begins to grow at such a rate that it would reach its final value (E/R) in the time L/R. This is the inductive time-constant

$$T_I=L/R \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

If, on the other hand, the inductance be removed and a constant E.M.F. be suddenly impressed in the circuit, the condenser begins to charge at such a rate that if it continued to do so at the same rate it would be fully charged $(Q=CE)$ in the time CR. This is the condensive time-constant of the circuit.

$$T_C=CR \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

The quantity $\sqrt{(LC)}$ is the geometrical mean of the other two time-constants ; for

$$1/\omega_0=\sqrt{(LC)}=\sqrt{[(L/R)(CR)]}=\sqrt{(T_IT_C)} \quad . \quad . \quad . \quad . \quad (26)$$

It is the time that would be taken for the vector to rotate through

one radian if the resistance had been negligible. By inserting T^1 and T_C in the equations instead of their equivalents in terms of R, L and C, the equations take a somewhat simpler form.

We shall draw the vector diagram (Fig. 6) for the instant at which the circuit is closed and the oscillations started. At that instant the condenser contains its original charge; the current is zero, but is about to flow in the discharging, or negative way. OI must, therefore, be drawn horizontally to the left, and OQ, its time integral, is $(90°+\psi)$ behind it and has $1/\sqrt{(\omega^2+a^2)}$ times its amplitude. OI', its rate of change, is the same amount ahead, and has $\sqrt{(\omega^2+a^2)}$ times its amplitude.

From the geometry of the diagram we can see that the initial amplitude of the charge is

$$\frac{Q_0}{\cos\psi}=\frac{\sqrt{(\omega^2+a^2)}}{\omega}\cdot Q_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

and that of the current is

$$\frac{\sqrt{(\omega^2+a^2)}}{\cos\psi}\cdot Q_0=\frac{(\omega^2+a^2)}{\omega}\cdot Q_0 \quad . \quad . \quad . \quad . \quad . \quad (28)$$

The diagram also gives the initial phases and so we can write

$$Q=\frac{Q_0}{\cos\psi}\epsilon^{-aT}\sin(\omega T+90°-\psi) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

$$=Q_0\times\frac{\sqrt{(\omega^2+a^2)}}{\omega}\cdot\epsilon^{-aT}\sin(\omega T+90°-\psi). \quad . \quad . \quad . \quad (30)$$

And

$$I=Q_0\times\frac{(\omega^2+a^2)}{\omega}\cdot\epsilon^{-aT}\sin(\omega T+180°). \quad . \quad . \quad . \quad . \quad . \quad (31)$$

$$=-Q_0\times\frac{(\omega^2+a^2)}{\omega}\cdot\epsilon^{-aT}\sin\omega T \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

We can easily determine ω, a, and ψ in terms of R, L and C, by equating the corresponding coefficients of the typical differential equation and the one obtained for our problem; but we can almost as readily obtain them directly from the vector diagram.

Draw RI along OI, and balance it by two vectors LI' and $1/C\,.\,Q$ along OI' and OQ respectively. These form two sides of a parallelogram of which $-RI$ is the diagonal. The last two vectors must be equal to one another since they make equal angles with OI, and the line adjoining their extremities is consequently at right angles to OI. Using the geometry of the diagram, and the known relationships

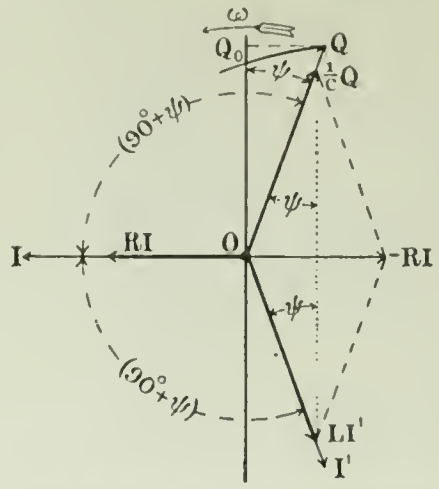


Fig. 6.—Vector Diagram for Oscillatory Discharge of Condenser.

between the amplitudes, I_A, Q_A and I'_A, we can get what we require. The steps in detail are given in the original Paper.

Oscillatory Charge of a Condenser.

When a constant E.M.F., E, is suddenly introduced into an oscillatory circuit we have

$$O=E_R+E_L+E_D+E \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

$$=-RI-L\,.\,I'-\frac{1}{C}Q+\frac{1}{C}Q_0 \quad . \quad . \quad . \quad . \quad . \quad (34)$$

Q_0 being the final charge.

or,

$$O=(Q-Q_0)+CR\,.\,Q'+LC\,.\,Q'' \quad . \quad . \quad . \quad . \quad (35)$$

Since the addition of a constant quantity to a variable does not alter the rate of change of the latter, nor its second rate of change, this equation is of the same type as before, but it is now $(Q-Q_0)$, which is a shrinking sine function of the time, instead of Q.

At the instant the E.M.F. is introduced both the charge and the current are zero, but the latter is about to assume a positive or charging value. We therefore draw (Fig. 7) OI horizontally to the right, and the $(Q-Q_0)$ vector, of $I/\sqrt{(\omega^2+a^2)}$ times the amplitude $(90°+\psi)$ behind it in phase.

The projection on the vertical of this last vector, the length of which is $Q_0/\cos\psi$, gives the instantaneous value of $(Q-Q_0)$. That of Q can be obtained by adding Q_0, or measuring up from the initial point of $(Q-Q_0)$ instead of from O.

We can now write down the following equations:—

$$Q=Q_0+(Q-Q_0)=Q_0+\frac{Q_0}{\cos\psi}\epsilon^{-aT}\sin(\omega T-90°-\psi) \quad . \quad . \quad (36)$$

$$=Q_0\left\{1-\frac{\epsilon^{-aT}}{\cos\psi}\sin(\omega T+90°-\psi)\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (37)$$

$$I=Q_0\times\frac{\sqrt{(\omega^2+a^2)}}{\cos\psi}\times\epsilon^{-aT}\sin\omega T \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (38)$$

$$=Q_0\times\frac{(\omega^2+a^2)}{\omega}\times\epsilon^{-aT}\sin\omega T \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (39)$$

It can be shown by comparing coefficients, or in the same way as before, that the values of a, ω, and ψ for the oscillatory charge are the same as those for the oscillatory discharge. By comparing Figs. 6

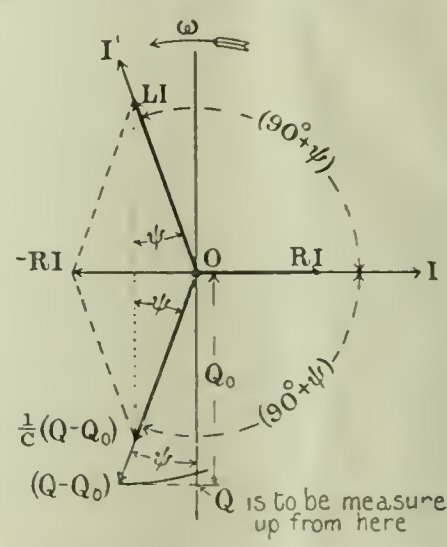


Fig. 7.—Vector Diagram for Oscillatory Charge of a Condenser.

and 7, or equations (29) and (32) with equations (36) and (39), it will be seen that the sum of the charges in the two cases is always Q_0, and that the currents are alike but opposite. Thus the values of Q during the charge can be found by subtracting the corresponding values during the discharge from Q_0, and those of the current by simply changing the sign.*

In addition to a geometrical treatment of the case of critical damping, the original Paper develops a new method of representing an exponential function by a vector spinning about the axis of projection with its extremity tracing a spiral on the cone swept out.

From the properties of such vectors the relationship between the hyperbolic and circular sines and cosines is placed in a new light, and the ordinary equations for "overdamped oscillations," such as the non-oscillatory charge and discharge of a condenser, are deduced without making use of the results of the calculus.

TESTS ON A POLYPHASE CONTINUOUS-CURRENT CONVERTER OF 3,000 KW. CAPACITY.†

BY C. F. HOLMBOE.

The electrolytic preparation of hydrogen is carried on in Fredrikstad in Norway under the author's supervision; this is probably the largest installation of the kind in the world. Hydrogen is prepared in six large batteries, each consisting of 200 elements of the bell type, and is obtained by the electrolytic dissociation of a solution containing 15 per cent. of caustic soda. Current is obtained from three converters. Power is taken from the end of a long transmission line, to which many industrial consumers are connected, and which is, therefore, exposed to considerable fluctuations of voltage. The power factor ought not to fall below 0·8, according to the contract with the transmission authorities: the direct-current voltage has to be varied over wide limits, and while paying due regard to economy it is very necessary to guard against the possibility of breakdown. The ordinary rotary and the cascade rotary did not comply with these conditions, so it was necessary to use some kind

* Reference may be made to a Paper by Prof. A. E. Kennelly on "Vector Diagrams for Oscillating-Current Circuits" ("Proceedings" of the American Academy of Arts and Sciences, Vol. XLVI., p. 373, 1911), which gives many interesting applications of vectors to oscillatory circuits and contains a full bibliography on the subject.

† Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 11, 1915.

of motor and to couple it to a generator. The synchronous motor with its high-power factor is unnecessary in view of the possibility of having power factors down to 0·8 ; it is very sensitive in operation and not capable of taking much overload. We are, therefore, reduced to the asychronous motor. In the sizes under consideration it is quite as efficient as the synchronous motor, and is 18 per cent. cheaper; it has, too, the advantage of being simpler to manage. The first units which were supplied had an output of 1,500 kw., but lately the new machines that have been installed give 3,000 kw. ; these are described in the present article. These latter machines have three bearings, provided with ring lubricators, the middle one being arranged with water cooling.

The polyphase half has an input of 3,500 kw. at a mean voltage of 5,000, the speed is 372 revs. per min., and the frequency 50. The

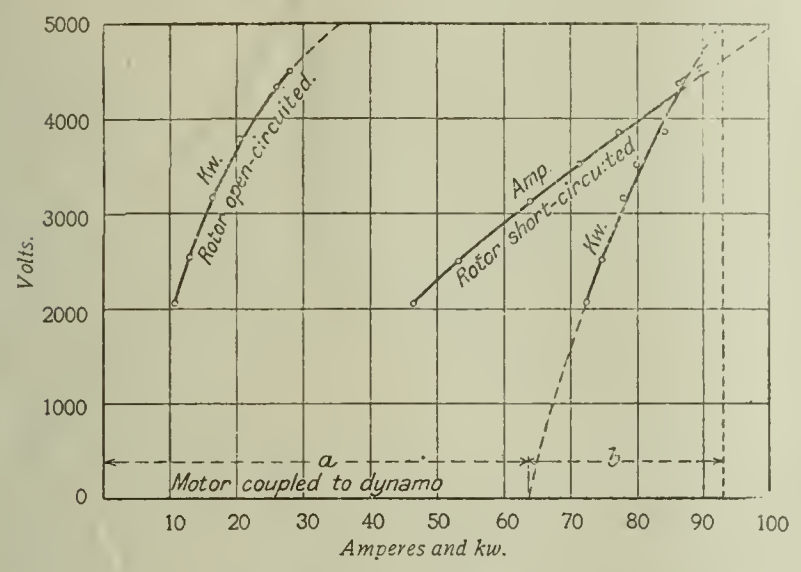


Fig. 1.—Test on No-load.

active stator iron consists of iron sheets, 0·5 mm. thick, separated by paper; these are arranged in 13 groups, with a space of 10 mm. between each. The conductors are of copper strip, insulated with cotton, the whole being enclosed in a covering of compressed mica. The air was entirely removed from the portion of the coils, embedded in the stator, and an asphalt compound was pumped in in order to prevent any glow discharges. The windings are arranged in two layers, the ends being secured by bolts and nuts suitably insulated from the frame. The rotor has a simple rod winding, and the active rotor iron consists of the rim of a flywheel with 10 arms. The ventilating gaps in the rotor are not exactly opposite those in the stator, in order to avoid the whistling noise which is sometimes caused at high speeds. The slip-rings are of bronze, carried on insulated spindles in the usual way. The motor is started through a liquid resistance, which by its gradual variation prevents any kind

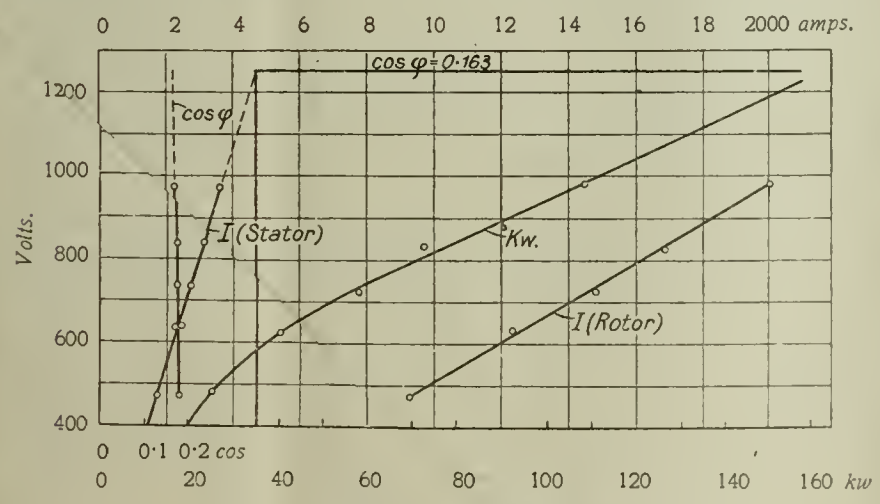


Fig. 2.—Test on Short-circuit.

of electric shock. Arrangements are made for artificial cooling by two fans, which revolve with the rotor. The results of the tests which were carried out with the rotor open and short-circuited are given in Figs. 1 and 2. Fig. 3 gives the Heyland-Ossanna diagram ; this shows that at full load the efficiency is 94 per cent., the slip 1·6 per cent., and the power factor 0·915. On the basis of these results the following calculations are founded. The total output is 3,500 kw., with an efficiency of 95·68 per cent ; losses in friction, windage and fans are 30 kw., *i.e.*, 0·82 per cent. ; losses in the iron 29·5 kw., or 0·81 per cent. ; copper losses 98·3 kw., or 2·69 per cent. The copper losses are estimated on the assumption that there is a mean temperature of 70°C. in the conductors, and the eddy current losses in the conductors are put down at 20 per cent. of the ohmic losses.

The continuous-current generator has an output of 3,000 kw. at 500 volts ; thus the normal current is 6,000 amperes, the current being divided between 14 poles. The winding is carried out on the loop system with equi-potential connections. Compensation windings

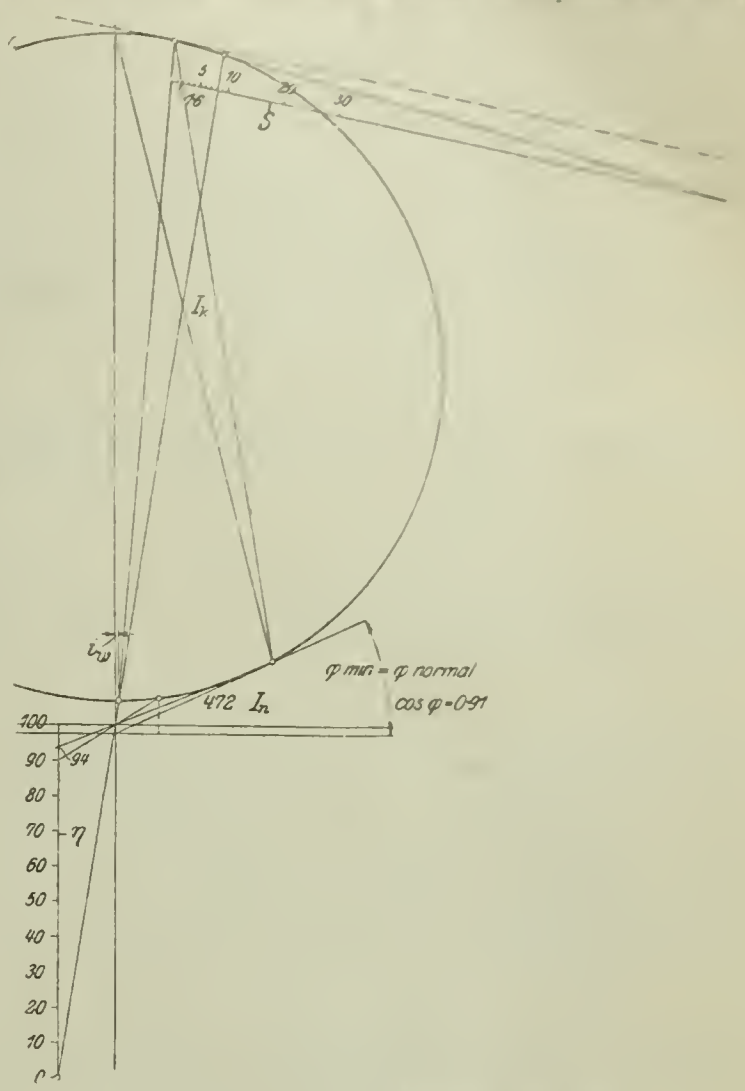


Fig. 3.—Heyland-Ossanna Diagram.

in the pole shoes and commutating poles are provided to ensure sparkless running. The high circumferential speed of 41·4 metres per second gives a reaction voltage of 6·7, while the mean voltage between adjacent segments of the commutator is only 20. The commutator

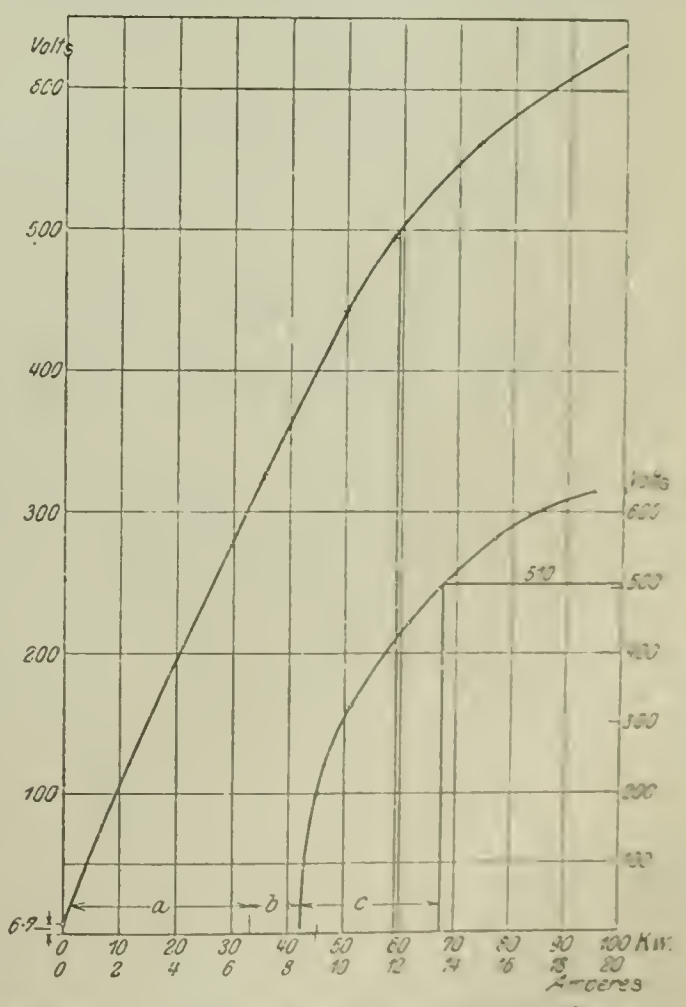


Fig. 4.—No-load Curves for Direct-current Generator.

is arranged in three sections, each of a width of 230 mm. "Morganite" carbon brushes are used and are loaded with a current density of 7·45 amperes per square centimetre, the manufacturers

stating that a density of 9 amperes per square centimetre is permissible. The results of the tests are shown graphically in Fig. 4, from which the following figures are deduced. The total output was 3,000 kw. and the efficiency was 94·97. Windage and friction losses absorbed 33·1 kw., *i.e.*, 1·047 per cent ; brush friction amounted to 0·294 per cent., *i.e.*, 9·3 kw. ; iron losses were 0·794 per cent., or 25·1 kw. ; copper losses in the armature, commutating poles and compensation windings were 75·6 kw., or 2·393 per cent. ; magnetising losses 5·7 kw., or 0·18 per cent. ; losses in the field regulator were 1·57 kw., or 0·049 per cent. Losses due to the resistance between the brushes and the commutator were 8·4 kw., or 0·27 per cent. A mean temperature of 70°C. in the conductors has been assumed for the purposes of these calculations. A drawing showing the general arrangement of the machine is given in the original Paper.

"SPEEDING UP" IN AN ENGINEERING FACTORY *

BY R. RANKIN, B.SC.

(*Concluded from page* 91.)

Summary.—The author discusses the logical basis of bonus systems of payment. The results obtained with the system adopted and the difficulties encountered are described.

In what follows two examples are given without excess of detail to illustrate the methods followed in actually fixing the amount of work to be set as task ; in each case a fairly good workman was selected for timing purposes. In the timing and analysis, considerable judgment had to be exercised in the use of the figures obtained. Refinements in timing and alteration of methods were impossible on account of the urgency of the matter ; but, in view of the good results obtained, this only indicates that, were such refinements introduced, the methods are capable of giving even better results.

Example I.—In this the workman used a template into which he fitted certain parts of the complete piece of work he had to produce, then proceeding to unite them, and so produce the completed article. The parts had previously been prepared to some extent by boys. After each complete operation the template had to be brushed clean.

All subsidiary operations were timed for several complete operations and average times obtained. By addition of the average times it was found that the average time spent on each complete piece of work was 11 minutes 15 seconds, and, by summation of the "unit" times, as the times for the subsidiary operations may be termed, the figures given in Table II. were compiled.

Table II.

Nature of operation.	Sum of "unit" times.		Percentage of total time taken.
	Min.	Sec.	
Cleaning template	0	17	2·5
Assembling parts and removing completed article	0	58	8·6
Fitting parts and undoing completed article.	5	45	51·0
Making completed article : actual skilled work	4	15	38·0

From these figures it appeared that about 60 per cent. of the man's time was occupied in doing work which could be done by unskilled men or boys. A little judicious examination showed that five minutes was sufficient for the skilled work. Exclusive of carrying parts and the completed article, work occupying 2 minutes 45 seconds had to be done on the parts before the skilled operation could be performed. This, together with the time already spent on the parts by boys, practically amounted to five minutes, and the work was accordingly re-arranged so that there were four skilled men in a gang, each man being provided with a boy ; and their work benches were so disposed that a youth was kept going doing the work of removing the completed articles and cleaning the templates for the whole gang, the carrying being cut down to almost nil. Some minor mechanical alterations were made on the templates and tools to give greater ease in handling and to prevent haste causing damage.

The result was that whereas, on the average, prior to the alteration, 2·37 completed pieces were produced per skilled man per hour, an average of between 11 and 12 became the rule. Of course, working on the bonus system the men and boys earned much higher wages than formerly, the minimum increase being 20 per cent. ; but, notwithstanding this, the labour cost per completed piece was reduced by 63 per cent. when 11 pieces were done per skilled man per hour.

Example II.—In this the parts going to make up a complete piece of work were built up in a structure analogous to a template, and which may be called by that name. The parts were what have been termed complete pieces in Example I., a number of them being assembled in the template and united as mentioned, the process of uniting them being carried out in steps as the parts were added in pairs. Practically no unskilled labour was employed on this work, the work being done by highly paid men. The men worked in pairs, one pair to each template.

In order that unit times might be obtained, it was decided that one man only should be timed. A man was accordingly selected, and his mate put on another job. The former thereupon refused to work, but, on being reasoned with, made a start. Several times he stopped and resumed again on being pressed, due note being, of course, made of the duration of the stoppages. In this way the operations on two pairs of parts were timed fully, although under difficulties. It may be said that all through a good deal of obstruction was experienced while this example was being dealt with, and that, after the first set of reading had been obtained on the main part of the complete operation, some estimation of less important parts had to be resorted to in the first instance.

Table III.

Operation.	Time.	
	Minute.	Second.
Placing parts	2	0
Setting up tools and doing work	2	15
Dismantling and trimming off	2	10

Table III., excluding the carrying times, shows the average times taken. These figures showed that, provided all materials, &c., were ready to hand, and that one labourer did the first item in the table and another the third, one skilled man could keep two labourers going. Working in this way would necessitate three templates per skilled man.

It was decided to try this method on the day following the timing. The foreman was notified accordingly, with the result that next day he undertook to do the parts of the work on which it had been proposed to put *two* labourers. He was a skilled man himself, and it was clearly an arranged matter between him and his men, he himself being a trade unionist. To avoid friction this was agreed to ; it was anticipated that some interesting figures would be obtained.

The foreman kept the other man going quite comfortably, and progress was limited by the latter, although, if looked at casually, he seemed to be quite busy. The stop-watch showed, however, that he was taking 4·9 minutes to do what on his earlier timing took 2·25 minutes ; in other words, he was malingering. The foreman took somewhat less time to do the other two parts of the operation, and it was, therefore, proved that the relative durations of the several unit operations as previously ascertained were about correct. A great many hitches and mistakes occurred during the timing of this method, no doubt arranged for beforehand, but the time wasted on each occasion was carefully noted, so that the men deceived no one but themselves.

Little comment was made on the results, but it was decided that only the placing of the parts should be done by a labourer, and that he should keep two skilled men going, as it will be seen he could by reference to the last table. This avoided questions of trade union etiquette ; and, in any case, it was intended later on to put semi-skilled men on the work, in which case the cost of labour would not be affected much by the difference between unskilled and semi-skilled rates of pay. This method was put into force and insisted on at once, and proved very successful. Two templates were required, the skilled men being placed between them.

This method was rendered easy by the fact that the parts were added in pairs, which allowed S_1 and S_2 each to deal with one part at the same time and in the same template. The figures obtained showed that each complete piece could be dealt with, as far as this stage of the compete operation was concerned, in 37 minutes. An allowance of 40 minutes gave a margin, so that the two pieces would take 80 minutes.

After this was done the pieces had to be turned over by means of block and tackle and certain work done on them in that position, after which they were put aside as finished. Some further observations having been made, a time-table was drawn up for the completion of the whole job. What was expected was conveyed to the foreman, with the result that it was not obtained. The calculated time was 2 hours 40 minutes and the actual time 2 hours 57 minutes. The 17 minutes taken to do the work in excess of the calculated time

* Abstract of a Paper read before the Junior Institution of Engineers.

was lost in supposititious hitches, &c., which were observed without remark.

Some alterations were made in the templates which made the work considerably easier, and then the semi-skilled men were started on the work in another department. A little professional jealousy was exhibited, and on the first timing the semi-skilled men did the work in 2 hours 42 minutes, which absolutely vindicated the times built up by observation of unit times. During this period the men never left their work, and, of course, this could not be kept up. There was, however, no difficulty in getting two complete pieces done in three hours.

The skilled men, prior to the alterations, were turning out three pieces in 13 hours, of which 3½ hours was overtime ; this was the rule at the time. The alterations, by making it possible to abolish overtime, employ semi-skilled men and speed up the output, resulted in a decrease in labour cost of 66 per cent. In addition, it should not be overlooked that the overhead charges were also largely reduced.

In the case of work on which the men are engaged individually, each turning out his own quota of completed articles, and not in gangs, or, if in gangs, where the absence of one man does not interfere with the work of the others, as is practically the case in Example I., which has been described, no difficulty is met in calculating wages on the bonus system adopted, even if a man is absent. Replacement of the skilled man is not so easy. In the event of one skilled man losing time, say, in the morning, the following method of wages calculation, adopted in the work described in Example II., prevents injustice or error : Let the task set be n pieces in t hours. Then skilled man hours per piece$=2t/n$. In one hour work to be done by two skilled men$=n/t$, involving two man-hours—*i.e.*, the task is equivalent to $n/2t$ pieces per man-hour.

Hence, in the calculation of wages, the number of tasks completed is found by division of the number of pieces actually completed by n/t. The time per task is found by dividing the number of tasks into the hours worked by the skilled men, if both have been at work all the time. If one man has lost some time, and has not been temporarily replaced, the number of *man-tasks* is obtained by division of the number of completed pieces by $n/2t$. The time per task is then found by division of the man-hours by the man-tasks. Using this quotient, the pay clerk obtains from the rate-curve the rate of pay corresponding to the rate of work, and each skilled man is paid at this rate for the actual number of hours he has worked. The labourer is paid at the corresponding rate shown on the curve corresponding to his base rate, although, of course, there being only one man to keep going, he has an easier time, unless this man makes him assist more than usual to get the work forward.

The two examples given serve to show the methods of dealing with the timing and analysis. It may be mentioned that, in dealing with many kinds of work, the stop-watch clearly indicated that not only were methods faulty, but that the men were doing far less work than they could have done without any alteration in methods. In such cases, as a matter of policy, until the men found by experience that nothing was made of such revelations, a rearrangement of work was always made, if only to a small extent, so as to provide an explanation for the increased output.

The figures given in the following table are further fair samples of the amount of work done in the ordinary way prior to the introduction of the bonus system and that done afterwards. The approximate reduction in labour cost per piece is also given. Similar results were obtained in practically every case in which timing was carried out and the bonus system of payment adopted.

Table IV.

Pieces done per hour.		Reduction in labour cost per piece.
Originally.	Under bonus.	
60	132	19 per cent.
53	168	15 ,,
64	129	27 ,,
45	120	40 ,,
62	108	28 ,,
10	90	59 ,,
13	26	22 ,,
6	14	32 ,,
6	36	66 ,,

The results shown in Table IV. may seem eminently satisfactory, and it may appear from what has been said that the obtaining of them was, after all, a fairly simple matter. However, the difficult part of the work has scarcely been touched upon, as a matter of fact, although just referred to at the beginning of the Paper. It consisted in putting the system into general operation in the face of considerable opposition. No doubt this was misguided opposition, and may be recognised as such now by those concerned, but it was none the less troublesome on that account.

As there are, doubtless, many members of our Institution who have been impressed with the necessity or desirability of taking some such steps as have been described in this Paper, the author ventures, although with some diffidence, to give a short account of his experiences in the more administrative part of the work, in the hope that this may prove useful and suggestive. A rude awakening probably awaits the engineer who thinks that such work as this can be lightly undertaken. It must be recognised, before any steps are taken, that trouble is almost inevitable, and it is essential that, once started, there should be no faltering. It might almost be said that nothing short of success can justify the attempt, for the loss of prestige consequent on failure in a matter of this sort would be almost fatal to discipline and efficiency in the works. It, therefore, behoves the engineer or works manager who intends to start on a "speeding-up" campaign to count the cost carefully, and not to leave unconsidered any possible cause of failure.

In the author's case the first work to be timed was that which was most urgently required, and the departments engaged in doing this work in its various stages were dealt with in turn. Example I., which has been described, deals with the work done in the first department tackled. Example II. illustrates the work done in the second department. In the first department no open opposition was experienced, but in the second there was what has been alluded to in the example. In the next department—let it be called, for reference purposes, Department III.—the first serious trouble was met. Here there were a very large number of semi-skilled men engaged on the work in question, each man turning out 6·5 pieces per hour. Timing, which was strongly objected to, showed that only a fairly simple rearrangement was necessary to make the output 15 per hour. Further, a subdivision of the work and the employment of unskilled labour made possible an output of 30 pieces per semi-skilled man per hour. One squad was set working on this latter system for a day, and, without being specially watched or pressed in any way, each semi-skilled man turned out 29 pieces per hour over the whole day, much to their own dismay, evidently.

On the day following this, however, the whole of the men refused to work on the system, and a strike was threatened. A demand was made for an all-round increase in wages of over 20 per cent., without any increase in the amount of work done. This, of course, could not be considered. Finally, as, on account of the large number of men in this department, the work was not being held up in other departments on account of this one, and as there was more pressing need of speeding up elsewhere, a compromise was effected. It was agreed that the output should be speeded up by 50 per cent., the men working by the same methods as before, and a 20 per cent. increase in wages was given to all in the department. This increase was, of course, in line with what was being done under the bonus scheme. The matter was then dropped in this department for the time being, the men being told that it would be taken up later on, and they were asked to weigh up the advantages of the bonus system in the meantime.

It may be mentioned, as showing the difficulties experienced in timing, that three men were timed one after the other. The first two worked fairly well ; the last—one of the most experienced men in the department—by going through unnecessary operations, was able to take twice as long over the work as the others ; and yet, to an unpractised eye, he would have appeared busy all the time.

The next department—No. IV.—was then visited, but before anything could be done in the matter of timing a request was made by the men for an immediate increase of 20 per cent. all round. They were told that it was proposed to grant such an increase, but that it would be paid on the bonus system, under which timing of the work was necessary for the purpose of fixing the task. One of the men's representatives making the request was chosen to be timed, and timing was at once proceeded with, but only for a short time, as it was rather late in the afternoon. Sufficient observations were made to make it possible to consider rearrangements before the next morning, when the men were told timing would be resumed : and the figures obtained showed that, even without rearrangement, a much greater output was possible than that obtaining.

The speedy action taken in at once timing one of their delegates had, no doubt, its effect on the men ; but on the following morning this man refused to allow himself to be timed, and it was stated that the men were unanimous in their decision to resist the timing. As the work in this department was seriously behind, and as the observations made on the previous day showed that, without rearrangement, an output of 34 pieces per hour could easily be obtained, as against the customary output of between eight and 12, there was nothing for it but to insist on the timing, with the result that the men went on strike.

It was at this stage that a general increase was given all round

the works in lieu of the prevailing "war bonus." This increase was not given in cases where the men were already working on the bonus system, nor in Department III.

There were various interviews with the strikers' delegates, at which the matter was discussed in all its bearings, and efforts made to show the men that it was to their own great benefit to adopt the system; by doing so they would increase their earnings and the urgent work would be got out to time. In spite of everything, an ultimatum was sent in to the effect that they would not work on the proposed system, but were going to hold out for their increase, irrespective of the amount of work done.

At one of those interviews the delegates laid great stress on the difficulty they alleged they had in turning out, on some types of work, what they called the "recognised quantity." As regards the work immediately in dispute, they stated that the labour cost was 1s. 3d. per dozen pieces, and that they were prepared, considering the urgency of the work, to increase the output so as to reduce the labour cost to 1s. 2½d. per dozen pieces. This shows the force of the remark, made at the beginning of the Paper, that straight piecework—which had been in force in the factory in previous years—leads to the men's selling pieces of work to their employers rather than their ability to turn out pieces of work.

In the meantime the author, trying his own hand at the work and taking extreme precautions to avoid defective pieces, succeeded in working at the rate of 30 pieces per hour, and, in addition, some of the work was sub-let *pro tem.* to another firm.

In due course a consignment of pieces made by the latter firm and some made by the author were passed into Department III., which was next in order in the process of manufacture, with the result that the men there would not touch them, but went out on strike in sympathy with the others from Department IV. It was pointed out to them before they went out that they were going to lose money, and that they had only themselves to blame, or, if not themselves, the men already out, who, incontestably, had no just cause to strike and cause loss to men in other departments in the factory. The force of this was evidently clear to those men, and, no doubt, also to those already on strike, who knew perfectly well that they were not being asked to submit to anything unreasonable.

The consequence was that shortly afterwards the delegates from Department IV. made overtures for a settlement, and after considerable discussion they agreed to give the system a trial. This decision was reached about mid-day on a Friday, and the men from Department III. desired to resume work at once. As, however, they had gone out simply in sympathy with the others, they were told that they would have to remain out until the following Monday, when work would be resumed generally in both departments. This served the double purpose of pleasing the first batch who went out on strike and who had taken umbrage at the last lot, and of showing the latter that their services could also be dispensed with for a time if necessary.

On the resumption of work it was necessary to effect some rearrangement in the method of working, not for the sake of increasing the speed of working, but to provide the men with a partial excuse for the increased output which was inevitable. This being done, timing was carried on for a week, practically every man on day shift being timed, so that an average performance could be reckoned on; and, allowance being made for certain difficulties inherent in the work which occasionally interfered considerably with the output, it was finally decided to set 34 pieces per hour as the task.

On the following week the men were on night shift who had been timed, so, in order that no mistake should be possible, the author remained in the department all night with them. Unfortunately, one of them "struck a bad patch," and this affected not only his own output but that of the others. It was clear from their demeanour that the man who was experiencing the trouble was setting the pace, and that the others were not doing what they could do. The average per man-hour during the night was 26½, and the task was set at 26 after considerable argument; but the men were told plainly that it was realised that the task was being set lower than it should, and would not have been set at this figure had it not been for certain circumstances, one of which was the extreme urgency of the work.

The result was a saving in labour cost on this particular work of 44 per cent. on day shift and 33⅓ per cent. on night shift when only the set task was done. The saving was less on night shift on account of certain allowances made to night workers. The actual saving per 24 hours per skilled man was 21s. 6d. when only 26 pieces were done per hour. As a matter of fact, the saving was, in time, considerably more than this, for as the men gained confidence to use their best efforts without fear that their rates would be cut they did an astonishing amount of work, and the labour cost per piece closely approximated to the possible minimum.

To illustrate the groundlessness of the statements the men made to a newspaper reporter, it is only necessary to say that, on the particular class of work they referred to, instead of doing from 8 to 12 pieces per hour, they usually did between 50 and 70 pieces; in one instance a man for some reason went off at express speed and actually did 90 pieces per hour, keeping up this pace for a whole day.

While timing was being carried out in this department, it was finally decided to base the task on 54 minutes' actual working in the hour. In this way 10 per cent. of the men's time was their own, in which they could take a rest or attend to their personal requirements, and in addition a further time allowance had to be made to comply with certain Factory Act requirements. It may be said that the result was entirely satisfactory, and that when the men realised that they were not going to be penalised they worked so hard that the time allowances were really necessary, and not in the nature of a luxury.

The work was now being turned out so fast that it was evident that something further would have to be done in Department III. It was expected that the increased wages earned in other departments would not be without their effect. The men in this department were working night and day shifts, and many were working overtime on both shifts. This was the cause of bad time keeping, and an attempt was made to introduce a system of three eight-hour shifts per day, but this the men would not consider. As the eight-hour shift system would be more expensive to the firm as far as that department was concerned, the suggestion was not pressed. The men were accordingly given another chance of working better on the ordinary shifts, and a notice was posted to the effect that it was necessary to keep the plant going continuously, and the men were requested to put in the full number of working hours, any who showed themselves unable to stand the strain to have their hours reduced. The last clause in the notice was to make it possible to put pressure on any man continuing to upset things by losing time.

No improvement was shown—in fact, rather the reverse—and it became necessary to arrive at a definite settlement of the matter as well as to insist on the introduction of the bonus system. No amount of reasoning was of any avail, and a strike was inevitable. The time chosen for forcing matters to a conclusion was just shortly before the Whitsuntide holidays, and the weather was not very good—two factors which were reckoned on as of assistance in shortening the period of the trouble.

As anticipated, the men went on strike, and from time to time sent in deputations on the subject of their demands. They stated clearly that they were out to have their own way, and meant to have it. It was impossible for new men to be started on account of picketing being resorted to. A number of the men were willing to resume work and do as they were told, but the agitator element was strong among some of them, and the latter would not hear of any compromise. Their final ultimatum was as follows, and is given as an example of the attitude which, without doubt, was taken up by many workers throughout the country at that time:—

"We, the workers in the —— shop, agree to resume work on the old system, and are willing to turn out the amount of work which we originally did at the increased rate of pay, on condition that we have a written agreement that you will not interfere with the men any more, nor try to introduce the bonus system, which we will not entertain at all."

Such a demand, of course, could not be considered. The men were told that there was no work for them on those terms, and advised to go away peaceably. It was some days, however, before they did so. They did not seem to realise that it was possible for them all to be turned away. They did, however, realise it in time, and the majority went, but some applied for re-engagement. The latter were engaged, and were required to sign an undertaking that they would do what they were told and refrain from causing troubles. With this nucleus and some new men, whom it was possible to take on from time to time, the work was resumed and the bonus system put at once into operation. All timing was done over again, and although the rearrangement originally proposed was not put into force for several reasons, the task set on the work in question was 21 pieces per hour, as against the original 6·5. After everything had been got going it was found possible to turn out with between 20 and 30 men a part of the work which originally took 80 to do.

As has already been indicated, it was only after a good deal of consideration that the author ventured to set down briefly the difficulties described in the latter portion of the Paper, and it is hoped that his doing so will not be misunderstood. The object has been to warn the unwary against falling into the error of seeing only the desirable results, overlooking the pitfalls by the way, and because of this failing to obtain the object aimed at.

There would seem to be, in the ultimate, no good reason why workmen should not do their best when at work, and why there should be any great difficulty in introducing a system of payment by results which guarantees a reasonable minimum. Unfortunately in this country, at least—the only one in which the author has had

experience—there seems to be a feeling of antagonism between employers and employés. No doubt there are faults on both sides, but in many cases and in normal times it should not be impossible to arrive at a mutual understanding. Unless there is a measure of confidence between masters and men, instead of suspicion and distrust, very little can be done. In the process of getting rid of this distrust there may be a fight; but a fight sometimes clears the air. If the employer fights fairly, irrespective of what the men may do, and stands by any mistakes he may make which favour the men, his only object being to get a square deal for both sides, the result can hardly fail to be good.

The British working man, like the rest of us, has his faults; he would probably be the last to deny it. Fighting seems to be in his blood; the present war has shown that he would almost rather fight than work. He is difficult to force; let us—although it may not be easy—try to lead him. This does not imply that he should have all his own way or all he asks for, but rather that his side of the question should be fairly considered and the employer's side fairly represented to him. Reason seems, generally, to prevail in the end. In the works dealt with in the Paper the feeling of the men, after the strikes and after the "roots of bitterness" had taken their departure, was much better and more friendly than it had ever been.

TRANSFORMER DESIGN.

(*Continued from p.* 80.)

BY F. M. DENTON, A.C.G.I.

Summary.—A general discussion is given of the nature of the problem of transformer design, and the author sets out Arnold's method of design for constant potential transformers. He then deals with the conditions ensuring maximum electrical and commercial efficiencies, and discusses the advisability of designing power transformers for minimum cost. A rule is developed by the aid of which designs of power transformers may be based upon commercial efficiency rather than upon minimum cost. The author then gives an outline of the method of design proposed by Arnold in 1910 and a comparison of Arnold's later and earlier methods. Comparative designs are worked out and a schedule is given, based upon Arnold's method of 1904.

These comparisons urge the question whether the condition $G_i/G_k=£_k/£_i$ is not, theoretically as well as practically, more sound as a basis for the cheapest design than the condition $G_i/G_k=£_k/3£_i$ proposed in Arnold's later edition.

Arnold gave neither proof nor explanation for his choice in the 1904 edition of the condition $G_i/G_k=£_k/£_i$, but the argument seems a fairly obvious one.

We may suppose a power transformer of given rating has been designed—for the sake of argument a single-phase core type transformer—and the designer wishes to discover whether his design is the cheapest possible of its type and approximate pattern (relative proportions). He may argue thus: If I were to make a number of alternative designs of similar rating and constants, some having more copper and some less than the one I have just made, and plot a curve between cost along the vertical axis and weight of copper along the horizontal axis, I should, of course, find that my first design, if it were indeed the cheapest possible, would be at the bottom of a valley in the curve, where for an appreciable distance the curve is sensibly horizontal. My design would lie at a point on the curve for which a small change in the weight of copper or of iron would produce no change in the cost. There is, therefore, no need for me to plot such a curve; all I need do is to assure myself that if I change the weight of copper or of iron by 1 per cent., making the consequent adjustment in the iron or copper necessary to keep the rating of the transformer unchanged, the total cost shall be found unchanged. I will therefore try increasing the cross-section of the iron (keeping B constant) by 1 per cent. This will cause G_i to increase by 1 per cent., whilst the number of turns and so also the weight of copper will have to be reduced 1 per cent. on account of the increased flux. It might be said that I have neglected the increase in the mean length of a turn necessitated by the increase in Q, and also the increase in iron length. But the former is very small. If there were no insulation at all and the copper were wound tightly around the iron the increase of 1 per cent. in Q would mean an increase of half of 1 per cent. in the length of the shortest turn and about ½ per cent. in the mean turn. But in practice the length of the mean turn is proportional not to $\sqrt{Q}$ but rather to $\sqrt{(Q+\text{cross-section of insulation and air spaces})}$ and the cross-section of the insulation, &c., will change much less than Q changes. Moreover, when I reduce the turns by 1 per cent. I take the outer turns which are the longest of all, and so keep down the value of the length of the mean turn. The length of the iron will usually change inappreciably for a small change in Q, first because the total iron length is many times greater than the width of the core, and, secondly, because, the copper section having been reduced, the length of the yokes may be slightly reduced whilst still keeping the same value for f_k (the winding space factor). There can then be but little error in saying that when G_i is increased by 1 per cent. G_k will be decreased by 1 per cent. It then follows, as already shown, that the minimum cost will be obtained when $G_i/G_k=£_k/£_i$.

This argument and conclusion, with which the best actual designs seem fairly well to accord, is, in my opinion, sound. It must now be compared with that of Arnold's 1910 edition.

Assuming that the mathematical reasoning which leads to Arnold's conslusion that G_i/G_k should be made equal to $£_k/3£_i$ has been correctly put into words, it may first be noticed that in addition, of course, to the constancy of KVA, f, B and s, Arnold assumes that in discussing whether or not a given design is the cheapest possible the designer should compare it with alternative designs in which both the ratio l_i/l_k and $l_k/\sqrt{Q}$ are the same as in the trial design. *With these assumptions* the conclusion is, no doubt, logical, that the cheapest design will be that for which $G_i/G_k=£_k/3£_i$. But it seems to me that the assumption spoken of ought not to be made. The designer should compare his trial design with others of similar type and approximately similar pattern, and in such transformers, of given rating, neither l_i/l_k nor $l_k/\sqrt{Q}$ will be constant. Referring to THE ELECTRICIAN, p. 80, what object was there in allowing l_i to be increased 1 per cent. when l_k was so increased? The cross-section of the copper had become less and the periphery of the window would probably, in practice, bear reduction when Q was increased. To do as Arnold's argument proposes would be to provide an unnecessarily large window area, and would reduce f_k without reason. In practice the increase of Q might even bring a slight reduction in the ratio l_i/l_k, whilst the general shape (pattern) of the transformer would be but inappreciably changed. Nor would $l_k/\sqrt{Q}$ remain constant, for l_k is proportional not to $\sqrt{Q}$, but to $\sqrt{(Q+\text{cross-section of insulation, \&c.})}$, and a 2 per cent. change in Q would usually bring but an inappreciable increase in the section of the insulation.

The point I am trying to make may, perhaps, further be illustrated by supposing that Arnold's designer wished to compare his design with one having, say, 2 per cent. smaller iron section. The mean length of a turn would, by Arnold's assumption, be reduced 1 per cent. and so the length of iron path would have to be decreased by 1 per cent. (to keep l_i/l_k constant). The number of turns must, however, be *increased* by 2 per cent., and the reduction of iron length and of window area makes this impossible except by an increase of f_k.

Thus, it appears that Arnold's assumptions are incorrect. They seem to overlook the fact that when KVA, V, f, B, s and f_k are given, there is only one design of given type and of exactly given pattern (that is to say, given relative proportion and given l_i/l_k) possible, and that when a designer wishes to compare his design with others to see if it is the cheapest possible, he must compare it with others of *somewhat different relative proportion* in which KVA, V, f, B, s and f_k are the same.

The argument in THE ELECTRICIAN, p. 45, shows that the ratio of l_i/l_k is constant for a line of transformers of similar pattern and various KVA outputs and for which f, B, s and f_k are constant, but it is wrong to suppose that this ratio should be exactly constant for alternative designs of the same KVA output.

As will be pointed out when referring to the alternative designs in a later section of the article, the designer must use his own judgment as to the merit of the pattern he has obtained in his design. He can find out whether it is the cheapest possible design amongst transformers of similar rating and con-

stants, and of approximately the same pattern by comparing it with designs having slightly less and then slightly greater values of Q. In place of making the actual comparison he may rest satisfied that the result would be favourable to his own design, provided the ratio G_i/G_k is about equal to $£_k/£_i$.

There is no speedy and certain method of determining what are the best relative proportions for the designer to take.

Following Arnold's earlier method, the designer is given a lead as to the first trial choice of the ratio l_i/l_k, but when this choice has been made the merit of the design is greatly dependent upon his choice of h (determined by AS). Arnold's later method is to assume a value for G_i/G_k and then take various alternative values of h. The two methods thus amount to about the same thing, and both are fairly in accord with the theory proposed in the 1904 edition.

It may be asked, Would not a transformer designed so that G_i/G_k was equal to $£_k/3£_i$ possess some practical distinction? The answer, in my opinion, is that such a transformer would be the cheapest of the series of alternative designs of equal rating, all having the same values of f, B and s and of the ratio l_i/l_k and $l_k/\sqrt{Q}$, but all having different values of f_k. The transformer having $G_i/G_k=\frac{1}{3}£_k/£_i$ would be a freak because of its excessive proportion of copper, and those amongst which it stands out in point of cheapness would be freaks on account of their unreasonable space factors. Such a transformer would be quite out of the running, in point of cost, with other transformers of similar rating and constants in which the ratio G_i/G_k was greater.

In view of the criticism on the preceding page of Arnold's derivation of the condition $G_i/G_k=£_k/3£_i$, it may be asked why similar objection is not made to the method by which, in the 1904 edition, the condition $G_i/G_k=0{\cdot}36\ £_k/£_i$ is derived for lighting transformers, since this method also involves the assumption that $l_k=k_1\sqrt{Q}$ and $l_i=k_2\sqrt{(\text{window area})}$.

The answer is that, in this case, the error introduced by the assumptions is comparatively small. Examination of the steps in the derivation of the 0·36 condition show that the k_1 and k_2 expressions for l_k and l_i are inserted not in the ratio l_i/l_k, but in the product $l_i\times l_k$, so that the assumption made is that the product $k_1\times k_2$ is constant, not that k_1 and k_2 are each constant. And consideration of the practical conditions of transformer construction shows that such an assumption is not unreasonable. For, considering k_1, it may be observed that if Q is great l_k approaches equality with $\sqrt{Q}$ and k_1 approaches unity, whilst if Q is small l_k is much greater than $\sqrt{Q}$ and k_1 is greater than unity; k_2, on the other hand, may approach unity when Q is small, and is much greater when Q is great.

Thus, the variations of k_1 and k_2 with Q, in addition to being small, are of opposite sign, and it is not unreasonable to expect the product k_1, k_2 to be about constant for transformers of given rating and constants and of approximately the same pattern.

It is probable, however, that in the majority of designs Arnold's constant 0·36 or 0·46 is too low, and better results might be obtained by using 0·6 to 0·8. The common-sense derivation, by aid of the percentage rule given above, of the 0·36 condition for the minimum cost of a lighting transformer may quite readily be written down, and the method may prove useful when it is desired to work out the minimum cost condition in a case for which the changes of l_i and of l_k for a given change in Q can be approximately estimated at the outset.

In a lighting transformer the efficiency, the iron loss and so also the copper loss are fixed. And since the copper loss is obviously proportional to $G_k\times s^2$ it follows that G_ks^2 is constant, that is to say, s is proportional to $1\sqrt{G_k}$, and for a 1 per cent. change in G_k, s will change half of 1 per cent. In examining a design to see whether modification of the dimensions will reduce the cost, let Q be increased by 1 per cent. Then, since we are to assume that l_k is proportional to $\sqrt{Q}$ it follows that l_k will be increased by $\frac{1}{2}$ per cent.

The volume, and so G_i, will be increased by $(1-\%l_i)$ per cent., where $\%l_i$ stands for the percentage decrease in l_i. And as the total iron loss is to remain constant $B^{1\cdot6}$ must be decreased by $(1-\%l_i)$ per cent.; that is to say, B must suffer a reduction of $\frac{1}{1\cdot6}(1-\%l_i)$ per cent. Hence, Φ the flux becomes $\left\{1-\frac{1-\%l_i}{1\cdot6}\right\}$ per cent. greater, and the number of turns must be reduced by the same percentage. The total cross-section of copper in the transformer will be decreased by $\left\{1-\frac{1-\%l_i}{1\cdot6}+\%\right.$ increase of $\left.s\right\}\%$. That is to say, by $\left\{1-\frac{1-\%l_i}{1\cdot6}-\frac{1}{2}\right.$ the percentage decrease of $\left.G_k\right\}$ and the total change in G^k will be a percentage decrease of

$$\left[\left\{1-\frac{1-\%l_i}{1\cdot6}+\tfrac{1}{2}(\%G_k)\right\}-\tfrac{1}{2}\right],$$

the symbol $\%G_k$ standing for percentage change in G_k. and the $\frac{1}{2}$ being the percentage change in l_k. It follows that the change in G_k is

$$2\left\{\tfrac{1}{2}-\frac{1-\%l_i}{1\cdot6}\right\}\text{ per cent.}$$

Now, the percentage change in l_i is one-half the percentage change in the window area (since it is to be assumed that $l_i=k_2\sqrt{\text{window area}}$), and, therefore, one-half the percentage change in the total cross-section of the copper; that is to say,

$$\%l_i=\left[\tfrac{1}{2}\left\{1-\frac{1-\%l_i}{1\cdot6}+\tfrac{1}{2}(\%G_k)\right\}\right]\text{ per cent.}$$

$$=\left[\frac{1\cdot6}{2\cdot2}-\frac{1}{2\cdot2}+\frac{0\cdot8}{2\cdot2}(\%G_k)\right]\text{ per cent.}$$

Inserting this value of $\%l_i$ in the expression for the change in G_k we have :—

$$\%G_k=-0{\cdot}2+\frac{1{\cdot}2\times0{\cdot}6}{2\cdot2}+\frac{0\cdot8}{2\cdot2}(\%G_k),$$

$$\%G_k=0{\cdot}226\text{ per cent.},$$

whence $\%l_i=0{\cdot}341$ per cent. and $\%G_i=(1-\%l_i)\%=0{\cdot}659$ per cent. Thus, the weight of iron has increased by 0·659 per cent. and that of copper has decreased by 0·226 per cent. If the transformer has been properly designed for minimum cost these changes will have left the total cost unaffected: that is to say, the increase in the cost of the iron will be equal to the decrease in that of the copper, or

$$\frac{0{\cdot}659}{100}G_i£_i=\frac{0{\cdot}226}{100}G_k£_k,$$

$$G_i/G_k=0{\cdot}344£_k/£_i.$$

Had the quality or thickness of the iron been such that the iron loss per kilogramme varied as $B^{1\cdot7}$ the result obtained would have been $G_i/G_k=0{\cdot}46£_k/£_i$.

With alloyed iron of ordinary thickness the total loss varies as about B^2 and the ratio G_i/G_k works out equal to $£_k\ £_i$.

The results thus obtained under Arnold's assumptions with regard to l_i and l_k, namely, that $l\propto\sqrt{\text{window area}}$ and $l^k\propto\sqrt{Q}$ may now be compared with those obtained under the assumption that for a 1 per cent. change in Q neither l_i nor l_k will appreciably change.

For iron for which the total loss varies as $B^{1\cdot6}$ we have :—

Let Q be increased by 1 per cent.; the volume of iron and also G_i increase by 1 per cent., hence B must be reduced by (1/1·6) per cent. and so Φ goes up by (1—1/1·6) per cent., and the turns may be reduced by (1—1/1·6) per cent. But G_k will be reduced by the percentage reduction in turns plus the percentage increase in s (which equals half the percentage change in G_k); that is to say—

$$\%G_k=\left\{\left(1-\frac{1}{1\cdot6}\right)+\tfrac{1}{2}(\%G_k)\right\}\text{ per cent.,}$$

or

$$\%G_k=\left\{2\left(1-\frac{1}{1\cdot6}\right)\right\}\%=0{\cdot}75\text{ per cent.}$$

Thus, the 1 per cent. increase in G_i brings 0·75 per cent. decrease in G_k and the minimum cost condition becomes :—

$$G_i/G_k=0{\cdot}75\ £_k/£_i,$$

which differs greatly from Arnold's result, $0{\cdot}36\ £_k\ £_i$.

It is particularly interesting, however, to note that for iron for which the total loss is about proportional to B^2 the two methods give one and the same result—namely,

$$G_i/G_k=£_k/£_i.$$

So that for such iron the minimum cost condition is the same for lighting as for power transformers.

Note on the Condition of Maximum Efficiency in a Power Transformer.—Arnold's method of design of power transformers attaches much greater importance to the condition of minimum cost than to that of electrical efficiency, and makes no mention of commercial efficiency. The wisdom of this will now be considered, and to this end the theoretical conditions ensuring maximum electrical efficiency must first be carefully gone into.

Assuming constant applied voltage at constant frequency, the total electrical loss in a transformer is made up of copper loss which varies when the load varies and of iron loss which is about constant for all loads. The efficiency may, therefore, be expressed thus :—

Efficiency=(output/input)=(output/output plus losses)

$$=[V_2I_2\cos\theta/\{V_2I_2\cos\theta+(L+RI_2^2)\}],$$

in which V_2, I_2 and $\cos\theta$ are the load voltage, current and power-factor per phase respectively, L is the iron loss per phase in watts and R is the total resistance per phase referred to the secondary circuit (that is to say, $R=R_2+R_1(t_2/t_1)^2$). It is readily seen that this expression for the efficiency will have its maximum value for that value of I_2, which makes L equal to RI_2^2. This is usually proved by differentiating the expression with respect to I_2, and setting the result equal to nought. To the mathematical mind the result is obvious by mere inspection. To the mind of the ordinary student it is apt to be one of those wonderful disclosures made possible only by the calculus. It may, therefore, be not inappropriate to call attention here to a simple though neglected rule, the truth of which is readily grasped by any thoughtful student, by aid of which this and a host of other such problems may be solved at a glance without any reference to the calculus. The rule is this : *If a quantity be changed by* 1 *per cent. the square of that quantity changes by* 2 *per cent., the cube by* 3 *per cent., and so on.* For strict accuracy the change mentioned should be, not 1 *per cent.*, but 1 *per infinity*, though for practical purposes 1 per cent. is usually small enough. The truth of the rule becomes evident to the student when he works out a few special cases, and when he considers such matters as the relation between the linear, superficial and cubical expansions of a body when heated. In grasping this simple rule the student has really grasped the meaning of the statement $dx^n/dx=nx^{n-1}$, for if dx be chosen as 1 per cent. of x we have dx=1 per cent. of x ; hence, $d(x^n)=n$ per cent. of x^n, therefore

$\{d(x^n)/dx\}$ =(n per cent. of x^n)/(1 per cent. of x)

$$=(n/100)x^n/(1/100)x=nx^{n-1}$$

With the percentage change rule in mind the consideration of the condition that the expression

$$(VI\cos\theta)/\{VI\cos\theta+(RI^2+L)\})$$

shall be maximum is simple. For when I has been so chosen that this expression is a maximum any change in I will reduce the value of the expression. First, suppose I to have been so chosen that RI^2 is less than L, and let I be increased by 1 per cent. The numerator is thus increased by 1 per cent. as is also the first term in the denominator ; RI^2 is increased by 2 per cent. and L not at all. And since RI^2 is supposed less than L the whole expression (RI^2+L) has been increased *less than* 1 per cent. Thus, each term in the expression for the efficiency has gone up by 1 per cent., except the second term in the denominator, and this has been increased by less than 1 per cent. Hence, the efficiency has been increased. Had I been so chosen that RI^2 was greater than L then a decrease of 1 per cent. in I would have caused an increase in the value of the efficiency. Obviously, then, the efficiency will be maximum when RI^2 is equal to L.

This simple and oft-stated condition of maximum electrical efficiency appears, at first sight, to be in contradiction to another useful statement, namely, that *for a given power output from a given transformer the maximum efficiency is obtained when the copper loss is less than the iron loss by some* 10 *to* 20 *per cent.*

There is no discord between this and the preceding statement. The first statement—copper loss equals iron loss—refers to a transformer designed for and used with a definite applied voltage. Under this condition the best efficiency will occur for that value of current for which $RI^2=L$. The second statement says that for a given power output (no restriction being put upon voltage applied) the lowest total loss will occur when the iron loss is somewhat greater than the copper loss. This simply means for instance, that if a transformer designed for an applied voltage of 110 volts, and giving out 20 *K.V.A* has an efficiency of 97 per cent., it will be possible to take 20 *K.V.A* from the same transformer at possibly 97·5 per cent. efficiency by applying, say, 112 volts instead of 110. The truth of this rather unusual statement is obvious when it is considered that whilst the output is proportional to the product VI and, therefore, for a given transformer, to $B\times I$ the losses are proportional, copper loss to I^2 and iron loss to about $B^{1.7}$. Taking, then, a transformer in which the voltage and current are such that the copper loss is equal to the iron loss, we may if we like increase V and, therefore, B by 1 per cent. and decrease I by 1 per cent. without changing the power output. But a 1 per cent. increase in B means a 1·7 per cent. increase in the iron loss, whilst the 1 per cent. decrease in I means a 2 per cent. decrease in copper loss. On the whole, therefore, the total loss has been reduced. And obviously the reduction may in this way be continued until the ratio of copper loss to iron loss is about 2/1·7. Here again the percentage rule has come in useful.

The condition for maximum efficiency just dealt with is sometimes put in the form : *With a given transformer to be worked with given total losses the maximum efficiency is obtained when : The total copper loss=eddy current loss in the iron, plus* 80 *per cent. of the hysteresis loss.* The same condition obviously ensures that with a given output the losses shall be at a minimum. The full mathematical proof is as follows : For a transformer of given output the product (flux×current) must be constant, that is to say $(B\times Q_i)(s\times Q_c)$=constant, where Q_i and Q_c stand for the total cross sections of iron and of copper respectively. Hence, λBV_isV_c=constant, where V_i and V_c are the volumes of iron and copper respectively, and λ is a constant connecting the cross section with the volume of the transformer. Now the total losses are :

$$(C_1B^{1.6}V_i+C_2B^2V_i+C_3s^2V_c),$$

C_1,C_2 and C_3 being constants. The condition that the total shall be minimum is the same as that F shall be a minimum where

$$F=C_1B^{1.6}V_i+C_2B^2V_i+C_3s^2V_c+\lambda BV_isV_c.$$

To find this condition we may write

$$\delta F/\delta s=2C_3sV_c+\lambda V_iV_cB=0$$
$$\delta F/\delta B=1{\cdot}6C_1B^{0.6}V_i+2C_2BV_i+\lambda V_iV_cs=0.$$

Multiplying these equations by s and B respectively and subtracting, we eliminate λ, and find that

$$2C_3s^2V_c-1{\cdot}6C_1B^{1.6}V_i-2C_2B^2V_i=0,$$

that is,

$$C_3s^2V_c=C_2B^2V_i+0{\cdot}8C_1B^{1.6}V_i.$$

This result may readily be obtained by the percentage rule thus: Since the output is constant a 1 per cent. change in voltage would demand a 1 per cent. change in current, that is to say, 1 per cent. decrease in B would demand 1 per cent. increase in s. Now the total loss is

$$k_1B^{1.6}+k_2B^2+k_3s^2,$$

and when this is at a minimum a 1 per cent. change in s or in B (accompanied, of course, by the consequent change in B or in s required by the condition of constant output $B\times s$=constant) will have no effect on the total. Let then s be increased by 1 per cent. B will have to be decreased by 1 per cent. and hence $B^{1.6}$ will be decreased by 1·6 per cent., and B^2 by 2 per cent. s^2 will be increased by 2 per cent. The total will remain unchanged and we may write : 2 per cent. of the copper loss = 1·6 per cent. of the hysteresis loss+2 per cent. of the eddy loss.

Mr. A. F. Burgess has given me the following almost literal mathematical translation of the commonsense method just employed.

Expressed as a fraction of the load the total loss is:

$$X=(k_1B^{1\cdot6}+k_2B^2+k_3s^2)/W,$$

where W stands for the load in volt amperes.

Now in a given transformer B is proportional (for given frequency) to V, the voltage applied, so that instead of $k_1B^{1\cdot6}$ we may write $bV^{1\cdot6}$, and instead of k_2B^2 write aV^2. The total copper loss k_3s^2 may be written rI^2 or rW^2/V^2. The expression X may now be put into the form

$$X=(aV^2+bV^{1\cdot6}+rW^2/V^2)/W$$

The load being constant whilst V is supposed variable, the minimum percentage loss and the maximum efficiency will be obtained when dX/dV is nought, that is when

$$(1/W)(2aV+1\cdot6bV^{0\cdot6}-2rW^2/V^3)=0,$$

or

$$aV^2+0\cdot8bV^{1\cdot6}-rI^2=0,$$

that is when

Eddy loss+80 per cent. hysteresis loss=copper loss.

The first rule for maximum efficiency says that a transformer for a given voltage will have maximum efficiency when used at that current output, which makes the total RI^2 loss equal to the total iron loss.

The second rule says that if such a transformer be now used on a slightly higher voltage but at the same KVA output, the efficiency will be better than it was before.

We might go still further, and say, referring again to the first rule, that if this transformer with its excessive applied voltage were now allowed to give out excessive current, so that, once more the copper and iron losses became equal, the efficiency would be still higher. And so on until the transformer were burned out. The point is that if the transformer was economically designed for its original rating in volts and amperes the application of excessive voltage would cause excessive local temperature rise (in the iron), and the design would have to be regarded as an imperfect one for this new condition of applied voltage.

Arnold carefully discusses both the conditions just dealt with and clearly distinguishes between them. Kapp on page 122 of his 1908 edition of "Transformers" appears to suggest that Arnold is in error upon the matter.

It is interesting to apply the percentage rule to the determination of the maximum efficiency condition for a lighting transformer. It was shown, mathematically, that the condition to be satisfied is

$$E_i/K_u=0\cdot36£_k/£_i.$$

The total cost is $(E_iKVA£_i+K_uKVA£_k)$,

and the design has to satisfy the condition that $K_uE_i^{0\cdot36}$ shall be a constant, say g. Thus the value of E_i has to be found, which will make $(E_i£_i+g£_k/E^{0\cdot36})$ a minimum.

The required value of E_i may be recognised by applying the common-sense rule that for the minimum condition a 1 per cent. change in E_i (accompanied, of course, by the changes thereby made necessary in the other quantities) will produce no change in the total. Now by the percentage rule a 1 per cent. change in E_i means a 0·36 of 1 per cent. change in $E_i^{0\cdot36}$. Hence if the total is to remain the same in spite of the 1 per cent. change in E_i the condition will have to be fulfilled that

$$\text{1 per cent. of } E_i£_i = 0\cdot36 \text{ of 1 per cent. of } g£_k E_i^{0\cdot36},$$

or

$$E_i£_i/100 = (0\cdot36/100)(K_uE_i^{0\cdot36})£_k E_i^{0\cdot36},$$

that is, $E_i/K_u=0\cdot36£_k/£_i$, the same result, of course, as was obtained by the orthodox form of the differentiation.

(To be continued.)

Electrically-Driven Sinking Pump. "The Engineer" illustrates a vertical pumping set which Holden & Brooke, Ltd., of Manchester, have constructed for the South Moor Colliery Co. The pump delivers 600 gallons of water per minute against a head of 33 ft. and runs at 1,160 revs. per min. It is driven through a flexible coupling by a 13 B.H.P. totally enclosed motor, made by Greenwood & Batley, Ltd., which is supplied from three-phase mains at 40 cycles. The whole of the plant is self-contained in a structural steel framework, and can be readily slung in a pit shaft.

SERVICE BRANCHES FROM EXTRA HIGH-TENSION CIRCUITS.*

BY D. M. MACLEOD.

Summary.—The question of an efficient and economical mains lay-out has become of paramount importance. This is discussed in the Paper, and comparisons between costs of looping-in, laying branch cables, and other methods are given.

In the case of, say, a modern power company operating by virtue of its Parliamentary powers over an extensive area of comparatively widely-scattered industrial communities, it is quite conceivable that as development progresses the outlay in mains and services per kilowatt of demand on the generating station will exceed the cost per kilowatt of generating plant and power-house buildings to give such demand. This being the case, every method and device must be inaugurated and tried to reduce to a minimum the outlay involved in feeder and network extensions, compatible with reliability of supply.

It is not surprising, therefore, to find the ring-main system extensively used for public electrical distribution networks, the route of such ring circuits being generally laid out to follow a certain line of actual or prospective development.

To achieve the best results from this method of distribution it is essential that some system of balanced protective gear should be installed, as it is exceedingly difficult, if not impracticable, so to arrange a series of overload and reverse-power "trips" as to give the necessary discriminative action when isolating a section on which a fault has developed. Attempts have frequently been made to grade a system of overload protective devices so that any cable failure can be localised as much as possible, but generally these attempts have either failed completely or the results obtained therefrom have been of so uncertain a nature as to lead to their abandonment. Such a result is what one might expect in all cases, except, say, that of a feeder energised and fed from only one end.

When a supply is required for a large power consumer there is seldom any question as to its being obtained from or incorporated with the nearest available ring main, even should the consumer's works be situated some distance therefrom, as the importance of the supply on the commercial as well as on the engineering side is such as to justify the capital expenditure involved in looping in the ring-main circuit and providing the necessary sub-station and balanced protective equipment.

In some cases, however, and these are by no means uncommon, a comparatively small supply for an isolated works may be all that is required, or a new works may be starting up, the ultimate development of which is a matter of uncertainty; or, again, the supply may be required simply to augment the output from a private plant or as a week-end and stand-by supply to such plant. In the cases enumerated, both the financial and the engineering aspects of the problem require very careful consideration, more especially where the works to be supplied are situated at some little distance from the route of the supply cables. Viewed from the financial standpoint, it is often found that the return to be expected is totally inadequate to justify the heavy outlay that would be entailed in looping-in the ring-main cables. The portion looped-in must be, of course, of the same carrying capacity and sectional area as the ring-main cable, and that being so, the sectional area would be out of all proportion to the prospective load. Under these circumstances the supply authority requires to exhaust every possible economical method of distribution in order to fulfil its obligations and ensure at the same time an adequate return on the capital employed.

The problem is somewhat simplified by running a single extra-high-tension branch service from a switch-house situated on the route of the ring-main cable. By so doing, the cost of a loop-in can be saved; but unless the route length of the service is fairly considerable, this advantage is largely discounted, if not entirely eliminated, by having to equip a switch-house at the point of junction.

The following table gives some indication as to the percentage cost of various methods of delivering a supply of, say, 100 kw. to a point distant, let us assume, one mile from the line of route of a ring-main cable, it being understood that the point of supply is so far removed from any transforming station that a low-tension service line is not considered to be economically practicable:—

(*a*) Cost of looping-in ring-main cable, auxiliary cables, and consumer's substation equipment	100
(*b*) Cost of laying branch cable and auxiliary cables, building and equipping switch-house, and equipping consumer's sub-station	64
(*c*) Cost of laying branch cable and auxiliary cables, link box, and equipping consumer's sub-station	53

* Abstract of Paper read before the Scottish Section of the Institution of Electrical Engineers.

The percentages are calculated for underground cables in each case. In the case of (*a*), overhead transmission is not admissible, as the expense of a double line built in accordance with Board of Trade requirements and accepted modern practice would show to very little advantage compared with underground cables laid in a common trench. Overhead transmission is, however, often quite admissible in the case of (*b*) and (*c*), and if adopted would make the percentage cost of these two methods still more favourable.

These figures show at once the economy in first cost in using branch services controlled from an extra-high-tension link box at the point of junction. The results achieved with these boxes have been so uniformly successful that in the author's opinion the time has now arrived when a description, together with an account of the method of application and operation, should be published for the benefit of those members who may be specially interested.

Specifications and preliminary sketches clearly defining the functions and conditions to be met were submitted in 1907 to the principal manufacturing firms throughout this country. At that time the application of link boxes to 11,000-volt circuits was considered to be so daring that one or two firms declined to tender, and were good enough to give a friendly warning against the dangers underlying such an experiment. Fortunately, however, Messrs. Siemens Bros. submitted a design which clearly fulfilled all the requirements of the case, and which provided, in the author's opinion, a reasonable margin of safety both as to the insulation of the current-carrying parts and as to that most important consideration, the safety of the operator. The design submitted was, subject to a few modifications, the one finally adopted by the power company with which the author is connected.

The general arrangement of the link box is shown in the Paper. Each main and service cable is brought into the box in such a manner as to leave no doubt in the mind of the operator as to its identity. This condition is obviously a very important feature, and is a point frequently overlooked in link-box design.

The link box consists essentially of a rectangular cast-iron box in three portions, so arranged as to facilitate assembling and jointing. The internal fittings consist of a number of porcelain cells, one for each cable core. Details of one of these cells are given in the Paper. Through the bottom of the cell pass two studs, one of which is in metallic contact with a 'bus bar, and the other is directly connected with one of the cores of the cable. To these studs are attached two main contacts, and these again are connected together by means of a removable link. The porcelain cell is of a suitable depth to provide for the link being immersed in oil. Each cell is provided with a glass cover, and in the centre of each link is a screwed hole into which the operating rod is screwed when the removal or insertion of a link is either necessary or desirable. These cells are assembled in groups corresponding to the number of phases, and they are embedded in the box compound with which the greater portion of the cast-iron box is filled.

The complete jointing of one of these boxes occupies too much time to permit of all the work being done at the site. Obviously the ring circuit would require to remain open all the time this work was being carried through, and that being so, the risk has to be taken of another section of the main opening under fault conditions, thus endangering supply to a more or less extensive area. This difficulty is got over most conveniently by jointing into the link box short lengths of cable of the required sectional area. This work can obviously be done either at the power house or at the nearest available depot.

These boxes are not intended to break load, but simply to disconnect a line under pressure. As a matter of fact, in one or two cases of emergency a connection has been both broken and made under load, but the carrying out of this operation demands a cool head and a steady hand, the flash and noise when the circuit is either made or broken under these conditions being considerable.

Special care has in all cases to be taken to eliminate any traces of moisture inside the box, and this is done by means of an exterior vessel containing calcium chloride. This exterior vessel is directly connected with the box by means of a short piece of screwed tubing, so that the chemical can be renewed when required without the necessity of opening the box cover.

It has been found in practice to be quite feasible to take branch services off sections of cable controlled with balanced protective gear. At first sight it might appear that the taking off of such intermediate services would disturb the static balance in the current-transformer secondary circuits. Theoretically this is undoubtedly the case, but when it is borne in mind that in actual practice the relays employed in connection with a balanced protective system are usually set for operating on a fault current of from 60 to 200 amperes, it will at once be apparent that there is an ample margin within which it is possible to give a branch supply without materially impairing the efficiency of the protective system. Nevertheless, it has been found necessary to install a no-volt release at the supply or consumer's end of such service branches, as otherwise the static balance is liable to be disturbed in the event of any sudden fluctuation of voltage, caused, for example, by a fault on the external circuit.

Supplies given off these service branches are subject to the disadvantage that they are liable to temporary interruption if a fault should occur on that portion of the ring main circuit off which the branch is tapped. This is, however, not a serious objection, as it is a simple matter to test out, disconnect the faulty section, and restore supply over the sound portion of the ring-main section. Obviously it is in this connection that the disconnecting links are of special value.

In the Paper two diagrams are given. One of these shows a four-way extra-high-tension link box having two service branches; one service conveys a supply to a brick-works and the other to a bridge-building works. Owing to the gradual growth of the supplies referred to, and also to the general development in the immediate vicinity, it became necessary to supersede the link box with a switch-house equipment.

This example, one of many, shows the adaptability of such a device for development purposes. In this particular case there can be little doubt that had it not been possible to give these two supplies by means of service branches both supplies would have been most difficult to arrange, as the initial revenue from them could not have yielded the company a reasonable return on the capital outlay involved in either looping them on to the ring circuit or supplying them from a fully equipped switch-house built on or near the route of the ring-main cables.

It will be readily understood that in a widely scattered industrial area the field for such applications is fairly extensive. These branches are often extended from time to time for miles, continuing from one point of supply to another, until in the ultimate course of development it is found practicable to reconnect the far end either with another similar branch or with another point on the ring circuit, the branch ultimately becoming part of a subsidiary ring. The original box is then withdrawn and a switch-house substituted in its place. It is quite clear that, with development carried out in such a manner, it is possible to make each extension on a minimum of capital outlay, the supply network by a process of steady growth being extended over a wider area to the mutual advantage of the industrial community and the supply authority.

A duplicate service implies complicated switchgear arrangements and the introduction of parts liable to go wrong or cause trouble. The introduction of balanced protective systems, and indeed all forms of discriminating cutouts, may be regarded as an eloquent commentary on the fallibility of electrical equipments and as an expression of the desire of engineers to obtain greater reliability. One of the chief sources of reliability is simplicity, and the author is a confessed advocate of the single-branch service as the most direct method of securing reasonable freedom from failure for all classes of supplies, except those the magnitude or importance of which makes inclusion on a ring-circuit imperative. All such service branches should, in every case, be laid complete with the necessary auxiliary cables for a telephone service and pilot wires, so as to permit of the steady development of the branch in the direction already indicated.

In connection with the present European crisis, sundry war service supplies have been given from these link boxes, this course being dictated by the extreme urgency of the demand and the difficulty in obtaining deliveries of switchgear owing to manufacturers' work coming under Government control for the manufacture of munitions. These services have been maintained under the most onerous conditions without the slightest interruption, and have proved themselves to be entirely satisfactory from every point of view.

A demand sometimes arises for small lighting and power supplies for farms or residential property along the route of overhead transmission lines. There is a growing tendency to make the granting of wayleave facilities, especially through residential estates, conditional upon the giving of a lighting supply to the owner's house. Where such a condition has been imposed it can be very readily met in the case of a low-tension transmission line, but in the case of an extra-high-tension the solution is not so simple. The author has met the difficulty by using small pole-type transformers.

DISCUSSION.

Mr. R. B. Mitchell (Glasgow) said that where the revenue accruing did not warrant considerable capital expenditure the junction boxes described in the Paper were very useful. Proper precautions should be taken to render easy the identification of individual cables and 'bus-bar contacts. He had not found assembling in the workshop a great success, and in congested city areas it was difficult to assemble near the actual job. Facilities should be provided for earthing the cable at the box. He

showed a simple device which enabled the earth connection to be made in the box. By substituting for the lid of each cell a porcelain lid with a fitting attached contact was made with the cable terminal contact, the fitting being connected on the outside of the lid by length of insulating conductor to an earthing stud on the side of the box. He did not think that calcium chloride was necessary in ordinary conditions. He had experienced trouble through the glass lid of the box breaking, due to temperature changes, and he suggested the substitution of a porcelain lid. The surges which took place in the system rendered necessary the fitting of a no-volt release.

Mr. W. Nairn (Glasgow) said he had anticipated five years ago that these boxes would give a good deal of trouble, but not a single failure had occurred, which said much for the design of the box. The 3 kw. pole-transformer was an innovation in this country of more than passing interest, as they facilitated the taking of extra high-tension transmission lines through agricultural districts.

Mr. D. A. Starr (Glasgow) said that Mr. Macleod did not seem to have that complete confidence in the transformers which one found in Canada. He (the speaker) had seen many of these transformers erected on poles in Canada without any cover or protective housing.

Mr. W. B. Hird (Glasgow) said it struck him as wonderful that any one should attempt to link up services inside a box containing cables carrying 11,000 to 20,000 volts, and the covering used to protect the transformers in this country might be due to our climatic conditions.

Mr. J. K. Stothert recalled some of his early experiences with single-phase transformers working at 2,500 volts. They overcame their difficulties due to damp by using calcium chloride. They had, however, many other difficulties which the Paper showed had since been successfully tackled.

Mr. A. P. Robertson (Glasgow) asked if drying out with a vacuum, as was done with telephone cables, would not get over the need for using calcium chloride.

Mr. Granger (Glasgow) asked what precautions were taken to keep the pits containing the transformers free from flooding.

Mr. R. Allan Brown (Falkirk) said he would like to know the size of the pit. Where cables ran down narrow streets with pavements 5 ft. or 6 ft. wide he did not think it possible to put a box under the pavement. He had found it necessary to run a high-tension branch off into a switch house.

Mr. H. T. Burton (Glasgow) said the development of the high-tension service lies in the overhead link when the inconsistencies of wayleave laws shall have been removed by fresh legislation. He had supervised the erection of a 6,000-volt 50 k.v.a. transformer in the south, mounted on a pole without any protection. Mr. Macleod's views from his long experience would have been interesting as to high-tension services on the Merz-Hunter system.

Mr. Macleod, in reply, said it would be easy to alter the design of the box to suit 20,000 volts. He thought the absence of a protective cover might tempt the passing small boy. The size of the protecting frame was 4 ft. square, the box chamber being flush with the outside frame, and the depth 16 in. to 18 in. He thought Merz-Hunter protection as regards insulators was likely to cause more trouble than it prevented, so far as overhead construction is concerned.

Mr. Hampton proposed a vote of thanks to Mr. Macleod, and said that as representing a company which had services from the Clyde Valley Co. all over their area he could not remember any occasion when they had a total breakdown or when they were entirely minus supply, which spoke well for the way in which the company's distribution system was carried out.

SIR J. J. THOMSON ON RADIATION FROM ATOMS AND ELECTRONS.

(*Concluded from page* 90.)

Leaving this subject, Sir Joseph turned to the Zeeman effect for the purpose of ascertaining whether the vibrating particle was an electron or a particle of greater mass. By electron, Prof. Thomson remarked, he understood not a free electron but an electron associated with an atom; spectroscopic effects due to free electrons had never been observed, and with the enormous velocities of electrons enormous displacements should indeed result. Faraday had been able to demonstrate the rotation of the plane of polarisation by the magnetic field, but not any direct effect on the light of a sodium flame, *e.g.* Zeeman produced sparks between the poles of strong magnets and then found that the lines of the respective metal were broken up; it was at first thought that each line gave rise to a triplet (one in the position of the old line, two others symmetrically right and left of it), but the resolutions were found to be complex and of various types. The particles upon which the effect depended were very small; but particles smaller than atoms had been unknown at the time, and the effect had, therefore, been greater than had been expected. To demonstrate the effect of the magnetic field, Prof. Thomson approached a magnet to the straight beam of kathode particles issuing from a Wehnelt kathode; the beam was deflected and turned into a circle and a spiral when twisted back to the origin. In this spiral the particles were spinning round the magnetic axis, and as the period of one rotation depended only upon He/m (H=field intensity, e=charge, and m=mass of particle), the particles travelled rapidly in a wide spiral and slowly in a narrow spiral (of small radius), the period being always the same in a uniform field. Now, imagine an atom to be an intrinsic magnetic system with a radial magnetic axis. An electron falling into an atom would spin about that axis at the speed He/m; when an additional field, H_0, was applied, the rate would be $(H \pm H_0)e/m$, according as the direction of the second field superimposed was the same or the opposite of the first, and the speed of the electron would be greater or smaller in the ratio $(H \pm H_0)/H$ When the second field was at right angles to the first, the H_0 would have no effect at all; when at an angle θ, the cos θ would come in. This view made it possible to account for the great variety of types and effects of different magnitudes observed in the Zeeman resolution, if we imagined the atom to have several magnetic axes somewhat as it had several crystallographic axes. Thus, hydrogen and helium lines gave triplets; in sodium, groups of five and of four components were observed; mercury lines resolved into groups of three, six, nine components; neon showed a very complex resolution; one iron line was not broken up at all, others gave quintets, &c. The general rule was that all lines belonging to the same spectrum series were resolved in the same way, but lines of different series yielded different resolutions; banded spectra were not resolved; most of the lines of secondary spectra, at any rate, had not been broken up. The resolution effects could only be ascribed to electrons, not to atoms, which were too heavy.

The Zeeman effect, Prof. Thomson proceeded, could not be demonstrated to an audience, but the rotation of the plane of polarisation was shown. A sodium flame was burning between the poles of a strong electromagnet; outside these poles were the two nicols, beyond them, on the one side, the lanterns, on the other the screen. The white light from the lantern, shining through the sodium flame, produced a bright spot which became dark when the nicol was turned; when the field was excited, the spot was visible again. The effect would have been more marked if the lantern had itself given sodium light. The analogy of the deflection of the electron, at right angles both to the field and to the direction of its motion, was exemplified with the aid of a model, a gyrostat (resembling a wheel with its vertical axle) suspended by a string. This model was made to spin like a conical pendulum. First, the gyrostat was at rest. Then the wheel was spun; the pendulum motion of the system was accelerated (when the pendulum and the gyrostat movements were in the same direction) or retarded.

Up till a few years ago, Prof. Thomson concluded, the resolution of spectrum lines had only been accomplished by magnetic forces; quite recently Stark had also succeeded with strong electric fields. For this purpose Stark had placed behind the perforated kathode a perforated plate, which he charged electrostatically so as to produce a potential gradient of 1,700 volts per millimetre between the two plates. Then the lines of hydrogen and helium were split up, somewhat as in the Zeeman effect. The peculiarity, however, was that the effects were not symmetrical and very irregular. Of the three components of a triplet, for instance, the central one was not in the original position; all the components might be on the one or on the other side of the original line, or there might be no components at all.

Continuing this subject in his last lecture, Sir Joseph showed slides by Stark, on which spectrum lines were resolved into components (sometimes into double sets of components) by electric fields of 28,500 volts per centimetre. The hydrogen line H_α gave three, H_β four components, H_δ became very complicated; the helium line D_3 was unaffected, other helium lines were resolved into two, three or four (double sets) components. In lithium, again, one line remained unchanged, others gave two, three or four components. It was noteworthy that this resolution was not uniform for the various lines of an element belonging to the same Balmer series. This effect seemed to be responsible for the great broadening of certain lines under certain conditions. Thus, when the electric discharge passed through hydrogen, many charged ions would be formed in whose neighbourhood strong electric fields would be set up; but these fields would not be uniform nor constant, and different broadenings corresponding to different degrees of resolution would result. The banded spectra might be accounted for in this way. Yet this view was not quite clear, and a further consideration of the intrinsic magnetic field in an atom (previously referred to) might prove useful. The lecturer had said that the electrons would spin round the magnetic axis, and anything altering the field would alter the rate at which they were spinning and the position of the spectrum line. The movement of the electron was itself responsible for the field. When the path of the electron was a circle, the magnetic field would be that produced by a current flowing in this circle, and would have a moment of momentum $=\pi a^2 v$, where v was the velocity of the electron and a the radius of the circle. If this moment were altered, the magnetic field and the position of the line would be altered. Now

imagine an electric system, a dipole, analogous to the magnetic system, in the atom. Lines of force would issue from that dipole axis, and an electron coming in would assume a certain equilibrium position in that field, and would revolve round the axis (to which it would be attracted), creating a magnetic field by its revolution. If, now, an external electric field were applied, the balance position and the moment of that electron would be altered, the magnetic field thus be changed and the spectrum line be shifted. It had also been suggested to ascribe the radiations to the movements of the electrons in their regular orbits; but there was a great difficulty about that. When an electron radiated it lost energy; its field intensity would then diminish, and the orbit, depending upon the field, should become smaller. On that view it would be very difficult to understand the constancy of the lines; on the other hand, there could be no light without radiation. For that reason the steady movements of the electron did not explain the phenomena.

Leaving these arguments, Sir Joseph passed to the question of the constitution of the energy in the light, which was attracting more and more attention. Newton had regarded light as consisting of small corpuscles moving at great speeds; his light was molecular in structure, and there was a definite unit of light, and no fraction of the unit. The undulatory theory regarded the light energy as being a perfectly continuous quantity, without subdivision. The latter theory had been so enormously successful that it had been thought the only one; yet if the electromagnetic theory had been developed in Newton's days, Newton might have conquered. What was known now of effects of electricity on light called for a way of uniting the two theories, and the lecturer would try to indicate how that might be done. He would first demonstrate the molecular structure of light, though that really required quantitative, and not merely qualitative, proof. When ultra-violet light fell on a metal, the metal emitted electrons at a considerable measurable speed. That velocity did not depend upon the intensity of the light. The rule was not: the more energy, the greater the speed, as it should apparently be on the undulatory theory. As long as the quality of the exciting light remained unchanged, the intensity (which would be great near the plate, and small yards away) did not matter; the energy and speed of a particle depended only on hn, where h was Planck's universal constant and n the frequency. A metal plate was exposed to the lantern beam and connected with a Zeleny electroscope. When the plate and electroscope were charged negatively, a loss of charge was indicated by the electroscope; when the charge was positive there was no loss, because the positive charge bound the electrons which would have been liberated, and it could be shown that the amount of positive charge required entirely to stop the leakage did not depend upon the intensity of the beam, nor (subject to certain corrections) upon the material (metal) struck; but it did depend upon the frequency. Now, on the Newton theory, that was to be expected: more light of the same quality would hit off more corpuscles, but all at the same speed. In another demonstration ultra-violet light fell on a quartz flask containing some mercury vapour. The flask was held horizontally, and the beam passed through the bottom of the flask up into the neck, in which two strip electrodes (bent to form a kind of open horseshoe) were inserted. Here the effect depended upon rendering the vapour conductive by light of a definite wave-length (not above a certain λ), and the effect set in suddenly with light of that λ. Interposition of a sheet of glass stopped the effect. In Newton's theory, again, the corpuscles would knock the electrons out, but many corpuscles of red light would be unable to produce the effect of a few electrons of ultra-violet light.

This latter effect, ionisation of a gas, was more strikingly produced by Röntgen rays, and the laws of this X-ray effect were very simple: Let the rays be absorbed, then determine the number of conducting particles. According to the early experiments, that number had been considered as being independent of the nature of the gas, and explanations had been given (also by the lecturer) on that basis; but that was true in a certain sense only (Barkla). The ionisation was due, not directly to the X-rays, but to the electrons which they liberated from the gas molecules, and—provided the bundle of X-rays were completely absorbed—the number of electrons was indeed independent of the nature of the gas (whether that be hydrogen or heavy mercury vapour), and depended only upon the energy of the beam. For every ray unit which disappeared an electron made its appearance. That fact proved the molecular structure of Röntgen rays just as convincingly as the law of electrolysis, that a certain quantity of electricity liberated electrochemical equivalents of the elements, proved the existence of atoms of electricity. A mechanical model might help us to form a picture of these relations. Imagine a Röntgen ray as a tube (ring) of electric force, considered positive in the direction of the arrow; and, further, a straight tube of force joining the positive and negative charges of a neutral atom. When the two systems approached one another, the two tubes would swell towards one another (as indicated in Fig. 7); they would then break up and unite (in the manner indicated by the dotted lines). If the force in the ring were stronger than that in the atom, the negative particle of the latter would be pulled out by the tension in the ring and shoot up. The Röntgen ray would cease to exist as such, but the negative particle would appear as a kathode particle, which, coming back, could produce a Röntgen ray.

Such a ray unit could take the place of Newton's corpuscle of light, and these considerations could explain the electrical phenomena; but they failed when we came to deal with optical phenomena and interference. Interference required a regular sequence of units extending over thousands of periods. All the units seemed to be independent of one another, and yet they had to act in perfect unison. How was this regularity to be understood? The regularity, Sir Joseph thought, was forced upon the units by the medium through which they passed; only those units got through which showed that regularity. In this connection a statement, often ignored, made by Stokes in the early days of Röntgen rays, should be borne in mind: There would be no refraction unless the vibration

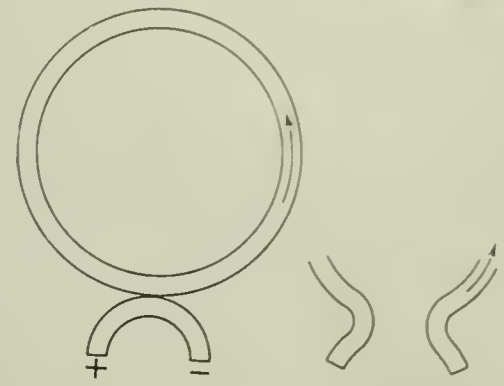


Fig. 7.

continued for a certain period; the atoms had first in some way to be made to swing in time before refraction could occur. Supposing we had a molecule of a refracting substance whose electrons and field were disturbed by the arrival of a light unit. When a second light unit arrived the direction of the first and second fields might instantaneously be the same or the opposite. The energy flow was always at right angles both to the electric and the magnetic forces (according to the corkscrew rule). If that flow were in the original direction, it would pass through; if not, and if the first field were stronger, the new unit would be repelled, and either be reflected or travel to and fro, as the opposing force diminished, until it fell in step. Only those particles could pass through which were in step, and they would show the optical regularity we observed, the regularity being forced upon them by the medium, not by the source.

Those who had read Newton's "Optics" would remember his speaking of "fits of easy reflection" and "of easy refraction," phrases which had called forth much cheap satire as to artificial and arbitrary arguments. But, Prof. Thomson thought, from the electromagnetic theory those fits were corollary to the conception of energy trans-

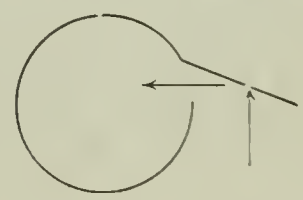


Fig. 8.

mission in the electromagnetic field. Energy meeting energy in the same direction would be in the fit to flow, energy of the opposite direction would be in the fit of easy reflection, and these fits were not a bad way of expressing the phenomena of transmission. The medium imposed the regularity on the units which enabled them to pass, and in some such way the corpuscular theory might be combined with the undulatory theory.

Sir Joseph finally repeated an experiment which he had performed the previous afternoon when discoursing (in the same place) on "Genesis and Absorption of X-Rays." In order to illustrate that soft rays could not give rise to kathode rays of sufficient energy to ionise a gas, but hard rays could, he speeded up a Coolidge tube. The rays fell on a copper plate hinged to a vessel containing some gas. The direct rays could not enter, but the induced kathode rays could find their way in (Fig. 8). The ionisation was shown with the aid of a Zeleny electroscope.

Mr. Everett, Sir J. J. Thomson's Cambridge assistant, was in charge of the demonstrations.

Erratum.—In our issue of April 21, first column of page 89, 18 lines from the bottom, *read:* "Now in the discharge tubes the particles of the gas . . . were moving at speeds of 10 or 100 million cm./sec." *instead of:* "10 or 100 cm./sec."

The Electrician.

The Oldest Weekly Electrical Journal (established weekly 1861—1878).

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*

Advertisement Rates, &c., forwarded on application to the Publisher.

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by Wednesday. Renewals of expiring Advertisements, alterations to standing Advertisements and Wrapper Advertisements by Tuesday evening.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **12.30 P.M. THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRICAL MEASURING INSTRUMENTS: THEIR DESIGN, CONSTRUCTION AND APPLICATION. By C. V. Drysdale, D.Sc., and A. C. Jolley *In preparation.*

ELECTRIC LIFTS AND HOISTS. By Gilbert Rowe, M.I.E.E., &c. *In preparation.*

ELECTRIC BLASTING APPARATUS AND EXPLOSIVES : With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.

THE SHOT-FIRER'S GUIDE : A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.

THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.

THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*

BOILER FEED WATER. By F. A. Anderson. Price 6s. nett.

LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.

SECONDARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.

THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.

INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903). Full Report of Proceedings at, 8s. 6d. ; post free, 8s. 9d. ; abroad, 9s.

INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.

BRAKES FOR TRAMWAY CARS. By H. M. Sayers. Price 2s. 6d. nett.

ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.

ELECTRICITY IN HORTICULTURE. By Prof. S. Lemström. Illustrated. 3s. 6d. nett.

RADIO-ACTIVITY : AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M.A. Price 4s. nett.

MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by C. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.

PRACTICAL NOTES FOR ELECTRICAL STUDENTS. By A. E. Kennelly & H. D. Wilkinson. Price 4s. 6d.

A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Gelpel and H. M. Kilgour. Price 7s. 6d. nett.

THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.

ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.

THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. C. Bond, M.I.E.E. Price 2s. 6d. nett.

CARBON MAKING FOR ALL ELECTRICAL PURPOSES. By Francis Jehl Price 10s. 6d.

"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Down, Wh.Ex., A.M.I.Mech.E. Price 2s. 6d. nett.

Further portions of this list of "THE ELECTRICIAN" SERIES OF BOOKS appear each week

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM): A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d each, post free. Hanging Cards : 8d. each post free. Pocket Books, complete in envelope, 2s. 6d., post free.

"THE ELECTRICIAN" TABLES OF ELECTRICITY SUPPLY.

These important Tables and Data relating to Electricity Supply in the United Kingdom in 1916 (which have been published annually since 1887) are now obtainable, price 3s. net, post free 3s. 3d.

The Tables of Colonial (and certain Foreign) Electricity Supply, Power and Traction Stations are also obtainable, price 2s. 6d. net., post free 2s. 9d.

The two sets of Tables are supplied, price 5s. net., post free 5s. 4d.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

"ELECTRICIAN" VOLUMES AND BACK NUMBERS.

A very limited number of Back Volumes and Back Numbers of THE ELECTRICIAN are available. The difficulty of making up complete sets of ELECTRICIAN Volumes is increasingly great ; it is advisable, therefore, that early application should be made for these volumes and numbers. Particulars on application.

A set of ELECTRICIAN Volumes (First Series) for the period November 9, 1861, to May 28, 1864, can also be supplied. These Vols. are scarce.

SPECIAL NOTICE.

In order that we may be able to supply the newspaper trade effectively and meet the requirements of the Post Office, we are sending THE ELECTRICIAN to press a few hours earlier every week. All editorial and news matter for the next current issue of THE ELECTRICIAN must reach us as much earlier as possible, but not later than WEDNESDAY MORNING, and advertisement text and blocks must reach the offices as much earlier as possible, but not later than TUESDAY EVENING, during the continuance of the War. Displayed Advertisements not for proof before first insertion can be taken until NOON ON WEDNESDAY, and Official Announcements, Auctions and "Smalls" of all kinds of which no proofs are required before insertion can be accepted up to FIRST POST THURSDAY MORNING.

AN EXTRAORDINARY BILL.

In the American Congress recently a Bill was introduced, which the "Engineering Magazine," in calling for prompt action, describes as "a bill prohibiting the most enlightened wage systems ever yet devised by man."

The purpose of the Bill is to make it unlawful for any officer, manager, superintendent, foreman or other person having charge of the work of any employé of the United States Government to make or cause to be made with a stop-watch or other time-measuring device a time study of any job of any such employé between the starting and completion thereof, or of the movements of any such employé while engaged upon such work. Furthermore, without regard to the true interests either of employer or employé, in the text of the Bill it is stated that no premiums or bonus or cash reward shall be paid to any employé in addition in his regular wages, except for suggestions resulting to improvement or economy in the operation of any Government plant.

Violations of the provisions of this Act shall be deemed a misdemeanour, and shall be punished by fine or by imprisonment. The preceding section is dear to the heart of the lawyer, who usually gives one the idea that the section setting out the pains and penalties for breaking the law is an afterthought. Were it our business to make laws we should endeavour to arrest the attention of the reader and to arouse his interest by using clarendon type for this section, and by putting it before the preamble. Our legislators are too lenient with us. Every day it is becoming more apparent that neither fines nor imprisonment deter those who are so minded from breaking the law, and it is patent to most thinking people that sooner or later we shall have to punish the law-breaker by banishing him.

This extraordinary Bill must dismay many Americans whose names and good works are as well known in this

country as in the United States. It is common knowledge that for over a quarter of a century the "Engineering Magazine" has laboured incessantly in furthering the progress of the science of management. We would go so far as to state that it is due mainly to the unceasing efforts of our contemporary that there is such a science, and the complete record of the science, drawn from the world's factories and workshops, is to be found in its columns.

We are at a loss to discover the true motive behind the Bill for which Mr. TAVENNER stands sponsor. The feeling is that it is a sinister one, and by some it is thought that the move contemplates the inclusion of all Government contractors. In commenting editorially on this proposed dangerous labour legislation, which, in some respects, is not unlike some of our worst legislation, our contemporary states that "the necessity for exposing and blocking this legislation is so manifest that a committee, representing leading engineering societies, the National Association of Manufacturers, the National Metal Trades Association, and many local chambers of commerce, has been appointed to take active steps in opposition," and continues, "If public hearings be granted, any needful number of workers under the bonus and premium plans will appear before the Local Committee of the House to give personal testimony to their satisfaction with the new system of wage payments."

In these pages we have constantly urged that employés should be fully represented on such committees, for, no matter how good the intentions may be, neither capital nor labour can fully consider both sides of the question. The proposed legislation, if put into execution, is likely to have such a profound effect in retarding industrial development that both employer and employé can, for the time being, afford to sink their little differences in order to be in a position to speak with no uncertain voice to those whose desire it appears to be to put back the clock for 30 years and who would have us revert to the barbaric conditions which characterised employment a quarter of a century ago. For this reason we think it would strengthen the committee to seek the close co-operation of labour.

Had we the least doubt as to there not being sufficient work to go round to find employment for all, we should think little of this attempt to eliminate scientific management from American workshops. Rather should we be inclined to congratulate our manufacturers on the short-sightedness of their competitors in giving to them all the advantages to be derived from the application of the science.

Striking testimony as to its worth was given to us recently by an engineer of the old school who owns a works giving employment to about 500 hands, and engaged upon two lines, one of which is highly standardised and the other partly so. For the last 10 years it appears that every effort has been made by the young and progressive works manager to introduce what our friend called "system" into the works and offices, and we were told that the results were "simply amazing." An inspection of several of the balance-sheets proved the truth of this, and an hour's examination of the system in use showed us that what they were doing in reality was equivalent to forming simple words from the initial letters of the alphabet. Nevertheless, the results were amazing. One can well imagine the nature of the results that will be obtained when our engineers and factory owners can think in the language of which the alphabet, which they are now learning, is the beginning.

The subject is such an important one to our manufacturers, and such a vitally important one to our artisans, that we urge them, both employer and employé, to sink their trifling differences and to co-operate with a view to deriving, to the full, the benefits which scientific management offers. We venture to think that by so doing, the differences, which in the past have strained the relations between the two to the point of rupture, will be forgotten.

REVIEWS.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free, on receipt of published price, adding 3d. for books published under 5s. Add 10 per cent. for abroad or for foreign books.]

Experimental Wireless Stations: Their Theory, Design, Construction and Operation. By P. E. EDELMAN. (Minneapolis: Published by the Author.) Pp. 272. $1.5.

As to the usefulness of this book, which is now in its third edition, there can be no question. Many readers, who are not interested in the sections dealing with details of apparatus, will find invaluable the very complete list of U.S. patents on wireless telegraphy, telephony and control which is given at the end of the book. In this list, patents from 1881 to the beginning of 1916 are included, and the classification of the patents into 60 or more groups is decidedly good.

A review of the first edition appeared in THE ELECTRICIAN a little more than two years ago. To the present edition a supplement has been added with the object of bringing the book well up-to-date. The notes cover a wide field and are illustrated by means of line diagrams. Those desirous of making their own stations will find plenty of designs from which to make a choice, and for the most part the manufacture of the apparatus is well within the capabilities of anyone familiar with the use of ordinary tools and workshop processes. The author, very properly, leaves much of the detail to be filled in by the reader.

There are three statements in the preface to which we take exception. These are: (*a*) The earnest experimenter is separated from the wireless engineer . . . . . by a very small space of time and application to study; (*b*) wireless to-day offers opportunities which are perhaps not exceeded by any other art or trade; and (*c*) the remuneration is limited only by the capabilities and temperament of the individual and the circumstances concerned. These have nothing to do with the book, but parents reading them, along with accounts of the "wonders of wireless" in the non-technical press, might draw wrong conclusions from them. The facts are: (*a*) Between the earnest experimenter and wireless engineer there is a great gulf fixed as there is between the earnest private and general; (*b*) the opportunities in wireless are no greater than those in a hundred trades and professions; and (*c*) the remuneration of the leaders in wireless work is to-day comparatively small, and those who are not leaders but merely operators get paid what they are worth, which means that they can only command a wage well below that of the engineering artisan. Theirs also is a blind-alley occupation from which but few escape.

Elements of Heat-Power Engineering. By C. F. HIRSHFELD and W. N. BARNARD. (London: Chapman & Hall.) Pp. xvi.+815. 21s. net.

Of things mechanical probably the steam engine is the one that has had the most profound effect on mankind, and the study of the steam engine is an education in itself. Till comparatively recently it was customary for authors to give titles such as "The Steam Engine," or "The Steam Engine and Other Heat Engines" to their books. Nowadays, on account of the steam turbine, it is necessary to use "Steam Power," or "Heat-Power Engineering" for the title page. We would not have it otherwise, but before the steam engine disappears and before those responsible for the design, construction and operation of our big engines go to their rest we should like to see published a work entitled "The Philosophy of the Steam Engine." The authors and publishers of such a work would earn the gratitude of many engineers.

To the engineer an intimate knowledge of the steam engine is indispensable, for there is probably more of the theory and

practice of engineering in a steam engine than in anything else. In all likelihood 2,000 years hence engineering students will study the steam engine in order to account for facts in engineering that have been handed down since the nineteenth century, just as in our time the lawyer studies Latin in order to understand Roman law.

The book under review is the second edition of a work that was published about four years ago. Written by professors of engineering at Sibley College, Cornell University, it is intended primarily for students in mechanical engineering in their junior and senior years, after they have completed courses in physics, chemistry, mechanics, mathematics and machine design. The authors have attempted to include in a single volume not only the elementary thermodynamic theory of gases and vapours and their cycles, but also the consideration of the sources of heat, the methods of making it available for useful purposes, its utilisation in the various types of heat engines and their auxiliary apparatus, together with a discussion of the fundamental theory, the ideal and actual performance and the practical considerations connected with such apparatus.

Since the appearance of the first edition Prof. Ellenwood has published valuable and extensive steam charts, which are said to have a much wider field of application and greater accuracy than have the Mollier charts. A discussion of these important new charts appears in the present edition, and as an appendix is given a two-page Ellenwood chart which has been redrawn from the original. This great work of more than 800 pages, containing 180 well-drawn illustrations and 12 chapters, as well as problems, appendixes and tables, will deservedly rank high in the literature on the subject. The book can be unreservedly recommended to all those who are interested in any of the several branches of heat-power engineering, either as students or practitioners.

Machine Design. By A. W. Smith and G. H. Marx. (London: Chapman & Hall.) Pp. xii. + 500. 12s. 6d. net.

It is not unlikely that in course of time this book will be looked upon by engineers in the United States as our engineers look upon "Unwin"—a book which, in all probability, has, at some time or other, been used by practically every draughtsman in this country.

The book under review first appeared in 1905, and is now in its fourth edition. This, of itself, is sufficient recommendation. The authors assume a knowledge of pure and applied mathematics and endeavour simply to give principles that underlie all machine design, as well as to suggest methods of reasoning which may be helpful in the designing of any machine. Those who require something more than a book from which to copy other people's drawings, and mistakes, will in all likelihood find in this book, which is innocent of working drawings, much that is useful and original.

AN UNUSUAL FOUNDATION FOR A TURBO-ALTERNATOR.*

BY G. L. KNIGHT.

In providing for the installation of a 22,000 kw. turbo-generator at the Gold-street generating station of the Edison Electric Illuminating Co., of Brooklyn, N.Y., some very unusual conditions and difficulties were encountered which called for exceptional methods in overcoming them. The turbine is the last of six units in the station.

In 1911, when the adjacent 12,000 kw. vertical unit was installed, it was intended to make the next machine a duplicate, and to install it during the following year, or not later than 1913. In view of this plan, the foundations, below the basement-floor level, together with the connections to the condensing tunnels, were made in 1911. Conditions of load, however, made it unnecessary to purchase additional capacity until 1914. In the meantime steam-turbine design had undergone rapid changes, due principally to the increase in rotative speeds, which resulted in greater economy in steam consumption per kilowatt-hour, and decreased cost per kilowatt of the entire unit.

* From "Engineering News," slightly abbreviated.

It thus became possible to purchase a 22,000 kw. turbo-generator, at 1,500 revs. per min., the steam consumption of which was 12½ lb. per kilowatt-hour, in place of the 12,000 kw. vertical unit previously planned, which would have had a steam consumption of 15½ lb. per kilowatt-hour at 750 revs. per min. In short, the capacity of the unit was nearly doubled, the efficiency increased 20 per cent. and the cost per kilowatt decreased by about 30 per cent. At the same time the machine would fit into just the space required for the smaller unit. The principal dimensions of the new turbo-generator are: Length overall, 45 ft.; width overall, 19 ft. 2 in.; weight of turbine, 241,000 lb.; weight of generator, 342,000 lb.; total weight, 583,000 lb.

The turbine required a condenser having 35,000 sq. ft. of surface; the condenser-shell and tubes weighed, empty, 300,000 lb., and when completely filled with water, 618,000 lb. The conditions in the station, with regard to condensing tunnels and adjacent apparatus, with the necessary requirements of accessibility and handling, made it necessary to install the condenser immediately under the steam turbine, with its long dimension parallel to the centre-line of the turbine shaft.

As in the reaction type of turbine the clearances of the blading are very close, it is extremely necessary in planning a foundation for such a unit to make the deflection negligible and to reduce the vibration to a minimum. For this purpose, mass concrete for the foundation

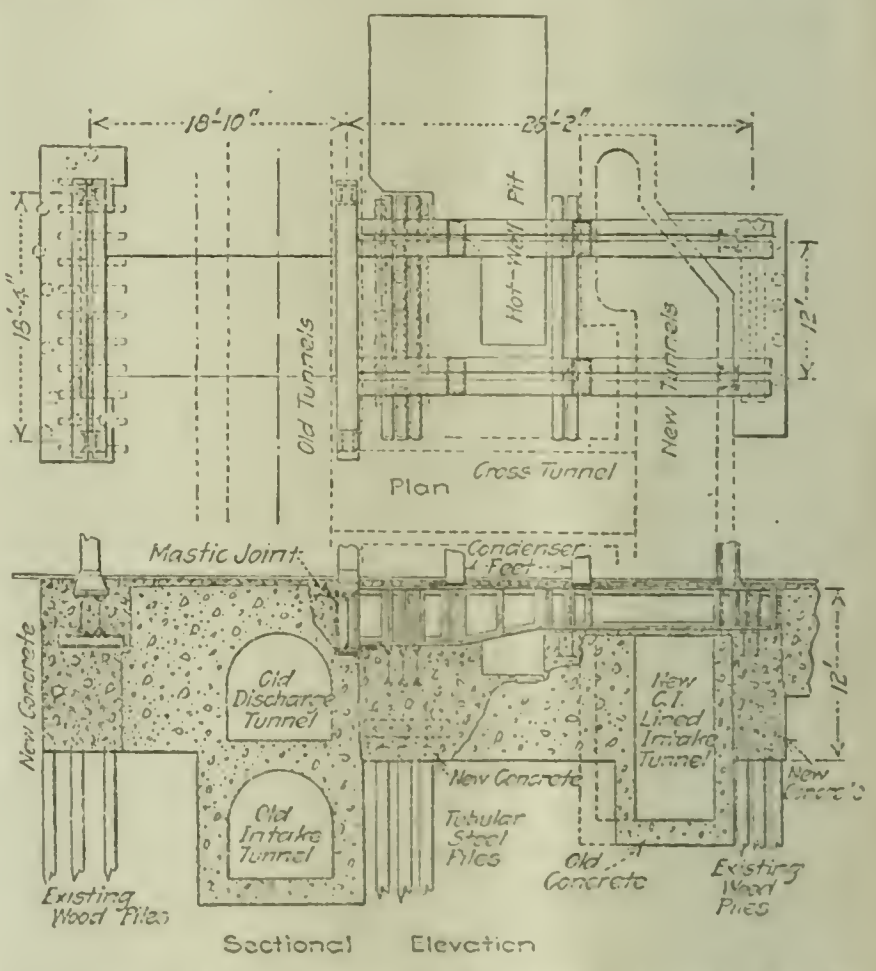


Fig. 1.—Foundation Substructure, showing Cantilever Girders at Right.

would have been best, but on account of the position of the condenser, the height available from the basement floor to the main floor of the turbine room and the clearances necessary, it was found impossible to provide space for a concrete foundation. Structural steel was naturally the next available material, and it was decided to erect a steel platform with very liberal allowances for factor-of-safety.

There are two concrete condensing-water tunnels in the station, both of which pass through the area occupied by new foundation, as shown in Fig. 1. The easterly one consists of a condensing inlet and a discharge tunnel; the other tunnel is for inlet water only, and extends some 24 ft. below the surface of the basement floor, hereafter referred to as datum. In the first case the discharge tunnel is over the inlet tunnel, each of them of horseshoe shape 8 ft. wide by 8 ft. deep. This structure was not strong enough to carry the load of the turbine foundation and machine; it therefore was necessary to build the foundation independent of the tunnel structure.

The westerly tunnel, built in 1912, is of reinforced-concrete construction lined with cast-iron plates. It is on good bottom, so that there was no danger in placing some additional weight on the concrete wall.

Referring to the cross-section, shown in Fig. 1, it will be seen that the structural design adopted consists of a pair of cantilever girders resting on a fulcrum of three girders supported by sectional tubular-steel piles filled with concrete. The cantilever girders carry in turn

the middle columns of the turbine foundation at one end just beyond the fulcrum, and at the other end the two columns under the steam end of the turbine. The same girders support the condenser, as shown in Fig. 1. The columns supporting the outboard end of the generator are entirely independent of the rest of the foundation, because of its being impossible to carry the foundation over the discharge-tunnel structure. In this case it was unnecessary to put in additional substructure, as there were good wooden piles in place; furthermore, the soil was sufficient to carry the load of 1½ tons per square foot, even had the piles not existed.

In constructing the foundation, the first work to be done was to clear away and cut out all the mass concrete previously installed for the foundation. The mixture was 1 : 3 : 5 (gravel).

The method consisted of drilling rows of holes 6 in. apart to the depth desired, using air and steam drills, and then breaking off in shelves with plug and feathers. The concrete, while hard and homogeneous, was very difficult to excavate. Instead of coming away in blocks, it shaled off in 3 in. or 4 in. layers, and in no case were the pieces large. This rendered the progress of the work very slow, and the cost of excavation ran up to an almost prohibitive figure.

When excavation had been carried on sufficiently to permit pile driving, a machine was brought into the building and set up over the work, and driving began.

How the Piles Were Tested.

When about half of the piles had been driven to the refusal stated, or work had been stopped on them on account of obstruction, it was

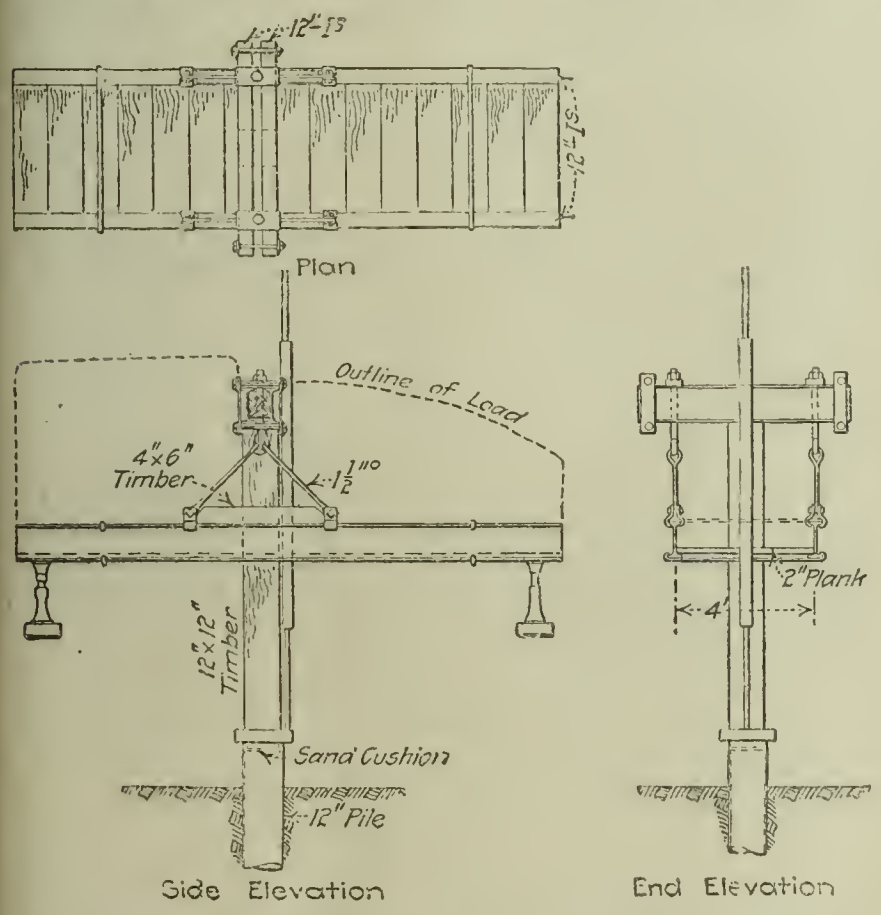


Fig. 2.—General Arrangement of Rig for Testing the Piles.

decided to concrete two piles typical of existing conditions and test them with actual load, so as to be able to judge the necessity of going deeper with the remaining piles

The piles were designed to carry a load of 20 tons each, and it therefore was desired to load them with at least 30 tons, and if no settlement occurred, to continue the loading up to 40 tons. The test rig used is shown in Fig. 2. It will be seen from the drawing that the platform of I-beams on which the load rests is supported on jacks during the loading process. Provision is made to back off the jacks slightly at first for balancing, and afterwards back away with 1 in. or more clearance of the blocking to allow for possible settlement. This precaution prevented accident from any shifting of the load.

Readings were taken with a level on an iron rod resting directly on the pile-cap and protected from the load pigs by an iron pipe through which it passed freely. To the level rod was secured a piece of white paper on which a fine pencil line was drawn at the start of each loading, so that very accurate readings were possible.

Tables given by the author show the results obtained on two of the piles. The loading material consisted of pigs of cast-iron, each weighing about 42 lb. From this point the placing of the piles was completed expeditiously. As soon as placed, they were dredged out with orange-peel buckets and filled with concrete. As the piles when driven contained water to depths varying with the condition of the soil at the bottom of the pile, the concrete had to be placed with a tremie, precaution first being taken to place about a foot of broken stone in the bottom of the pile, and to tamp it well. After filling, each pile was given about five blows of the driver to settle it in place. Concrete was then placed round the pile tops to a depth of about a foot above them, and a double grillage of I beams was placed to distribute the load over the piles. The foundation concrete was then brought up to within 2 in. of the bottom of the cantilever grillage girders, in readiness for the steelwork.

It took just one month to place the 23 piles, working 24 hours a day and seven days a week.

For the foundation for the end columns, on both the east and the west ends, the concrete was placed on a bed of broken stone, which had been tamped solidly to a depth of 1 ft. In one operation the concrete was brought up to a level of 1 in. below the bottom of the grillage beams. The structural steelwork presented no unusual difficulties.

ON A GENERAL BRIDGE METHOD FOR COMPARING THE MUTUAL-INDUCTANCE BETWEEN TWO COILS WITH THE SELF-INDUCTANCE OF ONE OF THEM.*

BY CHARLES H. LEES, D.SC., F.R.S.

To get rid of the waste of time in balancing, the author has introduced into his laboratory the bridge arrangement shown in Fig. 3, which allows an induction balance to be obtained with the ratio arms used in the steady balance whatever may be the relation between the inductances of the coils. If, further, the routine given below be followed no waste observations are made.

In Maxwell's form of bridge, Fig. 1, after the balance for steady current has been obtained, the shunting resistance T is adjusted till there is no throw of the galvanometer on making or breaking the cell circuit. With the resistances and inductances shown in the figure we then have

$$L/M = -\{1 + P/Q + (Q-S)/T\}.$$

This is a continuous induction balance; that is, it holds however the E.M.F. applied to the bridge is varied.

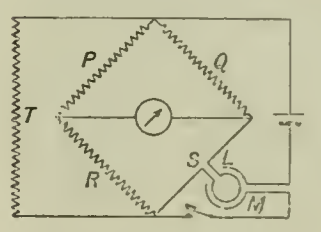


Fig. 1.
Maxwell.

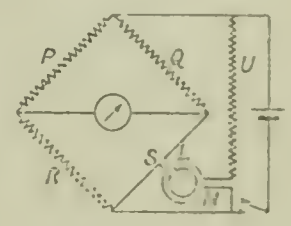


Fig. 2.
Brillouin.

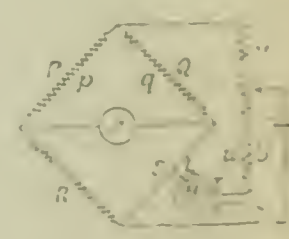


Fig. 3.

From the form of the expression for L/M it is evident that the method is only applicable to cases in which the mutual inductance between the coils is less than about half the self-inductance of the coil in the bridge arm.

To get over this difficulty Brillouin arranged the coils as in Fig. 2. When the bridge is balanced for steady currents the condition for the inductive balance is

$$L/M = -(Q+S)/(T+U).$$

This balance is not a continuous but an aggregate or integral one: that is, the total flow of electricity through the galvanometer from one steady state of distribution of currents in the arms of the bridge to another steady state is zero.

When M is large compared to L it is always possible to get an inductive balance by increasing U whatever values of P and Q have been used in getting the steady balance. But if M is small compared to L no value of U will give an inductive balance unless Q has been taken large enough. In practice this often leads to waste of time.

With the connections as shown in Fig. 3, the resistances P, Q, R, &c., carrying the currents p, q, &c., we have for no current through the galvanometer $r=p$, $s=q$.

$$Pp = Qq, \quad (P+R)p + (Q+S-LD)q = MDu,$$
$$(P+R)p + V(p-q) = (T+U+ND)u - MDq,$$

where $D=d/dt$.

On eliminating q and u from these equations we get for a steady current balance

$$(P+R)/(Q+S) = P/Q, \text{ that is } R/S = P/Q.$$

For an aggregate or integral balance for changes from one steady

* Abstract of Paper read before the Physical Society of London.

state to another we have on introducing the condition for steady balance, $L/M = -\{Q+S+(1+Q/P)V\}/(T+U)$.

The balance, like Brillouin's, is, therefore, an aggregate or integral one, since the condition for continuous balance for all E.M.F. changes is not satisfied.

In practice P and Q are the proportional arms of a Post Office box, and should be of the same order of resistance as that of the coil whose self-inductance is to be compared, but need not be equal. The coil of resistance S is placed in the open arm of the bridge. In boxes in which the galvanometer leads are connected to the ends of P and Q the final adjustments of the third arm R to give a balance for steady currents may be made by inserting between P and R a short length of resistance wire and altering the length till R is increased by the necessary fraction of an ohm. The actual resistance of the wire may be ascertained by taking proportional parts. If the connections of the keys of the box do not allow a wire to be inserted in this place a corresponding short length may be put in series with the coil S and its value calculated by taking deflections in the same way. The second coil should be connected through a second resistance box VU to those terminals of the bridge to which the cell is usually attached, and the cell in the first instance connected to the same two terminals. The steady balance is then obtained by taking out the infinity plug at U, making the cell circuit before the galvanometer circuit, and adjusting R by means of the plugs and the wire till the deflection of the galvanometer is reduced to zero.

The trouble due to drift in R is least when the inductive balance is obtained on breaking the cell circuit rather than on making. The direction and magnitude of the throw of the galvanometer on breaking the cell circuit should be noticed. This direction is that of the self-inductance throw. Now insert the infinity plug in U, so that the mutual-inductance comes into play, and again notice the direction and magnitude of the throw. If the second or composite throw is greater algebraically than the first or self-inductance throw the second or mutual inductance coil must have its connections to the bridge reversed. If the composite is less algebraically than the self-throw the connections are right. If the composite throw is zero we have a direct balance. If the composite throw is of opposite sign to the self throw the resistance U should be increased till the composite throw becomes zero, V being kept zero. This is the Brillouin arrangement. If the composite throw is in the same direction as but less than the self, transfer the cell lead to the U' end of the resistance box, thus making U' zero, and adjust V till the throw is zero. This is the new arrangement. None of these alternatives require the original steady balance to be disturbed, and by following the routine suggested there is no time wasted in useless observations, whatever the quotient of L by M may be.

The following example illustrates the method :—

Inside coil L in bridge arm. P Q =100 ohms. Steady balance with V 0, U ∞. With R=77 deflection 17·7 left, R=76, 16·1 right. Hence, R for balance 76·48 ohms. Wire resistance adjusted to give balance. Induction balance. Throws on breaking cell circuit.

V 0, U ∞, self 25 left ; U 0, composite off scale left. Connections of mutual coil reversed ; composite 4·3 left. Hence U made =0 and V adjusted till with V=22 ohms throw zero. T found 129·7 ohms. Hence L/M 220·48/129·7 1·70. On increasing P and Q to 1,000 ohms it was found that V should be 0 and U=505 ohms for balance (*i.e.*, Brillouin's arrangement). Hence L/M = 1,076/635 = 1·70 as before.

DEPOLARISATION IN LECLANCHE CELLS.*

BY M. DE KAY THOMPSON AND ERNEST C. CROCKER.

Summary.—An investigation is described from which it appears that (1) The carbon and pyrolusite particles should have the same size, and this should be within certain limits ; (2) the purity of the pyrolusite affects the depolarisation materially ; (3) the mixture of carbon and pyrolusite should contain 55 to 60 per cent. pyrolusite ; (4) polarisation by hydrogen is completely prevented by the dioxide, the remaining polarisation is that due to ammonia. This may be largely overcome by the addition of zinc chloride to the solution.

Leclanché recommended that the manganese dioxide should be mixed with carbon and that both should be coarse in size.† This point was investigated, in 1873, by Beetz, who found that the best depolarisation is obtained with the carbon "coarse" and the manganese dioxide "fine."* The exact sizes were not given. On account of the incompleteness of the previously published work, and on account of the fact that the depolarising mixture is made in such different sizes in different makes of Leclanché cells now in use, it was decided to make a study of the comparative efficiency of depolarising mixtures of carbon and manganese dioxide, when the sizes of the particles and the relative amounts of the substances present in the mixture were varied. This was the primary object of the following investigation, although in the course of the work the mechanism of polarisation was also studied, as will be seen below.

Determination of the Best Sizes of Carbon and Pyrolusite Particles.

The experiments for determining the best sizes of carbon and pyrolusite in the depolariser were carried out in cylindrical battery jars 13 cm. high and 11 cm. in diameter. The anodes were sheet-zinc cylinders 10 cm. high and 9 cm. inside diameter, made for "Samson" batteries. The electrolyte was in all cases a 15 per cent. solution of ammonium chloride, to which was added varying amounts of zinc chloride. The cathodes were carbons taken from "Columbia" dry cells. These carbons were thoroughly cleaned and placed in porous Pukal clay cups 14 cm. high and 5·8 c.m outside diameter. The depolarising mixture was then packed, dry, around the carbon by tamping with as much pressure as was considered safe for the porous cups. The method of testing was to connect four cells in series, in each of which only a single factor was varied, and to pass through them a constant current from an external source, measuring at definite intervals the voltage of the cathode against a normal calomel electrode. The circuit was opened momentarily during the measurement to prevent the drop in voltage in the cell from affecting the results. The factors thus studied were (1) size of carbon and pyrolusite particles, (2) relative amounts of carbon and pyrolusite, and (3) purity of pyrolusite.

The carbon used to mix with the pyrolusite consisted of equal parts of gas carbon and Acheson graphite. The pyrolusite used in all experiments, unless otherwise stated, was the 95 per cent. natural product, obtained from Eimer and Amend. The following table gives the analysis of the pyrolusites used after crushing and sizing :

Grade.	Size.	Per cent. MnO_2
95 per cent.	16/30	97·4
95 per cent.	60/120	94·0
85 per cent.	60/120	90·7
Artificial, fine.	—	68·5

In giving sizes of particles, the notation 16/30 means that the particles passed through a sieve with meshes 1/16 in. square, and were held by a sieve with meshes 1/30 in. square. The mixture for the tests on the sizes of particles in the depolariser was 90 grammes of carbon thoroughly mixed with 90 grammes of pyrolusite. Not more than one-third of the theoretical depolarising power of the pyrolusite was used up in any run.

The results of the preliminary tests are given in Table I. The current was kept constant at 0·25 ampere, and the solution contained 15 per cent. of ammonium chloride.

Table I.—*Effect on Polarisation of the Sizes of Pyrolusite and Carbon Particles. Preliminary Tests.*

Size of particles.		Open circuit voltages.		
Carbon.	MnO_2.	Initial.	1 hour.	5 hours.
4/10	8/16	1·48	1·17	1·06
4/10	30/60	1·54	1·12	0·92
4/10	through 126	1·38	1·05	0·78
10/20	8/16	1·49	1·21	1·10
10/20	16/30	1·49	1·22	1·08
10/20	30/60	1·45	1·20	1·06
10/20	through 120	1·29	1·06	0·91
20/40	8/16	1·47	1·23	1·09
20/40	16/30	1·49	1·24	1·09
20/40	30/60	1·46	1·23	1·08
20/40	through 120	1·36	1·07	0·93
40/80	8/16	1·46	1·21	1·08
40/80	16/30	1·47	1·22	1·09
40/80	30/60	1·44	1·21	1·08
40/80	through 120	1·37	1·12	0·98

These results show that the finest pyrolusite gave the poorest depolarisation. Where the pyrolusite and carbon particles were of approximately the same size the depolarisation was best, and became poorer as the sizes differed more and more from each other.

Table II. contains the results of further study of the more favourable mixtures. The results are the average values obtained from two similar cells. The cells were made up in the same way as those used in the preliminary runs, and were allowed to stand 12 hours before

* Abstract of a Paper read before the American Electrochemical Society.

† Wiedemann, "Die Lehre von der Elektrizität," I., 850 (1893).

* *Ibid.*, p. 853.

beginning the run. One quarter of an ampere was passed for an hour, taking open circuit voltages with the normal electrode at the times 0, 15, 30 and 60 minutes. The current was then increased to 0·50 ampere, and the open circuit voltage taken at the end of 15 minutes. The cells then stood on open circuits for 15 minutes. After this rest, 1·5 amperes were passed for 15 minutes, and the open circuit voltage read at the end of this time. The electrolyte was a 15 per cent. solution of ammonium chloride to which 0·7 per cent. zinc chloride was added to give steadiness to the single potential of the zinc electrode.

Table II.—*Effect of Size of Carbon and Pyrolusite on Depolarisation. Final Tests.*

No.	Size of		Open circuit voltage.					
			0·25 ampere.				0·5 amp.	1·5 amp.
	Carbon.	MnO_2.	0 min.	15 min.	30 min.	60 min.	15 min.	15 min.
1	10/20	8/16	1·56	1·41	1·35	1·28	1·21	1·01
2	10/20	16/30	1·57	1·41	1·35	1·27	1·18	0·92
3	4/10	8/16	1·53	1·37	1·31	1·25	1·16	0·87
4	4/10	16/30	1·55	1·31	1·23	1·16	1·01	0·12
5	40/80	30/60	1·53	1·42	1·37	1·29	1·24	1·11
6	20/40	16/30	1·55	1·42	1·36	1·28	1·20	1·07
7	20/40	8/16	1·54	1·39	1·34	1·27	1·19	1·05
8	20/40	30/60	1·53	1·39	1·34	1·27	1·19	1·04
9	40/80	60/120	1·48	1·37	1·32	1·25	1·17	1·04
10	through80	60/120	1·46	1·38	1·34	1·29	1·23	1·10

The results in Table II confirm the results of the preliminary tests. On grinding the pyrolusite and sizing, the largest and smallest sizes differed in purity by 2·4 per cent., but the difference in purity in the sizes 8/16 and 16/30 was only a small part of this, and, therefore, not enough to account for the differences in polarisation observed. The difference must, therefore, be due to the difference in the size of the pyrolusite.

As to the absolute sizes of the particles of the depolarising mixture, there seems to be very little choice between the sizes tested in these experiments. The results indicate that the particles should be smaller in diameter than 1/10 in. (0·25 cm.). Also, the poor depolarisation with pyrolusite smaller than 1/120 in. (or 0·02 cm.) diameter indicates the lower limit. The particles of the depolariser should accordingly be less than 1/10 in. and larger than 1/120 in. in diameter.

Other tests showed that a change in the purity of the pyrolusite of 4 per cent. has a decided effect on the depolarisation.

Table III. shows the effect on depolarisation of varying the relative amounts of carbon and pyrolusite in the depolarising mixture. The electrolyte contained 15 per cent. ammonium chloride and 5 per cent. zinc chloride. The pyrolusite was the 95 per cent. grade. The method of carrying out the experiment remained the same.

Table III.—*Effect of Relative Amounts of Carbon and Pyrolusite on Depolarisation.*

No.	Per cent. MnO_2	Sizes.		Open circuit voltage.					
				0·25 ampere.				0·5 amp.	1·5 amp.
		MnO_2	C.	0 min.	15 min.	30 min.	60 min.	15 min.	15 min.
1	58	16/30	16/30	1·56	1·45	1·40	1·33	1·27	1·07
2	42	16/30	16/30	1·52	1·40	1·35	1·30	1·23	0·96
3	31	16/30	16/30	1·50	1·37	1·33	1·28	1·22	1·01
4	69	16/30	16/30	1·54	1·36	1·32	1·27	1·14	0·04
5	55	30/60	30/60	1·55	1·45	1·40	1·34	1·27	1·14
6	60	16/30	12/20	1·58	1·45	1·40	1·34	1·26	1·03
7	50	16/30	12/20	1·54	1·42	1·37	1·31	1·24	1·00
8	55	16/30	12/20	1·56	1·42	1·37	1·32	1·23	0·95

Experiments 1 to 4 are comparable because the size of the depolariser is the same. Of these the 58 per cent. mixture gave the best depolarisation. In experiments 6 to 8 the 60 per cent. mixture gave the best depolaristaion. These results indicate that the depolariser should contain approximately 60 per cent. of manganese dioxide.

The Cause of Polarisation in Leclanché Cells.

Manganese dioxide is considered a weak depolariser, because when a continuous current of appreciable magnitude is taken from a Leclanché cell there is a steady fall of voltage. It is natural to assume that at least a part of the polarisation is due to the incomplete oxidation of the hydrogen, which may be supposed to form on the decomposition of the ammonium radical and its subsequent splitting up, represented in the equation

$$2NH_4 = 2NH_3 + H_2.$$

It has been found, however, that even with the highest current densities there is no liberation of hydrogen. This was shown by using a large lump of pyrolusite as the positive electrode in a small cell. (Contact was made by wrapping the end not immersed in the ammonium chloride solution with a copper wire.) With a zinc anode this cell gave on open circuit 1·53 volts. A current of 0·25 ampere was passed for 12 minutes without any evolution of hydrogen. The surface of the pyrolusite was 5 sq. cm. in area, so that the current density had the very high value of 0·05 ampere per square centimetre. Furthermore, none of the cells showed any trace of gas bubbles during the tests. It is therefore evident that pyrolusite oxidises one atom of hydrogen in each ammonium radical liberated on its surface, or on the surface of carbon in intimate contact with it, with 100 per cent. efficiency, and that no molecular hydrogen is formed. Whether this oxidation takes place while the hydrogen is still in the ammonium radical or while in the nascent state is an open question.

The cause of polarisation in the Leclanché cell must, therefore, be the other cathode product, the ammonia, or, as is shown below, by the hydroxyl ions resulting from the ammonia. If this be the case, the removal of the ammonia as rapidly as it is produced should prevent polarisation, except in so far as it is the result of the coating up of the pyrolusite. That ammonia reduces the potential of the positive electrode (or causes polarisation) is shown in Table IV., in which are given the voltages of cells of the type

$$Hg \mid HgCl, KCl \mid NH_4Cl, NH_4OH \mid MnO_2, C.$$

(The current tends to flow in the cell from left to right.)

Table IV.—*Effect of Different Concentrations of Ammonia and Ammonium Chloride on the Potential of the Positive Electrode.*

Concentration of NH_4Cl. Per cent.	Concentration of ammonia. Per cent.		
	0	0·5	5
0·1	0·48 volt	0·37 volt	0·22 volt
1·0	0·48 ,,	0·41 ,,	0·35 ,,
10·0	0·48 ,,	0·44 ,,	0·38 ,,
Saturated	0·48 ,,	0·44 ,,	0·39 ,,

The following methods of reducing the hydroxyl-ion concentration may be considered :—

1. Increase of the NH_4 ion concentration, thereby driving back the dissociation of the ammonia.
2. Addition of H ions.
3. Addition of a salt of a weaker base than ammonia : the ammonia would tend to unite with the acid and liberate the weaker base.
4. Addition of a neutral substance to combine with ammonia (NH_3).
5. Addition of a neutral substance to destroy the ammonia.

Table IV. shows that for a given concentration of ammonium chloride an increase in the ammonia concentration lowers the voltage, also that for a constant ammonia concentration an increase in the ammonium chloride raises the voltage as indicated under 1.

2. The addition of hydrogen ions is impracticable because of the solvent action on the zinc electrode. The salts which ammonia forms with such weak acids as boric acid, acid phosphates, and acids of the acetic series, are hydrolised to such a large extent that the alkalinity is only partly removed. This accounts for the unsatisfactory results which were obtained with these acids.

3. The salts of any base weaker than ammonia hydrolyse to such an extent that the hydrogen-ion concentration becomes too high and the zinc becomes attacked.

4. Zinc chloride combines with a considerable amount of ammonia, and it was found well suited for reducing the hydroxyl-ion concentration.

5. Formaldehyde was tried for the purpose of destroying the ammonia, but it attacked the ammonium chloride, setting free hydrochloric acid, which in turn attacked the zinc.

The Paper concludes with a study of manganese dioxide as an oxygen electrode.

THE VARIATION OF THE RESISTANCE OF IRON WIRES WITH THE TEMPERATURE ON ALTERNATE CURRENT CIRCUITS.*

BY PROF. W. PEUKERT.

The effective resistance of iron wires on alternate-current circuits depends on the current and frequency as well as on the size of the wire and its precise composition. Results have often been published, and considerable interest attaches to the subject in cases where iron has been used to replace copper. The resistance also depends on the temperature, but there has been little experimental work done on this subject. Generally speaking, the alternate-current resistance increases with the temperature; it may be said

* Abstract of an article in the "Elektrotechnische Zeitschrift," No. 44, 1915.

Table I.—*Iron Wires, 4 mm. in Diameter.* (*a*) *Experiments with Alternate-current, Frequency 50.*

Temp. Centi-grade.	Current, amperes.	Watts.	Alternate-current resistance.	Current, amperes.	Watts.	Alternate-current resistance.	Current, amperes.	Watts.	Alternate-current resistance.	Current, amperes.	Watts.	Alternate-current resistance.
90·0	6·02	84·0	2·318	9·25	200·0	2·338	12·60	320·0	2·222	16·09	536·0	2·094
85·0	6·06	88·0	2·396	9·10	192·0	2·319	12·06	325·6	2·239	16·00	521·6	2·039
80·0	6·04	84·4	2·313	9·08	188·4	2·285	12·00	313·6	2·178	16·00	528·0	2·063
70·5	6·05	88·0	2·350	9·12	170·4	2·289	12·02	320·0	2·215	16·00	520·8	2·034
60·0	6·10	84·0	2·257	9·06	182·8	2·227	11·98	304·0	2·118	16·01	509·0	1·953
52·0	6·01	80·4	2·226	9·03	180·0	2·207	12·05	314·4	2·162	16·03	504·0	1·949
36·0	6·00	76·9	2·111	9·04	170·4	2·088	12·04	292·8	2·020	15·98	475·2	1·861
19·5	6·01	71·6	1·982	9·00	159·2	1·965	11·98	272·0	1·895	15·98	488·8	1·757

(*b*) *Experiments with Direct-current on 4 mm. Iron Wires.*

Temp. C.	Voltage.	Current, amps.	Resistance.	Temp. C.	Voltage.	Current, amps.	Resistance.
88	9·31	6·09	1·552	50·0	8·38	6·05	1·385
80	9·09	6·00	1·515	40·0	8·03	6·09	1·318
70	8·85	6·02	1·470	30·0	7·80	6·10	1·279
69	8·54	6·04	1·414	17·5	7·45	6·14	1·213

Table II.—*Iron Wires, 6 mm. in Diameter.* (*a*) *Experiments with Alternate-current, Frequency 50.*

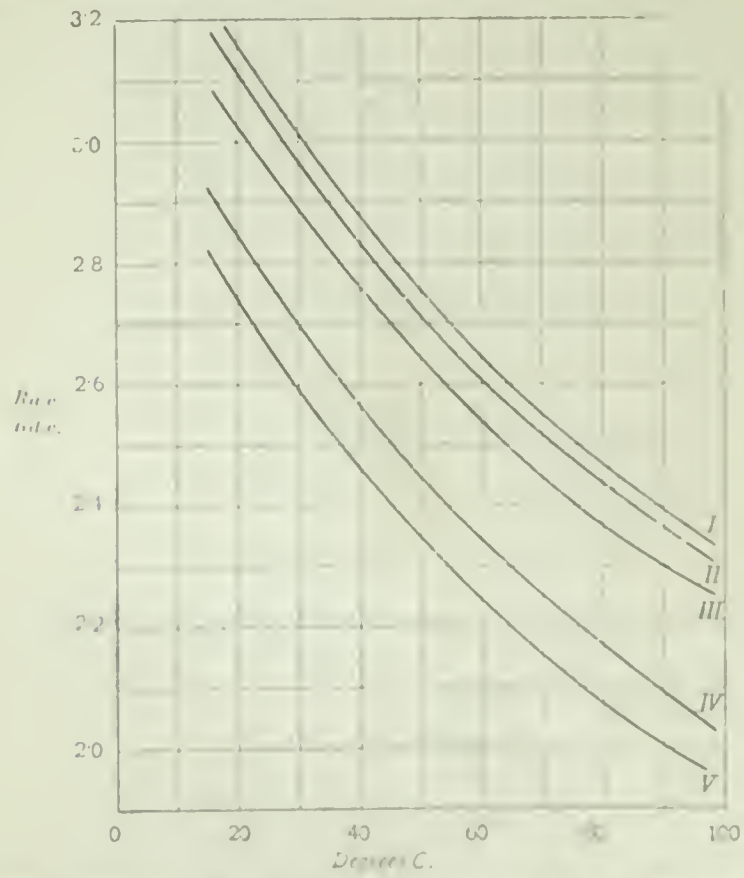
Temp. Centi-grade.	Current. amps.	Watts.	Alt.-current resist.	Current, amps.	Watts.	Alt.-current resist.	Current, amps.	Watts.	Alt.-current, resist.	Current, amps.	Watts.	Alt.-current resist.	Current. amps.	Watts.	Alt.-current resist.
90	6·00	28·0	0·7796	9·07	64·0	0·7780	11·98	105·6	0·7358	15·96	172·0	0·6753	19·20	238·0	0·6456
80	6·00	26·6	0·7389	9·07	62·2	0·7561	11·96	102·8	0·7187	16·00	168·4	0·6578	19·20	232·0	0·6293
70	6·00	26·4	0·7334	9·07	61·0	0·7415	11·92	100·4	0·7066	16·10	168·8	0·6512	19·10	228·0	0·6250
61	6·00	26·0	0·7222	9·08	60·0	0·7277	11·96	99·6	0·6963	16·00	164·8	0·6438	18·80	220·0	0·6225
51	6·05	24·0	0·7049	9·03	58·0	0·7113	12·04	99·2	0·6843	16·00	160·8	0·6281	18·96	218·8	0·6085
42	6·03	24·6	0·6766	9·00	56·2	0·6939	12·00	96·0	0·6667	16·00	157·6	0·6156	19·04	215·6	0·5947
33	6·06	24·4	0·6644	9·01	55·6	0·6849	12·20	96·8	0·6504	16·04	156·0	0·6064	19·10	214·8	0·5888
18	6·00	23·0	0·6389	9·07	55·6	0·6637	12·18	94·8	0·6390	16·22	156·0	0·5932	19·26	212·4	0·5726

(*b*) *Experiments with Direct-current on 6 mm. Iron Wires.*

Temp. C.	Voltage.	Current, amps.	Resistance.	Temp. C.	Voltage.	Current, amps.	Resistance.
90	3·232	10·23	0·316	51	2·643	10·01	0·262
80	3·117	10·13	0·308	42	2·454	10·13	0·242
70	2·097	10·12	0·293	33	2·004	10·34	0·232
61	2·082	10·12	0·278	18	2·226	10·75	0·207

to be the ratio of the energy-consumption or Joulean heat to the square of the current: it is always greater than the direct-current resistance, therefore, the energy-consumption and heat in an iron wire on alternating current is always greater than on direct current if the current has the same value in the two cases. The energy-consumption is greater mainly because of the eddy currents that arise, causing an extra heating effect. If the temperature of the iron wire rises, its specific resistance increases; its specific conductivity, therefore, decreases; the eddy currents, therefore, decrease, and consequently the heating effect they produce.

It may, therefore, be supposed that the ratio of the alternate-current resistance to the direct-current resistance decreases with a rise in temperature, though it always remains greater than unity. It was first pointed out by Richter that the alternate-current resistance of a copper winding, embedded in a slot, decreases with an increase of temperature. The author, therefore, thought the matter to be of sufficient interest to warrant a further investigation, and carried out a series of experiments on iron wires of 4 mm., 5 mm. and 6 mm. diameter. In order to determine the influence of temperature alone, the current was kept constant, as well as the periodicity; the temperature was, therefore, the only variable. For this purpose the iron wire was placed in a drying oven, which was electrically heated in such a way that the temperature was maintained absolutely constant while the different readings were taken. Thermometers were embedded in the apparatus, so that it was possible to be absolutely certain that the constant temperature had been reached. The energy-consumption in the iron wire was determined by a wattmeter: the current and the periodicity were kept as constant as possible. The small unavoidable variations of current had no effect on the results. At the same temperatures the direct-current resistance was indirectly determined from the current and voltage. The results are given in the appended tables, and the author gives curves constructed from these figures. He also gives curves showing the variation of the ratio of the alternate-current resistance to the direct-current resistance, according as the temperature varies. This ratio decreases with increasing temperature, and this decrease is more marked in the case of the thicker wires. These tests confirm the statement that with iron wires the extra heat, due to the current, decreases with increasing temperature.



Curves showing Ratio of Alternate-current Resistance to Direct-current Resistance with 6 mm. Iron Wires and Varied Temperature.

I., 6 amperes; II., 9 amperes; III., 12 amperes; IV., 16 amperes; V., 19 amperes. (Ordinates represent the ratio of the two resistances, R_{ac}/R_{dc}.)

MODERN PRACTICE IN THE CONSTRUCTION AND MAINTENANCE OF RAIL JOINTS AND BONDS IN ELECTRIC RAILWAYS.*

BY E. R. SHEPARD.

In connection with the study of electrolysis and electrolysis mitigation, the attention of the Bureau of Standards has been called to the past and present high rate of rail joint and rail bond failures and the consequence of such failures upon the electrolysis conditions throughout the country. With the idea of collecting information on the best present-day practices of bonding tracks, a circular letter was prepared and copies were sent to 130 operating companies. The letter asked for information as to the number and types of bonds and joints in use and for the average life and causes

* Technologic Paper No. 62. Bureau of Standards (U.S.A.).

of failure of each type; also for the manner and time of testing bonds and the criterion for replacement. Other questions of minor importance were also included. The present Paper is largely a compilation of the data submitted by 42 companies answering the inquiries, and also includes information collected by a representative of the Bureau who spent five weeks in the field and visited upward of 50 companies in the interest of the investigation. An historical and descriptive discussion of the various types of modern bonds and joints is followed by a compilation and analysis of all available information on each type. Among the principal features brought out in the analysis of the data are the following:—

Soldered bonds of all types are falling into disuse. A few companies, however, employing thoroughly experienced and careful workmen still continue to use them.

A large percentage of the many rail-bond failures in past years has been the result of imperfect methods of manufacture and of ignorance and carelessness in installation.

Practically all types of modern bonds, when selected to meet local conditions and installed according to the best modern practices, will give satisfactory results with an almost negligible percentage of failures on joints which are properly maintained.

No one type of bond can be said to be better than all other types. Each has its advantages and disadvantages, and the selection of a bond for any particular service should be governed by the type of construction on which it is to be used, the grade of labour available for installation and upon numerous other local conditions.

The problem of rail-bond maintenance is largely that of joint maintenance. No bond can be expected to last continuously on a loose and poorly-supported rail joint.

The surfacing of all newly-installed joints and the tightening of all bolts soon after installation and at regular intervals thereafter will do much to prevent loosening of joints and cupping of rails.

Improved bolts having a high elastic limit and a great ultimate strength appear to be giving excellent results, and their universal adoption is recommended on all new work.

Difficulty has been experienced in obtaining sufficient room for concealed bonds, particularly on the smaller rails. This difficulty has been largely overcome in several of the improved patent joints now on the market. It is recommended that bonds and joint plates be selected only after laying out a section of the joint on the drawing-board and providing a proper clearance for the bonds.

The life of concealed bonds on exposed rails is much shorter than on rails in city streets, owing to the expansion and contraction in the joint on the former type of construction. Such expansion and contraction can be overcome by the use of improved mechanical joints, supplemented by expansion joints at regular intervals. It is believed that such construction would prove itself to be of ultimate economy, and is recommended, at least on an experimental basis.

Both the compressed terminal and the pin terminal types of bonds are giving excellent results where proper attention is given to their installation. The former type requires more care in the expansion of the terminal, while the latter type requires greater accuracy in the drilling of the holes. Each has its peculiarities, and should be selected only after due consideration to local conditions.

A strict adherence to the code of bonding rules given in "Richey's Electric Railway Handbook" is recommended.

Stranded bonds appear to be giving better satisfaction than ribbon bonds, as the conductors of the latter type are more easily separated and broken. Exposed ribbon bonds should have a clip or band at the centre of the bond to prevent this separation of the conductors.

The use of solder in connection with the application of mechanically-applied bonds will undoubtedly add to their life if the work is carefully performed. Its use, however, does not always appear to be justified, as good results under modern conditions can be obtained without it. Its use should depend entirely upon local conditions.

The use of tinned terminals and plastic alloys in connection with mechanically-applied bonds appears to be a good practice. Their use is recommended where trouble from corrosion of terminals has been experienced.

Mechanically-applied head bonds are comparatively modern, and are, therefore, more or less in the experimental stage. However, their use is increasing, and in most installations they appear to be giving fairly satisfactory results. They are short, cheap and easily installed. Their contact resistance appears to increase with time, but not ordinarily to the point of failure. When installed in city streets they are subjected to vehicle traffic, and some failures must be expected.

Electrically-welded bonds have a low and permanent contact resistance. Theft of this type is difficult, and, owing to the shortness of the bond and its tenacious contact, has been reduced to a minimum. Failures of the head bond from the breaking of ribbons have been quite prevalent, but are being reduced by a modification in the design of the bond.

Welded joints are being used more than ever before, but there is also a growing tendency to adopt improved mechanical joints and various forms of special joints, several of which are a combination of welded and bolted or welded and riveted joints. These special joints seem to be meeting the demands of service with fewer failures and better results generally than any of the standard types.

Power economy alone will not justify the best modern practice in bonding. Such practice, however, is justified and strongly recommended from the standpoint of good voltage conditions in the return circuit, which not only make for good electrolysis conditions, but also for satisfactory operation. The present practice of basing the criterion for bond replacements upon a joint resistance which is defined in terms of the resistance of a given length of adjacent rail is shown to be somewhat irrational, but owing to its simplicity and ease of application the continuation of the practice is recommended. From 6 ft. to 10 ft. of rail as the limiting resistance for rail joints is shown to represent good practice, and it is recommended that these figures be not exceeded under ordinary conditions.

The Paper calls attention to the fact that the problem of track bonding is in a state of evolution. New inventions and improvements in methods and practices have been so frequent during recent years that many types of bonds and joints can still be said to be in the experimental stage. Carefully-kept records and a free interchange of experiences on the part of the operating companies will do much toward the establishment of definite and standard practice in this particular field.

The Paper contains 34 figures.

LEGAL INTELLIGENCE.

S. T. Baldry v. Sun Electrical Co. (Ltd.)

At the Lambeth (London) County Court on the 20th inst. Judge Parry gave his decision in this application for compensation under the Workmen's Compensation Act, made by Samuel Theodore Baldry (aged 14 years) through his father (Joseph W. Baldry). The facts were reported in our issue of April 7 (p. 26). The lad was engaged on waxing vulcanite blocks, and took a piece of metal to another youth requesting to be told what it was. The information was given, and as the applicant was walking away the other boy threw the small piece of metal over his shoulder. It caught applicant in the right eye, the sight of which he lost. His Honour, in giving judgment, said a suggestion was made that the boys were larking, but their evidence convinced him that this was not so. They were taking an intelligent interest in their surroundings and seeking information from each other, as human children of their age would do, and, according to modern educationalists, should be encouraged to do. He had no doubt that that was an accident arising out of and in the course of applicant's employment, and made an award in his favour of half wages of 9s. 10d. a week since the date of the accident, with costs.

Re Leitner Electrical Co. (Ltd.)

The Registrar of Companies (on the application of the liquidator) had made an order in chambers under sec. 174 of the Companies (Consolidation) Act, 1908, requiring a Mr. W. R. Preston to attend at chambers on April 11 to be examined on the part of the liquidator as a person capable of giving information concerning the trade, dealings, affairs, or property of the company, and the order required him to bring with him and produce the documents mentioned in the schedule to the order. The schedule referred, among other documents, to any minute books, account books, day books, or any other books of J. Stone & Co. (Ltd.) Mr. Preston had been a director of the Leitner Electrical Co. (Ltd.), and he was a director and the chairman of J. Stone & Co. (Ltd.), and there had been trade dealings between the two companies. Mr. Preston did not attend before the Registrar on April 13, but counsel appeared on his behalf and objected that the order was wrong and oppressive, because the documents were not in the possession or custody of the witness. The Registrar adjourned the matter to the Judge.

Mr. B. A. Hall (for the liquidator) now submitted that it was the duty of the witness to attend for examination. Any objection that he had to produce a document could be taken if and when he was asked to produce it.

Mr. Owen Thompson (Mr. Gore-Browne, K.C., with him), for Mr. Preston, submitted that the order was wrong in form and in substance, because it was impossible to comply with the schedule.

Mr. Justice Neville said the essence of the order was that the witness should attend for examination. He could have said that he had not the documents. That difficulty could be got over by serving the secretary of the company with a subpœna duces tecum. What witness had done was to disobey the order of the Court, and he was not going to be lenient about it. It should be understood that the orders of the Court were not

to be laughed at or disregarded. Let the Registrar appoint another day for the witness to attend for examination. If he did not attend he would know how to deal with him, and he must pay the costs of this application.

Unlicensed Tramcar Drivers.

At Croydon, on Saturday last, the local Magistrates heard 35 summonses against the manager of the South Metropolitan Tramways Co. (Mr. A. V. Mason) for allowing four drivers and 30 conductors to act without licences, and those so employed were also summoned.

For the defence, Mr. E. M. GIBSON admitted the offences, and suggested that the reason why the men deserted the company was not that they feared the employment of women drivers, but that the strike was arranged some time ago to take place at Easter, when the company would be severely pushed owing to the greater demand upon its staff. He added that the manager immediately acquainted the police with the means he had taken to cope with the emergency, and that the licences were all taken out at the earliest possible opportunity. None were allowed to drive except those who were competent and safe. The company and the union had agreed on arbitration, and the men had remained out in defiance of their union.

The Bench said that the police had acted quite rightly, but they were unanimous in dismissing the summonses.

PARLIAMENTARY INTELLIGENCE.

Royal Assent.—The Royal Assent to the following Acts of Parliament was read on April 19: Finance (New Duties), War Risks (Insurance by Trustees), Imperial Institute (Management).

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1913 SPECIFICATIONS.

27,646 SIEMENS & HALSKE AKT.-GES. Circuit arrangements for telephone systems. (30/11/12.)

1914 SPECIFICATIONS.

17,175 MOLLER. Process for electrically separating suspended bodies from electrically-insulating fluids, especially gaseous fluids. (22/7/13.)

Consists of a process for separating suspended bodies from electrically insulating, especially gaseous fluids, by means of an emitter and a field surface using negative electricity for feeding the emitter, and adjusting the difference of potential between the emitter and the field surface to a value which is higher than the maximum voltage limit obtainable when the emitter is fed with positive electricity.

24,537 GROB. Electromagnets.

Consists of two single electromagnets acting in opposition, in which the movement of the armature or mechanically-connected armatures is produced by a strengthening of the magnetic flux of the one magnet and a weakening of the magnetic flux of the other, wherein through the movement of the armature or armatures a controlling device is brought into operation whereby, for instance, additional windings on the magnets have the effect of still more strengthening the flux of the stronger magnet, and of weakening still more the flux of the weaker magnet.

24,841 ALLIES ELECTRIC LAMP CO. (Le Naour.) Machines for cutting the globes of electric incandescence lamps and the like.

1915 SPECIFICATIONS.

892 SOC. ANON. DES ETABLISSEMENTS L. BLERIOT. Dynamo-electric machines and installations. (7/2/14.)

1,221 MOORE. Electric arc-lamp carbon ferrules.

2,841 B.T.-H. CO. (G.E. Co.) Systems of electric ship propulsion.

4,138 HERBERT TERRY & SONS (LTD.) & TERRY. Electric conductors, cables and the like.

4,230 WADE. (Leeson.) Winding machines for winding electrical coils.

4,285 HULTMAN. Automatic telephone exchange systems. (18/3/14.)

4,483 DEHN. (Schweitzer & Conrad.) Fusible electric cut-outs.

4,582 SMITH. Telephone systems. (25/3/14.)

4,593 VON POST. Means for establishing positive electrical connection between an aeroplane or the like, and its base.

4,595 B.T.-H. CO. & WEDMORE. Protection of alternating-current electric systems.

A method of protecting a three-phase alternating-current system by means of reverse relays consisting in so modifying the characteristic of the relay and coupling the windings to the system that on the occurrence of abnormal conditions in the system the characteristic or some portion of the characteristic of the relay will occupy the quarter of the vector diagram representing lagging reverse current.

4,664 B.T.-H. CO. & YOUNG. Magneto-electric machines.

4,675 STERLING TELEPHONE & ELECTRIC CO., BELL & BARCLAY. Mine and other electric signalling systems.

4,738 B.T.-H. CO. & WEDMORE. Protection of alternating-current electric systems.

Provides apparatus for disconnecting a portion of the system in the event of a fault to earth or between phases in the system or portion of the system protected by the apparatus, said apparatus comprising reverse current relays associated with parallel conductors, said relays having their current coils excited by current flowing in the opposite direction to that required to operate them, such as the difference in the currents carried by the two conductors does not exceed a predetermined percentage of the current carried by one of them.

4,849 GOTTSCHALK. Apparatus for electrically detecting vibrations.

4,862 RIVERS-MOORE. Electric oscillating systems. (Addition to 1,649/10.)

Consists of an apparatus for producing high potential discharges comprising a condenser connected in series with the primary of a high-tension transforming device, an inductance bridged in parallel across the condenser and primary, a source of supply bridged across the inductance, and an interrupter in the circuit of the source of supply adapted to make and break the circuit for definite intervals.

4,896 SHARP. Electric switches as applied to stop motions on textile machinery.

4,953 SMITH. Sound-magnifying appliance for telephonic and telegraphic purposes. (18/4/14.)

4,999 MORDEY. Electric welding.

5,240 JOEL. Joints of pipes and couplings applicable to electrical conduit fittings and like purposes.

5,373 B.T.-H. CO. (G.E. Co.) Methods of and means for amplifying electric potential variations.

A wireless receiving system in which the received waves are impressed upon the grid circuit of an electron discharge relay the plate circuit of which contains a source of energy and a current limiting device in series, the resultant potential variations between the terminals of the current limiting device being impressed upon the grid circuit of a second electron discharge relay.

6,407 B.T.-H. CO. (G.E. Co.) Regulation of dynamo-electric machines.

A regulator comprising an electromagnetic braking device mechanically coupled to the generator shaft and controlled by the generator, so that when the generator tends to deliver E.M.F. or current in excess of the demand a corresponding braking effort is exerted on the generator shaft.

6,895 CURTIS, MACKLEY & IGRANIC ELECTRIC CO. Starting switches for electric motors.

7,080 BRITISH THOMSON-HOUSTON CO. (General Electric Co.) Windings or conductors of electrical apparatus.

7,081 BRITISH THOMSON-HOUSTON CO. (General Electric Co.) Electrical apparatus provided with windings.

7,211 B.T.-H. CO. (G.E. Co.) Electric circuit-controlling devices. (Addition to 16,327/14.)

7,316 THOMAS TRANSMISSION (LTD.) & THOMAS. Timing of electric ignition in internal combustion engines. (Addition to 2,245/15. Cognate application, 7,934/15.)

7,647 BOOTHROYD & CALLENDER'S CABLE & CONSTRUCTION CO. Junction boxes and the like for electric wiring installations.

8,019 STEEL, PEECH & TOZER, LTD., & BOWEN. Lifting electromagnets.

8,513 B.T.-H. CO. (G.E. Co.) Electric welding and brazing apparatus.

9,957 MARINO. Preparation of electrolytes for use in the electrolytic deposition of metals. (Patent of Addition not granted.)

10,485 JAMES. (Annand.) Electric magnetic recording apparatus for telegraph circuits.

11,075 W. R. SYKES INTERLOCKING SIGNAL CO. & TARRANT. Railway signalling apparatus.

16,900 BOWDEN & THOMPSON. Cables for the distribution of electrical power. (Divided application on 4,585/15. March 24.)

17,411 SMITH. Electrical apparatus for heating liquid.

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

March 27, 1916.

4,479 ROMANES. Electric furnaces for smelting and refining metals.

4,509 DUPONT & M.P.P. SYND. Contact-breakers for magneto-electric generators.

March 28, 1916.

4,558 B.T.-H. CO. (G.E. Co., U.S.) Electric discharge apparatus.

4,540 GIBSON. Evaporator coils.

4,561 COOPER. Electric dynamos.

4,575 SALT. Holders for incandescent electric lamps.

March 29, 1916.

4,590 SMETHURST. Submarine searchlight.

4,596 JOEL. Portable electric battery lamps.

4,620 BAIRD. Spark-plugs.

4,625 KING. Electric torches.

4,629 MILLER. Electric ignition of explosives.

March 30, 1916.

4,661 STURTEVANT. Bomb or explosive shell, and apparatus for lowering, sustaining and exploding same by electricity from aeroplane, &c.

4,674 FLEMING. Light telegraphy.

4,681 YOUNG. Signalling apparatus.

4,683 HENLEY'S TELEGRAPH WORKS CO. & JUDGE. Electric switches.

4,688 CHRYST & KELTERING. Electrical systems for engines. (16/7/14, U.S.)

4,691 JENKINS. Apparatus for guiding trolley pulley of electric cars and locomotives to overhead wire.

4,697 B.T.-H. CO. (G.E. Co., U.S.) Electric oscillators.

4,699 ALDENDORFF. Switching apparatus for inter-connecting telephone lines by electro-mechanically-controlled switches.

4,703 HARVEY. Circuit-breaking apparatus for electrical heaters.

4,713 ALQUEN. Electric cutouts.

March 31, 1916.

4,773 MCCOLL. Alternating-current systems.

4,752 DONOVAN. Combined electric lampholders and switches.

4,775 GRANT & MORGAN CRUCIBLE CO. Carbon brushes for electrical machines.

4,780 MARINO. Electrolytic deposition of zinc on metallic surfaces.

4,788 CHITTY. Dynamo-electric machines.

April 1, 1916.

4,806 DIXON. Signalling systems and apparatus. (22/4/15, U.S.)

4,816 B.T.-H. CO. (G.E. Co., U.S.) Wireless signalling systems.

4,827 TURNBULL. Automatic cut-in and cut-out for electric circuits.

April 3, 1916.

4,837 BAYLES, BRISLEE & BRITISH INSULATED & HELSBY CABLES. Electrical batteries.

4,852 PRENTICE. Electric fuses.

4,859 TAYLOR. Sparking plugs for internal-combustion engines.

4,865 CREASEY. Sparking plugs for internal-combustion engines.

4,901 HELLER. Electric heating devices. (16/7/14, Germany.)

April 4, 1916.

4,938 COATES. Electric time switches.

4,942 BYGRAVE & RELAY AUTOMATIC TELEPHONE CO. Automatic or semi-automatic telephone exchange systems.

4,959 DE FOREST. Electrical means for producing musical notes. (24/4/15, U.S.)

4,962 CROCHAT. Electrical driving, particularly for motor vehicles.

April 5, 1916.

4,981 CARTER. Electric diaphragm horns.

5,009 BERELEN & CHAMBERS. Magneto-electric machines.

April 6, 1916.

5,038 LEWIS. Arc lamps.

5,053 JACOBS & PILLARD. Portable electric torches &c.

5,061 PETITHORY. Telephone instruments.

5,069 FILDES. Electrical hand lamps.

5,070 FERGUSON & MECHANS (LTD.). Ships' telegraphs, &c.

5,085 CLELAND & MILLER. Magneto-electric machine.

5,090 ROBERTS. Signalling devices.

5,091 MARKS. (American Model & Instrument Co.) Electrical circuit systems.

5,092 LINCOLN. Electrically bonding rail-ends.

5,104 CURTIS & IGRANIC ELECTRIC CO. Enclosure for wire gear.

5,111 RYAN. Sound-receiving apparatus.

April 8, 1916.

5,163 BRUMELL PATENTS CO. & CROCKATT. Electrically indicating presence of saline, alkaline or acid impurities in feed-water for steam generators, &c.

5,171 GRAY & WILKIE. Electric fittings.

5,175 BENNIE. Holders for arc lamp carbons, &c.

5,191 RATTEY. Accumulator cells, &c.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	129	A New Combined Switchplug. Illustrated	26
Imports and Exports of Electrical Manufactures	130	**Electric Vehicle Progress Supplement—No. 27.**	
Business Notices	130	Battery Carts v. Horses for Dust Collection	1*
Bankruptcies, Liquidations, &c.	130	Petrol, Steam and Electric Vehicles	1*
Electricity Supply	130	An Edison 5-Ton Vehicle. Illustrated	2*
Lighting and Power Notes	131	The Electric in Operating Service. Illustrated	2*
Traction Notes	131	Tractor Haulage. Illustrated	4*
Telegraph and Telephone Notes	131		
Empire Notes	132	Tenders Invited	133
Foreign Notes	132	Tenders Received & Accepted	134
Miscellaneous Notes	132	Companies' Meetings and Reports	134
The Round Table	21	New Companies, &c.	135
"Mazda" Shade for Subdued Lighting. Illustrated	22	City Notes	136
Electric Winding Plant in a Scottish Colliery. Illus.	22	Electrical Companies' Share List	136
Alternating-Current Two and Three Phase Induction Motors. Illustrated	24		

COMMERCIAL TOPICS.

The Consular Service. It is announced that the Foreign Office has intimated to the Association of Chambers of Commerce of the United Kingdom that it is prepared to enter into consultation with a committee of business men in regard to the changes which may be necessary in the Consular Service. In the re-organisation of this important service it is well to remember that there should be close co-operation between the Foreign Office and the Board of Trade, the department of the Government which is primarily responsible for the trade and commerce of the country. In the past there has not been that mutual support and sympathy which should have existed between the two departments, and this has been due—at least, in part to the view that commerce and trade scarcely came within the scope of the work of the Foreign Office. There can be no doubt that, apart from the ordinary Consular officials, commercial attachés and other members of the Diplomatic Service can, if properly trained and directed, perform good work for the commerce of the Empire, and we are glad to see that the Foreign Office seems to be alive to the importance of the question. We should like to see the number of commercial attachés increased and their work better organised, and we also hope that in future we shall have a large percentage of technical men, especially engineers and chemists, among the higher Consular officials.

* * * *

Board of Trade and Commercial Inquiries. At the recent meeting of the Advisory Committee of the Board of Trade Commercial Intelligence Branch, it was reported that the number of written and personal inquiries received at the Commercial Intelligence Branch of the Board of Trade (exclusive of the foreign sample section) during the past year was 57,400, compared with 40,600 in 1914.

In view of the success of the British Industries Fair, the Board of Trade have decided to hold a similar fair next year, to be opened on Feb. 1. Amongst matters considered by the Committee were the financing of British and German trade respectively in China, a proposed commercial mission to Russia, the amendment of the law relating to patents, trade marks and designs, &c.

* * * *

Trade After the War. As we go to press the interesting announcement is made that the President of the Board of Trade has appointed two Committees which will deal with the electrical and British textile trades respectively, particularly in their relation to international competition and their consolidation and protection. The Electrical Trades Committee, which has its address at 7, Whitehall-gardens, London, S.W., is comprised of the following: Hon. Sir Charles A. Parsons, K.C.B., F.R.S. (chairman), Mr. J. Annan Bryce, M.P., Mr. T. O. Callender, Mr. James Devonshire, Mr. B. M. Drake and Sir John Snell. We are rather surprised to note that the chairman of the British Electrical and Allied Manufacturers' Association is not on this Committee. Though these names are well known and highly respected in electrical circles it can scarcely be said that they are representative of the various branches of the industry. The gentlemen whose names we have given may each be considered to represent certain distinctive branches of electrical engineering, but unless Sir Charles Parsons is the authorised representative of the B.E.A.M.A., we suggest that that important Association be given the opportunity of voicing its opinions on the Committee, and that its Chairman, Mr. F. R. Davenport, be elected for the purpose. Then, again, the interests of electricity supply cannot be considered to be in the hands of any one particular member of the Committee as at present constituted. The company and municipal interests have succeeded in getting together upon several matters of mutual interest, and there should be no difficulty in selecting a central station engineer who would have sufficient breadth of view to represent both branches of this important public service. We think that some representative is required in this case, because the electricity supply interests are among the most important purchasers of electrical plant in the country. If steps are to be taken to encourage the purchase of dynamo-electric machinery manufactured in this country it is desirable that a more definite lead be given by the electricity supply interests in the future than has been the case in the past. Before the war the electrical instrument section suffered severely from German competition, and on the Committee there should also be a representative of telephone and telegraph engineering.

* * * * *

Battery Vehicles and Refuse Collection. In "Electric Vehicle Progress," published with this issue, we reproduce from a report submitted to Sheffield cleansing department by Mr. J. A. Priestley, superintendent, some interesting figures collected from actual experience with battery-driven vehicles for the carting of towns' refuse. These figures have been compared with those obtained by horse haulage in the city of Sheffield, and extend over a period which may be considered sufficiently long to render the results of considerable value. An item of importance in the report reads as follows: "A charge of 1d. per unit is made against the vehicle for current used, but this does not represent an actual expenditure, as the electricity is obtained from the destructor installation, and the refuse consequently produces power for its own collection." We think that the last phrase might very well be used as a powerful selling argument for this type of vehicle. It is a condition of things which cannot obtain in any other form of propulsion for dust-collecting vehicles. The figure of 1d. per unit in these circumstances is on the high side, as it is not an accurate figure of the cost of electricity generation from towns' refuse. Energy at 1d. per unit is, however, offered by a large number of public electricity stations throughout the country, and therefore it may be accepted as a useful figure for comparing battery-driven with other classes of vehicles for this kind of work. Another feature of interest attaching to the report is the employment of battery vehicles in so hilly a district as Sheffield. The success of the vehicles in such a locality should do much to remove the prejudice which still undoubtedly exists against accumulator road traction. This prejudice is not entirely confined to vehicle users. It exists to a lamentable extent among electrical men, and not a few of them central station engineers. We have consistently urged that the battery-propelled vehicle, *in its own field*, is unrivalled by any other power-propelled vehicle, and that abundant proof of this claim would be forthcoming so soon as the vehicles were tested under operating conditions side by side with other methods of traction. So far as refuse haulage is concerned, the central station engineers may look askance at the use of accumulator vehicles where the charging is done from the destructor plant. This would, however, be an extremely narrow view to take of the situation. The more battery vehicles there are on the road the greater will be the tendency to make use of them in their proper sphere of labour. There still remain an abundance of trades and industries in which they can be satisfactorily employed and derive their energy from the town's mains. We feel sure that Mr. Priestley's experience at Sheffield will be utilised to the utmost by those who are at present pushing the sale of these vehicles in this country. Cleansing superintendents and officials of a similar class will be made ready converts where figures, based on operating experience, are available.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From April 17, 1916, *to* April 20, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

LONDON.—*U.S.A.:* Elec. machinery, £1,827; elec. lamps, £500; telephone material, £340; unenumerated, £2,149. *Holland:* Elec. lamps, £6,809—10 pkgs.; wire and cable, £21; unenumerated, £361. *France:* Elec. lamps, £112. *Switzerland:* Elec. lamps, £188; unenumerated, £282. *Italy:* Elec. machines, £81. *Japan:* Unenumerated, £348. *Sweden:* Elec. lamps, £165; elec. machinery, £3,500. *Egypt:* Elec. lamps, £13; unenumerated, £20. *Denmark:* Unenumerated, £189.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Unenumerated, £175. *Melbourne:* Elec. machinery, £208; unenumerated, £183. *Sydney:* Elec. machinery, £250; wire and cable, £3,885; unenumerated, £474. *Wellington:* Elec. machinery, £199; unenumerated, £107. *Perth:* Unenumerated, £17. *Christchurch:* Unenumerated, £150. *Dunedin:* Unenumerated, £108. *Lyttelton:* Unenumerated, £101. *Brisbane:* Unenumerated, £5,389. *Nelson:* Unenumerated, £19. *Hobart:* Unenumerated, £43.

AFRICA.—*Durban:* Elec. machinery, £1,272; wire and cable, £356; unenumerated, £2,194. *Cape Town:* Wire and cable, £115. *Port Elizabeth:* Wire and cable, £207; unenumerated, £140. *Beira:* Wire and cable, £37; unenumerated, £111. *East London:* Unenumerated, £157.

CANADA.—*Toronto:* Unenumerated, £34.

ADEN:—Unenumerated, £24.

EGYPT.—*Alexandria:* Wire and cable, £225; unenumerated, £33. *Port Sudan:* Unenumerated, £20. *Port Said:* Unenumerated, £14.

GIBRALTAR.—Unenumerated, £51.

WEST INDIES.—*Barbados:* Unenumerated, £11.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Unenumerated, £96. *Calcutta:* Unenumerated, £109. *Ceylon:* Unenumerated, £1,578. *Madras:* Wire and cable, £90; unenumerated, £24. *Bangkok:* Unenumerated, £372. *Medan:* Wire and cable, £348.

JAPAN.—*Yokohama:* Unenumerated, £24.

ITALY.—*Genoa:* Unenumerated, £280.

HOLLAND.—*Amsterdam:* Unenumerated, £1,284.

FRANCE.—*Paris:* Elec. machinery, £995; unenumerated, £563; wire and cable, £150. *Dieppe:* Unenumerated, £420.

SWEDEN.—*Gothenburg:* Elec. machinery, £50. *Stockholm:* Unenumerated, £95.

SPAIN. *Huelva:* Unenumerated, £128. *Malaga:* Unenumerated, £95.

PORTUGAL.—*Lisbon:* Wire and cable, £2,127; unenumerated, £170.

FOREIGN GOODS (duty paid and free).

Melbourne: Unenumerated, £17. *Port Elizabeth:* Unenumerated, £47. *Calcutta:* Unenumerated, £75. *Paris:* Unenumerated, £40. *Madras:* Unenumerated, £217. *Cape Town:* Unenumerated, £78. *Sydney:* Unenumerated, £62.

IN TRANSIT.

Adelaide: Elec. lamps, £91. *Brisbane:* Elec. lamps, £231. *Melbourne:* Elec. lamps, £255. *Natal:* Elec. lamps, £1,420.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

In order to expedite delivery of telegrams the Edison & Swan United Electric Light Co. (Ltd.), Ponders End, Middlesex, notify that it would be glad if their customers would in future address all telegrams "Ediswan Enfield" when communicating with the Ediswan Works.

The business of the Telephone, Light & Power Co., of 20, West Campbell-street, Glasgow, is being wound up, the sole partner, Mr. W. B. Whyte, having joined H.M. Forces.

Plant for Sale.—Greenock Corporation electricity department have for sale a 500 B.H.P. Belliss triple expansion engine and 300 kw. Silvertown dynamo, 5/600 volts. Offers to the Chief Engineer and Manager, Mr. F. H. Whysall, M.I.E.E., by Friday, May 5. *See also an advertisement.*

BANKRUPTCIES, LIQUIDATIONS, &c.

An application for the discharge of Arthur Faraday Hawdon, electrical engineer, Yetholm, Elmfield-gardens, Gosforth, will be heard on May 11 at the County Court, Westgate-road, Newcastle-on-Tyne.

A meeting of creditors of the British Accumulator Co. (Ltd.) will be held at Tanfield buildings, Bradford, on May 4.

Claims against the Ilkeston Motor & Electrical Engineering Co. (Ltd.) (in vol. liq.) are to be sent by May 16 to Mr. Alan Boaler, King-street, Nottingham.

Mr. L. Simon, Newmarket-terrace, Newmarket-road, Norwich, has been appointed liquidator in the voluntary liquidation of Norman & Beard (Ltd.).

The Ardwick Electric Regulator Co. (Ltd.) is being wound-up voluntarily, and Mr. J. W. Shepherd, 78, King-street, Manchester, has been appointed liquidator. A meeting of creditors will be held at 67, Princess-street, Manchester, on May 5.

A meeting to receive an account of the winding-up of the Telephonic Electric Co. (Ltd.) will be held on May 22 at Balfour House, Finsbury-pavement, London, E.C.

ELECTRICITY SUPPLY.

EXTENSIONS.

Leeds.—The Corporation were recently recommended to apply to the L.G. Board for sanction to borrow the following sums for the electricity undertaking: £30,000 for additional cost of buildings for the new generating station, £20,000 for mains and £15,000 for sub-stations.

London County Council.—At the meeting sitting last week the following loans to local authorities for electricity supply purposes were sanctioned: Bermondsey Council £2,773, Stepney Council £3,000, and Woolwich Council £27,500.

Luton.—The electrical engineer (Mr. W. H. Cooke) reports that two new boilers, an economiser and steam piping and ash handling plant will be required for next winter's load.

The Council is recommended to increase the salary of the assistant electrical engineer (Mr. H. A. Kell) from £200 to £215 per annum, and that of the chief technical assistant (Mr. A. H. Gates) from £182 to £200 per annum.

Nelson.—The Electrical Engineer has been authorised to obtain estimates for a turbo-generator set.

St. Pancras (London).—The Government have authorised the contracts for the two new boilers and the building extension required in connection with King's-road station to be expedited, but the installation of the coal storage bunkers and coal and ash handling plant are to be left over, if possible, in order to economise in the use of steel.

The Electricity Committee, however, think it important that the whole of the portion of the station extension scheme now arranged for should be allowed to proceed without modification, and they have appointed a deputation to wait upon the Government department in order to explain the urgent needs of the case.

Stafford.—On the advice of the consulting engineer (Mr. S. L. Pearce), application has been made to the L.G. Board for sanction to the raising of £16,000 for extensions of plant at the electricity works. The extensions are urgently required in order to cope with the greatly increased and increasing demands for current for power.

In consequence of the great urgency of the matter, the Gas and Electricity Committee have been authorised to deal with the tenders when they are received.

GENERAL.

Bradford.—The Electricity Committee have agreed to give a supply of electricity in bulk to Messrs. Jeremiah Ambler & Sons.

Bristol.—The Corporation recently adopted a recommendation of the Electrical Committee to recognise the exceptional services of Mr. Robert Parker, who had retired from the position of foreman of the electrical generating station after 22 years' service, by giving him a testimonial in money or kind of the value of £50.

Grimsby.—The Electric Lighting Committee have decided not to accept any new consumers of current for lighting purposes, as the generating plant is already overloaded, and extensions cannot be carried out at present.

In his report, the acting-engineer (Mr. A. S. Channon) said the Committee could only maintain supply next winter by continuing the present lighting restrictions, whether or not the need for them under the Defence of the Realm Act had ceased. A scheme of extensions should be prepared, so that orders could be placed immediately on the close of the war. The Committee adopted the Engineer's report, and agreed, in the event of the war being over by next winter, to continue the existing restrictions as to private and public lighting.

Manchester.—The Electricity and Gas Committees have decided to contribute £80,000 to relief of rates.

The Electricity Committee met on the 19th inst. for the purpose of reviewing the financial results of the working of the department during the year ended March 31 last, and approving the estimates for the current year.

Last year it was found that, in view of the increase in coal costs and in other expenses it was necessary in order to maintain the £30,000 annual contribution in aid of rates, to raise electric supply charges, by 10 and 15 per cent. on lighting and power respectively. In the result the margin available for rate aid at the close of the year proved to be only £28,175, the difference of £1,825 having to be taken from the reserve fund. The corresponding surplus in the previous year was £34,926. Comparing the results in the year just ended with those for the previous year, it was found that the kelvins sold had risen from 127¾ to 141¼ millions, an increase of nearly 11 per cent., and the income therefrom had risen from £530,740 to £605,652—a difference of 14 per cent.

For the year 1916-17 the committee estimate that the sales will increase by about 12 million kelvins. Owing, however, to the extraordinary cost of coal now prevailing, the incidence of which was only felt during a part of the previous year, and in a lesser degree to other new costs, the esti-

mated surplus on the year's working is only £9,000. To provide the £30,000 for rate aid it will, therefore, be necessary to withdraw the balance in the reserve fund (£10,057) and to carry forward against the year 1917-18 a sum of £10,943.

Teignmouth.—The Urban Council will allow the proposed Shaldon Electric Lighting Co-operative Society to use overhead mains, provided steel poles are employed in certain streets.

Watford.—The Urban Council has been authorised to borrow £1,625 for the electricity supply department.

Woolwich.—A supply of current is to be given to a large firm, necessitating the purchase of apparatus at a cost of £140.

Having regard to the fact that the amount of coal to be handled at Globe-lane station has nearly quadrupled, and there is every possibility that it will further increase, the Electricity Committee's original proposal to purchase a grab to be fitted to the existing telpher is insufficient to meet present needs, and it is reported that other arrangements have now been made in connection with the existing extensions now being completed.

The Council has received sanction to the borrowing of £3,290 for mains, transformers, &c.

LIGHTING & POWER NOTES.

Doncaster.—The Water Committee are considering the question of installing electric pumping plant at a cost of £300 for pumping river water.

Sanatorium Lighting.—The County Tyrone Tuberculosis Committee propose to install electric lighting plant in the new sanatorium.

Scarborough.—The Council have instructed the Lighting Committee to consider the question of adopting electric lighting in certain of the main streets after the war.

Stirling.—The War Office has declined to reconsider the question of the lighting of the local hut encampment.

The War Office had already decided to adopt electric lighting, but the Town Council desired that gas should be used, and appealed to the military authorities. The War Office, however, considers electric lighting to be more suitable and it adheres to its former decision.

TRACTION NOTES.

Birmingham.—At last week's meeting of the Tramways Committee the chairman (Councillor Barrow) said that no definite decision had yet been arrived at with reference to the running of trailer cars. A trailer car was being prepared, and it would shortly be placed on the Handsworth route as an experiment.

The scheme for constructing a branch tramway off the Erdington route, near Salford Bridge, so as to open up communication with Tyburn has been postponed until the end of the war.

Goods Traffic by Tramcar.—Owing to the shortage of labour and carting facilities the manager of the Bradford Corporation tramways department (Mr. C. J. Spencer) is making an interesting experiment in the transit of goods by tramcar.

A vehicle has been built by the tramways department which will carry wool, coal, or other merchandise from the railway goods depot, and follow the tramway system to almost any part of the city. It is calculated that one of these vehicles would do the work of 10 men and 10 horses and carts, and at considerably less cost. The matter has been placed before the Board of Trade, who have granted every facility.

Lambeth (London).—By using two motor-driven street sweepers the Council has been enabled to scrap 30 horse-drawn sweepers, and in six months to effect a saving of £827.

Leyton.—Having regard to the extra duties imposed upon the tramways manager consequent upon the Council's resolution not to insure against third-party risks, it is proposed to increase his salary from £400 to £425 per annum, rising by annual increments of £25 to £500.

L.C.C. Tramways.—In submitting the annual budget of the L.C.C. last week, Sir Geo. Goldie, Chairman of the Finance Committee, said he deprecated the drawing of any conclusions as to the financial prospects of the tramways from their position under war conditions.

He said that not only the Tramways Undertaking but the whole traffic system of London was being operated under exceptional conditions. They had once more to face a deficiency, *i.e.*, the balance on net revenue account, after providing for interest on and repayment of capital was expected to be on the wrong side. Although they described the balance in their accounts as a deficiency, it was not a loss in the commercial sense to the extent to which it might be caused by the amount set aside for repayment of capital being in excess of the annual depreciation of the assets. The result of the year just closed was likely to show an improvement on the original estimate, and in fact [illegible] was expected to be reduced to £64,102, notwithstanding the strike in May, 1915, which occasioned a loss estimated at £100,000. The working expenses instead of being about 6¼d., as in 1914-15, were expected to be in the neighbourhood of 8d.

Manchester.—The annual estimates of receipts and expenditure were considered by the Tramways Committee last week.

The Committee agreed to contribute £100,000 in relief of rates, as on two previous occasions, but to do this the Committee calculate they will have to take £10,865 from reserve. The rate contribution was fixed by the Council three years ago, and before another year passes a fresh arrangement will have to be made. The large payments in respect of war service allowances are a serious drain on the financial resources of the department. For the year ended March 31, 1915, the allowances amounted to £31,764. Last year the amount was £[illegible], and for the current year it is thought they will go up to £[illegible], a total of £[illegible] in three years. To meet these payments the Committee have been obliged to transfer smaller sums each year to reserve and renewals fund than they would have done in normal circumstances. In 1914-15 the sum transferred was £48,614 less, and in 1915-16 it was £[illegible] less than it would have been in ordinary times. For the current year the Committee will make no addition at all to the fund, instead of transferring £99,450 as they would wish to do.

The estimated expenditure for last year was £882,500, and the approximate expenditure up to March 31, 1916, was put down at £939,416. The estimated expenditure for 1916-17 was fixed at £950,365, increases in practically every department being provided for. The total revenue was £939,416 (against £901,876), the car-miles run were 18,486,491 (against 19,155,051), the revenue per car-mile was 12·196d. (11·3d.), and the passengers carried were 209,853,344 (202,768,420). Last year's revenue was higher than that of 1915 by £27,540, and £14,106 higher than that of 1913-14, which was a record year. During the past year, although the number of passengers carried was greater, the ordinary working expenses were considerably less than in either of the two preceding years. An increase under the head of general expenses was due to an increase in amount paid in local rates. For the past year £49,507 was paid in rates (against £45,794). An increase in power expenses was accounted for by the greater price paid for electrical energy, due to the higher cost of coal.

The estimates for the current year are based upon an estimated car-mileage of 18,500,000. After making provision for payment of £100,000 to the city fund and meeting extraordinary expenditure arising out of the war (£94,000 for war service allowances, &c., and £40,000 in one year) the department will not only be unable to make any provision for renewals, but it is estimated that there will be an actual deficiency of £10,865, which it is proposed to meet by a transfer from the reserve and renewals fund.

Motor Omnibuses and Upkeep of Roads.—A new clause has been inserted by the House of Lords in the Local Government (Emergency Provisions) Bill prohibiting the use of any new routes by omnibuses or other vehicles except with the consent of the local authority or the L.G. Board.

The new clause will not interfere with vehicles used for commercial or trade purposes, but is intended to apply solely to such vehicles as omnibuses, chars-à-bancs, wagonettes, stage coaches and other carriages plying for hire or used to carry passengers at separate fares. At present these vehicles are only taxed to the extent of their carriage licences, and it is probable that local authorities will, before consenting to new routes being opened up, insist on proprietors paying a contribution towards the upkeep of the roads.

Nottinghamshire and Derbyshire Tramways Act, 1903.—The Board of Trade have extended for one year (from Aug. 15, 1916) the period limited by the Act for the purchase of lands required in connection with tramways Nos. 19, 20 and 21, authorised by the Act.

South London Tramway Strike.—The strike of employés of the South Metropolitan Electric Tramways & Lighting Co. came to an end on Tuesday, when the men decided to return to work. The strike, however, continues on the Croydon Corporation tramway system.

Southampton.—The Tramways Committee has decided to purchase an Edison battery automatic tip wagon, at a cost of £[illegible], and to pay for same out of the depreciation and renewals fund.

West Ham.—The Board of Trade has consented to the doubling of the tramway track of the interlacing line in Woodgrange road.

TELEGRAPH & TELEPHONE NOTES.

Radiotelegraphy.—"Indian Engineering" says construction work at the new wireless station at Maymyo (Burma) is being rapidly pushed on, the main building being about half finished, and one of the steel masts has risen to nearly 200 ft., to which another 65 ft. have to be added.

Telephony in Argentina.—The proprietors of a telephone service between the districts of General Pueyrredon and General Alvarado.

has applied to the Government of the Province of Buenos Ayres for permission for 20 years to utilise the Government's telegraph posts to connect Mar del Plata and La Plata by telephone. He undertakes to charge a tariff 25 per cent. lower than that of any other company.

EMPIRE NOTES.

Australasia.—The Premier of Tasmania (Mr. Earle) recently stated that power from the Great Lake hydro-electric station would be available in May.

The "Commonwealth Engineer" says representatives of the Government Hydro-electric Department, the Hobart Chamber of Commerce and Hobart University recently waited upon the Premier, and asked for Government assistance in establishing a science research laboratory. It was pointed out that if electro-chemical or electro metallurgical undertakings were to be inaugurated in Australia they would come to Tasmania, where unlimited cheap power was available. The Premier said if the Federal authorities assured him that they recognised Tasmania's possibilities, he would recommend the cabinet to appropriate £2,000 for the purpose referred to.

Blue Mountains Shire Council has arranged a contract with Katoomba (N.S.W.) Electric Supply Co. for 15 years, for supply of current to a minimum of 150 60-c.p. street lamps at Blackheath, Medlow, Wentworth Falls and Lawson. The council reserves the right to take over poles, wires, &c., at the end of five years at cost price, or during the following 10 years at cost price, less 3 per cent. per annum for depreciation. The cost of private lighting will be 6d. a unit for fewer than six lights, and 6d. weekly for 25 c.p. lamps.

Fitzroy, Northcote and Preston (Victoria) Tramway Trust has borrowed £25,000 at 5½ per cent., and decided to appoint an engineer. The trust has decided not to amalgamate with the Brunswick and Coburg trust.

Footscray (Victoria) Municipality which obtains its current from the Melbourne Council made a profit last year on its electric supply undertaking of £2,834. Receipts were £13,944. Expenditure included £4,901, paid to Melbourne Council for current.

At a recent meeting of Sydney City Council, the Electric Lighting Committee recommended that the Council adhere to its resolution providing that during the war 10 per cent. preference be given to goods manufactured by British companies, and 5 per cent. preference to goods manufactured by Allied companies; that British companies be taken to mean companies where a majority of the shares are held by natural born subjects of the British Empire. This recommendation has been made in consequence of a reference from the Council that the Committee consider the desirability of substituting 30 per cent. preference in the case of British, and 10 per cent. in the case of Allied companies.

The city electrical engineer (Mr. H. R. Forbes McKay) recommends that arrangements be made for the mutual supply of electricity between the Government tramways department and the Council's electric supply system.

The Australian Commonwealth trade statistics for February show that the imports during the month were valued at £5,963,000, an increase of £1,177,000, compared with February, 1915. These included iron and steel, £151,000; and metal manufactures, £252,000. Exports during the same period were £6,554,000, increase £1,213,000.

India.—"Indian Engineering" says: In view of the growing demand for electric power in Mysore Mr. S. G. Forbes, Chief Electrical Engineer, has formulated two projects to supplement the present works at Cauvery Falls.

These are known as the Shimsha and Kedeclatu schemes, estimated to cost 67 lakhs and 30 lakhs respectively. Power from these would be fed into the existing transmission cables. Increased production up to 40,000 B.H.P. is provided for, with a further possible increase up to 50,000 B.H.P. In discussing a Paper on this subject before the Mysore Engineers' Conference, Mr. Forbes forecasts a possible supply of 3,000 B.H.P. to 4,000 B.H.P. for Madras City, and expresses the opinion that the railway from Bangalore to Mysore can be electrified with beneficial results, and that the schedule of trains could be so arranged that power consumption would be fairly uniform throughout the day at an average of 1,000 B.H.P.

FOREIGN NOTES.

Argentina. The "Review of the River Plate" says Buenos Ayres municipal lighting department has been reorganised under the direction of Senor J. R. Castaneiras.

A new electric power house was inaugurated at Oliva (Province of Cordoba) in March.

The request of the Compañía Alemana Transatlantica de Electricidad for permission to supply electric current by means of overhead wires in certain of the less densely populated districts of Buenos Ayres has been granted, similar permission being accorded to all other electrical companies operating in the city.

The Government have authorised the Buenos Ayres Western Railway to construct in their own workshops, with the assistance of the Great Southern Railway, the coaches required for the company's electric service between Once and Moreno. The Western Railway had originally contracted for these coaches in Germany, but the war involved the rescission of this contract, and British firms had to decline it owing to pressure of war orders.

A meeting of the new co-operative association for the supply of electrical energy in Mar del Plata was held recently. The installation is expected to be working in the approaching summer. It is proposed to charge 40 cents. per unit in summer and 25 cents in winter. The present uniform tariff is 70 cents. The provisional secretary is Senor E. J. Quesada.

The Sociedad Entrerriana de Teléfonos has purchased the telephone concession worked by Señor Toncon in the city of Concordia.

Brazil.—The "Financier" says Norwegian subscriptions have been invited to an electric tramway undertaking for the service of a productive area near Rio de Janeiro.

The minimum capital (which has been partly subscribed and partly assured) is 2,700,000 kroner, and the maximum 2,925,000. The issue is made under the auspices of the Norwegian South American Development Agency and the Anglo Norwegian Land Co. The line, which has hitherto been worked by horse traction, starts at Campo Grande, which is a station on the railway from Rio to Santa Cruz, will serve for goods and passenger traffic in a fruit-growing district. The concession dates from 1915, and is for 45 years.

Uruguay.—The "Review of the River Plate" says, with regard to the Uruguayan Government's exploitation of the electric light and power industry, some idea of the magnitude of the undertaking is conveyed in the last annual report of the Minister of Finance.

This shows that in the year 1914-15, the energy produced by the State power-houses amounted to 27,563,553 units, compared with 27,354,961 in 1913-14, and there are 26,502 consumers. Petroleum fuel has been substituted for coal in the central power house, Montevideo, the result being a substantial economy in working expenses. The State also has power-houses at Colonia, La Paz, Las Piedras and Punta del Este, and is erecting others at Guadalupe, Tacuarembo and Pando. Power-houses are also projected at Maldonado, San Carlos, Artigas, Treinta y Tres, José Batlle y Ordoñez, Nueva Palmira, Dolores, Rosario, Sarandí del Yí, and Santa Lucía.

To show the gain by substituting oil fuel for coal it is stated that the West India Oil Co. undertook to supply 30,000 tons per annum for two years as from Dec. 1 last at $11 Uruguayan (gold) per ton (about £2. 7s.), whereas coal freights from the U.S.A. to Buenos Ayres are at £5, and from Cardiff £3, and coal is selling in Uruguay at £6. per ton.

MISCELLANEOUS NOTES.

Bravery Rewarded.—At Salford on the 18th inst., Sergeant W. R. Smethurst, of the Royal Sussex Regiment, was presented with the Distinguished Conduct Medal for conspicuous gallantry in the field.

Sergeant Smethurst, who was a reservist, had been for several years a motorman in the service of the Salford Tramways Committee. On Sept. 25, 1915, near Le Rutoire (Loos) his officers were put out of action, and at a trying and difficult moment he took command of his company, and by his bravery and courageous example (though seriously wounded) materially assisted in the attack upon the enemy. The presentation took place at a meeting of the Tramways Committee, at which the chairman (Ald. Linsley) presided, and stated that 528 employés of the committee had joined the army, and 25 had given their lives for their country. The medal was affixed to Sergeant Smethurst's tunic (upon which were the ribands of decorations he had already won) by the Deputy Mayor. The gallant sergeant was also presented by the Tramways Committee with an illuminated copy of a resolution passed by the Committee, congratulating him, as one of their employees, upon the great distinction he had won.

Customs Decisions. According to a recent decision regarding import of motor vehicles, chassis and accessories into New Zealand, cyclometers, speedometers and recorders, taximeters, electric batteries and switchboards, lamps and lamp covers, gas generators and lubricators will only be classed as parts of the vehicles to which they belong when accompanying such vehicle.

A new import tariff, taking effect from Jan. 19, 1916, fixes various new duties upon imports into the Solomon Islands (Western Pacific). Amongst the items which are duty free are machinery and component parts thereof which the High Commissioner may from time to time specify, including electrical, refrigerating, mining, sawing, steam engines and boilers and oil engines, gas engines and hot air engines; rails (iron and steel), sleepers, fish plates, switches, crossings, turntables and parts thereof and bolts and nuts imported with and belonging to same.

Derby Chamber of Commerce Year Book, 1916.—We have received a copy of the first issue of this book.

Messrs. Benrose & Sons, Midland place, Derby, through whom the book is issued, state that its distribution in allied and neutral countries is an attempt to open up business abroad. The book, which consists of over 200 pages, contains a history of the Chamber, statistics relating to Derbyshire, particulars of public utility services, a history of Derby, particulars relating to Chesterfield and Burton-on-Trent, information regarding manufacturing and other industries, British commercial

attachés, trade commissioners and consuls abroad, foreign moneys, weights and measures, procedure in regard to exports to Australia, Canada and other British possessions, British Chambers of Commerce abroad, a classified trade index of firms in Derbyshire and district, in English, French, Russian and Spanish, &c.

Exports to China and Siam.—Further lists of persons and firms in China and Siam to whom goods may be consigned by persons in the United Kingdom have been published. Amongst the firms mentioned is the Eastern Engineering Works (James Turner), Tientsin.

Maschinenfabrik Oerlikon Shareholders.—The London manager and chief engineer of the Maschinenfabrik Oerlikon (Mr. C. Wüthrich) writes to say that from time to time detrimental remarks as to the status of the company have come to his notice. In most (if not all cases) it is difficult to trace the source of their origin, and they are almost impossible to counteract effectively.

Mr. Wüthrich states that in consequence of these remarks he caused, on the occasion of the last general meeting of the company, legal measures to be taken for recording the nationality of the shareholders, and as a result a statement has now been issued by the works, the original of which is held in the London office. There are 16,000 shares, and of these 14,711 are held by Swiss citizens. Mr. Wüthrich traced a holding of some 1,000 shares in this country, and the shares to be apportioned to other countries must, therefore, be quite negligible. The document is duly attested by a Swiss notary, and the signature of the latter is attested by the British Pro-Consul.

More Enemy Firms Wound Up. The Board of Trade have issued 123 Orders up to date for the winding up of businesses controlled by alien enemies.

Amongst the latest are Lobenthal & Co., bronze powder and carbon merchants, 17, Carthusian-street, London, E.C. (Controller: Jas. Morton, 50, Gresham-street, E.C.); Ernest Wahlen, glass and china merchants, 88, Oxford-street, London, W. (Controller: Alfd. Page, 28, Kingstreet, Cheapside, E.C.); United Chemical Works (Ltd.), 9, Farringdon-road, London, E.C. (Controller: C. Bramwell Smith, 79, Basinghall-st., E.C.); Schliemanns Oil & Ceresine Co. (Ltd.), oil and wax merchants, London House, New London-st., London, E.C.

Tribunal Cases. At Lambeth (London) last week an application was made for exemption by an electrician employed by the South Metropolitan Electric Supply Corpn.

As an outside worker it was stated that it was a moot point as to whether he was in the revised list of reserved occupations. His grounds for exemption were that he was in a reserved occupation, and that he was employed on public utility service. Applicant's departmental manager (who was sent for) informed the tribunal that the men were exempt. That morning he had received a letter from the Ministry of Munitions declaring that the men previously exempt so far as public electric lighting companies were concerned were still exempt.

The Mayor said they would adjourn the matter for inquiry. Exempted men ought to have badges and certificates, and the tribunal should not be burdened with their appeals.

TENDERS INVITED.

Cables and Meters.

GLASGOW Corporation invite tenders for the supply of Cables (including small i.r. Cables and Flexibles) and Meters for 12 months from May 31 next. Specifications and forms of tender from the chief engineer of the electricity department, Mr. W. W. Lackie, 75, Waterloo-street, Glasgow. Tenders to the town clerk, Sir John Lindsay, by 10 a.m. May 4. *See also an advertisement.*

Transformers, Terminal Boxes, &c.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. May 31 for supply of Transformers, with Terminal and Fuse Boxes during five years. The first order will be for 220 transformers to be delivered in six months. Specifications, &c., from the Commissioners' Offices, Spencer-street, Melbourne.

The Town Clerk, municipal offices, JOHANNESBURG, will receive tenders until noon June 6 for the supply of 500 c.i. Joint Boxes and 200 Hanks of Trolley Rope (contract No. 112). Specifications, &c., from the municipal offices, Johannesburg.

Meters.

MELBOURNE (Victoria) Council require tenders for Electricity Meters. Forms of tender from Messrs. McIlwraith, McEacharn & Co., Billiter Sq.-bldgs, London, E.C., to whom tenders by noon May 1.

Telegraph Material.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

Turbo-Alternator, Electric Generator, Gas Producer Plant, &c.

The NEW SOUTH WALES GOVERNMENT Railways and Tramways Department invite tenders for the supply and erection of a 2,500 kw. Turbo-Alternator for the Zarra-street (Newcastle, N.S.W.) power house. Specification (No. 470) from the Electrical Engineer, and tenders to Chief Commissioner for Railways and Tramways, Phillip-street, Sydney, by noon May 3.

WANGANUI (N.Z.) Borough Council require tenders by noon May 9 for the supply and erection of Additional Plant at their tramway power house, including Pressure-type Gas Producer Plant, Gas Engine, Electric Generator and Switchgear. Specification, &c., from the Town Clerk.

Generating Plant, Mains, Transformers, &c.

OAMARU (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1, 1s. for each contract.

Tramway Construction, Tramcars, &c.

The Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, require tenders by May 19 for the construction and working, for 60 years, of an electric Tramway in BILBAO, connecting the existing system with the Irala-Barri district. Minimum rolling stock required to commence is one motor and one trailer coach for passengers, and one motor goods coach and two trailer goods wagons. An option on the concession is held by the Sociedad Tranvia Urbano de Bilbao.

DUNEDIN (N.Z.) City Council require tenders by 5 p.m. May 17 for six Electric Tramcars and sections of Cars (Bodies, Electrical Equipments and Trucks). Specifications, &c., from the Town Hall, Dunedin.

JOHANNESBURG (Transvaal) Council require tenders by noon June 6 for supply of two Manganese Steel Crossings. Specification, &c., from the Municipal Offices, Johannesburg.

The Public Works Dept., Madrid, will receive tenders until noon May 30 for the Construction and Working, for 60 years, of an Electric Tramway in MELILLA (North Africa). The minimum rolling stock required is 16 coaches, with motors and accessories. An option is held by Don Felipe Ezquerro.

Motor Generator, &c.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. May 10 for Motor Generator and Accessories for Battery Charging of Baggage Trucks, also Switchboard and Connections (contract No. 29,796).

Steam Pipes, &c.

SALFORD Corporation want tenders by noon May 8 for high pressure Steel Steam Pipes and Separator: and c.i. Pipes and Valves. Specifications from the Borough Electrical Engineer.

Electric Cable, Cranes, &c.

The SOUTH AFRICAN RAILWAYS ADMINISTRATION require tenders by noon May 1 for the Supply of 1 Mile of 0·9 sq. in. Single-stranded Copper Conductor of Armoured and Lead-sheathed Paper-insulated Cable, suitable for 660 volts d.c. (contract No. 700); and until noon May 15 for the supply of two 50-ton Electric Overhead Travelling Cranes for new erecting shop at Salt River workshops (contract No. 701). Specifications and forms of tender from the Secretary, Tender Board, South African Railways Headquarters Offices, Johannesburg. Tenders for the cranes will also be received up to May 15 by the High Commissioner for South Africa, 32, Victoria-street, London, S.W., at whose office also specifications may be obtained.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. May 17 for the supply and erection of a 2-ton Electrically operated Goods Elevator at the Jolimont car shed. Specifications from the Commissioners' Office, Spencer-street, Melbourne

TENDERS RECEIVED AND ACCEPTED.

BRADFORD.—The Corporation has accepted the following tenders for plant for Valley-road generating station :—

Musgrave & Co., induced draught plant and two steel chimneys : Electrometers Limited, three 50 H.P. fan motors ; Ferranti Limited, two 250 k.v.a. transformers.

LONDON.—London County Council has accepted the tender of W. Downs (Ltd.) (lowest tender) for foundations for turbo-generator at Greenwich generating station, £4,751. (Seven tenders received ; highest, £6,853. Architect's estimate, £4,500.)

SUNDERLAND.—The Corporation has accepted the following tenders :—

Babcock & Wilcox, superheater tubes ; G. & J. Weir, impellers for pumps ; India Rubber, Gutta Percha & Telegraph Works Co., insulating tape ; Dussek Bitumen Co., box compound.

EAST HAM.—The following tenders have been accepted for engineers' sundries :—

F. Bird & Co., Pryke & Palmer, Docker Bros., Middleton Bros., M. G. Davis & Co., W. Stone & Son.

SOUTHAMPTON.—The Corporation has decided to divide the contract for electricity meters between Ferranti (Ltd.) and Chamberlain & Hookham, and the engineer has been authorised to purchase any additional meters from the British Thomson-Houston Co. at prices not exceeding those quoted by the two first-mentioned firms.

The Tramways Committee has accepted the tender of G. P. Wilson for the supply of brake blocks and castings, at £5. 12s. 6d. per ton.

LEYTON.—The quotation of Edgar Allen & Co. has been accepted, at £480, for the supply of a new lay-out.

MANCHESTER.—The Guardians have accepted the tender of Drake & Gorham (Manchester Branch) for the supply of electrical materials required in connection with the additional electric lighting of the main side of the Withington Institution.

Government Contracts.—The following tenders were accepted by the British Government Departments during March :—

War Office.—Baird & Tatlock (London), Ltd., chemical apparatus, &c. : Premier Accumulator Co. and Pritchett & Gold & Electric Power Storage Co., secondary batteries ; British Insulated & Helsby Cables, Callender's Cable & Construction Co., Connolly Bros., Hooper's Telegraph & India Rubber Works, Johnson & Phillips, Liverpool Electric Cable Co., St. Helen's Cable & Rubber Co., Saxonia Electrical Wire Co., Siemens Bros. & Co., and Yorkshire Cable Co., electric cables and wires ; J. C. Fuller & Son and Siemens Bros. & Co., electric cells ; Butters Bros., Grafton & Co., and Stothert & Pitt, cranes and parts ; Day Motor Co., electric lighting sets ; Aster Engineering Co., Austin Motor Co., W. H. Dorman & Co., Electric & Ordnance Accessories Co., Fyfe, Wilson & Co., Keighley Gas & Oil Engine Co., Arthur Lyon & Wrench, New Pelephone Engine Co., Norris, Henty & Gardeners and Parsons Motor Co., generating sets ; Brimsdown Lamp Works, Bulpitt & Sons, Dick, Kerr & Co., Edison & Swan United Electric Light Co., E. Griffiths & Sons, A. Lyon & Wrench and Siemens Bros. Dynamo Works, electric lamps ; Park Royal Engineering Co. and Siemens Bros. & Co., switchboards ; British Electric Transformer Co., transformers ; Pinching & Walton, electric lighting, &c., Crayford ; V. G. Middleton, ditto, Clipstone Camp, Mansfield, and Park Hall, Oswestry ; Girdleston & Co., erection of power house and equipment, Wigton.

India Office.—Lancashire Dynamo & Motor Co., generator sets.

H.M. Office of Works.—Aldons & Campbell, electric passenger lift, Edinburgh Inland Revenue Office ; Medway's Safety Lift Co., electric paper and coal lifts ; Waygood-Otis (Ltd.), electric passenger lifts.

Post Office.—Creed, Bille & Co., telegraph apparatus ; British Insulated & Helsby Cables and Siemens Bros. & Co., telephone apparatus ; General Electric Co., testing apparatus ; Bullers (Ltd.), iron telegraph arms ; Telegraph Construction & Maintenance Co., telephone cable ; Thos. Bolton & Sons, Shropshire Iron Co. and F. Smith & Co., Ltd. (inc. in London Electric Wire Co. and Smiths), bronze wire ; Thos. Bolton & Sons, British Insulated & Helsby Cables, Elliotts Metal Co., Ltd., Johnson & Nephew, Shropshire Iron Co., Ltd., F. Smith & Co., Ltd. (inc. in London Electric Wire Co. and Smiths), and Wilkes, Son & Mapplebeck, copper wire ; Rylands Bros. and Whitecross Co., g.i. wire.

FINANCIAL MATTERS.

COMPANIES' MEETINGS AND REPORTS.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The report for the year ended March 31 states that three quarterly interim dividends of 15s. per cent. on the ordinary stock and £1. 10s. per cent. on the preferred stock were paid in May, July and November, 1915, absorbing £157,500, and in February the directors paid the final dividend for the year 1915, amounting to £1. 10s. per cent. on the ordinary stock, £1. 10s. per cent. on the preferred stock and £1. 10s. per cent. on the deferred stock. These payments absorbed £262,500, being the rent paid by the Western Union Telegraph Co. for the year, equal to 3¾ per cent. on the ordinary stock, 6 per cent. on the preferred stock and 1½ per cent. on the deferred stock. A bonus of 1s. 9d. per cent. upon the ordinary stock and 5s. 6d. per cent. upon the deferred stock was paid on Feb. 1, 1916. The balance at credit of revenue account (£67,153. 3s. 4d.) includes £1,528. 3s. 4d. interest received, and the balance of £65,625 is available for payment of dividends for the quarter to March 31, 1916.

BATH ELECTRIC TRAMWAYS (LTD.)—The accounts for 1915, after providing for the preference dividend and sinking fund instalment, show an available balance of £8,486, which the directors recommend should be carried forward to augment the reserves available for depreciation and renewals.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—Mr. E. Garcke, who presided at the meeting last week, said that despite the many difficulties of the past year they had maintained the improvement of recent years. The gross profits were a little larger, but their general charges had been £1,200 higher, and they had spent £1,200 more on maintenance of plant and buildings, so that the net distributable profits (after paying debenture interest) were £17,300, compared with £19,100 in 1914. During the year they had spent £31,962 on capital account in connection with contracts on which they were engaged. In view of the fact that they were paying 10 per cent. per annum on the prior lien debenture stock, and that the present was not a good time to make an issue on the most favourable terms, they were postponing doing so as long as possible, and meanwhile were utilising their profits and temporary loans to provide the cash for capital expenditure. The performance of the Ljungstrom turbine continued to be highly satisfactory. Naturally, some of the directions in which they looked for sales in that class of plant were closed for the time being, and development had to some extent been delayed, but during the year they had supplied Ljungstrom sets to the Government and for munition works, as well as electricity supply stations and to industrial undertakings, in every case with gratifying results. Ljungstrom sets of larger size were now in course of installation. The unusual advantages offered by that novel turbine in the way of steam economy, together with the thorough reliability of the design, were attracting world-wide attention, and orders were in course of execution for Japan and New Zealand. The Swedish Ljungstrom Company had made phenomenal progress, and found itself for the time being unable to cope with the great demand that had arisen for their turbines. The figures representing the total output by the parent company, as well as the Brush Company, were really remarkable. The total amounted to 133,000 kw., thus showing that the Ljungstrom turbine had passed completely out of the experimental stage. Their own arrangements for the manufacture of the turbine, with its auxiliaries, on a more extended scale were well forward.

CITY OF SANTOS IMPROVEMENTS CO. (LTD.)—At the meeting last week the chairman (Mr. D. M. Fox) said there was a falling off in the tramway passenger and freight traffics. The number of passengers carried during 1915 was 14,870,776, a decrease of 3 per cent. The consumption of energy for electric light and power showed a steady increase. Undoubtedly the results from that department must be considered as being satisfactory, more especially having regard to existing conditions. There was, however, some improvement in local business circles.

COLOMBO ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—A dividend of 10 per cent. (tax free) has been declared for the past year. A sum of £15,000 has been placed to general reserve and renewal fund, which has been dealt with by writing off £5,000 from the special renewal fund. The amount carried forward is £8,165.

CUBA SUBMARINE TELEGRAPH CO. (LTD.)—The total receipts of the 12 months ended Dec. 31 last were £45,310. 11s. 2d., while the expenses amounted to £29,120. 18s. 8d., leaving a balance of £16,189. 12s. 6d., to which has to be added £7,891. 5s. 2d. brought forward, giving a total of £24,080. 17s. 8d. The directors regret to report that several of the cables were seriously affected by earthquakes, cyclones and other causes during the year, necessitating heavy expenditure both of cable and for steamer hire in repairing same, amounting to £13,654. 15s. 10d., which has been charged against revenue. Interim dividends were paid on Oct. 21, viz., at rate of 10 per cent. per annum (less tax) on the preference shares, and at rate of 5 per cent. per annum (tax free) on the ordinary shares. £2,500 has been placed to pension fund and the directors now recommend payment of final dividends at the same rates as the above, making total dividends for the year of 10 per cent. on the preference shares and 5 per cent. on the ordinary shares, £7,580. 17s. 8d. being carried forward.

FIFE TRAMWAY, LIGHT & POWER CO. (LTD.)—The profit for 1915, together with balance brought forward (after paying debenture interest and providing instalments for debenture stock redemption) amount to £19,980. From that sum 6 per cent. on preference shares for the half-year has been paid, absorbing £5,382 and leaving £14,598. The directors propose payment of 6 per cent. interest on preference shares for half-year to the end of December (absorbing £5,029), a dividend of 3½ per cent. on the ordinary shares (£2,830), the transfer to reserve of £3,000, carrying forward £3,737. The increased earnings on power and lighting were sufficient to make up the deficiencies in the revenue from the tramways. Mr. W. Low, who presided at the recent meeting, said the earnings of the Dunfermline & District Tramways Co. decreased by £1,600, being £13,650, but so far the current year showed a substantial improvement. The company had obtained powers for an extension of time in which to build tramways to the south of Dunfermline and for additional lines from Dunfermline to Rosyth and Inverkeithing, and from Lochgelly to Kinglassie.

INDO-EUROPEAN TELEGRAPH CO. (LTD.)—The ordinary general meeting was held yesterday (Thursday), and was adjourned owing to the year's accounts not being yet available. A full report will appear in our next issue.

JOHNSON & PHILLIPS (LTD.)—The profit for the year on trading accounts, &c., after making provision for bad and doubtful debts, and after charging to revenue upwards of £9,000 for maintenance of buildings, plant, &c., amounts to £69,083. 19s. 7d. Adding balance brought forward (£24,295. 12s. 5d.) and deducting dividend paid April 30, 1915 (£8,750), the balance is £84,629. 12s. Out of this sum remuneration of directors, auditors' and trustees' fees require £1,958. 5s. 6d., interest on debenture stock to Dec. 31, 1915, £5,727. 6s. 3d., reserve re debenture sinking fund, £7,181. 19s. 4d., interest on second debentures to Dec. 31, 1915, £2,500, depreciation on machinery and plant, &c., £12,148. 11s., interest on loan, £1,063. 3s. 4d., and reserve account, £20,000, leaving available a balance of £34,050. 6s. 7d. The directors recommend payment of a dividend at rate of 5 per cent. per annum on the ordinary shares (tax free), which will require £8,750, leaving to be carried forward £25,300. 6s. 7d. The directors have transferred £20,000 to reserve account, in order to meet contingencies in connection with the war.

RIVER PLATE ELECTRICITY CO. (LTD.)—The net revenue for 1915, after providing for administration expenses, bad debts and all necessary depreciations, amounts to £38,713, and with £20 513 brought forward the total is £59,226. The board proposes a dividend of 7 per cent. for the year on the ordinary stock, to set aside as special provision for bad debts £5,000, income tax £5,000 and to carry forward £18,387. The persistence of unfavourable trading conditions in the Argentine, aggravated by the prolongation of the European war and the great rise in freights and cost of materials, has adversely affected the results. The continuance of hostilities has also prevented the payment of interest upon the 5 per cent. obligations of the German Trans-Oceanic Electric Co. of Berlin. It has likewise prevented the eighth annual payment of £2,300, due upon April 1, 1916, on account of the amortisation of the 5 per cent. obligations being made. No dividend is included in the year's receipts upon the 21,000 £1 shares of the Argentine Electricity Co. received in connection with the sale of Tucuman, but upon the issue of that company's report, due shortly, it is expected that a small dividend will be declared. The important capital improvements and extensions at Ensenada and La Plata in progress during the last two or three years have been completed. No further capital expenditure is in contemplation.

WILLANS & ROBINSON (LTD.)—For 1915 the net profit was £16,726. 0s. 8d., after payment of debenture interest, provision for depreciation of plant and machinery and revaluation of stocks, allowances to employees on active service, as well as special provision on account of outlays and commitments arising from war conditions. The directors are pleased to report that during the year the Queen's Ferry works were disposed of. In 1913 the majority of the ordinary shares were acquired on terms by interests whom Mr. H. Barber represented. An opportunity has arisen by transfer of the greater part of such interests of introducing additional parties. The directors consider this will be advantageous to the company's interests, and a resolution confirming the conditional release of Mr. Barber from his covenant not to transfer the shares, will be submitted to the shareholders for approval. Warrants will be issued covering the dividends on "A" and "B" preference stocks, and interest on the funding certificates. A dividend for the year of 10 per cent. on the ordinary shares is recommended, leaving £8,776. 0s. 8d. Of this it is proposed to carry £7,098. 19s. to reserve, and to distribute the balance of £1,677. 1s. 8d. among the holders of "B" stock and ordinary shares in manner provided by the articles.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ATKEY (LONDON) (LTD.) (143,550.)—Reg. April 10, capital £25,000 in £1 shares (20,000 preference), to take over the export branch of the business of A. R. Atkey & Co. (Ltd.), of Nottingham and London, and to carry on the business of importers and exporters of goods and merchandise of all kinds, general merchants and commission agents, mechanical, electrical and general engineers, [illegible] manufacturers, &c. Private company. First directors are A. P. Atkey (life managing director), R. E. Roberts, H. E. A. Smith, T. D[illegible]ams, S. Benjamin and M. L. Paget.

BAXENDALE BROS. (LTD.) (143,544).—Reg. April 8th, capital £5,000 in £1 shares, to take over the business of a dealer in electrical supplies carried on by W. I. Baxendale at Liverpool, as Baxendale Bros., to carry on the same and the business of electricians, electrical and mechanical engineers, manufacturers of, dealers in, agents and contractors for electrical, mechanical, telegraphic, telephonic, and other appliances, motor cars, &c. The company may not carry on any electrical business within 12 miles of Manchester Town Hall. Private company. First directors are W. I. Baxendale (permanent managing director, with £[illegible] per annum) and W. Walker. Reg. office: 29, Harrington-street, Liverpool.

BOROUGH GARAGE CO. (LTD.) (143,655).—Reg. April 19, capital £1,000 in £1 shares, to carry on the business of manufacturers of, agents for and dealers in motors and motor cars and vehicles of all kinds (except ordinary cycles), electrical and mechanical engineers, founders, &c., and to adopt an agreement with J. Baxter. Private company. First directors are R. Burgess (chairman), F. Youngman, G. S. Samuels and W. Dierdin. Reg. office: 141, Milton-road, Gravesend, Kent.

ENTENTE ENGINEERING CO. (LTD.) (143,564.)—Reg. April 11, capital £5,000 in 4,000 "A" shares of £1 each and 8,000 ordinary shares of 2s. 6d. each, to carry on the business of manufacturers of and dealers in war material and munitions, machinery and tools, civil, mechanical or electrical engineers, &c. Private company. Reg. office, 65, Londenwall, E.C.

LOWCOYLE ENGINE CO. (LTD.) (143,557.)—Reg. April 10, capital £15,000 in £1 shares, to adopt an agreement with W. D. Verschoyle, to acquire interests in and turn to account patents for improvements in internal combustion engines of the two-stroke cycle type, to carry on the business of manufacturers of and dealers in aeroplanes, seaplanes, motor cars, &c., mechanical and electrical engineers. Private company. First directors are A. Legette and W. D. Verschoyle, F.C.S. Reg. office, 26-27, Queen Anne's-chambers, S.W.

MITCHAM RUBBER CO. (LTD.) (143,592.)—Reg. April 13, capital £50,000 in £1 shares, to carry on the business of indiarubber, asbestos, gutta percha and cotton belting, ship and engineers' stores manufacturers and dealers, electricians, telegraph and electrical engineers and contractors, submarine and other cable and telegraph instrument manufacturers, wire drawers, &c.

N.E.C.T.A. (LTD.) (143,669).—Reg. April 19, as a company limited by guarantee, but having a share capital of £4,000 in £1 shares, 2,000 being 6 per cent. cumulative preferred. Each member undertakes to contribute not more than £1 in event of winding up. The objects are: To enter into contracts (*a*) to obtain special trade discounts on the purchases or dealings of members or others, and (*b*) to indemnify clients of members or others against the supply of faulty workmanship or materials to carry on, as principals or agents, the business of manufacturers, repairers, commission agents, contractors or dealers in electrical machinery, instruments, appliances, wires, cables, accessories and apparatus, electricians, electrical, mechanical or general engineers, &c. The management is vested in a council, which shall consist of such persons who are existing members of the Central Board of the Electrical Contractors' Association (Incorporated) as shall consent to be members of the company and act thereon. The first are W. Cross, P. Collinson, H. Marryatt, J. Orringe, W. R. Rawlings, W. A. Shaw and S. H. Webb. Secretary: L. G. Tate. Reg. office: 20, Bucklersbury, E.C.

PRECISION SCREW CO. (LTD.) (143,612.)—Reg. April 14, capital £3,000 in £1 shares (2,000 preference), to carry on in the U.K. or elsewhere the business of manufacturers of screws, particularly screws and parts for electrical and scientific instruments and small engineering and scientific apparatus, &c., and to adopt an agreement between E. Homberger and F. E. Collinson. Private company. First directors are E. Homberger and F. E. Collinson (both permanent, subject to holding £500 shares). Reg. office, Provost Works, Macdonald road, Walthamstow.

VICTOR HORSMAN (LTD.) (143,639).—Reg. April 17, capital £1,000 in £1 shares, to take over the business of an electrical, mechanical, automobile and kinematograph engineer, and manufacturer of electrical apparatus and accessories, carried on by V. E. Horsman at Liverpool as Victor Horsman & Co. Private company. First directors are V. E. Horsman (life governing director, with £250 per annum as remuneration) and Mrs. D. M. Horsman.

MORTGAGES AND CHARGES.

DERBY LAMP WORKS (LTD.) Second mortgage debenture, dated March 30, 1916, to secure £2,000, charged on company's undertaking and property, present and future. Holder, W. L. T. Arkwright.

NEWTON & WRIGHT (LTD.)—Land registry charge on certain land in Islington, dated March 27, 1916, to secure all moneys due or to become due from company to Union of London & Smiths Bank, 455, Oxford-street, W.

WOODBRIDGE & DISTRICT ELECTRIC LIGHT CO. (LTD.)—Issues on various dates from Oct. 27, 1913, to March 31, 1916, of £1,000 debentures, parts of series of which particulars have already been filed.

CITY NOTES.

MEMORANDA (April 26).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 57 1/16. Consols Pay Day, May 4. Stocks and Shares Ticket Days, May 11 and 30. Pay Days, May 12 and 31. Price of silver, 32 1/16 d.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The directors have decided to recommend payment of a final dividend on the ordinary shares at rate of 11 per cent. per annum for the half-year ended Dec. 31, 1915, making, with the interim dividend paid in November last, 9 per cent. for the year. £52,000 is placed to depreciation and renewals fund, and £10,000 to reserve, the same as in the previous year.

DAWLISH ELECTRIC LIGHT & POWER CO. (LTD.)—The report for 1915 states that, though the results were affected by the war, the gross profit was little less than in 1914. A dividend of 1½ per cent. has been declared on the ordinary shares and £121 carried forward.

MONTREAL LIGHT, HEAT & POWER CO.—The directors have declared a quarterly dividend of 2½ per cent., being at rate of 10 per cent. per annum.

SOUTH METROPOLITAN ELECTRIC LIGHT & POWER CO. (LTD.)—At a meeting of the holders of the 4½ per cent. debenture stock last week an extraordinary resolution was passed making modifications in the trust deeds so as to define more clearly the obligations of the company thereunder with regard to setting aside sums to depreciation, &c.

SUBMARINE CABLES' TRUST.—Notice is given that in accordance with the terms of the trust deed 38 certificates will be redeemed from the surplus funds of the Trust by a drawing which will take place on May 1 prox., at 2:30 p.m., at the offices of the Trust, 34, Electra House, Finsbury-pavement, London, E.C., for payment at £120 per certificate, on and after that day at Messrs. Glyn, Mills & Co., 67, Lombard-street, London, E.C.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date April 26, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17½d.
Solid Drawn Copper Tubes	19d.
Brazed Copper Tubes	19d.
Brazed Brass Tubes	19½d.
Brass Wire	16⅝d.
Copper Wire	19d.
Rolled Brass	16⅝d.
Brass Sheets	17½d.

	per ton.
Copper Sheets	£152 0 0
Spelter	£103 0 0
English Lead	£35 10 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£108 0 0
Clean Brass Scrap	£71 0 0
Braziery Copper Scrap	£95 0 0
Old Lead	£31 0 0
Old Zinc	£80 0 0
Hollow Pewter	£125 0 0
Black Pewter	£85 0 0
Gun Metal	£85 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date April 24, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£72 0 0
Clean Copper	£107 0 0
Braziery Copper	£95 0 0
Gun Metal	£85 0 0
Old Lead	£31 0 0
Tea Lead	£29 0 0
Old Zinc	£72 0 0
Hollow Pewter	£135 0 0
Shaped Black Pewter	£95 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £115; Blowpipe Solder, £120.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, April 25. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., April 25.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	10¼	4 19 5	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	9⅛	6 3 1	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅛	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	5 0 0	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	80	5 0 0	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	6 18 6	..
5	5%	Do. Ord.	3⅛	6 19 6	Aug, Feb
5	4½%	Do. City Pref.	2⅛	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅛	6 5 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12	6 13 4	Feb, Aug
10	6/0	Do. 6% Pref.	10	6 0 0	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10½	6 13 4	Mar, Sept
10	6%	Do. 6% Pref.	10½	5 14 3	Feb, Aug
St.	4½%	Do. 1st Deb.	86½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	9[illegible]	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	7[illegible]	5 17 8	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6/-	London Elec. Supp. 6% Pref.	4½	7 1 2	..
St.	4%	Do. 4% Mort. Debs.	80	5 0 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅛	6 4 6	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99¼	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	91½	5 9 3	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	3⅛	6 10 7	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., April 25.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5⅞	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅝	6 0 3	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp 4½% Db. St.	83	5 8 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅛	7 6 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅛	6 10 5	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4⅛	5 11 7	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	79	6 6 7	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	71½	8 7 10	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	67½	5 18 6	..
St.	4%	Do. do. Assented Def. Ord.	64½	6 4 0	..
St.	4½%	Do. 4½% Pref.	99½	4 10 3	Jan, July
St	4%	Do 4% Deb. St.	93½	4 5 9	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	62½	8 0 0	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅜	5 19 6	Jan, July
St.	4%	Do. 4% Pref.	64	6 5 0	Mar, Sept,
St.	4%	Do. 4% Debs.	85	4 14 4	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	26	3 16 11	Feb, Aug
St.	3½%	Do. 3½% Pref.	77½	4 10 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	74½	4 13 9	Feb, Aug
St.	3½%	Do. 3½% A Debs.	82½	4 4 6	Jan, July
St.	3½%	Do. 3½% Debs.	83½	4 4 1	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	10⅜	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	92	4 7 0	May, Nov
St.	4½%	Do. 4½% First Pref.	71⅞	6 5 5	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 7	Jan, July
St.	4%	Do. 4% Debs.	71½	5 12 1	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	70½	5 13 6	Jan, July
St.	4%	Do. 4% Guar. Stock	68	5 17 7	Mar, Sept
		Electric Manufacturing, &c.			
1	14%	Babcock & Wilcox Ord.	2⅜	5 0 8	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	5%	Brit. Aluminium Ord.	1⅜†	4 11 5	Mar
100	5%	Do. Prior Lien Debs.	89½	5 12 0	Jan, July
1	6%	Do. 6% Pref.	⅞†	6 17 2	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10⅜	7 2 0	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅜	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref.	⅞	6 17 2	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛†	7 5 5	April
100	6%	Do. 6% Prior Lien Debs.	100½	5 19 8	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65⅜	6 1 8	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	11⅜	6 9 0	Jan, July
5	2/6	Do. 5% Pref.	4⅛	5 19 5	Feb, Aug
St.	4½%	Do. 4½% Debs.	93	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅞	7 13 8	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	1⅛	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	⅛	7 7 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs	72	5 11 1	Jan, July
.5	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do, 6% Pref.	9⅛	6 4 8	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14½†	6 15 7	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4⅛	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	9⅛	10 1 3	Feb, Aug
10	5%	Do. Pref.	7⅜	6 15 7	Apl, Oct
12	20%	Telegh. Con. & Maln. Co.	35	6 18 0	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1⅛	4 5 9	May, Aug
1	6d.	Do. 5% Pref.	⅝	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	80	5 0 0	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jan, Dec
St.	4%	Willans & Robinson B. Cum. Pref.	41½	9 12 9	..
St.	4%	Do. 1st Mt. Deb. St.	50½	7 18 5	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	99	6 1 2	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	21⅞	6 19 11	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69	5 15 11	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7⅛	6 1 8	May, Nov
10	10%	Do. 10% Pref.	14	7 2 10	..
5	5/0	Direct Spanish 10% Pref.	7½†	6 13 4	..
10	4%	Direct United States	5⅛†	7 0 8	Ja,Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	143½	4 17 9	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	62½	5 12 8	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	79	5 1 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77	5 3 11	Feb, Aug
10	7%	Do. Ord.	14½	24 19 1	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co.	35½	6 3 11	Ja, My, Jly
25	13%	Indo-European	50	6 10 0	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2⅜	4 7 8	April
1	7%	Do. 7% Pref.	1⅜	3 13 5	July
10	1%	West India & Panama Ord.	1⅛	8 4 4	May, Nov
10	6%	Do. 1st Pref.	7⅞	7 12 11	May, Nov
10	7%	Western Telegh. Co.	14½	5 0 0	Mr, Jly,O,Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½†	4 10 3	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅝	6 12 5	Nov.
1	10%	Oriental Telephone Ord.	1⅜	5 8 6	Apl, Oct
St.	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6	6 13 4	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅛	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	84½	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	11½	5 4 4	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10⅛	5 17 1	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	82½	6 1 9	Ja, Apl, Jly,O
..	4%	Do. $100 Pref	70	5 14 3	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	124†	4 1o 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅛	6 10 8	Mar, Sept
St.	5%	Do. 5% Debs.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10⅛	5 18 6	..
St.	4½%	Do. 4½% Deb.	87½	5 2 10	Jan. July
5	9%	Calcutta E S Corp. Ord	6⅞	7 5 5	May, Nov
5	5%	Do. 5% Pref	4⅛	5 14 3	Mar, Sept

* And 13½% bonus. † Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,981. [VOL. LXXVII. No. 5.] **FRIDAY, MAY 5, 1916.** PRICE SIXPENCE
Abroad 9d., or 20 cents. or 1½., or 90c.

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 137
Arrangements for the Week.. 139
The Excitation of Synchronous Machines. By T. Schou. Illustrated 140
The Problem of Voltage Transformation. By Dr. F. Schröter. Illustrated .. 142
Electrical Oscillations from Mercury Vapour Tubes. By Benjamin Liebowitz. Illustrated 144
Horizontal Luffing Crane with Balanced Jib. Illustrated 145
Transformer Design. By F. M. Denton, A.C.G.I. Illustrated. *Continued* 147
The Amplitude and Phase of the Higher Harmonics in Oscillograms. By Prof. G. W. O. Howe, D.Sc. 149
Physical Society..... 150
Ruhleben Camp School 151
Solution of Smoke, Fume and Dust Problems by Electrical Precipitation. By Linn Bradley..... 152
A REAL "NATIONAL DISASTER" 154
REVIEWS..... 155
Treatise on Electricity [Pidduck].
British Destiny: The Principles of Progress [Dunlop].
The A.B.C. of Electricity [Meadowcroft].
Engineering and Scientific Research. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. 156
CORRESPONDENCE..... 160
"Speeding Up in an Engineering Factory" (H. Ambrose Carney, Harold J. Brocklehurst and G. C. Stevens).
LEGAL INTELLIGENCE 162
The "Electrician" Commercial and Industrial Section .. 163-170

NOTES.

Engineering and Research.

LAST Monday a conference on engineering and scientific research was held by the Society of Engineers. This was opened by Prof. J. A. FLEMING, whose Paper on the subject will be found in abstract in another column. The Paper loses, perhaps, a little of its force owing to the large ground which it covers. Although it is well to realise the extent of the field of inquiry we must remember that if anything is to be done of serious value it is necessary to focus attention upon the most important points. Taking first the question of education, we agree with Prof. FLEMING that it would be a great advantage if boys, after completing their Board School education, were forced to attend technical continuation schools (not merely evening classes, which are comparatively useless). This is a method which is followed in Germany and it results in a proper understanding of the principles underlying the trade which the boy is to adopt. The problem of higher grades of education, however, is not so easily settled. A student can obtain a good technical knowledge of the various branches of engineering in many technical institutions at the present time in this country, but this will not avail him very much if he straightway gets the idea that it is quite unnecessary for him to maintain and to expand this knowledge. With regard to research, we quite agree with Prof. FLEMING that the last thing desirable is that research should be controlled by the Government. Government control has been painful enough in the history of the electrical industry, and we do not wish for any steps equivalent to the Act to Facilitate Electric Lighting which was passed in 1882 and which was supposed to "facilitate" the industry and did so much to retard it. What is required of the Government is money more than anything else and a fostering of research in the hands of bodies of men capable of knowing what should be done. We think that the various technical societies should already have this knowledge without the appointing of numerous committees; the latter may satisfy the public, but they generally result in very little being done.

ALTHOUGH discussions like that held last Monday are useful in clearing the air, we feel that they are being generally carried out from the wrong standpoint. It is all very well for eminent scientific people to come together and to decide what the manufacturers in this country should do, but the assumption is made that manufacturers do not know their own business. It may be that this is a right and proper assumption to make in certain cases, and that a proportion of our manufacturers are not sufficiently alive to the advantages of applied and pure science at the present day. This may be partially true, but it is certainly not the case generally with our larger and more important manufacturers. In regard to technical education in particular, it must be remembered that the product is used by the manufacturer, and it is to him we should turn in order to inquire whether the product is what it should be. From every point of view, therefore, it would be much better and would have more lasting results if the manufacturers would themselves come together and invite certain pure scientists to confer with them rather than for the converse method to be followed. We are glad to gather that this course is likely to be taken by what is known as the Manchester Group, and we hope that they will not linger in discussing all these questions adequately so as to reach some decision. It is eminently a matter for the engineering firms themselves to decide.

"Speeding-Up."

THAT Mr. RANKIN'S recent Paper on this subject has created a good deal of interest is evident from the heavy correspondence given elsewhere. With much of Mr. H. AMBROSE CARNEY'S letter we are in entire agreement. Like Mr. CARNEY we are opposed to the setting of "tasks," and to employers getting the idea that because a man takes 1·9 minutes on a job previously done in 2·25 minutes he is necessarily malingering. The reasons for such discrepancies oftentimes are of a most complex character, as shown by the recent report on Industrial Fatigue. The suggestion that Labour and Capital should be equally represented on any committees which may be appointed to investigate and report upon the matter is a good one, for in no other way can lasting and beneficial results be obtained. To the proposal that the new armies should be disbanded through civil reserves, "where every man would be trained in high-efficiency methods in that branch of industry for which he possessed the greatest capacity," we are entirely opposed. Mr. CARNEY'S suggestion that the State should continue to pay at least as much to each man during training as for Army service, is, in our opinion, in every way ill-considered. Surely when peace is proclaimed the men who have been fighting for

us will be allowed to return at once to their former occupations in order to begin to earn the wherewithal to provide homes for their families. Otherwise it looks as though the all and sundry employed on munitions at the present time will continue to hold positions to which our fighting men have the first claim. By some it is thought that it is less expensive to keep men in the Army than to keep them at home. This is not the case. But even if it were less expensive we should nevertheless still advocate the returning of the soldiers, and if the "out of work" question became acute on account of a few-million men being turned into the labour market we should, by compulsion if need be, form civil reserves of those who took no part in the war, in an endeavour to equalise the sacrifice. It is well to remember that those in the Army are the fittest specimens of the race, and that it is a national duty to see that the fit survive.

Statutory Charges for Electrical Energy.

After considerable delay, and in spite of opposition on the part of the local authority, the Newquay Electric Light & Power Co., has received an order from the Board of Trade empowering them to charge for electrical energy at the rate of 7d. per unit instead of 6d., and a minimum quarterly charge of 9s. 11d. up to 17 units. We need scarcely remark that the undertaking at Newquay is a small one and that the whole matter in itself is not of any great importance, but it serves to show the difficulty experienced at the present time by small undertakings which are handicapped by heavy increases in the cost of coal or oil in out-of-the-way localities. Not merely the small undertakings, but the larger undertakings also, are feeling it necessary to raise their charges to some extent. Under present conditions this is becoming inevitable, and it appears to us that such increased prices should be received without any great objection on the part of consumers and without opposition on the part of local authorities, and that such relief should be granted more readily by the Board of Trade for the period of the war. It is only a temporary measure which we ought to be prepared to face.

The Finance of the Telegraph Service.

It has been a sore point for many years that the telegraph service has been worked at a heavy loss in this country. We have cheap telegrams, but the individual who sends a telegram does not realise that in due course he is required by taxation to meet the loss on the telegram he has sent. At a recent meeting of the London Telegraph and Telephone Society, Mr. John Lee, the chief traffic manager to the Post Office, suggested two classes of telegram when normal conditions are once more resumed. His suggestion is that there might be the ordinary telegram at 8d. for 12 words plus a halfpenny per word and a deferred rate of 1d. for 12 words plus a halfpenny per word. Such a scheme would merely be following the example of the cable companies who have sought to maintain a load more nearly approaching 100 per cent. load factor by means of deferred rates. In the case of submarine telegraphy the capital expenditure is so enormous that the end services count for very little, and it becomes all important to keep a cable continually at work. In the case of short land lines the cost of the end services may be more important than the capital involved. It is difficult, therefore, to say how a deferred rate system might work out, but we think it may be said that any scheme for improving the load factor is likely to prove beneficial to the service as well as being a convenience to the public.

Level-Luff Cranes.

Till the introduction of electricity as a motive power, dock and similar cranes were usually provided with derricking mechanism of the non-compensating type, and the jibs of such cranes were not balanced. For reasons with which our readers are familiar, the electric crane, in little more than 10 years, made obsolete cranes of all other types except in those cases where no electricity supply was available. This remarkable achievement, due in part to the modernising of works, has resulted in the introduction of entirely new types and in the improvement of existing types of crane. One such improvement is the so-called level-luff gear, by means of which, when the working radius of the crane is altered, the elevation of the load is not altered. Another improvement is the balancing of the jib. The two together result in a considerable saving in energy consumption, besides giving important mechanical advantages. Although these are not peculiar to the electric crane, they nevertheless show to striking advantage on such cranes, partly on account of the ease with which tests may be made, and partly on account of the mechanical simplicity. Elsewhere will be found a description of one of the most recent horizontal luffing cranes, for which the important advantage of extreme simplicity is claimed. Furthermore, the new crane, which is the invention of Mr. C. M. Toplis, is quite normal in appearance and construction. The typical power consumption diagrams for cranes of the non-compensated and compensated types are very striking, and as a further illustration of the economy of the new cranes it may be stated that the derricking motor is rated at 5 h.p., whereas for the same load and speed an ordinary crane requires a 45 h.p. motor for operating the derricking mechanism. In view of this it is not surprising to find that large numbers of the new cranes are being supplied.

Lowestoft Electricity Supply.—We are glad to state that no damage was done to the electric power station or to the network at Lowestoft during the recent bombardment.

Lady Kelvin's Gifts to Glasgow University. It is announced that Lady Kelvin has made two notable bequests to Glasgow University, of which her husband was Chancellor at the time of his death. One of these is a sum of £5,000 for promoting research and the teaching of physical science in connection with the Chair of Natural Philosophy: the other consists of the numerous medals and decorations conferred on Lord Kelvin.

Coal Supplies. The Board of Trade have sent the following letter to gas and electric lighting undertakings, requesting them to inform their consumers that the consumption of coal for lighting purposes must be reduced by 10 per cent.

I am directed by the Board of Trade to state that, as you will be aware, difficulties have been experienced for some time in securing adequate supplies of coal for manufacturers of munitions and other consumers of national importance owing to the decline in the output of coal from the mines and the increase in the demand for war purposes.

The position has been met in the past to a large extent by a restriction of export, but the coal which is now being exported goes largely to meet the urgent requirements of our Allies or is valuable as a weapon in negotiating with neutral countries.

The Board have observed with some concern the recent decline in coal exports, and, in their opinion, it has become necessary that special steps should be taken to maintain and if possible to increase the exportable surplus of coal, and that for this purpose everything possible should be done to encourage economy in the use of fuel at the present time.

The question has been further considered by the Central Coal and Coke Supplies Committee, and they have recommended that a general policy of economy in lighting should be adopted, and that gas and electric lighting undertakings should be asked to do what they can to reduce consumption by a definite amount. The Board think there can be little doubt that there are many cases in which light is at present being used needlessly, or wasted altogether. They have accordingly decided to request the owners of gas and electric lighting undertakings that they should notify to their consumers that the Government desires to see the consumption of coal for lighting purposes reduced by 10 per cent., and that they should do all in their power by notices and inspection to see that this recommendation is carried out.

The Board would suggest that inspectors should be sent round as often as possible to examine meters and hand to the consumers, where necessary, a notice reminding them of the recommendation and calling attention to the fact that they have not yet carried it out.

The Board would be glad to be informed in due course of the steps which are being taken in the matter.

OBITUARY.

J. Stott.—The death is announced of Mr. James Stott, who was for many years engineer and manager of the Heywood Corporation electricity works. Owing to failing health he resigned his appointment about three years ago.

PERSONAL.

Mr. H. P. Gibbs, consulting electrical engineer to Mysore Government, and also general manager of the Tata hydro-electric scheme, in Bombay, is shortly going to the United States on leave.

Second Lieut. Reginald F. H. Nalder (East Surrey Regt.), son of Mr. Francis H. Nalder, was married at Streatham, London, on April 22, to Miss Kathleen Heaton Jacob.

APPOINTMENTS VACANT.

An advertisement announces that there are vacancies for two practical physicists at manufacturing works in London, for service at the conclusion of the war. Commencing salaries £500 per annum.

A firm of electrical engineers advertises for two engineers, with good commercial training, to manage branch offices in South Africa and Australia.

A switchboard attendant is wanted at once for electricity supply works. Wages 30s., plus 4s. war bonus. *See advertisement.*

Belfast Corporation invite applications for the appointment of general manager of their tramways. Salary £800, rising to £1,000. Applications to the Town Clerk (on forms supplied) by May 13.

INSTITUTIONS AND SOCIETIES.

Institution of Electrical Engineers' Benevolent Fund.—The annual meeting of the contributors to the Benevolent Fund will be held at the Institution of Electrical Engineers, Victoria Embankment, W.C., on Thursday, May 11th, at 9 p.m., to receive the report of the Committee of Management and statement of accounts and balance-sheet to December 31, 1915. An extraordinary resolution will also be submitted altering the constitution of the Committee of Management.

Royal Institution.—At the annual general meeting, when the Duke of Northumberland presided, the report of the Board of Visitors was read and the following officers and council were elected: President, the Duke of Northumberland; treasurer, Sir James Crichton-Browne; secretary, Col. Edmond H. Hills; managers, Sir Thomas Barlow, Sir W. Phipson Beale, Dr. Horace T. Brown, Sir James Mackenzie Davidson, Field-Marshal Lord Grenfell, Mr. Charles Hawksley, Sir Frederic Nathan, the Hon. R. C. Parsons, Sir James Reid, Sir Napier Shaw, Mr. Alexander Siemens, Prof. Silvanus P. Thompson, Lord Wrenbury, Sir A. F. Yarrow and Mr. Justice Younger; visitors, Mr. Horatio Ballantyne, Mr. S. G. Brown, Mr. J. F. W. Deacon, Mr. W. Duddell, Lieut.-Col. H. E. Gaulter, Dr. J. Dundas-Grant, Mr. J. W. Jarvis, Mr. H. R. Kempe, Mr. Francis Legge, Mr. Ernest R. Moon, Prof. Henry G. Plimmer, Sir W. W. Portal, Dr. A. W. Porter, Mr. H. M. Ross and Mr. Joseph Shaw.

Electric Vehicle Committee.—A meeting of this committee was held in London on the 14th ult. It was announced that all the associations, with the exception of the Tramway and Light Railways Association, whose reply had not been received, had renominated their representatives on the committee. The committee re-elected the representatives of the following: Provincial Electric Supply Companies, Makers of Electric Vehicles, Edison Accumulators (Ltd.), Chelsea Electricity Supply Co. (Ltd.). It was decided to invite the Motor Manufacturers' and Traders' Society to nominate a representative to sit upon the committee. The present officers of the committee were re-elected for the present year, except in the case of Mr. A. H. Seabrook, who is engaged upon work in connection with munitions. Dimensions for standards will in future be given in both metric and British measures, and, in regard to the British measures, exact dimensions will be quoted in mils. The secretary was instructed to bring this rule to bear in quoting dimensions of standards in the annual report of the committee. Mr. E. W. Curtis, of the General Vehicle Co., was nominated as the committee's representative upon the Tyre and Road Wear Research Committee of the Society of Motor Manufacturers and Traders.

Institute of Chemistry.—We have received Part II. of the "Proceedings" for 1916, giving an account of the 38th annual general meeting of the Institute. The President, Sir J. J. Dobbie, LL.D., D.Sc., F.R.S., gave his address, in which he alluded to Prof. Meldola's death as a great loss to the Institute. The financial position of the Institute was stated to be satisfactory, in spite of the war and the labour dispute which interfered with building operations. He stated that all ordinary laboratory glassware would in future be procurable from British manufacturers. The value of the work of the Glass Research Committee had been recognised by the Advisory Council on Scientific and Industrial Research. Referring to educational matters, the President stated we were all prone to self-congratulation that we overlooked the great progress that had already been made towards placing science education on a satisfactory footing. The great defect of our public schools was that their specialisation in classics, and other subjects never got a fair chance. He referred to the fact that standards of degrees and diplomas in our Universities differed widely, and the letters B.Sc., M.Sc., or D.Sc. told one little of the attainments of the respective graduates.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 5th (to-day).

Iron and Steel Institute.

10 a.m. At Great George-street, Westminster. Continuation of Annual Meeting. A number of Papers will be read.

Royal Institution.

5:30 p.m. At Albemarle-street, W. Discourse by Sir J. Mackenzie Davidson, M.B., C.M., on "Electrical Methods in Surgical Advance."

SATURDAY, May 6th.

Royal Institution.

3 p.m. At Albemarle-street, W. Lecture by Prof. W. H. Bragg, M.A., D.Sc., F.R.S., on "X-rays and Crystals: New Methods of Research." (Lecture I.)

MONDAY, May 8th.

Society of Arts.

4.30 p.m. At John-street, Adelphi, W.C. Lecture on "Vibrations, Waves and Resonance" (Lecture II.), by Dr. J. Erskine Murray, F.R.S.E.

TUESDAY, May 9th.

Faraday Society.

8 p.m. At the Institution of Electrical Engineers, Victoria Embankment, W.C. The following Papers will be read: "An Analysis of the Theory of Gels as Systems of Two Liquid Phases," by Mr. Emil Hatschek; "The Properties of Solid Solutions of Metals and of Intermetallic Compounds," by Mr. F. C. Thompson, M.Met., B.Sc.; "The Annealing of Metals," by Mr. F. C. Thompson, M.Met., B.Sc.; "The Changes in the Physical Properties of Aluminium with Mechanical Work," by Specific Heats of Hard and Soft Aluminium, by Dr. F. J. Brislee; "A Note on the Annealing of Aluminium," by Messrs. Richard Seligman and Percy Williams; "Grain Size Measurements and Importance of such Information," by Mr. Zay Jeffries, B.S., Met.E.; "A Contribution to the Theory of Solution," by Mr. E. J. Hartung, B.Sc.

Illuminating Engineering Society.

5 p.m. At John-street, Adelphi, W.C. Annual Meeting. Report by Research Committee.

THURSDAY, May 11th.

Institution of Electrical Engineers.

8 p.m. At Victoria Embankment, W.C. Annual General Meeting.

Institution of Electrical Engineers' Benevolent Fund.

9 p.m. At Victoria Embankment, W.C. Annual Meeting of Contributors.

FRIDAY, May 12th.

Physical Society.

5 p.m. At Imperial College of Science, South Kensington. Discussion on "The Latent Heats of Fusion of Metals and the Quantum Theory," by Dr. H. S. Allen, M.A.; "Losses by Light Distribution," by Mr. T. Smith, B.A.; "The Choice of Cemented Objectives," by Mr. T. Smith, B.A.

ENGINEERING INSTITUTIONS VOLUNTEER TRAINING CORPS.

Commanding Officer: Lieut.-Col. C. B. Clay, V.D.

Orders for week commencing May 8, 1916:

Drills: 6.25 to 7.25. 7.25 to 8.25

Monday, May 8th.—Sections 1 and 2, Technical: Sections 3 and 4, Squad and Platoon. Signalling Class and Recruits.

Tuesday, May 9th.—School of Arms 6 to 7 p.m. Recruits' Drill 7.15 to 8.15 p.m.

Thursday, May 11th.—Shooting for Sections 3 and 4. Recruits 5.45 to 7.45 p.m.

Friday, May 12th.—Sections 3 and 4, Technical: Sections 1 and 2, Squad and Platoon. Signalling Class and Recruits.

Saturday, May 13th.—Adjutants' Instruction Class at 2.30 p.m.

Sections for technical, parade at Headquarters, London Electrical Engineers, 46, Regency-street, S.W.: sections for shooting, parade at miniature ranges. Unless otherwise stated, all parades at Chester House

THE EXCITATION OF SYNCHRONOUS MACHINES.*

BY T. SCHOU.

Summary.—The undesirability of operating synchronous machines with different inherent characteristics is touched on. The relation between excitation and voltage of alternators and motors is next dealt with, and an equation for exciter rating is deduced experimentally.

The undesirable features of operating machines in parallel having different inherent characteristics are well known, and the tendency now is to accept certain recognised standards.

In what follows the writer will discuss machines having design features and performance characteristics that comply with the latest rules and suggestions of the A.I.E.E. and the Electric Power Club. The data and curves presented refer to 60-cycle machines, of standard voltages up to and including 2,400 volts, two-phase and three-phase, and alternators that will fulfil specifications given by the author.

In order to discuss intelligently the proper excitation for various machines of different kilovolt-ampere ratings at different synchronous speeds, it will be necessary to analyse in a practical way the vector diagram of an alternator. In Fig. 1 the vector E_0 represents the full terminal voltage, and, according to the saturation of the machine, calls for a field current I_0 at no load. Under ordinary load, however, this field current must be increased in order to maintain normal voltage at the terminals. This increase of field current is to compensate for the ohmic drop in the armature winding, the reactance drop, and the demagnetising effect of the armature ampere-turns or the armature current on the field. Both the ohmic drop and the reactance, as well as the demagnetising effect of the armature current, increase proportionally to the load of the machine or with the amperes per terminal, but whereas the ohmic drop will vectorially add (for a synchronous motor subtract) in line with the watt component of the armature current, the reactance drop will vectorially add in line with the wattless component, or at 90 deg. to the vector of the ohmic drop. The demagnetising effect of armature current on field increases the lower the power-factor.

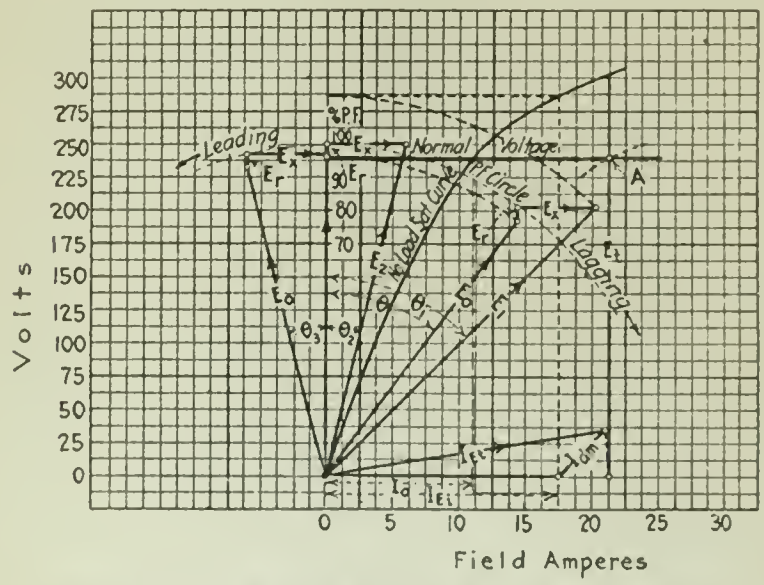


Fig. 1.—Relation between Voltage and Field-current Components in Synchronous Generators.

The unit is a steam-engine-driven three-phase, 60-cycle, 300-revs. per min. Y-connected machine rated at 40 k.v.a. and 240 volts, and operating at full load with a lagging power-factor of 80 per cent.

In Fig. 1 the vector diagram is shown for a condition of full kilovolt-ampere load at a lagging power-factor of 80 per cent. This vector diagram refers to a three-phase machine, the commercial test curve of which is shown in Fig. 2. To the terminal voltage vectorially represented as E_0 in Fig. 1 we add in phase with the watt component the vector representing the ohmic drop, $E_r = I \times R_{ph} \times \sqrt{3}$, where I = amperes per terminal and R_{ph} = resistance in ohms per phase. In phase with the wattless component, or at 90 deg. with E_r, we add vectorially the reactance drop $E_x = I \times X \times \sqrt{3}$, where X = reactance per phase computed in ohms.

The induced E.M.F., E_1, with an internal phase displacement, θ_1, necessitates, according to the saturation of the machine, a field current, I_{E1}. This field current is required to maintain normal voltage at the terminals compensating for the ohmic and reactance drop at full-load amperes. The demagnetising effect of the armature current at cos θ power-factor may be compensated for by a certain number of field ampere-turns or field amperes. This field current, I_{dm}, will vectorially add to I_{E1} in phase with the induced E.M.F. E_1. The resulting field current I_{E1} is the field current necessary to maintain normal voltage at the terminals at 80 per cent. lagging power-factor and full kilovolt-ampere load. Point a is one point (at normal voltage) on the 80 per cent. power-factor load curve, as shown in Fig. 2.

At unity power-factor the demagnetising effect of the armature current on the field is very small, and is due to phase displacement caused by the reactance between the induced E.M.F., E_2, and the armature current. At a certain leading power-factor, cos θ_3—, the armature current would neither magnetise nor demagnetise the field, but merely distort it. If the leading power-factor be further increased, the armature current would tend to magnetise the field of the alternator. At zero lagging power-factor the demagnetising effect of the armature current on the field of an alternator reaches its maximum. It is obvious that both the self-induction (armature reactance) and the armature reaction (demagnetising or magnetising effect of the armature current on the field), or the "synchronous reactance," as the combined effect of both has been termed, depend upon the current and phase displacement in its effect on the excitation of a synchronous machine. At lagging power-factors it will tend to demagnetise the field of an alternator, reaching its maximum demagnetising value at zero power-factor. At leading power-factors, however, it will tend to magnetise the field, reaching its maximum magnetising effect at zero leading power-factor.

Since in an alternator the rotation is against, and in a synchronous motor with, the magnetic attractions and repulsions between field and armature, it is obvious that, whereas lagging current will demagnetise the field of an alternator, it will magnetise the field of a synchronous motor.

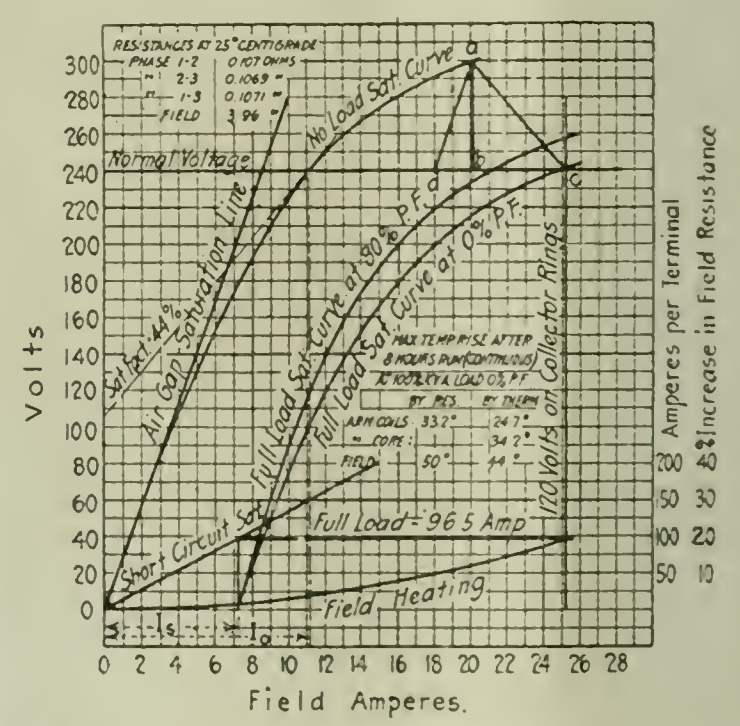


Fig. 2.—Performance Curves for Generator of Fig. 1.

Having detailed information as to the design, it is possible to calculate the effect of the "synchronous reactance" of any alternator at given kilovolt-ampere rating and power-factor, the result of such calculation, however, being only approximately correct. A very simple test run, however, will give the exact value of the "synchronous reactance" at any desired load. If an alternator be run at short-circuit, it is evident that the field current necessary for generating a certain current in the armature coils is just the field current required for overcoming the reactance and maximum demagnetising effect of this current. It is obvious, therefore, that the field current, I_s (Fig. 2), which is the field current at full-load current in the short-circuited armature, is the field excitation necessary to overcome the "synchronous reactance" at normal current no voltage, and will give the base point of the zero per cent., full-load-current power-factor curve.

If the full-load current saturation curve at zero per cent. power-factor be taken as in Fig. 2, we have a simple method of obtaining the vectorial values of the reactance and demagnetising effect. From point c on the zero per cent. power-factor curve at full-load current at normal voltage lay off $I_s = cd$ along the normal voltage line. Draw da parallel to the air-gap saturation line. Then the projection of da on the voltage axis, or ab, represents the reactance drop in volts, and vector bc to scale of field amperes shows the field amperes necessary to overcome the maximum demagnetising effect of the full-load armature current. The ratio between the no-load field current at normal voltage and field current at full-load current at short-circuit, or $I_0 \div I_s$ (Fig. 2), is termed the normal short-circuit ratio of the

* Abstract of an article in the "Electrical World."

alternator. Referring to the alternator test curve (Fig. 2), this ratio is 11·1÷7·2=1·54. If an alternator should sustain a short-circuit while excitation was set at no load, full voltage, then the armature coils would be subjected to a current equal to the short-circuit ratio times full-load amperes. It is obvious, therefore, that machines with high short-circuit ratio or close-regulation machines will be very sensitive to variations in field excitation, and also that the danger of ruining such a machine in case of short-circuit is great.

The following excitation curves and data are based on lines of 60-cycle machines of standard voltages up to and including 2,400 volts, two-phase or three-phase, having a short-circuit ratio of about 1·6 and operating as already outlined. With a given fixed excitation voltage of 125 volts at the exciter 'bus bars, and keeping in mind that the synchronous reactance and field leakage will increase with

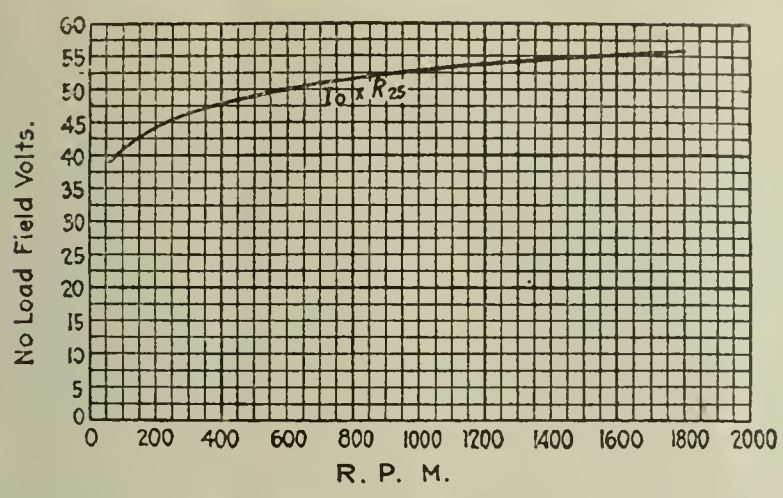


Fig. 3.—Empirical No-load Field Voltages at Different Synchronous Speeds.

decreasing synchronous speed, it is evident that in order to hold up voltage at 50°C. and rated kilovolt-ampere load the no-load field volts, or no-load field current at normal voltage times "cold" (at 25°C.) field resistance, will not be constant for all synchronous speeds, but will be of lower value the lower the speed. In Fig. 3 the no-load field voltage, $I_0 \times R_{25}$, is given at different synchronous speeds. This curve is, of course, empirical and based on experience with lines of 60-cycle machines. Fig. 4 gives kilowatt exciter capacities in percentage of the kilovolt-ampere rating of alternators at various synchronous speeds. These curves will be of interest and practical use in estimating, designing and operating. The curves are also of empirical nature, being based on test results of many 60-cycle machines at different ratings and synchronous speeds. They were originated by the writer in the following way in compiling the performance data for a complete line of 60-cycle machines. The

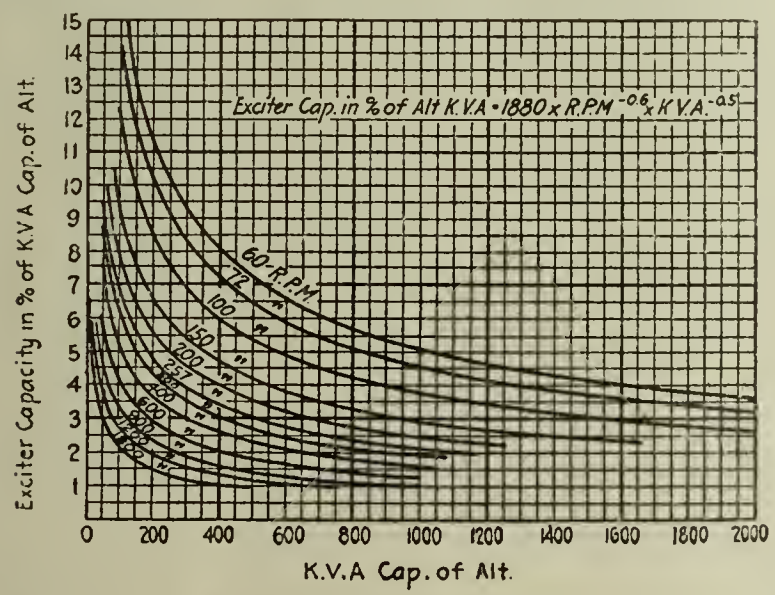


Fig. 4.—Ratio of Exciter Ratings to those of Alternators.

kilowatt exciter rating in per cent. of the alternator kilovolt-ampere rating was plotted against the kilovolt-ampere rating of the alternators, and the curves thus obtained at various synchronous speeds showed a distinct tendency to follow a certain mathematical curve. The values were re-plotted on logarithmic paper and showed up as straight parallel lines. From these the equation for kilowatt exciter rating of alternators at various synchronous speeds was found to follow the law $Y = cZ^{-n} \cdot X^{-m}$, where Y is the exciter capacity in per cent. of kilovolt-ampere rating of alternator, C is found to be 1,880, n is found to be 0·6, m is found to be 0·5, X is the kilovolt-ampere capacity of alternator, and Z is the synchronous speed in revolutions per minute.

When the exciter capacity and the no-load field voltage are given we can derive the complete rheostat information—that is, "cold" field resistance, no-load field current and full field current—of any alternator as follows:—

$$Q = P^2 \div R_{25} \times 1{\cdot}19,$$

where Q is the exciter capacity in watts, P is the excitation voltage (125 volts), R_{25} is the field resistance at 25° C., and 1·19 is the constant compensating for 50° C. temperature rise in the field as guaranteed. Or

$$R_{25} = 125^2 \div 1{\cdot}19Q = 13{,}150 \div Q.$$

The "cold" field resistance in ohms of alternator fields of different kilovolt-ampere capacities and synchronous speeds of the alternators are given in the form of curves, and the equation for the "cold" field resistance R_{25} was found in the same way as the exciter equation

$$R_{25} = 0{\cdot}695 \div \text{r.p.m.}^{0.5} \times \text{k.v.a.}^{0.5},$$

where r.p.m. is the synchronous speed and k.v.a. the capacity of the alternator. Further, $I_0 \times R_{25}$ can be found from the curve of Fig. 3. Therefore, I_0, the no-load field current of alternators, is found. Curves are given for the no-load field current of alternators of various kilovolt-ampere capacities and synchronous speeds.

$$I_0 = 37{\cdot}5 \div \text{r.p.m.}^{0.5} \times \text{k.v.a.}^{0.5}.$$

Knowing the "hot" field resistance $1{\cdot}19R_{25}$ and the exciter voltage at the collector rings (120 volts, allowing 5 volts drop in the brushes),

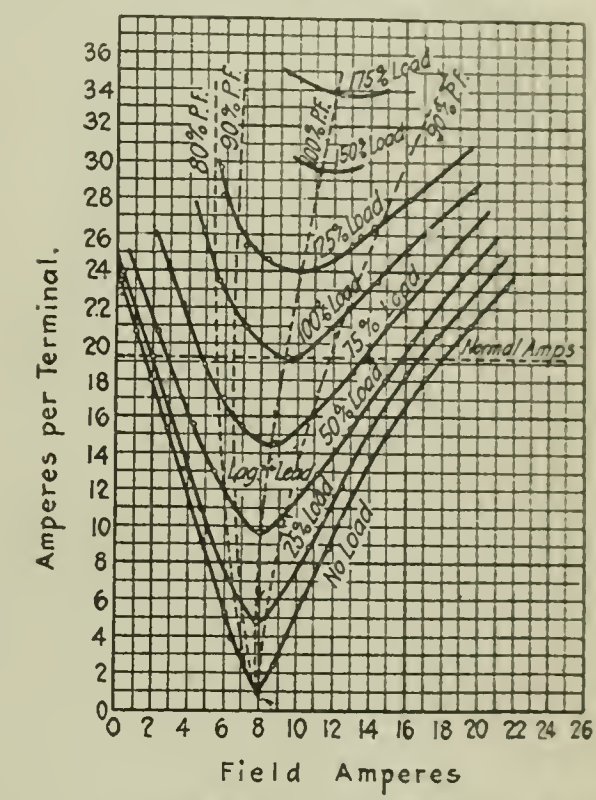


Fig. 5.—Field Currents Required to Maintain certain Power factors at Different Percentages of Rated Loads.

the full field or maximum field current ($I_{max.}$) evidently may be computed for the same line of alternators.

$$I_{max.} = 120/R_{25} \times 1{\cdot}19 = 100{\cdot}75\ R_{25}.$$

Curves for $I_{max.}$, plotted from the equation

$$I_{max} = 145 \times \text{r.p.m.}^{-0.6} \times \text{k.v.a.}^{0.5}$$

are given by the author.

Thus far the discussion has been confined largely to alternators. The excitating curves apply, of course, equally well to synchronous motors operating at leading or unity power factor. The fact that the synchronous motor may be operated at leading, unity or lagging power factor by varying its excitation makes it a very interesting machine. The electrical properties of the synchronous motor are so splendidly demonstrated and simplified in the V curves, showing its phase characteristics, that the writer deems it advisable to discuss them. Fig. 5 gives the tested V curves of a 20 k.v.a. 360 revs per min. synchronous motor, the commercial test results being reproduced in Fig. 6. The phase characteristics are curves showing the minimum value of the armature current when the motor is carrying a certain kilowatt load at a certain field excitation. They are V-shaped curves, being more and more pointed the less kilowatt or mechanical load the motor is carrying. When the synchronous motor is carrying a certain mechanical load, and its field current is regulated to draw minimum amperes from the line at this load, then the motor is operating at unity power factor. The V curves show that there is a very small variation of field current at different loads at 100 per cent. power factor. Furthermore, as the V curves become flatter and flatter at increased load they show that the higher the synchronous reactance (and thus the armature

reactance of the synchronous motor) the less sensitive is the synchronous motor to a change of field current or of impressed E.M.F.

Another interesting feature shown by the no-load V curve is the value of line current a synchronous motor will draw with no field excitation. Referring to Fig. 5, the motor would draw approximately 24 amperes, or 125 per cent. of normal amperes, when running at synchronous speed full voltage but no field excitation. This line current it is of interest to know, because it is the current the motor will draw from the line after being started up and reaching synchronous speed but before the field switch is closed. Knowing the saturation curve at no load and also at full-load current at approximately zero per cent. leading power factor, the line current drawn by the motor at synchronous speed but no field excitation

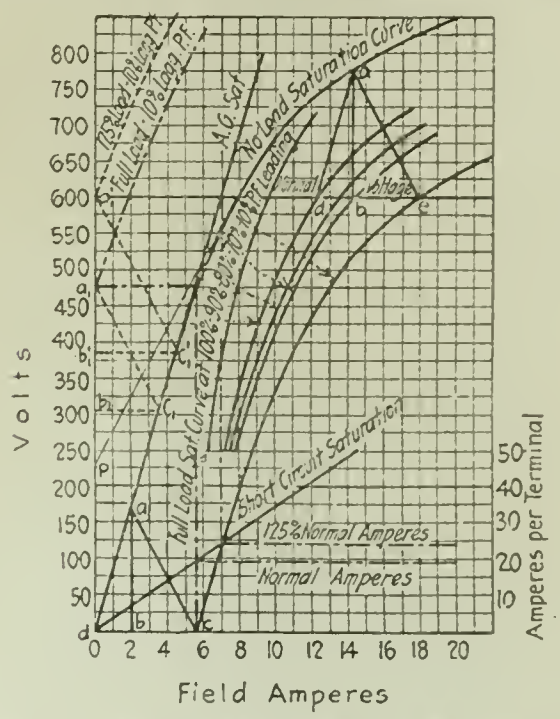


Fig. 6.—Construction for Analytically Computing Line Current from Saturation Curves.

may be found by construction in the following way: The full-load current saturation curve at approximately zero per cent. lagging power factor (Fig. 6) may be found by moving the triangle $a_1b_1c_1$, equivalent to triangle *abc*, that represents the same quantities already discussed in Fig. 2, in such manner that point *c* follows the no-load saturation curve, and the base line *bc* always remains horizontal. The intersection of the full-load current saturation curve at approximately zero per cent. lagging power factor with the ordinate representing the voltage axis evidently gives the impressed E.M.F. at which the motor would draw normal current from line with no field excitation. If line $a_1'c_1'$ is drawn parallel to line a_1c_1 through the normal voltage point on the voltage axis, then the line current the

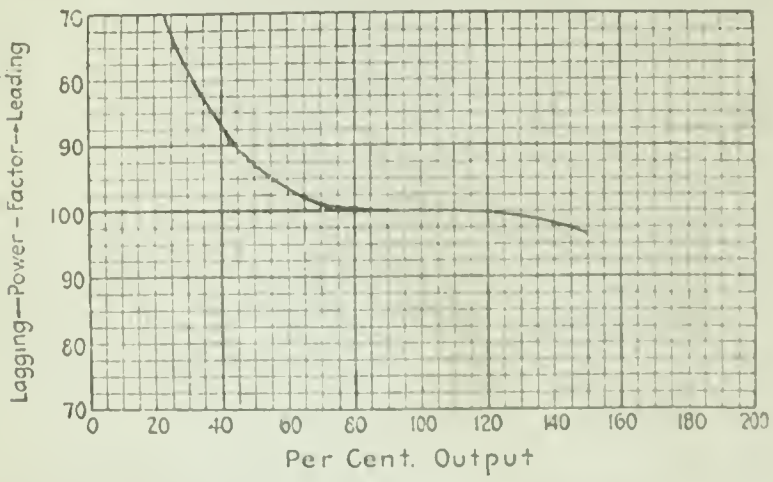


Fig. 7.—Effect of Change of Load on Power-factor of Synchronous Motor Excited to give Unity Power-factor with Full Load.

motor would draw at normal voltage but with no field excitation would be $a_1'c_1' \div a_1c_1$ times normal amperes.

Neglecting the saturation of the magnetic circuit, a synchronous motor running on any voltage at synchronous speed without excitation will draw a current from the line equal to the short-circuit current when run as a generator with field excitation corresponding to the above-mentioned open-circuit voltage. Should the synchronous motor take its excitation from the generator system exciter 'bus bars, which are regulated by a Tirrill regulator, then it can easily be computed what will happen to the operation of the synchronous motor if the excitation voltage should drop or rise in value, which will occur during load changes on the generating system.

For example, referring to Fig. 5, the motor, when operating at 100 per cent. power factor with a power output of 100 per cent. of normal, has a field current of 9·5 amperes. Should, now, the excitation voltage drop 28 per cent., or the voltage of the exciter 'bus bars drop from 125 volts to 90 volts, and the setting of the field rheostat and the power output of the synchronous motor remain unchanged, the field current of the motor will drop to 6·8 amperes. The motor would draw 21·4 amperes from line or operate at full power output at approximately 90 per cent. lagging power factor. Similarly, with a rise of the exciter voltage, the motor, carrying the same mechanical load as before, would settle down to operation at a certain leading power factor.

If the synchronous motor be excited from its own exciter, either directly driven or belt driven, then the excitation voltage of the motor would not be disturbed unless the frequency of the line current should change. If frequency and excitation voltage remain constant and the field excitation of the synchronous motor be set for full-load 100 per cent. power factor, then if the load on the motor should vary its power factor would vary as shown in Fig. 7.

If the synchronous motor be installed at the end of a long transmission line, with or without step-down transformers at the plant, it is then obvious, barring resonance effects, that the receiving voltage at the motor end is considerably lower than the generating station voltage, owing to the impedance drop in the line and the regulation of the transformers. The synchronous motor might or should in this case be over-excited to compensate for this voltage drop: and, in fact, synchronous motors are used as voltage regulators at the receiving end of the line. If the impedance drop of the line be heavy and the motor subjected to fluctuating power load, then its excitation might be regulated by a Tirrill regulator, keeping constant voltage at the terminals. In regulating the excitation of a synchronous motor with a Tirrill regulator it is to be recommended that exciters of the laminated-pole construction and with interpoles be used, as exciters of this construction will more readily respond to the instantaneous exciter voltage change, a feature needed for synchronous motors.

THE PROBLEM OF VOLTAGE TRANSFORMATION.*

BY DR. F. SCHRÖTER.

The following has reference to the question of working "weak current" networks from a central station, supplying light and power. Under "weak current" installations are included all kinds of electric bells and telephones, signalling devices, such as are used in factories, hotels and large steamers, also telegraphic apparatus, and many similar circuits, ordinarily fed from primary batteries. Usually Leclanché or dry cells are used: for telegraphic work Meidinger elements are largely employed. But there are many known drawbacks to primary batteries. Inventors have often tried to displace the primary battery by using the central station supply instead, and attempts of this kind fall mainly under four heads, viz., (1) inductive devices with transformer coils: (2) the use of condensers: (3) the use of voltage-distributors: (4) the use of vacuum discharge tubes. It is with (1) that the present Paper is mainly concerned. The inductive method of (1) has long been employed with alternating current in the well-known "reductor" transformers. They give four to eight volts on the secondary side, and can be permanently joined to the network without a loss exceeding 1 watt. In the so-called "bell" transformer, with direct current and an automatic breaker, it has often ingeniously been proposed by means of relays and such-like devices to generate a pulsating current, which might be suitable for a low-voltage circuit. But these plans are not simple enough to be effective. Condensers stop the direct current, but allow alternate current to pass. Therefore, if condensers are to be used, there must be a difference in the arrangement of the connections in the two cases. With direct current, the condenser is charged on the high voltage, and then discharged through the low-voltage circuit. Relays can be devised which do this automatically: but though the general principle remains the same in all cases, each particular case requires a re-arrangement of the details or of the adjustments. There are, however, certain cases where condensers can be used effectively on alternating current. A condenser will let through a certain definite current, which may be adjusted in any particular case to suit lamps of low voltages: but safety-devices are needed to guard against shocks and defects in the insulation: consequently this plan can only be used in exceptional cases. From what has been said,

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 51 and 52, 1915.

it can be seen that there are still gaps to be filled, and that there is room for improvements. It may, therefore, be well to describe the apparatus manufactured by the Hydra Company, of Charlottenburg, which employs vacuum tubes. Vacuum lightning conductors have been used which allow voltages above 300 to pass through to earth. Lately more sensitive tubes have been described, which allow voltages even less than 150 to pass through. These tubes have a negative electrode consisting of sodium or potassium, and are filled with argon, helium or neon at a pressure between 1 mm. and 3 mm. These gases are nowadays to be obtained cheaply as by-products in the manufacture of liquid air. These tubes are very suitable for allowing currents of definite strength to pass through to the low-voltage circuit. In this case it is certainly necessary to join one terminal of the low-voltage circuit to the bare neutral conductor of

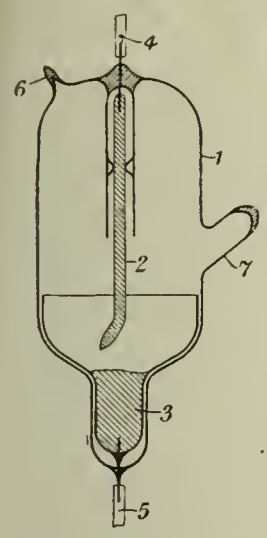


Fig. 1.—The Vacuum Tube, used as a Valve.

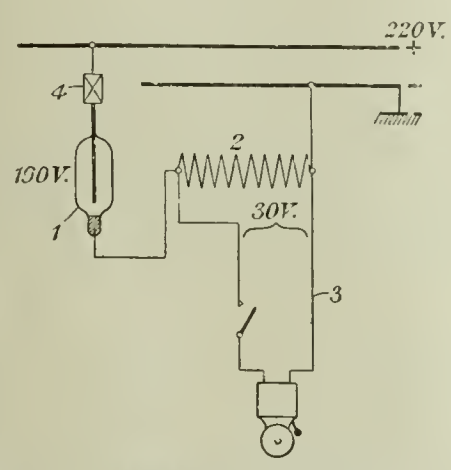


Fig. 2.—Diagrammatic Outline of the Connections to a Bell Circuit through a Vacuum Tube, used as a Valve.

the high-pressure supply. If there is no bare neutral conductor, then difficulties certainly arise, which cannot be at the moment discussed. If, now, we consider two conductors maintained with a pressure of 220 volts between them, let us imagine them to be connected through one of these vacuum tubes in series with a resistance of about 1,000 ohms. A glow discharge will take place, through which a small current passes, the voltage at the terminals of the tube being high. This depends on the fact that there is a fall at the cathode which varies according to the load from 85 to 150 volts. The following table gives an outline of the characteristic phenomena of such a tube.

Table I.—*Giving the Voltage of the Glow Discharge in a Tube Filled with Neon and Helium to a Pressure of 3 mm., with a Cathode of Potassium.*

Volts.		Milliamperes.
100	.....	1·8
108	.....	5·6
115	.....	10·5
123	.....	37·7
128	.....	47·0
133	.....	56·7
139	.....	76·1
31 (arc)		175·0

If the current rises above a certain amount, the cathode volatilises, and an arc results. The voltage over the tube falls considerably, and the current rises. The current is carried partly by the gas and partly by the cathode vapour. Currents of 2 amperes and more can be passed continuously through tubes such as those shown in Fig. 1. Here 2 is an iron anode ; 3 is the cathode consisting of a fused alkali-amalgam ; 6 and 7 are the fused tips through which the evacuation and filling of the tube take place. We see that so long as there is a glow discharge in the tube, this takes the greater part of the voltage ; the resistance of the tube, however, varies considerably with the external resistance.

These facts explain the principles on which apparatus can be constructed and connected to the supply network. Fig. 2 gives the outline, and supposes a bell to be connected to a network supplying 220 volts. The vacuum tube 1 takes 190 volts, and is in series with a resistance 2, the bell being connected as shown and taking the remaining 30 volts. A fuse, 4, is added by way of precaution, and would come into operation if any part, such as the bell or resistance, were accidentally short-circuited. The amount of power that is broken at the switch contacts is so small, as the author shows by the consideration of a special case, that there is no danger to be apprehended from sparking at the contacts, provided the fuse is so proportioned that it blows as soon as an arc starts in the tube.

We can now consider cases in which this idea is practically applied. Let us suppose it is a question of lighting up a signal lamp from different points, the wiring and switch contacts at the various points being on the same scale as that at present usual for signals operated by primary batteries. The lamp may be supposed to be connected to the mains through a contact which is operated by a high-resistance relay. This relay is in series with the vacuum tube and with another resistance of reasonable amount, the whole being connected to the mains, and this circuit being complete in itself and totally independent of the lamp circuit, except in so far as the contact operated by the relay is concerned. Then a series of contacts may be arranged so that at any of these points the auxiliary resistance can be short-circuited. This short-circuiting of the auxiliary resistance will have the effect of increasing the current through the tube and the relay ; and whereas the relay under normal conditions, does not close its contact, this increase of current lifts its armature, closes the contact, and so lights the lamp. The various parts of the circuit are so proportioned that the voltage across the auxiliary resistance does not exceed 30. The current flowing in the tube, and corresponding to the glow discharge, has the remarkable property that none of the gas is occluded, and the tube does not become "hard," so that it can be used continuously for a very great length of time. The various short-circuiting contacts can be arranged anywhere, and there can be as many of them as is desired. This and various other cases of the application of the principle are described in the original article by means of diagrams, which show the connections. Thus there is the case in which a battery is charged through one of these tubes, the charging current being small in amount and being passed continuously through the battery, so as to avoid the necessity of any supervision during the charging. The battery itself is used for furnishing current to some low-voltage circuits. Installations of this kind are often used on railway signalling circuits. The whole of an installation of this kind consists of a fuse in series with the vacuum tube and a considerable resistance and the battery, the whole being joined to the mains ; the low-voltage circuits are, of course, connected across the battery. An arrangement of this kind, as shown in Fig. 3, can be used to charge batteries from alternate current mains. The tube 1 acts as a rectifier. It is desirable to surround the anode with an insulating tube, which prevents the formation of cathodic discharges on this electrode. If, however, the tube is narrowed somewhat in the neighbourhood of the anode, this of itself is sufficient to suppress the one-half period of the alternate current. The efficiency even in the crudest arrangement is about 40 per cent., and this is quite sufficient when one remembers that simplicity and convenience are much more important in such cases than efficiency. A condenser is shown, connected up as a protective device. The following particulars may be of interest, and relate to an installation which has been found to work quite steadily, and which is entirely unaffected by the current which is taken, from time to time, from the battery. There are five small lead accumulators, which are con-

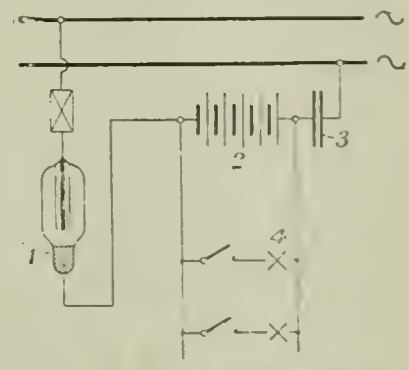


Fig. 3.—Showing the Tube used as a Rectifier, the Connections being made so that a Battery can be Charged Continuously.

nected to a vacuum valve-tube, which is in series with a resistance of 200 ohms, the whole being connected to an alternate-current network, giving 120 volts. Under these conditions the effective current in the circuit was about 30 milliamperes, while the current, charging the cells, and measured on an instrument with a moving coil, was 12 milliamperes.

Low-voltage installations can be worked very efficiently on these principles, in spite of the fact that only a small part of the applied voltage is really used ; it is in fact more economical than primary batteries, or accumulators, which need constant supervision, especially in cases where large installations are concerned. The more the apparatus is used the more efficient it is, seeing that the losses then form a smaller percentage of the whole of the energy consumed. This method has the advantage of transmitting quite automatically the energy received from the high-pressure network to that working at low pressure, and the amount of current taken on the low-voltage side does not affect the working of the system. The general arrangements are similar in all cases, and there is a steady output of continuous current. For these and other reasons, it seems likely that this type of device will find an extended field in the future : it is already doing useful work, and has been for the last two years on the market.

ELECTRICAL OSCILLATIONS FROM MERCURY VAPOUR TUBES.*

BY BENJAMIN LIEBOWITZ.

Summary.—An outline of the theory of arc oscillation is given, the subject is mathematically examined, and further experiments with mercury vapour tubes in a Duddell circuit are described.

Preliminary Theoretical Considerations and Experiments.—As is well known, there are three types of arc oscillations usually referred to as first, second, and third kinds respectively. Nasmyth has proposed the names "Duddell," "Poulsen," and "Wien" oscillations, which will be adopted here. In Duddell oscillations, the condenser current is smaller in amplitude than the direct current supplied; hence the total arc current is always greater than zero. Poulsen and Wien oscillations consist of condenser discharges of relatively large amplitude, alternating with periods of extinction of the arc. In Poulsen oscillations the condenser discharges are single unidirectional pulses, whereas in Wien oscillations the discharges are of the usual damped oscillatory form. Only the last two types of oscillations will be considered in this Paper.

The voltage fluctuations across an oscillating arc gives rise to periodic variations in the supply current, and these, though small, are of fundamental importance.

A typical diagram of connections is shown in Fig. 1. E is the source of direct current, R_1R_2 are series resistances, L_1L_2 series inductances, and A is any suitable arc, such as a Poulsen or Lepel arc. Condenser C, inductance l and resistance r comprise the oscillatory circuit, which is controlled by the switch Q.

Suppose that switch Q is open and that the direct current is flowing steadily through the arc. Upon closing Q the arc is extinguished, and the inductances L_1L_2 begin to discharge their stored energy into the condenser; *i.e.*, the supply current decreases and the

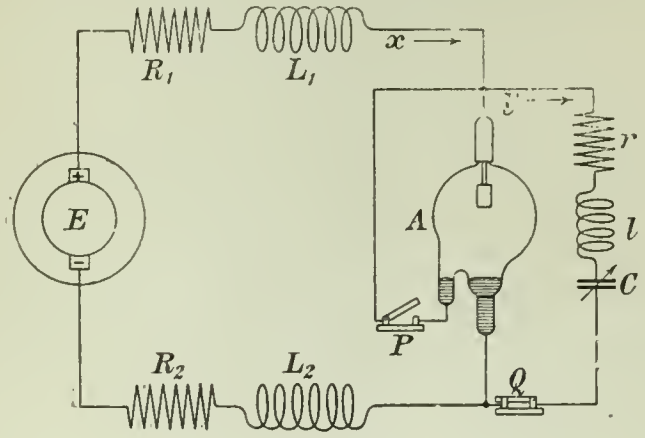


Fig. 1.

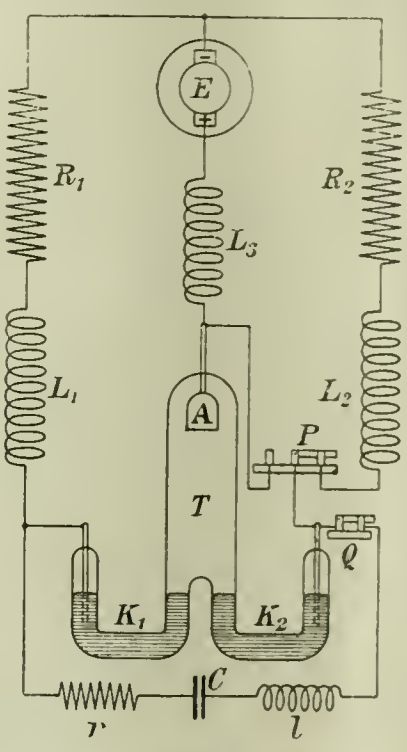


Fig. 2.

condenser voltage increases. This continues till C attains the sparking voltage, whereupon the arc becomes conductive, and allows the impressed E.M.F. to increase the supply current toward its original value. If the oscillations are of the Poulsen type the arc remains conductive only long enough for the condenser circuit to execute one half swing, at the end of which the arc is again extinguished and the condenser is charged to a negative voltage smaller than the sparking potential. The energy left in the condenser is now returned to the supply circuit, and the supply current therefore continues to increase till the condenser voltage is reduced to zero. This completes the Poulsen cycle, for energy now flows from the series inductances into the condenser until the sparking potential is reached again, &c. Hence, this cycle may be divided into three periods: (1) arc extinguished, condenser voltage increasing from zero to positive maximum, supply current decreasing: (2) arc conductive, condenser discharging, supply current increasing due to action of impressed E.M.F.; (3) arc extinguished, condenser voltage increasing from negative maximum to zero, supply current increasing due to action of impressed E.M.F. and reversed condenser E.M.F.

In oscillations of the Wien type, as in the preceding case, the extinction of the arc is followed by a decrease in the supply current and a rise of the condenser voltage to the sparking potential; but the ensuing discharge is now of the usual damped oscillatory form. During the discharge the arc is conductive and therefore allows the impressed E.M.F. to increase the supply current toward its original value. When the energy initially given to the condenser is practically all dissipated or radiated the discharge ceases and the arc becomes non-conductive again. The condenser then receives energy from the series inductances till the sparking potential is reached, as before, and the cycle repeats itself. Hence this cycle may be divided into two stages: (1) arc extinguished, condenser voltage rising, supply current decreasing; (2) arc conductive, condenser discharging, supply current increasing due to action of impressed E.M.F.

It is readily seen that in both types of oscillations the decreases in the supply current must be greater than the increases during the first cycles, and therefore that the supply current must suffer a permanent reduction. But if a steady state of oscillation is to be reached the increases in the supply current must eventually compensate for the decreases.

Preliminary Experiments.—The foregoing considerations indicate that the successful utilisation of the mercury vapour arc in a Thomson (or Duddell) circuit might possibly resolve itself into a question of merely putting a sufficiently large, properly constructed inductance in series with the tube.

The diagram of connections is that shown in Fig. 1. The condenser C in the oscillatory circuit was varied from 2×10^{-8} to 2×10^{-10} farads, approximately, the inductance l from the lowest values (inductance of the leads) up to about 0·006 henry. The switch P was used in starting the tube by tilting so as to make contact between the starting anode and the cathode in the usual manner. At times the starting anode was used as an operating anode, either alone or in conjunction with the regular anode. The supply voltage E was 240 in the first tests, but later this was raised to 500 and then to 750 volts. The supply current ranged from about 0·5 to about 2·5 amperes, but in most of the tests it was in the neighbourhood of 1 ampere. The total value of the series inductance was approximately 5 henries. This was composed of 10 coils arranged coaxially so as to get the greatest mutual and hence maximum total inductance. These coils had an inside diameter of 23·5 cm., an average outside diameter of 32 cm., and an average width of 5 cm. The tubes experimented with varied from a small mercury quartz lamp to a rectifier bulb 25 cm. in diameter. In some of the tests the bulbs were cooled by immersing them in oil: in others they were warmed by first passing large currents through them: in others still, no attempts were made to control the temperature.

All efforts to generate steady oscillations in these experiments failed. A mathematical investigation was therefore undertaken.

The equation $Ld^2q/dt^2+Rdq/dt+q/c=E$ is then applied to the problem on the assumptions that the transition from the non-conducting to the conducting state of the arc is practically instantaneous, when conducting that Ohm's law is obeyed, and that the series inductance is large. The results obtained were that the average counter E.M.F. P is given by $P=\frac{1}{2}(v_0-v_1)(1-K)$, that the mean value of the supply current must be $>\frac{1}{2}E/R$. The efficiency cannot exceed 50 per cent. For steady oscillation the supply volts must be $>(v_0+v_1)/(1+K)$, where v_0 is the breakdown voltage v_1 is the residual voltage, K is the ratio of time of discharge to time of charge of condenser.

The author then made some experiments with mercury vapour tubes in a Duddell circuit. Up to the present these efforts have not been very successful, but the writer is still of the opinion that steady oscillations can be obtained in this manner.

A Double-cathode Oscillator.—The arrangement of the apparatus is shown diagrammatically in Fig. 2. A mercury vapour tube, T, is provided with two mercury cathodes, K_1 and K_2, and an iron or graphite anode, A. The cathodes are connected to the negative

* Abstract of a Paper contributed to the "Physical Review."

terminal of the high-voltage generator E through their respective inductances L_1 and L_2 and resistances R_1 and R_2. The anode is connected to the positive terminal of E through the inductance L_3. Between the cathodes is connected the oscillatory circuit, consisting of inductance l, condenser C, resistance r and switch Q.

To facilitate the starting of the discharges the switch P is provided, which, if thrown to the right, connects cathode K_2 to inductance L_2, and if thrown to the left connects K_2 to anode A. When the switch is in the latter position, K_2 is an anode; the discharge from cathode K_1 can therefore be started by tilting the tube in the usual manner. After this has been done the switch P is thrown to the right and the tube is again tilted, which starts the discharge through K_2 without extinguishing that through K_1. During these initial operations the switch Q controlling the oscillatory circuit should be kept open. If the inductances L_1 and L_2 are sufficiently large, and if they have not too much distributed capacity, the parallel discharges between the two cathodes and the common anode are very stable.

When the switch Q is closed the stability of the parallel discharges is destroyed, and, if the necessary conditions are fulfilled, steady oscillations are obtained. As in the previous case, the oscillations may be divided into two classes, one analogous to Poulsen's, the other to Wien's.

The oscillations described are of nearly pure sine shape; they are, therefore, analogous to Poulsen's only in that the sparking potential is the same for each half swing. The sparking potential, however, need not be the same for each half oscillation, for the first rush of current may ionise the vapour so highly as to permit several successive discharges to pass before the tube regains its sparking potential. We have, therefore, a new kind of oscillations, which are analogous to Wien's. In other respects these oscillations are the same as the preceding.

Experimentally, the oscillations generated were always of variable amplitude, and the frequency of the amplitude variations was above audibility. This was determined by coupling the oscillatory circuit very loosely to an Armstrong receiver and observing the character of the sound produced. If the oscillations had been of constant amplitude, a clear note would have been generated in this receiver; actually, however, such a note was obtained but rarely, and then for short intervals of time only. Upon changing the receiver over into the ordinary audion type the sound produced was a steady hiss, indicating that the frequency of the variations in amplitude was above audibility.

Experimental Details.—The range of capacities employed was from 0·002 mfd. to 0·0002 mfd. approximately, hence the ratio l/C varied between 10^7 and 10^8; these are extremely high values. But large ratios of l/C cause corresponding reductions in the oscillatory currents, which, in consequence, did not exceed 1·25 ampers (root mean square value) in the present experiments. This does not necessarily mean a small available high-frequency current, however, for by closely coupling the oscillatory circuit with another having a much smaller ratio of l/C, the available current can be multiplied many times.

The author discusses some experimental details and states:—

It is not the purpose of this Paper to enter into the much discussed topic of the frequency of arc oscillations further than to give the results of measurements on the frequency of the present oscillator. These measurements did not go above 80,000 cycles per second, because regular oscillations could not be obtained with an inductance much smaller than 0·020 henry. The lower limit of the measurements was 50,000 cycles, as this was the lowest value for which the wave meter was calibrated; hence the frequency observations are confined to a rather narrow range. Although its power and efficiency have been very low up to the present time, the general behaviour of the oscillator indicates that it is excellently adapted for very large powers.

At first sight it would seem that the double-cathode method described here is but a slight modification of the parallel arc oscillator of Duddell and of Nasmyth. It is shown in the Paper that the difference depends on the fact that in this method the oscillatory current passes directly between the cathodes, whereas in the parallel arc method it passes through the arcs in series. The latter is, therefore, suitable for Duddell oscillations only.

Vacuum Fused Iron.—A Paper on "Vacuum Fused Iron, with Special Reference to the Effect of Silicon," by Prof. T. D. Yensen, University of Illinois, has been read before the American Institute of Mining Engineers. Prof. Yensen's work on the physical properties of the vacuum-iron group has been dealt with in our columns from time to time.

HORIZONTAL LUFFING CRANE WITH BALANCED JIB.

Summary.—A detailed description is given of a compensated derricking crane with balanced jib, which differs little in external appearance from a crane of the ordinary type, but which shows a considerable saving in power consumption.

One of the most important recent advances in crane design generally, particularly with reference to cargo-handling cranes, is the improvement which has been made in the means by which the luffing or derricking of the jib is carried out. In the older type of crane, the load and the jib are lifted several feet in luffing in the jib, thus absorbing a considerable amount of power. The modern crane is arranged so that the load follows a horizontal line whilst luffing the jib, and the latter member is balanced. It is obvious that the old system is an inefficient method of working as compared with the new one, inasmuch as in addition to the waste of power, comparatively slow speeds of working are inevitable. With a horizontal luffing crane and balanced jib, since the load follows a horizontal path when luffing in the jib, and since the jib is balanced in any position, the net theoretical amount of work performed in luffing the jib is nil. The principal advantages of such a system of working are clearly the exceedingly low power absorption and the rapidity and ease with which working is carried out.

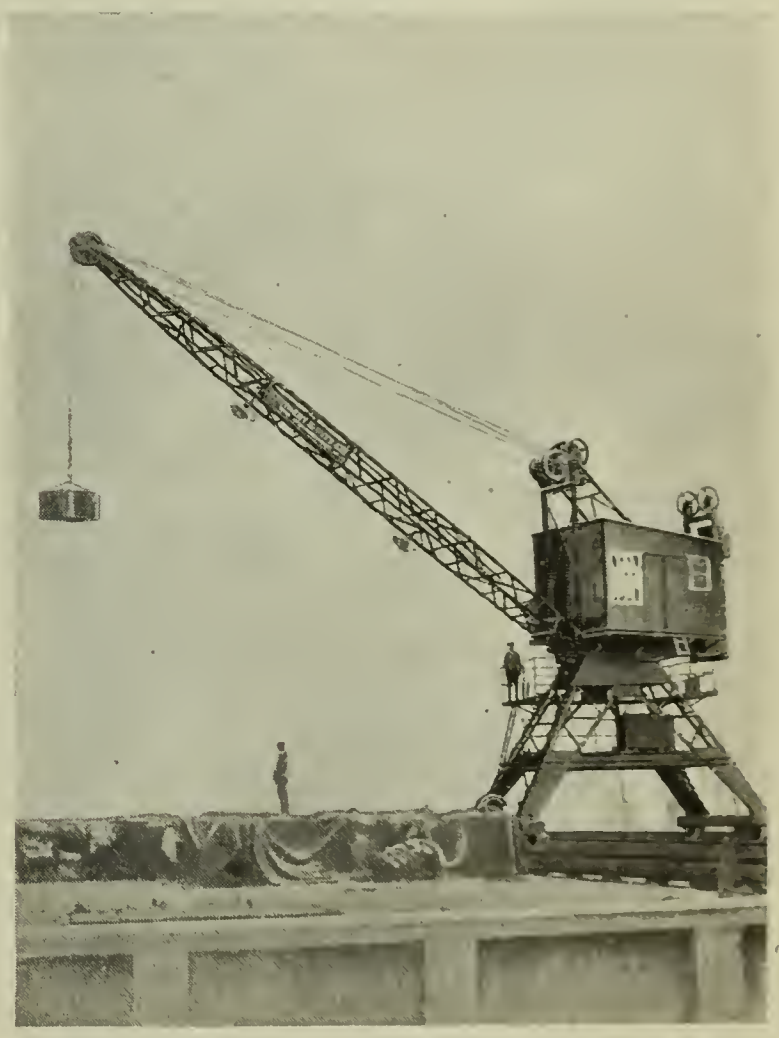


Fig. 1.—"Toplis" Horizontal Luffing Crane.

We illustrate in Fig. 1 a type of horizontal luffing crane, which is the invention of Mr. C. M. Toplis, and made solely by Messrs. Stothert & Pitt (Ltd.), Bath. Its primary claim over other types of horizontal luffing cranes are its extreme simplicity, there being no mechanical complications of any kind in the design. The jib is free from joints, and the whole design is founded on reliable mechanical principles; consequently it requires little attention, and the cost of maintenance is very low. The crane illustrated is one of 12 of various sizes, which are being constructed for the King George Dock, Hull, by Messrs. Stothert & Pitt (Ltd.), and is capable of lifting loads up to 1½ tons, and is also fitted with the motions of slewing, travelling and luffing. A plan of the machinery house is given in Fig. 2, showing the general arrangement of the machinery and control gear. The maximum radius is 50 ft., and the minimum radius 20 ft. The speed of hoisting 1½ tons is 250 ft. per minute: the speed of slewing 1½ tons at the maximum radius is 450 ft. per minute, the travelling speed is 50 ft. per minute, and the luffing speed is 150 ft. per minute. It will be noticed from the illustration that the crane is quite normal in appearance and construction, and that there are no intricate mechanical details to increase maintenance expenses, and give trouble to the engineer in charge. This

crane is fitted with a 5 B.H.P. motor for luffing at the speed given—viz., 150 ft. per minute—the economy of the arrangements being obvious from the fact that a non-horizontal luffing crane with an unbalanced jib would require to be fitted with a motor of about 45 B.H.P. to luff in the jib at the same speed.

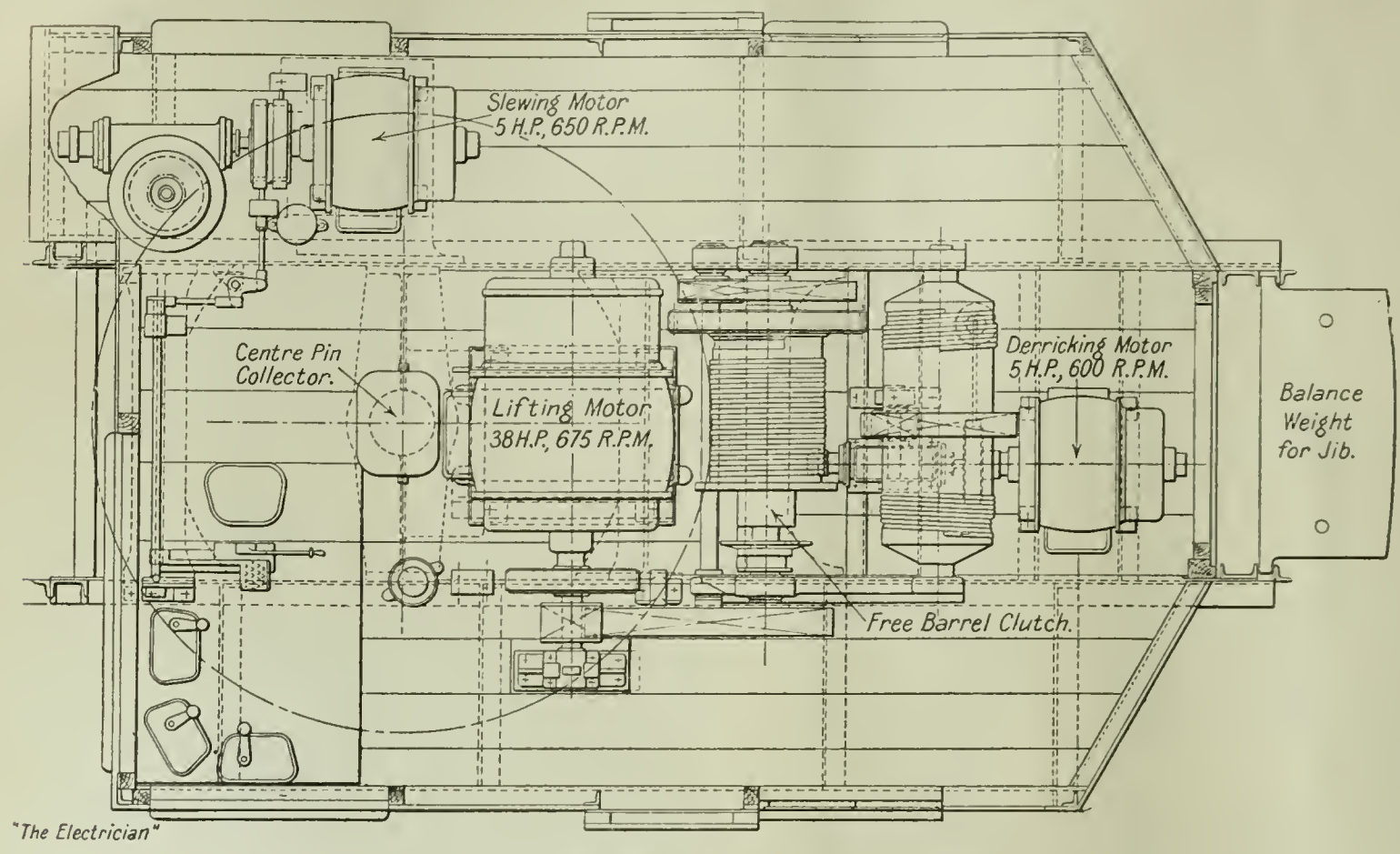


Fig. 2.—Plan of Machinery for Toplis Crane.

Fig. 3 shows a typical power consumption diagram taken from the luffing motor of an ordinary non-compensating crane, and the inner solid black area shows the power consumed in luffing the same load

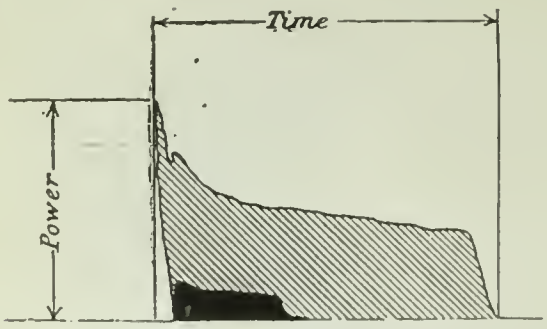


Fig. 3.—Typical Power Consumption Diagrams for Ordinary and Level Luff Cranes.

through the same horizontal distance with the Toplis luffing gear. The difference in the areas of the diagram shown by cross hatching represents the saving in power by use of the latter. The actual power

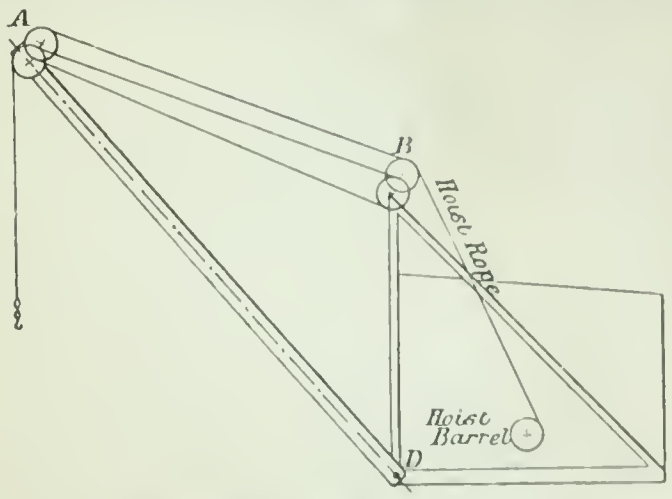


Fig. 4.—Arrangement of Hoisting Rope.

consumed as indicated by a wattmeter diagram was only 3½ H.P. in this instance with the Toplis gear, and even with this small expenditure of power it will be seen that the rate of luffing was approximately three times as fast as with the ordinary crane. The diagram also shows that the rate of power consumption for luffing is practically constant in the Toplis crane, whereas in the non-compensating crane it has very considerable variation.

In this type of luffing gear the essential feature of the horizontal movement of the load when luffing is obtained by a definite relation between the centres of the pulleys at the jib head A (Fig. 4), the pulleys above the front of the house B, and the jib foot pin D, combined with the method of reeving the hoisting rope. Fig. 4 is a diagram showing the simple arrangement of the hoisting rope. It will be noticed that there are no reverse bends in the reeving of the ropes, and the pulleys over which they work are relatively large in diameter.

An exceedingly important advantage claimed for this crane is that, owing to the great distance between the jib-head pulleys and the pulleys on the front of the house, no portion of the hoisting rope

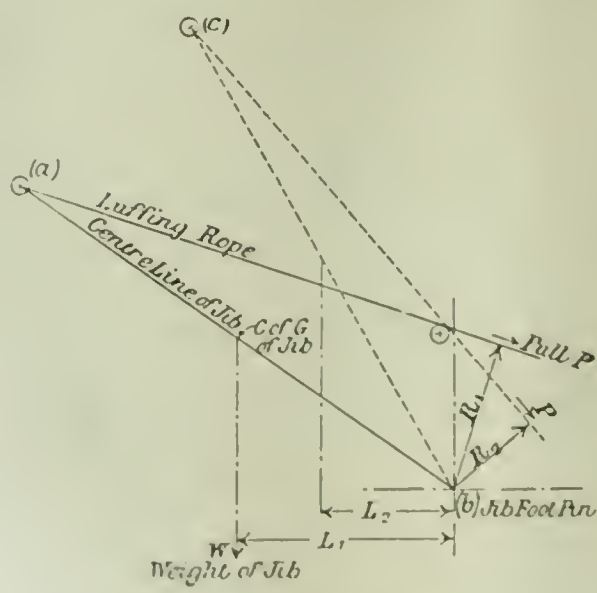


Fig. 5.—Diagram of Jib.

passes over more than two pulleys even with an extreme range of lift. Since in any ordinary crane the lifting rope passes over at least two pulleys, it will be seen that the conditions affecting the wear of the lifting rope are identical in the Toplis crane with the ordinary crane. It is a characteristic feature of this crane that the pull on the luffing rope is constant for all positions of the jib, and, therefore, a constant weight rising or falling in a vertical plane according to whether the jib is luffing out or in, will perfectly balance the jib in any position. This will be more readily understood on reference to Fig. 5, in which, if we assume the jib to be in the position *a b*, and

take moments about the point (*b*), the pull P on the luffing rope required to balance the weight of the jib is such that :—

$$P = W \times L_1/R_1.$$

If the jib is now assumed to be in any other position, say, *c b* :—

$$P = W \times L_2/R_2.$$

Since in this particular crane the ratio L/R is constant for any radius, the constant pull produced in the luffing rope will balance the jib in any position.

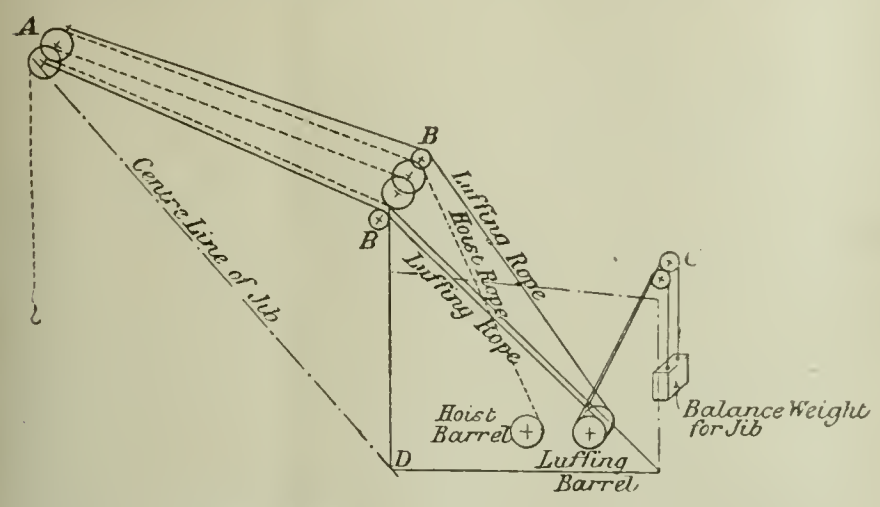


Fig. 6.—Arrangement of the Luffing and Hoisting Ropes.

With cranes of this type there is no tendency for the jib to "take charge" at the minimum radius or at the maximum radius, as the conditions applying to the equilibrium of the jib are the same in any position as the jib is always in perfect balance. Fig. 6 shows diagrammatically the arrangement of the luffing ropes and hoisting ropes, and also shows the application of the balance weight to the jib, as arranged in the actual crane illustrated.

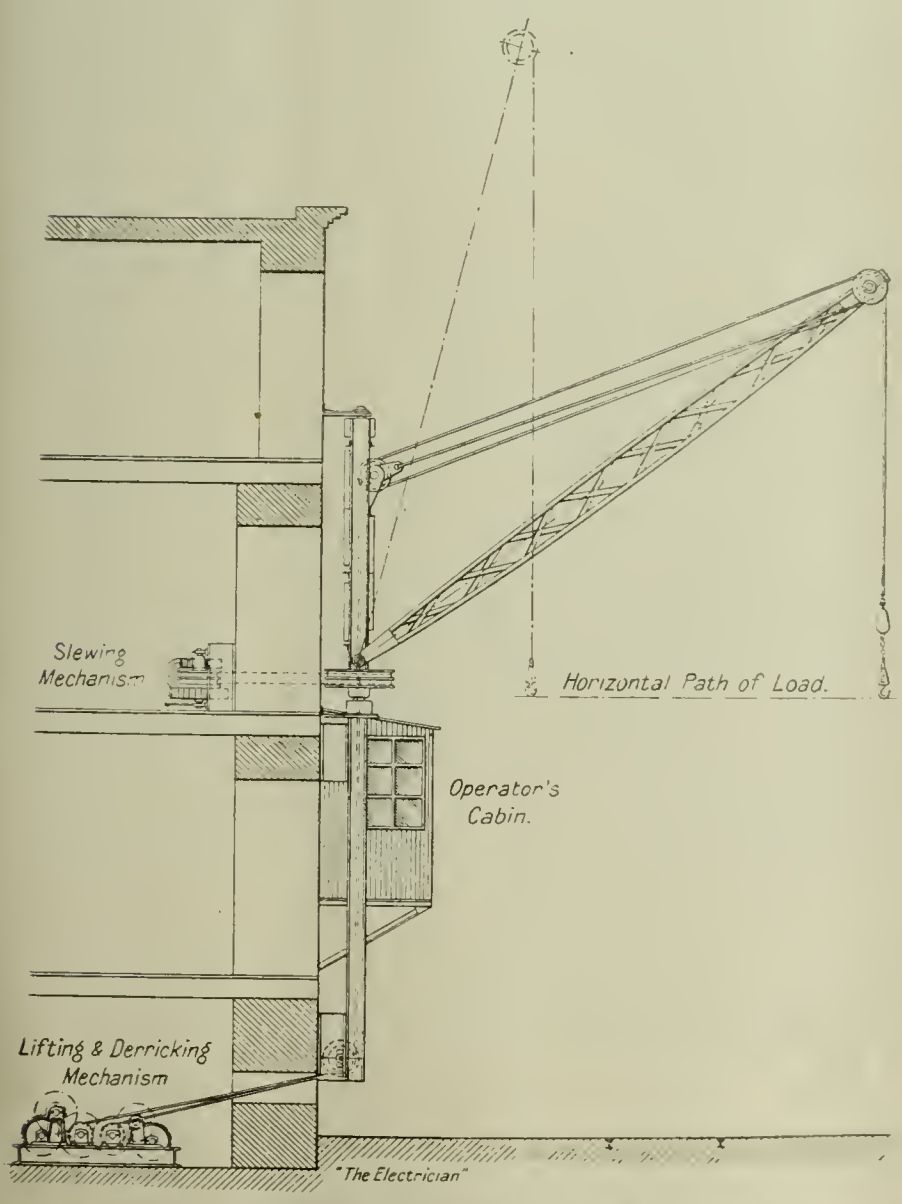


Fig. 7.—General Arrangement of Wall Crane.

This gear is particularly applicable to wall cranes, as will be seen from the general arrangement shown in Fig. 7. It is also equally suitable for cranes driven by electric, steam, hydraulic or hand power.

The makers have in hand and have executed large orders for these cranes, and we understand that cranes of this type give complete satisfaction wherever they have been installed.

TRANSFORMER DESIGN.

(*Continued from p. 116.*)

BY F. M. DE[illegible], A.C.G.I.

Summary.—A general discussion is given of the nature of the problem of transformer design, and the author gives an Arnold's method of design for constant potential transformers. He then deals with the conditions ensuring maximum electrical and commercial efficiency, and the question of the advisability of designing power transformers for minimum cost. A rule is developed by the aid of which designs of power transformers may be based upon commercial efficiency rather than upon minimum cost. The author then gives an outline of the method of design proposed by Arnold in 1910 and a comparison of Arnold's later and earlier methods. Comparative designs are worked out and a table is given, based upon Arnold's method of 1904.

We will now consider carefully the wisdom of designing a power transformer for minimum cost of manufacture, rather than for maximum electrical efficiency or for maximum commercial efficiency.

The commercial efficiency of a transformer might be written

$$\frac{\text{Money value received from the transformer per annum}}{\text{Money value expended upon the transformer per annum}}$$

$$\frac{\pounds VI \cos\theta}{\pounds VI \cos\theta + (\pounds_{i.} + \pounds RI^2)}$$

where £ is the wholesale value of one watt-year and $\pounds_{i.}$ the wholesale value of the iron loss for one year plus the interest and depreciation upon the transformer, with possibly the further addition of cost of floor space and attendance. The maximum commercial efficiency as thus defined would be obtained for a given transformer by so loading it that the copper loss should be equal to the iron loss plus interest and depreciation upon the transformer.

The strictly logical design would be based upon commercial efficiency as thus defined. But in designing a line of transformers for competition in the open market the items interest and depreciation, and cost of floor space and attendance are variable; they depend upon the part of the world in which the transformer will be used as well as upon the local conditions in the factory or station in which it is to be installed, and upon many other things. The logical design is possible only when all such details are definitely stated in the specification.

To get out a special design for each individual transformer would, however, add greatly to the cost of production, and in most cases the interest upon this extra cost would be more than the money saved by the improvement in commercial efficiency.

This is eminently true of small transformers, for which the cost of modification or development would form a large part of the total cost. An idea of the market value of modern transformers is given by the following figures: Transformers from, say, 50 *KVA* to 200 *KVA* for voltages not exceeding 10,000 volts, and frequencies of around 50 cycles per second, may cost from 20*s.* to 15*s.* per *KVA*, while those of 1,000 *KVA* and over may cost as little as 8*s.*, the total weight per *KVA* being in the first case 20 kg. to 10 kg., and in the second case 5 kg. to 3 kg.

Since, then, it becomes impracticable, owing to the impossibility of foreseeing the conditions under which a given transformer may have to work, to design every transformer for maximum commercial efficiency, it is necessary to make a compromise, and an endeavour will now be made to show that a safe compromise is to design for minimum cost whilst using high densities both of current and of flux.

In their effect upon commercial efficiency it would seem that electrical losses are more important in the case of large transformers than in that of small ones, for the large transformers cost less per *KVA*, and electrical losses form a large part of the total losses. The large transformers are, however, at a disadvantage in that the cost of attendance and cooling water or air blast must be added to interest and depreciation. Also it is a question whether, strictly, interest and depreciation on the switchgear and instruments needed for the transformer ought not to be set down in the expression for commercial efficiency. In this case the electrical losses would become of

even less importance for the large transformers than for the small.

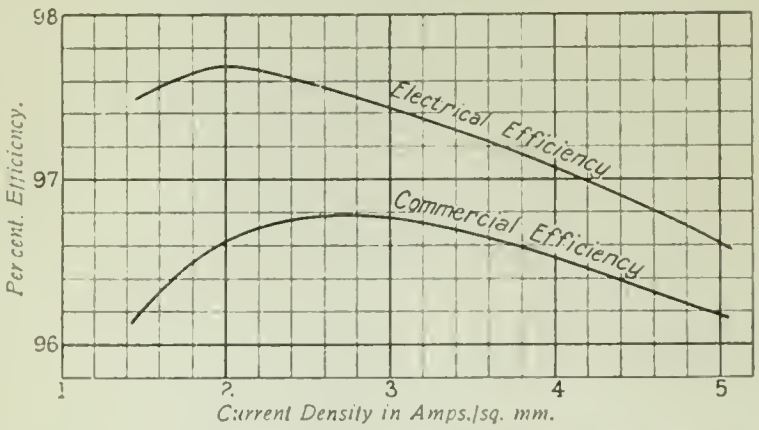
Table I. shows the various losses, and the electrical and commercial efficiencies for various current ratings for a transformer whose normal rating was: 200 *KVA* 25 cycle single phase air-blast, 4,000/330 volts 50/606 amperes. The weights of iron and of copper used in this transformer were G_i=1,110 kg. G_c=318 kg.

Table I.—*Showing the Effect of Varying the Current Output of a Transformer, the normal rating of which was:*

200 *KVA* 4,000/330 volt 50/606 amperes, 25 cycle. Weight of copper 318 kg. Weight of iron 1,110 kg. Cost of transformer £100. Iron loss (constant) 2,775 watts, costing 4,160d. per annum. Interest and depreciation assumed to be 15 per cent. of £100=3,600d. per annum. Total fixed losses (4,160d.+3,600d.)=7,760d. per annum. Cost of electrical energy assumed to be ½d. per kilowatt-hour or 1½d. per watt per year of 3,000 hours.

Current density *s*	RI^2 copper loss per year in pence.	Iron loss / Copper loss	Per cent. elec. efficiency	Per cent. commercial efficiency	Total fixed losses. / Total variable losses.
1·5	2,360	1·76	97·53	96·21	3·24
1·6	2,690	1·54	97·54	96·33	2·88
1·7	3,030	1·37	97·58	96·43	2·56
1·75	3,210	1·3	97·59	96·47	2·5
1·8	3,400	1·22	97·60	96·51	2·28
1·9	3,790	1·1	97·65	96·58	2·05
2·0	4,190	0·99	97·69	96·63	1·85
2·5	6,580	0·64	97·57	96·77	1·18
3·0	9,440	0·44	97·43	96·77	0·82
4·0	16,800	0·25	97·09	96·54	0·46
5·0	26,200	0·16	96·57	96·19	0·3

From Table I. we see first that in the case of this transformer (and it may be regarded as fairly typical of modern designs) the ratio of iron loss to copper loss may vary between wide limits



Curve to Table I, showing the effect of varying the current output of a 200 *KVA* Transformer.

with but slight effect upon the electrical efficiency, a change in the ratio of iron loss to copper loss from about 1·8 to 0·44, producing only 0·1 per cent. change in the electrical efficiency; and, secondly, that the commercial efficiency undergoes comparatively great change, the change between the limits just named being about 0·6 per cent., the maximum commercial efficiency occurring when the ratio of iron loss to copper loss is as low as 0·14.

In examining Table I. it must be borne in mind that all the rows of figures refer to one and the same transformer, the variable factor being the current output. We find that the maximum electrical efficiency would be about 97·7 per cent., and would occur when the current density was 2 amperes per square millimetre, whilst the maximum commercial efficiency would be about 96·8 per cent. occurring when *s* was about 3.

Such a current density as 3 or even 2 amperes per square millimetre would, however, cause excessive temperature rise, the density allowable for normal load being in the case of this transformer 1·75 amperes per square millimetre. At the current density 1·75, the electrical efficiency (97·59 per cent.) is but little different from the maximum possible, and the commercial efficiency (96·47 per cent.) is good.

So long as the prices of finished copper and iron, of labour and of electrical energy remain about what they usually are, and the electrical qualities of the materials undergo no great change, it will be found that the condition of equality of copper loss to fixed losses can be attained only by the use of excessive current density, or else by designing the transformer with an excessive proportion of copper.

The use of an excess of copper would depart from the condition of minimum cost, and so do more harm than good. The point here involved is important, and is apt to be found confusing. The rule is that *for a given transformer* the maximum commercial efficiency is obtained at that load for which the variable losses are equal to the fixed losses; but owing to the high cost of copper, and other commercial and electrical conditions, a transformer so built that the variable losses are equal to the fixed losses is a very expensive transformer, and it generally proves more economical to have a cheap transformer which must be run at some point below its theoretical maximum commercial efficiency than an expensive transformer which can be run at its maximum commercial efficiency. The commercial efficiency of the cheap transformer, though it is below the maximum of which (were it not for temperature rise) it would be capable, generally proves to be higher than the maximum possible commercial efficiency of the more expensive transformer. That this must be so in the case of commercial transformers is not surprising when the following facts are considered:—

Losses at normal densities and costs are of the following order:—

Iron loss, 2 watts per kilogramme; cost of iron, 8d. per kilogramme.
Copper loss, 6 watts per kilogramme; cost of copper, 42d. per kilogramme.
In one year of 3,000 working hours—
1 kg. of iron costs,
Iron loss at ½d. per kilowatt-hour ..... 3·0d.
Interest and depreciation at 15 per cent..... 1·2d.
1 kg. of copper costs,
RI^2 loss ..... 9·0d.
Interest and depreciation ..... 1·2d.

Thus, if the variable (the RI^2) loss is to be made about equal to the sum of the fixed losses (iron loss plus interest and depreciation), the weight of copper used in a transformer will have to be more than double that of the iron in order that the condition for maximum commercial efficiency should be fulfilled.

But a transformer designed with such an excess of copper would be a most expensive one, since the minimum cost condition demands that the relation of copper to iron shall be of the order of one to five. In practice it is found that the allowable proportion of copper to iron is so low (seldom, in fact,

Table II—*Showing the Effect of Varying the Proportion of Copper to Iron in a 100 KVA. Transformer.*

Constants assumed.—Weight of copper + weight of iron = 139,000 kg². Cost of assembled copper, 42d. per kilogram. Cost of assembled iron, 8d. per kilogram. Cost of electrical energy, ½d. per kilowatt-hour. Working hours per year, 3,000. Iron loss, 2 watts per kilogram of iron. Copper loss, 6 watts per kilogram of copper. Rate of interest, plus depreciation, 15 per cent.

Weight of copper, Kg.	Cost of copper pence.	RI^2 copper loss, pence.	Int. & dep. on copper, pence.	Weight of iron, Kg.	Cost of iron, pence.	Iron loss in pence.	Int. & dep. on iron, pence.	Total fixed losses.	Total elec. losses.	Total losses.	Per cent. elec. effiey.	Per cent. commercial efficiency	Iron loss / Copper loss	Fixed loss / Variable loss	Cost of transformer, £	Total weight of transformer, Kg.
167	7,000	1,500	1,050	833	6,660	2,499	1,000	4,549	3,999	6,049	97·42	96·12	1·67	3·03	57·0	1,000
200	8,400	1,800	1,260	695	5,560	2,085	834	4,179	3,885	5,979	97·47	96·17	1·17	2·32	58·2	895
210	8,810	1,890	1,321	663	5,304	1,989	796	4,106	3,879	5,996	97·48	96·15	1·05	2·16	59·0	873
300	12,600	2,700	1,890	463	3,704	1,389	556	3,835	4,089	6,535	97·34	95·82	0·52	1·34	68·0	763
373	15,700	3,360	2,355	373	2,984	1,119	448	3,922	4,479	7,282	97·10	95·37	0·33	1·17	77·6	746
400	16,800	3,600	2,520	348	2,784	1,041	418	3,982	4,644	7,582	97·6	95·19	0·29	1·1	81·6	748

exceeding 0·75) as to make it impracticable to load the transformer so that the RI^2 loss shall equal the sum of the fixed losses. In order to approach the desired condition as nearly as may be, the value given to the current-density should be as high as the method of cooling will allow, whilst the fixed losses, interest, depreciation and iron losses should be made as low as possible.

If a low flux-density were chosen the volume of the iron would have to be great, and so also the volume of copper (since the copper forms a belt around the iron). It is wise, therefore, to make the volume of the iron low and the flux-density high, and it is not unreasonable to say that a safe rule in the design of transformers for commerce is to choose as high a value as is found permissible for the densities of current and of flux and then design for minimum cost.

The design thus produced will not always be the best possible; some other design might have been found to give a higher commercial efficiency; but the designer may generally rest assured that both the electrical and the commercial efficiencies will be high, and he will have the comforting knowledge that the price is the lowest possible.

In Table II. is given a curve showing the manner in which the commercial efficiency and the cost might vary according to the proportion of copper to iron in a 100 KVA transformer. It is assumed that, since the output remains constant, the product $s \times B$ is constant, and thus that the products of the weights of iron times the weights of copper will remain about constant.

From these figures and curves the interesting fact is observed that the design giving the highest commercial efficiency (96·17 per cent.) is not the design costing least, the transformer costing £58 being a better commercial design than that costing £57.

A suggestion which seems reasonable is that the design of a power transformer should be worked out first on a basis of minimum cost, and that the distribution of copper and iron should then be modified (the product weight of copper times weight of iron being kept constant), so as to give the maximum possible commercial efficiency. The calculation necessary to modify a design which has been based upon minimum cost so that it becomes a design giving the maximum possible commercial efficiency is very simple.

Let the product weight of iron times weight of copper as determined by Arnold's method for minimum cost be "K."

Let "A" be the yearly output of the transformer in pence.

Let "B" be the copper loss per year in pence plus interest and depreciation for one year per kilogramme of copper at the chosen current-density.

Let "C" be the corresponding figure for the iron. Then

Per cent. commercial efficiency $= 100\{A/(A+BG_k+CG_i)\}$. And since $G_k \times G_i$ is to be held equal to K, we may write $G_i = K/G_k$, and the equation becomes

Per cent. commercial efficiency $= 100\{A/(A+BG_k+CK/G_k)\}$. This will be a maximum when the denominator is a minimum—that is, when (BG_k+CK/G_k) is a minimum. This obviously will be a minimum when $BG_k = CK/G_k$, for only then is it true that a 1 per cent. change in G_k produces no change in the expression (BG_k+CK/G_k). Maximum commercial efficiency will occur, therefore, when

$$G_k^2 = CK/B \quad \text{or} \quad G_k = \sqrt{(CK/B)}.$$

This simple expression gives at once the weight of copper which should be used in order that, whilst the product G_k times G_i shall be the same as for the cheapest possible design the transformer shall have the maximum possible commercial efficiency.

Applying the equation to the 100 KVA transformer of Table II. we have

A. 150,000d. (yearly output at ½d. per kilowatt-hour).

B. 15·3d. (yearly cost of RI^2 loss at ½d. per unit, plus interest and depreciation on the copper at 15 per cent. for 1 kg. of copper).

C. 4·2d. (yearly cost of iron loss, plus interest and depreciation).

K 139,000 kg.^{2} (the product of 167, the kilogrammes of copper, and 833 the kilogrammes of iron in the transformer, as calculated for minimum cost).

Then the total weight of copper that ought to be used to ensure maximum commercial efficiency would be

$$G_k' = \sqrt{(4{\cdot}2 \times 139{,}000 \div 15{\cdot}3)} = 196 \text{ kg., or say } 200 \text{ kg.}$$

Row 2 in Table II. shows the various losses and the efficiencies of the transformer so designed.

All that my suggestion really amounts to is this: In applying Arnold's minimum cost method use for the ratio $\frac{C}{B}$ the value $(G_i' \div G_k')$—that is to say, make the ratio of the weight of iron to the weight of copper equal to the ratio of the copper loss per year in pence plus interest and depreciation for one year per kilogramme of copper at the chosen current-density, to the corresponding figure for the iron.

The suggestion I have made sounds quite good though often the improvement brought into a design by its use will be hardly appreciable. For this there are two chief reasons. First, that the cost of material, labour and electrical energy and the electrical qualities of materials happen to be such that a transformer designed for minimum cost is fairly sure to have a commercial efficiency quite close to the maximum possible; and secondly, that practical conditions in the construction of transformers usually make it impossible to adhere at all closely to the dimensions theory would dictate. Moreover, if a number of successful commercial designs be taken and modified by the method I have suggested, it will often be found that the improvement produced in commercial efficiency is hardly visible, whilst the cost has gone up by an appreciable amount. The modified designs at the higher prices are, indeed, commercially better than the less costly designs, but the slight improvement in commercial efficiency would probably fail to outbalance, in the eyes of a purchaser, the apparent disadvantage of the greater price.

(To be concluded.)

THE AMPLITUDE AND PHASE OF THE HIGHER HARMONICS IN OSCILLOGRAMS.*

BY PROF. G. W. O. HOWE, D.SC.

Summary.—The author discusses the question of damping of a Duddell oscillograph system, and the effect of using different frequencies.

The author points out that for general purposes an oscillograph should be adjusted until there is a slight but obvious overshoot on applying a steady P.D., and refers to the work of M. André Blondel in "L'Eclairage Electrique," especially to the article appearing on October 28, 1902.

Similar curves to those obtained were published in THE ELECTRICIAN, Vol. LXIX., p. 357, 1912, in an article by Prof. Salomonson on "Some Points in the Use and the Theory of the Oscillograph," and he proceeds as follows:—

It is well known that the formulæ representing the oscillations of mechanical and electrical systems are similar, and that results obtained for electrical cases are directly applicable to the analogous mechanical cases.

The mechanical system which we are here considering consists of the strips and mirror of a Duddell oscillograph; by immersing these in oil, we not only increase the damping, but also the effective mass of the moving parts, since the strips cannot move without carrying with them some of the oil. This increase of the effective mass causes the resonant frequency of the system when placed in oil to be lower than it would be in air. The question which led to this investigation was the doubt as to the accuracy of the magnitude and phase of the ripples in the P.D. wave of alternators as recorded by the oscillograph.

The author shows since $4L = CR^2$, then, with critical damping, the magnification at resonance is

$$\frac{\omega_0 L}{R} = \frac{1}{R}\left(\frac{\omega_0 C}{}\right) = \frac{1}{2}.$$

so that the horizontal vector IR is twice as long as either of the vertical vectors $I\omega_0 L$ and $I\left(\frac{\omega_0 C}{}\right)$.

* Abstract of a Paper contributed to the "Journal" of the Institution of Electrical Engineers.

Considering now the more usual case when the applied frequency is less than the resonant frequency, let $k=\frac{\text{applied frequency}}{\text{resonant frequency}}$, so that $\omega=k\omega_0$, and

$$Q_{max.}=\frac{E_{max.}}{\omega_0 R}\cdot\frac{2}{k^2+1}.$$

We have assumed critical damping, for which we have found that $\omega_0 L=1/(\omega_0 C)=R/2$, where ω_0 is 2π times the resonant frequency.

Since, for critical damping, $\omega_0 CR=2$, the magnification in the above case will be

$$\frac{E_{max}}{\omega_0 R}\cdot\frac{2}{k^2+1}\div E_{max}\cdot C=\frac{1}{k^2+1}.$$

When $k=1$, *i.e.*, for resonance, this becomes 0·5, and as k is decreased the magnification approximates more and more closely to unity. When looking at an oscillogram one usually assumes that the magnification is unity for every harmonic. The angle θ which is the angle by which the condenser P.D. and, therefore, also the quantity or displacement lags behind the impressed E.M.F. :—

$$\sin\theta=\frac{IR}{E}=\frac{R}{R\sqrt{[1+(1/(2k)-k/2)^2]}}=\frac{2k}{k^2+1}.$$

The values of the magnification, and of the angle θ, are given in the table for various values of k, both smaller and larger than unity.

Table I. *Oscillograph with Critical Damping.*

$k=\frac{\text{Frequency}}{\text{Resonant frequency}}$	Magnification.	Phase displacement in degrees.
2	0·2	127
1·75	0·246	120·5
1·5	0·308	112·7
1·25	0·39	103
1	0·5	90
0·8	0·61	77
0·5	0·8	53
0·25	0·941	28
0·1	0·99	11·4
0·025	0·9991	2·86
0·01	0·9999	1·15

From these figures three curves are plotted—viz., with $R=R_{crit.}$, $R=\frac{\pi}{4}R_{crit.}$ and $R=0{\cdot}5R_{crit.}$, in which the magnification is plotted vertically and k horizontally.

Underdamped Oscillograph.—If, in the electric circuit, R be decreased, the magnification at resonance will still be

$$\sqrt{\frac{L}{CR^2}}=\frac{1}{\omega_0 CR}=\frac{\omega_0 L}{R},$$

but this will no longer be 0·5. If now the frequency be reduced to some value k of its resonant value, we have

$$Q_{max.}=\frac{I_{max}}{\omega}\cdot\frac{1}{\omega C}=\frac{E_{max}}{\sqrt{[P^2+(R/k-Rk)^2]}}.$$

A continuous E.M.F. equal to E_{max} would produce a displacement of $E_{max}C$; hence the magnification is equal to

$$k\cdot\frac{1}{\omega CR}\cdot\frac{1}{\sqrt{(k^4-k^2+1)}}=\frac{1}{\sqrt{(k^4-k^2+1)}},$$

since $k/(\omega CR)=1$.

The angle θ by which the displacement lags behind the applied force is given by the formula

$$\tan\theta=\frac{1}{1/k-k}=\frac{k}{1-k^2}.$$

Table II. *Underdamped Oscillograph.*
(Damping resistance = 0·5 of critical value.)

$k=\frac{\text{Frequency}}{\text{Resonant frequency}}$	Magnification.	Phase displacement in degrees.
2·0	0·277	146·33
1·75	0·371	139·53
1·5	0·512	129·82
1·25	0·729	114·25
1	1·000	90
0·8	1·11	65·8
0·5	1·111	33·7
0·25	1·03	14·92
0·1	1·004	5·76
0·025	1·0003	1·43
0·01	1·00005	0·57

The values given by these formulæ are shown in Table II. From these results three curves are plotted, with $R=R_{crit.}$, $R=\frac{\pi}{4}R_{crit.}$ and $R=0{\cdot}5R_{crit.}$, k being plotted horizontally and degrees of harmonic considered vertically.

A third table gives figures when the damping resistance is 0·7854 of the critical value.

The author concludes that for frequencies up to 0·2 of the resonant frequency, a knowledge of the damping is not important.

PHYSICAL SOCIETY.

At a meeting held on the 24th ult. at the Imperial College of Science, Prof. C. Vernon Boys, F.R.S., President, in the Chair, a Paper entitled

"The Laws of Variation of Resistance with Voltage at a Rectifying Contact of Two Solid Conductors, with Application to the Electric Wave Detector,"

was read by Mr. D. Owen, B.A., B.Sc.

The Paper contains an account of an investigation, the primary object of which was to determine the nature of the physical actions occurring at a rectifying contact. Resistance characteristics are given for various contacts, some including a mineral, some in which both elements are metals. It is shown that a *specific characteristic* may be drawn for any given pair of materials. The experimental results are in accordance with the view that the actions are thermo-electric, the main determining factors being the thermo-electric power and the temperature-coefficient of electric resistance. Based on the law of constancy of the voltage-coefficient calculations are given showing the best value of the resistance of the telephone in a wireless receiving circuit in which the contact detector is employed. The influence of a polarising voltage is also traced. The use of the combination of rectifier with a direct-current galvanometer as indicator of the balance point in an alternating-current bridge is examined, and it is shown that the minimum detectable alternating voltage cannot be reduced much below a millivolt.

Mr. Drddell thought the Paper was a very important contribution. He had no definite opinion as to the true explanation of rectifying contacts. In practice very much depends on the exact part of the crystal at which contact is made. With regard to thermo-electric forces, he had examined a large number of crystals in the hope of obtaining contacts which were more stable than those ordinarily employed, and he had concluded that no mineral which did not show thermo-electric effects was of any use as a detector. There might be exceptions in the case of metals, but the rule applied to all sulphides. His experience with regard to the receiving telephone differed somewhat from the author's. In a telephone the resistance and impedance depend on the frequency. In practice it seemed desirable to keep the impedance of the telephone of the same order as the resistance of the detector, and adjust the latter until the desired sensitivity is attained. In receiving strong signals one may employ very tight contacts in which it appears to be impossible that there should be any air film. A satisfactory rectifying action is still, however, obtained.

Prof. G. W. O. Howe thought that it was well to avoid flying off to new hypotheses in order to explain new phenomena if they could possibly be accounted for on well-known grounds. He was pleased to see that the author had been able to explain rectifying contacts without invoking any mysterious new properties. He was rather surprised to gather from the author's remarks that the thermo-electric theory was generally discredited. His impression had been that the work of Dr. Eccles had established it as the accepted explanation. Had any of the exponents of the electron theory attempted to give a detailed explanation of the observed phenomena on that basis? What was the origin of the "settling down" of contacts mentioned by the author? Was it a mechanical or thermal effect? He would like to hear just in what respect the results of Mr. Owen's work differed from those of Dr. Eccles.

Dr. W. Eccles remarked that he was glad to find such agreement on the absurdity of rushing to special explanations of these phenomena. Certain workers had thought that electrostatic attraction altered the area of contact. Others assumed the opening of trapdoors to let electrons through, the mechanism of the process being considerably more difficult to explain than the original results themselves. Prof. Fleming had found that many of the substances used as detectors were photo-electric—*i.e.*, they give off electrons under the action of light—and he assumed that resistivity phenomena were caused by a similar action of the longer electromagnetic waves. He (Dr. Eccles) had tried to put these points straight by explaining the phenomena in terms of well-known physical properties, such as the resistance coefficient, Peltier effect, &c., and had found it possible to account for all the effects. The theory proved unpopular because it had nothing occult about it. Mr.

Owen had dropped the Thomson effect from his treatment. He thought this was not justifiable, as the Thomson effect was a physical fact which must enter into the result in practice. Leaving it out of consideration simplifies the treatment, but loses the explanation of several of the erratic properties of detectors. For instance, the theoretical resistance characteristic curves obtained by Mr. Owen are parabolic. It is obvious however, that the experimental curves are of the fourth degree. The Thomson effect must be introduced to explain the way the curve bends off at the extremities. One important result of the author's was that for the same materials the value of R_m/R_0 was constant for any contact, light or heavy. This appeared to him to be due to the fact that increasing the area of contact by increasing the pressure was equivalent to putting two or more similar contacts in parallel.

Mr. A. F. HALLIMOND (communicated): I should like to congratulate the author on his reduction of the curves for each contact-pair to a specific resistance characteristic. If it is found that the same process can be employed in all cases a very useful and simple means of comparison will be established. The result seems the more remarkable in being based upon the resistance-curves, and I should like to ask whether the relation throws any light on the conditions obtaining at the contact when the pressure is varied. With reference to the heating of the contact, I believe that Prof. Pierce observed that at 80 cycles no lag occurred, such as might be due to heating. The author's arrangement by which the current may pass from 0·003 second would seem to be even more sensitive. Was any variation observed in the resistance with the time of passage of the current? With regard to the thermal effects, might I suggest the investigation of pyrite, a mineral in which adjoining areas may exhibit widely different thermal E.M.F.s?

The AUTHOR (in reply) said he was glad to learn that it was Mr. Duddell's uniform experience that high thermo-electric power and sensitiveness of a contact detector go together. In regard to the relation of impedance of telephone to the resistance of the contact he was quite prepared to find that the conclusions deduced from the simple treatment employed in the Paper required modification to conform to the actual conditions of practice. In reply to Prof. Howe's inquiry as to the cause of the "settling down," this was not due to thermal action; the small testing voltage was applied only at intervals, and was not itself the cause of the change described. The effect appeared to be of the nature of an adjustment of the molecules bounding the contact when their setting was changed; it was probably allied to the slow changes met with in the study of elastic strains. He did not go so far as to say that the thermo-electric theory had become generally discredited, but rather that it stood in need of confirmation. He would endeavour briefly to point out in what relation his own work appeared to stand to that of Dr. Eccles; this reply would cover some points of difference which Dr. Eccles had commented upon. Dr. Eccles employed coefficients representing the Peltier effect, the Thomson effect, and the temperature coefficient of resistance. The author finds that the existence of softening and consequent increase of area of contact due to rise of temperature becomes very important at the higher voltages. This effect is complicated and thus not amenable to mathematical treatment; the course adopted in the present Paper is, therefore, to restrict the application of the formulæ within small limits of voltage—say, a few tenths of a volt. Apart from this, the chief point of difference is in the emphasis laid on the relative value of the coefficients. The author finds that the experimental results in the case of all the mineral and metallic contacts tested may be explained without invoking the Thomson effect; the conclusion is, therefore, drawn that this term is of small importance in comparison with the Peltier effect, at all events at low voltages. It thus fortunately becomes possible to simplify the theory appreciably. Again, in the author's view not only does resistance admit of more precise measurement, but the statement of results in the form of resistance characteristics brings out the essential features of the behaviour of these contacts more clearly than if current characteristics are employed. In reply to Mr. Hallimond, the determination of resistance of contact as a function of pressure is not specially considered in the Paper. The tests here recorded tend, however, to show that pressure only enters in so far as it alters the area of contact. In regard to the question of time-lag, this is the subject of experiments now in progress. In reference to pyrite, the author fully grants that heterogeneity may and does exist in this and other cases; for further instance, in the high and low-resistance specimens of carborundum referred to in the Paper, both possessing high thermo-electric power, but of opposite signs in the two cases.

A Paper, entitled

"The Electrical Capacity of Gold-Leaf Electroscopes,"

was read by Dr. T. BARRATT, A.R.C.S.

A gold-leaf electroscope is frequently used to compare exceedingly small ionisation currents. For this purpose it is much more sensitive than a quadrant electrometer. If the capacity of the electroscope is known, the absolute value in amperes of the ionisation current can be deduced. A method is described for measuring the capacity of a gold-leaf electroscope, the method depending on sharing the charge of a parallel plate air condenser of measurable capacity as many times as necessary, and deducing the capacity of the electroscope from the observed drop of potential. The method gives consistent results when the experimental conditions are widely varied. The amount of deflection of the leaf appears to have little influence on the result.

On account of the lateness of the hour, the Paper was not opened for discussion. Several Fellows communicated remarks to the author, and these, together with his reply, will appear in the "Proceedings."

RUHELEBEN CAMP SCHOOL.

The prospectus of the above school has been sent to us by an Englishman interned at the camp since the outbreak of war. At the same time he sends in a letter an account of the work that is being done. We give below a note on the activities of the school, together with extracts from our correspondent's letter.

PROSPECTUS OF WORK FOR WINTER SESSION, 1915.

Managing Committee.

Chairman	Mr. A. C. [illegible], B.A. (Cantab.)
Secretary and treasurer ...	Mr. E. Mansley
Requisites manager	Mr. F. H. [illegible], B.A.
English and German ...	Prof. E. W. Parsons, B.A. (Oxford.)
French	Mr. L. Bonte, M.A. (Cantab.)
Arts	Mr. A. Baker, M.A. (Glasgow)
Commercial subjects	Mr. M. Wimfheimer, LL.B.
Science and mathematics ...	Mr. J. W. Blagden, M.A., Ph.D.
Engineering	Mr. A. M. Pennington
Nautical subjects	Capt. Henriksen, R.N.C.
Handicrafts	Mr. R. Venables

The school office is open daily from 3 to 4.30 p.m. Sunday excepted.

In a note addressed to the camp, it is stated that "Apology for the existence of the Camp School hardly seems called for," and refers to the large numbers who, "book in hand, haunt all quiet corners of the camp." It appears that only with the advent of warm weather was it possible to develop the work; the failure to obtain adequate accommodation "all but extinguished its life" during the winter. With regard to the syllabus above it is stated that as regards languages the Berlitz system is followed and special importance is attached to colloquial idiom. In addition, lectures are given on the history of the literature of England, of France and of Germany, special attention being paid to particular authors.

In the arts department are grouped classes in history, philosophy, music and drawing. The engineering department includes steam and steam engines, applied mechanics, machine construction and drawing and electrical engineering, both elementary and advanced. Special classes are held in chemistry for engineers and the Diesel oil engine.

[Extracts from Letter.]

"I take this opportunity of giving you some idea of the way in which education is organised in this camp, and enclose the leaflets published by the Camp School. You will see that the latter is divided into 12 departments, each with a representative on the general committee. An Education Committee, composed of . . . . , controls the school, the arts and science union, the libraries and the camp magazine. The school undertakes the kind of instruction that is usually given at technical colleges and universities, whilst under the auspices of the arts and science union, popular lectures are given, and the numerous scientific, technical and language circles are organised. We have a large library of English and foreign fiction, and a fine reference library of works collected in England and sent out by the Board of Education. . . . . The science departments have recently acquired space in one of the lofts for laboratories. The biological, physics and engineering departments will each have a laboratory, and there is also accommodation for private advanced work. We are making as much apparatus as possible ourselves . . . . . The more expensive things and materials we are able to obtain in small quantities from Berlin. Quite ingenious work has already been done privately, and I am expecting to see good results when the skill is organised and given better opportunities for development. To indicate what may be done . . . I may mention the following apparatus, all of which has been made in the camp: Two electric lanterns, complete with slides used to illustrate lectures, an electric clock . . . . . a delicate chemical balance in glass case, electrical apparatus and measuring instruments, and the other day I saw a most excellent transformer . . . I mention the things of interest to engineers only. To describe all the wonderful productions of our artists and craftsmen would take up much space.

Up to the present, tuition has been free and all educational services have been voluntary, but in the future we have to be self supporting. At a public meeting held last week we appealed for 1,500 marks to equip the school, and we got 1,650 marks! At the same meeting it was decided to ask all students to contribute one mark per month to defray current expenses . . . . Considering the difficulties, the work is as efficient as may be expected. We have about 1,200 students and 200 teachers . . . . We are preparing many sea faring men for the Board of Trade examinations. We have second and third engineers ready to take their extra chief's certificates, and men who, before joining the school, had no knowledge of algebra, now making excellent progress in the calculus. We hope to hold matric., Chamber of Commerce and Society of Arts examinations here very soon, and may, if the war lasts, hold Inter. B.Sc. and B.A. examinations . . . ."

SOLUTION OF SMOKE, FUME AND DUST PROBLEMS BY ELECTRICAL PRECIPITATION.*

BY LINN BRADLEY.

A statement that the earth's atmosphere contains a practically unlimited supply of materials highly valued by civilised man probably would bring to mind the fact that nitrogen compounds are being extracted from the air and used as fertilisers, or perhaps in connection with the manufacture of explosives.

But there are also being discharged into the atmosphere regularly many other materials, the aggregate value of which amounts to thousands of pounds.

The terms "smoke problem," "dust problem," "fume problem" have different meanings to residents of various localities. For instance, "dust problem" has one meaning to the superintendent of a calcium carbide plant, another meaning to the foreman of an iron blast furnace, and still another to a resident of a California desert town. "Fume problems" cover a great range, from garbage reduction works to sulphuric acid factories, including silver and gold refineries en route. Even "smoke problem" is not a specific term always meaning the same thing, because some people are inclined to designate as smoke every gas which they can see.

"Dust problems" refer to fairly large solid particles suspended in gaseous bodies. The dividing line between "fume" and "dust" is not sharp, and oftentimes collected dust may be a mixture of "fume" particles and "dust" particles. When the suspended particles are liquid, the term "mist" is generally used. Example, sulphuric acid mist, which contains minute drops of sulphuric acid of any strength. A "mist" is readily produced when saturated steam is suddenly mixed with cool, humid air. This "mist" is the so-called "visible steam." It may contain other water in the gaseous condition. Clouds and fogs are excellent examples of how readily these finely divided particles may be kept suspended in a gaseous body, and at the same time they indicate how futile it is to expect settling chambers to cause the deposition of all of the small particles carried through them by moving gases.

In New York City inquiries have ranged from the collection of diamond chips suspended in a small volume of air up to the collection of cinders and small pieces of coke from gases arising from boilers. It is obvious that saving was the object to be attained by collecting the diamond chips, while in the latter case the cinders and coke particles constituted a nuisance in the neighbourhood.

Plants in which dry, finely divided materials are handled or grinding operations conducted generally have the problem of confining the dust either for saving for sanitary reasons, or for preventing nuisances. Sometimes dust floating around a plant are very detrimental to rapidly moving machinery. Portland cement plants generally have severe dust problems as they feed finely ground materials into long cylindrical kilns near the point where large volumes of gas are rapidly emerging, and in such a manner that the gases pick up a large quantity of dust. Instances are known where the quantity of dust from a cement plant approaches from 200 to 400 tons per day. This dust is scattered broadcast over the district surrounding the plant.

At iron blast furnaces the finely divided ore is charged in such a way that dusting is facilitated. Reports have been obtained which show that the total amount of iron ore and coke lost in this manner amounts to a very large tonnage yearly, and when it is considered that this dust may be worth from 15s. to 17s. 6d. per ton the economic loss is better appreciated. The presence of this dust in the blast furnace gas is highly objectionable from other standpoints when the gas is to be used in gas engines for direct conversion into mechanical power, or burned in hot blast stoves or under boilers for conservation of the heat energy. Further, careful calculation has shown that by removing the particles from the gases from one iron blast furnace without cooling the gases, the value of the conserved heat energy might amount to about £5,000 per annum. One corporation is said to control at least 100 furnaces. Therefore, the saving in this way alone would approach £500,000 annually. Now add to this the value of the ore recovered in a usable form, the value of the water used in wet-cleaning methods and the power for pumping it, the value due to better hot-blast stove operations, saving in stove and boiler brickwork, labour, &c., and the economic value of electrical precipitation can easily be appreciated.

In the large smelteries of the Rocky Mountain States the fume and dust problems are of great importance, not alone because of the strife between the farmers and the smelting companies on account of crop damage, but because of the huge economic waste occurring in the operations.

The amount of sulphur being wasted in the smelting of valuable ores is extremely great. It is not unusual for a fair-sized smelter to waste 1,000 tons of sulphur daily by discharging it into the atmosphere in the form of a gas sulphur dioxide. And this is being done notwithstanding the fact that sulphur is a very necessary commodity for members of a civilised nation. It is the most difficult to obtain of any of the constituents of sulphuric acid, the basis of chemical industry.

Waste gases at smelteries and refineries also contain metals such as copper, lead, zinc, tin, gold, silver, nickel, and even less commonly-known elements such as arsenic, bismuth, selenium, tellurium palladium, antimony and various chemical compounds containing these. The recovery of these materials often would be warranted for the additional revenue which they would produce even under present circumstances: in others, it is desirable to develop processes for separating the constituents of the collected fume and dust. Investigations at one smeltery showed that metals having a gross value of approximately £800 per day were being discharged into the atmosphere.

The arsenic which can be produced from the waste gases of one Western smeltery would much more than equal the entire United States consumption. In order to allow for placing all of this arsenic on the market further uses must be found for it, otherwise it must continue to settle upon the ground in the surrounding district or be collected and stored until a use is developed for it.

While discussing markets it may be well to sate that price alone does not control the consumption of all product. At various copper refineries on the Atlantic seaboard some selenium is produced, for example. In the elementary form this may sell for around 5s. per pound, and yet, strange as it may seem, large quantities of it are being thrown into sewers. Contrary to the generally accepted theory, dropping the price to 5d. per pound would not find a market which would consume all that is now being wasted.

The daily press has contained much in recent months concerning brass and the necessity for high-grade zinc. Extensive investigations in large brass foundries have shown that perhaps 3 per cent. of all the zinc charged into the crucibles is burned off or volatilised and then passes up stacks and is discharged into the atmosphere, thus constituting an economic loss aggregating many pounds per annum. Analyses of material collected from the stack gases showed a zinc content of about 55 to 60 per cent., mostly as zinc oxide. Small amounts of cadmium and other compounds are present, but it seems possible to convert all of this zinc heretofore wasted into high-grade zinc, and this would be a distinct and important gain from an economic standpoint as well as being a source of profit to the owners of the foundries.

In the production of metallic zinc from ore a considerable percentage of zinc is lost as fume. In the industry this is known as "ventilator loss," as all of this white fume passes through large stack-like openings in the building roof just over the bank of retorts. This loss amounts to many pounds per annum.

In refining copper electrolytically, gold, silver and other materials are collected as slimes. When these latter are treated in a furnace for the recovery of the gold and silver considerable of these materials are lost as fume. In one plant near New York City these valuable fumes are being collected by electrical precipitation, and whereas previously the actual losses were several thousand dollars per annum, this has been so reduced that probably it does not now exceed £60 per annum.

At a sulphuric acid plant where a large quantity of acid is concentrated in stills considerable mist is made which is considered a nuisance. Investigation showed that 2 to 3 tons of sulphuric acid were being wasted daily as mist.

At another plant hydrochloric acid fumes had been killing vegetation in an adjacent park, but at present the trees and shrubs are thriving, as the acid fumes are being collected electrically. Fume and dust problems may exist within certain manufacturing operations, such as, for example, in the production of sulphuric acid by the contact process. Sulphur either free or combined with other elements is burned in roasters, the object being to produce sulphur dioxide. These gases (primarily air plus 6 to 7 per cent. sulphur dioxide) generally contain dust and fume and some sulphur trioxide, either free or combined with water, to form sulphuric acid. In order to further oxidise the sulphur dioxide to trioxide the gases are passed over a catalytic substance (ordinarily some form of platinum), and in order that the catalyser be effective the dust should be removed from the gases and the cleaned gases brought to the catalyser at a temperature of about 400° C. Furthermore, all arsenic, selenium, antimony, lead, &c., and their compounds must be removed as must nearly all sulphuric acid and water vapour. After the conversion to trioxide has been accomplished the absorption of the product by concentrated acid is quite readily accomplished.

* Abstract of an article in "Metallurgical and Chemical Engineering."

In one recent installation it has been found that by circulating 50,000 cubic ft. of air per minute in a closed system, removing dust, &c., by electrical precipitation, the saving in steam which would be required for pre-heating this quantity of air in cold weather much more than pays a good return on the investment. Here it is noted that the primary object was conservation of steam for pre-heating ventilating air.

Reference is hereby made to the article in the annual report of the secretary of the Smithsonian Institution for 1913 by Dr. Frederick G. Cottrell, entitled "Problems in Smoke, Fume and Dust Abatement," and to a Paper entitled "Practical Application of Electrical Precipitation,"" Proceedings" of the A.I.E.E., April, 1915, *See also* THE ELECTRICIAN, July 16th, 1915.

The statement has already been made that the progress with this particular industry has far exceeded that in any other country. While a member of the faculty of the University of California, Dr. Cottrell conducted experiments in electrical precipitation, and as these were so successful the work was transferred to near-by smelteries and acid plants. To him must be given full credit for the ingenious and practical method which is used for getting the proper kind of electric field, and for developing rational hypotheses and working bases for solving all kinds of fume, dust and smoke problems by electricity.

The desire of Mr. R. B. Mellon, of Pittsburg, to have the coal smoke nuisance in that vicinity eliminated was one of the motives leading to the establishment of the R. B. Mellon Smoke Fellowship of the University of Pittsburg. Partly as a result of the efforts of those engaged in this investigation, the Messrs. R. B. and Andrew Mellon have established the Mellon Institute of Industrial Research and School of Specific Industries.

It was pointed out that settling chambers do not and cannot adequately answer the purpose, since it is necessary to cause some force to act upon the particles in a readily controlled manner and in such a way that they will move away from the moving gas which serves to keep them suspended and separated. With a proper arrangement of pipes or plates and wires acting respectively as "collecting electrodes" and "discharge electrodes," it is possible to produce a discharge of electricity from the wires to the pipes or plates through gases present between them.

When this discharge is taking place with sufficient rapidity a beautiful violet light can be seen around the wires. It is true that ordinarily air and other gases are considered as unable to conduct electricity, but in electrical precipitation it is customary to employ very high voltages, such as, say, 75,000 to 100,000. With such voltages as these it is possible to subject a gas to such strains that it is changed from a non-conducting to a conducting medium. Of course, the conductivity is not of the first order of magnitude such as possessed by copper, nickel, &c. The discharge and collecting electrodes are not mechanically connected in any way, but on the contrary are necessarily kept spaced apart and insulated one from the other by high-voltage insulators. A large number of discharge electrodes may be connected by metallic wires or plates, and this is likewise true of the collecting electrodes, it being necessary only to keep these two kinds of electrodes in proper relation with each other so that the units of electricity are compelled to flow through the air or other gases present between them.

To further explain the phenomenon of electrical precipitation, the suspended particles may be compared to a pith ball in an experiment on static electricity. The more units of electricity upon a particle the greater is the force acting upon it, therefore in practice a strong discharge is maintained. Furthermore, the greater the voltage between the electrodes the stronger is the precipitation force. This makes it desirable to operate at a voltage just below that where a spark or arc would form. Moving gases exert a force upon suspended particles, and the greater the velocity the greater is this force. Hence, with a given precipitating apparatus there is an upper limit to the gas velocity at which the suspended particles may be completely removed.

If the polarity of the electrodes is too rapidly reversed, the particles will remain in suspension in the gases. For this reason direct current at high voltages is required, as alternating current at commercial frequencies is not suitable for this work. Large volumes of gases require, as a rule, more power than smaller volumes, but the power consumption is affected by other factors. Static machines do not furnish enough power for commercial installations and are not dependable. However, they give a desirable kind of current and potential for the work. In commercial installations the gases may pass between the electrodes in either a vertical or a horizontal direction. Ordinary black iron pipes about 12 in. or 18 in. in diameter by 15 ft. to 20 ft. long are in general use. These pipes may be connected to a gas chamber at each end in a manner similar to that in a tubular boiler. With this arrangement gases and suspended particles may readily be distributed to the various pipes and through them to another gas chamber having been cleaned during such passages. The cleaned gases may be conducted to other places as desired.

The precipitating apparatus may be designed for either hot or cold gases, and for corrosive or non-corrosive materials, and the product may be collected either wet or dry as conditions may indicate. In treating gases containing particles of acid kind in suspension, materials such as lead or stoneware are employed to avoid serious corrosion. Heat-insulating materials may be employed in the apparatus to lessen the loss of heat energy when desired. The gases may be either forced or pulled through by fans or other mechanical means, or if the gases are sufficiently warm natural draught may be employed. When treating gases which are explosive when mixed with air, they are kept under a pressure at least slightly greater than atmospheric until they have been cleaned.

The high-voltage direct current is obtained by transforming low-voltage alternating current into high-voltage alternating current and then converting or rectifying the latter into an intermittent high-voltage direct current. The amount of power required in commercial installations is relatively low, generally being much smaller than that necessary for any other gas-cleaning system.

A unique advantage of electrical precipitation is its ability to collect even the most minute particles. Another interesting feature is that components of gases of different volatility may be separated by what has been termed "fractional precipitation." In this method the gases are treated while at a high temperature to remove those materials which are then either solid or liquid, and then after further cooling the gases subjecting them to another treatment in a separate precipitator. Arsenic trioxide of high purity has thus been separated from copper, iron, zinc and other materials. It would be possible to obtain water-free tar in gas plants by this means, and also it might be possible to collect tars of different compositions. This offers a fertile field for investigation at gas plants.

At foundries where old tin cans and other waste metals are melted and made into sash weights, quite large tonnages of fumes high in tin, lead and zinc are thrown into the atmosphere. While the gross value of this material may be, say, £40 daily, the fact that these elements are present in such proportions as to render their separation difficult and very expensive by present methods permits owners of these plants to continue such wastage. Research should discover some practical and economical way of separating these constituents.

In smelting ores of certain districts for the production of copper, the contained lead is generally eliminated from the copper matte in the converters. This fume has heretofore been wasted, because the lead in such ores was of no value in so far as it never reached a market. Now that this valuable fume can be recovered and the lead marketed, it should be good practice to charge more such ores into the furnaces instead of studiously avoiding them.

There is a large tonnage of galvanised sheet-iron scrap produced yearly, the zinc on which is generally wasted. In some plants this material is charged into open-hearth steel furnaces and the zinc driven off into the atmosphere as fume. By concentrating this material at certain locations, the recoverable zinc fumes should warrant its collection. A somewhat similar problem exists at some iron blast furnaces, the ore containing zinc in such quantities as to warrant its recovery from the blast furnace gases. An interesting situation has been found at other blast furnaces which indicates a nice research problem. It was noticed that there were white fumes in the gases from the boilers, these being heated by blast furnace gas, burned after being wet scrubbed. A study of these fume-laden gases showed a quite large tonnage of potash compounds which, if collected and properly treated, would make an excellent fertiliser.

It is hoped that chemists, engineers and others will give more earnest consideration to smoke, fume and dust problems and endeavour to solve them, not only for the sake of better atmospheric conditions and for æsthetic reasons, but also for the values which are to be obtained when their solution is accomplished.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Office, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"An Intermediate Text-Book of Magnetism and Electricity." By C. F. Woodhouse, M.A. (Sedburgh: Jackson & Son.) Pp. x + 204. 6s. net.

"Alternating Currents." By H. R. Kempe. (London: Crosby Lockwood & Son.) Pp. viii. + 83. 3s. 6d. net.

The Electrician.

The Oldest Weekly Electrical Journal (established weekly 1861—1878).

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*

Advertisement Rates, &c., forwarded on application to the Publisher.

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by Wednesday. Renewals of expiring Advertisements, alterations to standing Advertisements and Wrapper Advertisements by Tuesday evening.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **12.30 P.M. THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U K) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRICAL MEASURING INSTRUMENTS : THEIR DESIGN, CONSTRUCTION AND APPLICATION. By C. V. Drysdale, D.Sc., and A. C. Jolley *In preparation.*

ELECTRIC LIFTS AND HOISTS. By Gilbert Rowe, M.I.E.E., &c. *In preparation.*

THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C.E., M.I.M.E., &c. Price 5s. nett.

ELEMENTARY THEORY OF ALTERNATE-CURRENT WORKING. By Capt. G. L. Hall, R.E. 3s. 6d. nett.

ELECTROMAGNETIC THEORY. By Oliver Heaviside. Vol. I. Price 12s. 6d. Vol. II. Price 12s 6d. Vol. III. 21s. nett. [postage 3d.

COMMON BATTERY TELEPHONY SIMPLIFIED. By W. Atkins. *Third issue* 3s. nett.,

ELECTRIC CRANES : THEIR DESIGN, CONSTRUCTION AND APPLICATION. By H. H. Broughton, M.I.E.E. Price 25s. nett, postage 9d. (abroad, 1s. 8d.)

ELECTRICAL TESTING FOR TELEGRAPH ENGINEERS. By J. Elton Young. Price 10s. 6d. nett, post free 11s

STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Price 7s. 6d nett.

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie, A.M.Inst.C.E. Price 10s. 6d. nett, postage 6d. (abroad, 1s.)

"THE ELECTRICIAN" PRIMERS (84 Primers in all, and a GLOSSARY). Single Primers 3d. each post free. *In One Complete Vol.*, 10s. 6d. *nett, or Three Separate Vols. (Vol. I.* 3s. 6d. *nett ; Vol. II.*, 6s. *nett ; Vol. III.*, 4s. 6d. *nett*). Prospectus free. The Primers are revised or re-written as new printings are called for, and new Primers are added from time to time. Five New Primers : Gas Engines (No. 52), Oil Engines (No. 52A), Common Battery Telegraphs (No. 60A), Electric Clocks (No. 79), Electric Impulse Dials (No. 79A), now ready. Revised Primers, 1914 and 1915 : No. 29 (Management of Dynamos and Electric Machinery) ; No. 46 (House Wiring for Electric Light) ; No. 63 (Repairing Submarine Telegraph Cables) ; No. 42 (Electric Ignition) ; No. 49 (Steam Engines) ; No. 54 (Comparative Advantages of Steam and Producer Gas for Power Production) ; No. 59 (Diplex and Quadruplex Telegraphy) ; No. 61 (Automatic Telegraphic Apparatus).

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation*

ELECTRIC TRACTION ON RAILWAYS. By Philip Dawson, M.I.C.E., M.I.E.E., &c. Handsomely bound ; fully illustrated. Price 25s. nett, postage 6d. U.K., abroad, 1s. 6d.

SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson, M.I.E.E. 15s. nett.

ELECTRICAL LABORATORY NOTES AND FORMS. Arranged by Dr. J. A. Fleming, M.A., F.R.S. Single copies 4d. nett, or in dozens at 3s. 6d. nett. Complete Sets of 50 Notes and Forms, 12s. 6d. nett, or in strong portfolio, 14s. nett ; or bound in strong cloth, 15s. nett. Spare Copies of Tabular Sheets, 1s. per dozen. Portfolios, 1s. 6d. each. Sectional paper, 1s. per dozen sheets. *Complete Prospectus post free on request.* These Notes and Forms are kept revised as new printings are required.

HANDBOOK OF THE ELECTRICAL LABORATORY & TESTING ROOM. Very fully illustrated. By Dr. J. A. Fleming. *Revised Editions now Ready.* Vol. I., 12s. 6d. nett. Vol. II., 14s. nett.

Further portions of this list of "THE ELECTRICIAN" SERIES OF BOOKS appear each week

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

A REAL "NATIONAL DISASTER."

From an English engineer interned in Germany we have received a copy of the Prospectus of Work for the Winter Session, 1915, issued by the Education Department of the Ruheleben Camp School, together with a letter setting out at some length the objects and achievements of this school. Extracts from the prospectus and from our correspondent's most interesting letter are given elsewhere. Our readers will remember that Ruheleben Camp is used only for the internment of civilians, and it is surprising that work of this character can be carried out under such disadvantageous circumstances. The idea of 1,200 students of advanced courses will be a revelation to many of our readers.

With such a striking example before us, we now ask, "What are we doing in the way of technical education?" To the many who wish us well in our endeavour to arouse the interest of people at home in higher technical education sufficiently to induce them to bring about reforms by speaking together, we offer no apology for harping on the one string on so many occasions. To those who question the desirability of so doing at such a time we would say that the string on which we are harping is the fundamental ; is, in fact, what we know to be the bedrock of our future prosperity. Such is technical education. To all engineers the subject is one of importance ; to electrical engineers it is one of vital importance, not so much in the mere making of dynamos and machinery, at which our people excel, but in order to ensure continuous developments in the future.

Ten years ago we attended a meeting at which the principal speaker, a man of ripe experience and rare organising ability, told his audience that in one of our large manufacturing towns no less than 600 Swiss held positions of trust in the workshops, factories and offices, and he told how Swiss children were brought up in the belief that though God had made them poor they would not be ignorant. What defence can we advance ? We who, notwithstanding our rich inheritance, know so little of higher industrial education, and whose primary education ill fits us to take our places in a progressive world. Never were reforms in our educational system more needed than they are to-day, and never in its chequered history has the Board of Education shown itself to be so inapt, inept and inert in dealing with the question of technical education. In truly British fashion, when the clamour in an irresponsible and unstable section of the daily Press in favour of capturing the trade of the enemy grew too loud to be ignored, and when the same subject was taken as the text for sermons, and was the common topic in the market place, committees were appointed to investigate and report upon the matter.

One such committee, appointed, we believe, with the best of good intentions, is the Advisory Committee on Research. For all we know to the contrary, this committee, as well as the numerous sub-committees attached to it, is doing work which would be invaluable if it were properly co-ordinated with work that ought to be done by the Board of Education, but is not. Through no fault of the committee, the maturing of its proposals will, again in true British fashion, result in the giving of high-salaried appointments to many ill-qualified to hold them, while those who refuse to worship at the official shrine will be left to follow

their own devices, as they have been left since the world began.

If it be admitted that research is a branch of education, and that technical education is, of necessity, the introduction to industrial research, then, surely, no one will deny the desirability of vesting the control of both sections in one department. This is not the official way, however, and when we discover that no work of real value has been done by either, as we shall discover, it will be impossible to lay the blame on the one department or the other.

We should be the more ready to temper our criticism if the one department were endeavouring to feed the other. The fact is that work in the one department is of so slight a character, under present conditions, that officers of the department are being drafted into other departments where there is work, of which they have little knowledge, to be done. Men, less dangerous than the rest, on the technical side have been handed over by the Board because there is no technical education to speak of being carried on at the present time. Let the doubting reader visit any of our universities or colleges for verification of this assertion. Although no work is being done, grants, practically as usual, are being paid, and, in common with the other spending departments of the State, money is being wasted.

To make as brave a show as possible, local education committees, to their credit, have formed classes for the teaching of Russian, for the teaching of business methods in a month and for the training of munition workers in three weeks. The students at these classes are for the most part girls and women, and we venture to think that the latter would find the rearing of children (not necessarily their own) at least as interesting as the *pseudo* war work on which they are engaged, and certainly more profitable to the State. For the present position the Association of Technical Institutions and similar bodies are as much to blame as the Board of Education. They have failed to make use of an opportunity, that would have been willingly granted to them by the Press, of pointing out the folly of allowing the colleges to be emptied. Like the others, they also have held meetings and appointed committees to consider what they could do "to help." Like the others, they also have done everything but the right thing.

When the above sources are exhausted we expect to see paper-bag cookery introduced in order to justify the continuance of our technical colleges. And in the meanwhile committees innumerable are striving to reach a common goal—namely, that of capturing the trade of the enemy, trade which has been built up by infinite organised labour, and as the result of a system of education of which we, for the most part, have no conception. The British lion, which at one time roared to some purpose, has in these days lost its voice, and now merely bleats when it finds the eagle prepared for the Day.

Our "leaders" have a few weeks in which to recognise the vital importance of technical education in connection with the war, and in this period they have to prevent the further emptying of the colleges, as well as to take such steps as will bring men back from the Forces to the colleges. The minimum number of such men required for higher engineering work is 3,000, together with 750 teachers. We appeal to the organisations representing the universities and colleges, and to the councils of the several engineering and scientific societies to state their case, as strongly as possible, to Ministers of the Crown. Failing to obtain satisfaction from Ministers, we urge them to wait upon the KING. If the scientific institutions will do nothing in the matter, we suggest that organised labour—the only thing that is organised in the country—should move, as only organised labour can move. To labour, technical education means bread and butter in the future, and unless they see to it the dilettante politicians will deprive them even of that.

Knowing, as we do know, that this is, first and foremost, a trade war, of what real use is it that our men should fight if on their return they find themselves deprived of the means of livelihood? A victory in the field without victory *absolute* in our workshops and factories were little better than defeat. The unthinking man wishes to capture the trade of the enemy. Rather do we wish to be certain, in the first place at any rate, that friendly neutrals do not capture the bulk of our pre-war trade. The new watch word of the American is "Preparedness." We ask, "Preparedness for what?" In this preparedness, judging from a mass of evidence before us, technical education seems to be playing an important part. Furthermore, we must endeavour to remember that as surely as we found Germany prepared a year ago last August, as surely shall we find the Germans prepared when peace is proclaimed. Britain owes it to her Allies, as well as to herself, that she shall not be unprepared a second time.

REVIEWS.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

Treatise on Electricity. By F. B. PIDDUCK. (Cambridge: University Press.) Pp. xiv.+646. 14s. net.

In this book an attempt is made to meet the needs of those who require an advanced text covering both the theoretical and practical sides of the subject, as far as this can conveniently be done in a single volume. Though complete in itself, the book is not intended for beginners, and the space saved by excluding elementary topics has been used to give an account of some of the more recent developments. The book may be divided into two sections; the first eight chapters containing all the principles necessary for a right appreciation of the subject, while the remaining six chapters form introductory accounts of special subjects, which may be consulted by students before starting on treatises devoted to them alone.

After a short mathematical introduction, a chapter, calling for no comment, is given on Permanent Magnetism. This is followed by a well-written chapter on Electrostatics. An explanation of the importance to engineers of several of the theorems in this chapter would be welcomed by many. Chapters IV. to VI. on Electric Currents, Magnetic Effects of Currents, and Thermo-electricity contain little that is original either in matter or method. They, along with Chapters VII. and VIII. on Induced Magnetism and Induction of Currents, would, in our opinion, be improved by including a number of carefully selected examples as well as by referring to recent research on these matters.

Chapter IX. on Applied Electricity is out of place in a work of this kind. Those who revel in Stokes' theorem and in Bessel functions of zero order will find that applied electricity has already been dealt with times without number by exceedingly able and practical men, and few students of electrical engineering will find anything new in this chapter. Certain of the information given is faulty, as the author will discover should he learn from his own book. In this section credit is given to Kelvin for a watt-hour meter that was invented and developed by Prof. Elihu Thomson.

Four chapters in the second section of the book are of particular interest and merit. They deal respectively with Electric Oscillations, Conduction of Electricity through Gases, Radioactivity and the Theory of Electrons. The first three are admirable in every way and are more complete than one would expect to find in a treatise on electricity. They form a fitting conclusion to a book which is highly creditable to the author and publisher, and which can be recommended to those

who, being properly grounded, desire to obtain a knowledge of modern electrical theories and research.

British Destiny: The Principles of Progress. By D. N. Dunlop. (London: The Path Publishing Co.) Pp. xi.+113. 3s. 6d. net.

This small volume consists of a number of essays, many of which have already appeared. The first subject considered is "British Civilisation," from the point of view of national principles and national unity. It is pointed out how greatly our civilisation depends upon initiative and tolerance. In dealing with the "Equilibrium of Society" the author refers to various systems of government, and reaches the conclusion that every people has the government which is suited to its understanding, and the world as a whole is regulated pretty much according to the average intelligence of man. The third essay is on "Co-operation." Here the author points out the importance of co-operation being voluntary. Organisations formed through external forces soon lose their vitality. Co-operation is urged from the standpoint of the good of society, and the co-operation of employers for the welfare of employés is welcomed from this point of view, even though there may be self-interest in the movement. It is admitted that the high quality of British goods is largely due to individualism, but there is no reason why individualism should be lost through co-operation.

Owing to the author's position as secretary of the British Electrical and Allied Manufacturers' Association, chief interest centres round the essay on "Free Trade or Protection." The view is taken that a war for commercial supremacy must be of little avail and that Free Trade is the ideal. The shortcomings of tariffs are set forth. The underlying sentiment is that we must not be "anti-German" but "pro-British." It is pointed out that high tariffs may eventually bring about their own destruction; but, nevertheless, the author admits that it is permissible to protect national industries, and that the purpose of protective tariffs in this country should be to make Great Britain strong. A tariff should not be used by Great Britain to fight others commercially with motives of supremacy. "But," the author concludes, "the time has evidently arrived when she will be compelled, in the national interest, to construct an instrument for defence and negotiation in order to protect herself until such time as the great Powers come to the realisation of the benefits of reciprocity." In the concluding essay, on "A National Industrial Federation," the author points out the importance of co-operation of all organisations, including trade unions, if the industry of the country is to continue on satisfactory lines.

The A.B.C. of Electricity. By W. H. Meadowcroft. (London: Harper & Brothers.) Pp. v.+127. 2s. net.

This little book contains nine chapters and 127 pages, and deals with magnetism, wireless telegraphy, the telephone and electric light and power and batteries. It also has an introductory note by Mr. Thos. A. Edison, who is "favourably impressed." The type of matter in the book may be judged from the following regarding the incandescent lamp:—

> You will notice that in the incandescent lamp the electricity does not need to jump as it does in the arc light, because we give it one continuous line to travel in. . . . the electricity *must* go through, and as it is strong enough to force its way it overcomes this resistance and passes on through the carbon to the wire at the other end.

And so on. It is essentially "popular."

ENGINEERING AND SCIENTIFIC RESEARCH.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

Summary.—The author deals with the want of co-ordination between the learned and technical societies, the Board of Education scheme, improvements in training, compulsory attendance at technical schools, relation between scientific research, engineering, and the position of engineering institutions in relation to schemes for assisting industrial research. Finally the author refers to the scientific organisation of the business side of engineering.

There seems to be a very complete agreement that one result of the great war in which we are engaged will be to render absolutely necessary certain reforms in our national systems of education, and especially in the attention given to pure and technical scientific knowledge. Hardly anyone disputes the propositions that scientific discovery and research must be brought to bear more fully on our national industries, and must be encouraged to a far greater extent than heretofore in this country; but the moment we go beyond these generalities we find great differences of opinion as to the best mode of giving effect to these desires.

Many scientific men have long and vehemently urged national attention to this matter, but the want of co-ordination between our various learned and technical societies and the strongly conservative element in our older Universities and public schools which resists a break with the past have prevented many useful changes being made.

The Board of Education Scheme.—An important step was, however, taken by the Government through the Board of Education last July in the establishment of a Committee of the Privy Council, and the appointment of an Advisory Council to deal with the question of scientific and industrial research as described in a scheme outlined in a White Paper. As this Committee and Council have already come into existence we cannot regard the scheme as merely a proposal to be discussed. We must accept it in a sense as an accomplished fact, but one in which the details may, we hope, be considered as open to modifications.

Since any such Government control over scientific research is bound to have a great influence in time on the direction of scientific work and its applications, it appears most desirable to gather views upon this scheme even after its inception, from those who are concerned with one of the most scientific of these industries, viz., engineering in all its branches.

It is estimated that the capital invested in Great Britain at present in plant and materials in the two branches of mechanical and electrical engineering is probably not less than £1,000,000,000. When we bear in mind the manner in which a single perfected improvement or invention can revolutionise a whole industry it needs no further argument to prove the necessity for careful attention to the progress of scientific research in connection with it.

It is a very widely held opinion that all that is required to effect reforms are Acts of Parliament, the formation of Committees, or the issue of regulations; but electrical engineers will no doubt remember an Act of 1882, somewhat ironically termed "An Act to facilitate Electric Lighting," which was passed almost coincidently with the completed invention of the incandescent electric lamp, the immediate consequence of which was to throttle effectively this nascent industry in Great Britain for six years.

Necessary Improvements and Reforms.—In the particular matter under discussion we have been compelled to recognise the manner in which important industries have died out or never thriven in this country in consequence of our neglect of scientific education and research.

We have to consider then: (*a*) The improvements in the training of men who will become engineers; (*b*) the best means by which scientific knowledge can be brought to bear on the problems of engineering; (*c*) the scientific method in relation to the business side of engineering.

Our educational systems from bottom to top are too bookish, too much devoted to the cultivation of memory and words, and not sufficiently leavened by a real knowledge of the facts of nature and power to draw true inferences from observations. The success of the Montessori system of training young children and of the Baden Powell Boy Scout movement in imparting self-directing power and vivid interest in learning about things, shows what can be done on right lines.

One barrier in the way of our industrial progress has been the imperfect scientific training of foremen, managers and young heads of departments in many engineering works. The young men who are brought in to fill directing positions have generally received the usual public or middle class school education with its entirely insufficient attention to scientific subjects. Even when this has been supplemented by a course at a technical college the time at the latter has been so much taken up with learning things which ought to have been learnt at school that the opportunity of acquiring advanced scientific knowledge or real power of independent investigation has been very much curtailed. We have to produce more men who can do new things, and not merely know about old ones.

Until this state of affairs is remedied it is perfectly futile for Great Britain to hope to gain pre-eminence over Germany in scientific industries.

One of the educational reforms which seems most necessary is the compulsory attendance of lads after leaving the Board School at a technical continuation school. Assuming he leaves at 14 or 15 and is taken on at an engineering works it should not be optional

* Abstract of a Paper read at a Conference of the Society of Engineers at Caxton Hall last Monday.

whether he attends a continuation technical school. He should be compelled to do it until he is 17 or 18 years old, as in Germany.

In the case of young men of higher social rank who have been to public schools I am very strongly of opinion that the practical experience in the shops and drawing office should not be deferred entirely until after the college course. The school education should have provided him with a thorough grounding in the elements of chemistry, physics and mathematics, pure and applied, and with a speaking acquaintance with at least one modern language. One year at a University or technical college should then prepare him to take advantage of some shop experience, and after that he should return to the college for a year or perhaps two for the advanced laboratory and design work.

The degree or diploma examinations should be made to depend more than they are at present on the results of practical laboratory and drawing office work.

In order to compress into this time the necessary training our methods and means of instruction must be much improved. It is essential now for every engineer to have a good working acquaintance with certain branches of mathematics. If he has no knowledge whatever of the calculus or trigonometry he finds it impossible to read many original Papers in the technical journals.

The great thing to guard against on the part of the student is premature specialisation. He should broaden as much as possible his knowledge of the principles of chemistry, mechanics, physics, mathematics, and metallurgy, and he will then be able, later on, to build up on this foundation. Unless he does lay this foundation he will not be able to follow or assist in improvements.

In the third and fourth year the student will, of course, have given time to learning as much as possible of the methods of testing both mechanical and electrical—as are required in engineering work, the especial object of which is to enable him to deal with the kind of problems which will present themselves in practice. It is of extreme importance that he should acquire sympathy with, and confidence in, scientific research, to give the data for engineering work.

The Relation of Scientific Research to Engineering.—We turn then to the subject which it is our purpose more particularly to discuss, viz., the relation of scientific research to engineering practice. We may roughly divide this research work into three departments. There are first the laboratory researches which aim at determining various physical constants of the materials used in engineering which are requisite to give data for design.

Then in the second place there are those researches which aid engineering by providing new methods of examination and test of materials or structures. As an instance of this, consider the invaluable aid rendered by what is now called metallography or the study of the internal structure of metals and alloys by the aid of the microscope. The founder of this branch of investigation was Dr. Sorby, of Sheffield, in 1864, who first began the microscopic examination of iron and steel.

The great development of pyrometry and high temperature thermometry by the invention and improvement of the thermo-junction and radiation pyrometer and the electrical resistance thermometer, due to the scientific labours of Callendar, Le Chatelier, Holborn, Féry, and many others have provided the engineer with implements of great accuracy for the measurement of high temperatures and made it, in fact, an exact science.

The improvement in the means of testing the mechanical or elastic properties of engineering materials by testing machines is another instance of the same class of research. Of late years the appliances for testing the mechanical properties of materials under repeated stresses, vibrations or blows have become important in giving the dynamic as contrasted with the static stress properties. One of the latest additions to the resources of engineering testing is the very ingenious application of polarised light by Prof. E. G. Coker to study the distribution and magnitude of stresses in celluloid models of beams, struts or riveted plates used in engineering structures. To this class of research we may add such methods as those introduced by Froude for ship designing. Froude invented the method of predetermining the resistance to propulsion of a ship by dragging small scale models of ships' hulls made of paraffin wax through water in an experimental tank.

Then in the third place we have a type of research which calls for special aptitude and insight, viz., those which lead to the discovery of some new process, material or machine.

An excellent example of this is the discovery made simultaneously by C. M. Hall in America, and P. Héroult in France when hardly more than students, which finally rendered the production of metallic aluminium in bulk a commercial success.

Further examples of the same important class of researches are given in the production of the various alloy steels, for example, tungsten, vanadium steels, with their extremely valuable properties. A nickel-chromium alloy called nichrome has been found to be of great service in electric heating by providing an inexpensive alloy which does not rapidly oxidise at a bright red heat.

Then we have additional illustrations in the galaxy of inventions which have made the internal combustion engine, aeroplane, steam turbine, wireless telegraphy, the polyphase alternator and synchronous motor such epoch-making appliances. Whilst the initial ideas in these things were all the outcome of genius their development has required the steady application of the scientific method and the commercial ability to find the means of doing it.

The really important question is, what are the conditions under which we can stimulate this originative power? It is partly due to natural gifts; partly to effective training and partly to the provision of sufficient appliances and means. Laboratories may, however, be built without number and Chairs and Scholarships endowed, but unless the right men occupy them very little results. The true answer to the above question is, I believe, that originality stimulates originality. A really great investigator not only discovers himself but imparts something of his powers to his associates. No one can have worked under Lord Kelvin or studied under Clerk Maxwell without having caught from them some inspiration and some small fragment of their passion for the discovery of new truths and methods of doing it.

The engineer requires scientific assistance and accurate gauges and measuring tools. This can only be done by a body like the National Physical Laboratory.

The Engineering Standards Committee of the various Institutions has rendered invaluable service by settling specifications and sizes to be used in engineering work.

In providing a large mass of accurate scientific data for use in engineering; electrical, mechanical, hydraulic and illuminating, the National Physical Laboratory has given most valuable service to engineering for the last 20 years. Nevertheless there are matters requiring assistance for which even its present resources are insufficient.

There are problems in connection with electrometallurgy and engineering which await solution for which our present appliances in private or university laboratories are insufficient.

We need in addition to the present resources of the engineering department of the National Physical Laboratory an increase in the facilities for metallurgical research work on a large scale, such as that conducted with valuable results at the University of Sheffield. Such a laboratory should be provided with full size smelting and refining furnaces by coke, gas and electric heating and with testing machines capable of dealing with test objects of commercial size even full-sized bridge members.

The engineering laboratories of some London colleges, such as University College, should have their accommodation and appliances largely increased.

Much of the work carried out would then be of a highly confidential character, and might have to remain unpublished but be communicated privately to firms and corporations concerned with the subjects of the investigation.

Industrial Co-operative Research.—In Germany much of the technical research work is carried out privately by private associations of the trades concerned. In Great Britain manufacturers in the same trade are far too prone to regard one another as rivals, whereas in the future they will have to stand much more shoulder to shoulder against their common and German antagonists who will be united against them.

Hence in many matters it would pay British firms in the same business to promote scientific research in common on certain problems of manufacture, subscribing together the funds to undertake it either at a national technical laboratory or at some technical college or university which may be provided with the proper equipment. Such information when obtained would then only be communicated to the members of the association or union.

There are, as every one knows, already in operation many powerful and important trade associations, such as the British Electrical and Allied Manufacturers' Association (B.E.A.M.A.), and many other kindred organisations which are doing and could extend this work with great effect.

The first direction in which our advances should be made is in improving the means for obtaining this early information on possible improvements and advances. In gathering in and bringing to early notice technical improvements greater assistance might, perhaps, be rendered by our technical papers and the "Proceedings" of our technical institutions. The field of knowledge is now so vast and technical literature so voluminous that it is becoming increasingly difficult for the busy engineer, whose day is occupied with settling contracts, specifications or routine work in an office or factory, to keep himself apprised of new departures in his own special work, even with the aid of all our ably conducted technical journals.

If we look carefully at the history of successful invention we see

that it always involves three things: first, a new idea or fortunate observation; secondly, the persistent following out of this idea to its logical issue by persevering work. But there is a third stage, viz., the translation of the process or discovery into a commercial manufacture. This stage requires capital outlay and often large preliminary expenditure before any return can be obtained, but also it involves and necessitates high ability in applying the scientific method to the commercial problem. The public do not understand this. They mostly think that an invention leaps full grown from the head of an inventor like "Minerva from the head of Jove."

The Position of the Engineering Institutions in Relation to Schemes for Assisting Industrial Research.—The point which requires consideration is whether the scheme promoted by the Board of Education will meet these requirements of technology and manufacture and especially of engineering. For one thing it is much to be desired that the Advisory Council should have on it members who represent the constructive and manufacturing side of engineering in various branches. As at present constituted it is chiefly representative of eminence in pure scientific knowledge.

A further reason for it is because many important problems which need attention are very large ones, and will require the assistance of many experienced men. Such problems are the conservation and more economical use of our national coal supply; the universal adoption of gas or of electric heating in place of the wasteful combustion of raw coal in domestic fire places, the electrical transmission of power from coal fields to great cities, are examples. The coal question in its various aspects is especially important. Of all European coalfields, Germany has the largest known reserves, though of inferior quality. There are three great coal-bearing districts in Germany, viz., the lower Rhine and Westphalian basin, Silesia, and the Rhenish district near Saarbrücken and Aix-la-Chapelle. The life of these fields has been estimated at 2,000, 1,200, and 4,000 years respectively, whereas the figures given by the Royal Commission on Coal Supplies in Great Britain fixed the life of ours at about 200 years. We have, however, the advantage of superior quality of material. Nevertheless we must bring, at once, the highest scientific knowledge to bear upon the subject of our more scientific coal consumption and use. These are matters quite beyond any individual or small committees to deal with, they demand the conjoint consideration of many minds. Hence it is to be hoped that the principal engineering institutions will unite in a strong request to the Government, if they have not already done so, to place representative engineers upon the Advisory Council, and also that in the disbursement of funds allocated to the assistance of industrial research, these institutions, as bodies, shall be to a considerable extent the avenues through which it is dispensed.

The present policy of the Government and Board of Education, is stated apparently to be the setting up of plethora of fresh Committees and ignoring the existing technical and learned societies.

Mr. Runciman has, recently, appointed certain Committees to report on measures to safeguard the commercial interests of iron, steel and engineering trades and on shipping and shipbuilding. The Advisory Council for Scientific and Industrial Research is also appointing Standing Committees to deal with Mining and Metallurgy, both non-metallic and metallic mining and nonferrous and ferrous metallurgy. Also an Engineering Committee is promised as well.

The result of all this must be to diminish rather than increase the very organisation and co-ordination required.

We are told that "in the multitude of counsellors there is safety," but it may seriously be doubted whether the same can be said of a multitude of Committees unless very carefully organised and correlated.

The head of the group concerned with pure scientific research should be the Royal Society acting not through a few, but all of its Fellows. At the head of the technical research an organised body selected from the professional and technical societies. At present, the Government prefer to ignore the existing societies and create fresh bodies of their own selection. The result will be to weaken these existing institutions and societies.

It is essential to guard against the bureaucratisation of science, and the safest and most simple method of avoiding this would be to make the great technical and professional institutions the means of advising upon the most important steps to be taken in aiding technology. The author does not consider that a Ministry of Science will assist matters at present.

We have first to create a great change in the attitude of the public mind towards scientific knowledge and research and develop the conviction that until it is regarded as a most serious pursuit we shall fail to make any firm advances towards victory in industrial war

The Scientific Organisation of the Business Side of Engineering.—Then we must glance in the last place at the applications of the scientific method to the commercial side of engineering.

No one who has studied, even casually, the German methods can fail to admit they have realised fully in commercial matters the truth that union is strength. Whilst British firms are regarding one another as competitors and greatly afraid to exchange information, their German rivals have adopted every possible means to weld together all portions of their commercial enterprise into one great machine. Our ideal has been largely individualism and competition, theirs has been organisation and co-operation. The German commercial system is essentially militant in nature and organisation. It is all part and parcel of the plan to achieve world conquest at any cost and by every means.

The first condition of success must be association and combination, and the second the scientific method in all things. The first principle of scientific investigation is to collect the facts and to draw deductions only by the light of full knowledge. The inference is that our information about foreign markets must be greatly increased. This means that our Consular reports must be improved, that foreign agencies must be staffed with men who have the necessary linguistic and scientific accomplishments.

In Germany, besides the assistance of their complete Consular reports and the help of carefully devised legislation and low export rates on railways, there are special institutes founded in connection with the universities for the scientific study of the problem of international commerce. Private firms also associate themselves into export societies. Thus manufacturers, shippers and financialists interested, say, in the Russian or South American trade, will club together to obtain information, support agents, and obtain facilities. Steps will probably be taken for a long time to come to prevent the re-establishment in Great Britain of that immense system of organised commercial espionage by Germans who took situations and appointments of all kinds here at reduced salaries, because they were partly supported by subsidies, to collect information and transmit it in weekly reports to their real employers in Germany.

In the main, however, we have to rely on bringing to bear scientific knowledge of all kinds upon the manufacture and distribution of goods and obtaining foreign markets for the same.

The author refers to the address of Mr. T. C. Elder,* and to a book entitled "British Destiny," by Mr. D. N. Dunlop. We have to cut ourselves adrift from the past and its contempt for knowledge.

The first steps in this seem to be large reforms in education, and the second reforms in our system of party government in which the true requirements of our national life are subordinated to the efforts to retain political power in the hands of individuals, clans or parties. The only desirable form of Government is an aristocratic Government in the true and proper meaning of the term, viz., Government by the most efficient and the best. The nation will have that Government when it demands it in sufficient earnest.

DISCUSSION.

The PRESIDENT, Mr. Percy Griffith, in moving a vote of thanks to Dr. Fleming (which was carried), said a distinguishing characteristic of the British engineer was a somewhat exaggerated respect for the liberty of the individual. Politically, this was excellent, but in business we had suffered from it, for by competing with one another we had helped rival nations. Dr. Fleming's Paper should be of assistance in avoiding a continuance of this state of affairs. We must, however, be careful to avoid going to the extreme of accepting German methods as universally preferable to our own, although engineers should consider the best way of modifying what had been proved to be defective in our old system.

Col. R. E. CROMPTON said he had been connected with the National Physical Laboratory from its foundation up to date and he had a somewhat higher opinion than Dr. Fleming appeared to have of the existing development of engineering research facilities. Many of the suggestions made by Dr. Fleming had been acted upon, and were now even in wartime, being acted upon to a very considerable extent. He felt that we wanted to increase the bulk of those who required engineering education in this country. Children should be educated in the love of scientific research. They loved science, but if they asked a simple physical question the nurse or mother could not answer it. Therefore the nurse and mother should be educated. Engineers should be in the majority, but they were a minority, and were ruled by a majority inferior to them in knowledge of the facts of Nature. In Germany the engineers and scientific men were the top dog. If they said a thing was to be developed the money would be found. Inventions in England were crippled by the piling on of underwriting figures, and that was why much good work in England had gone to Germany, where the grouped banks enabled the Germans to get the benefit of our chemical dye research and electrical and other work. He was one of the first to study questions which the Germans had taken up. He had a thousand men going when the A.E.G. had hardly started, but a few years later the A.E.G. had 15,000 men, and his had dwindled to 700. This was owing to the A.E.G. having been assisted by the grouped bank system. In a family of four boys at least three should be educated as engineers, instead of one as at present. We must not, however, stifle individualism as the Germans had done—the best men should be in the best positions.

Mr. ALFRED SAXON said he was a member of the Manchester Associa-

* An abstract of this was given in our issue of the 14th ult., p. 50.—EDS. *E.*

tion of Engineers. He was in fairly close agreement with Dr. Fleming. Manchester had been active with regard to the questions dealt with in the Paper, in connection with the Engineers' Club, and during the past week the Engineering Section of the Manchester Chamber of Commerce met to discuss draft resolutions in regard to the provision of increased facilities for scientific and industrial research after the war. The United States were securing somewhat of a monopoly in the markets of the world, and were strengthening their industrial and financial position to the fullest extent, and our eye should be kept on them. The grant made by the Board of Education would assist the work of the Manchester Association of Engineers in experiments at the Manchester School of Technology. Associations such as the Society of Engineers, the Institution of Mechanical Engineers and the other leading engineering associations of the country were the very channels by which the necessary research work could be carried through in connection with the technical colleges and schools, because there were men connected with all those associations who were engaged in the management of large engineering works, and who were prepared to spend time in assisting the workers at the schools or colleges. The engineering associations had been asked to appoint representatives on the Advisory Committee of the Engineering Branch, and he was one of those nominated. The late Sir William Bailey had said that the imagination should be cultivated in connection with engineering, and that somewhat bore out what Col. Crompton had said. The imaginative faculty was stronger in children than in adults. He agreed that continuation school training should be compulsory.

Prof. Miles Walker said research in regard to heavy machinery was not a thing that could be carried out easily by a national laboratory, as one must have heavy machinery at his disposal. There had not been enough experimenting when heavy machinery was made. A few years ago nearly all the big winding engines in this country were of foreign manufacture, because our manufacturers did not conduct experiments on a sufficiently extensive scale. When it was suggested that the delivery of a machine should be delayed, and a portion of the profit spent in conducting experiments it did not meet with great sympathy: the engineers had not the time to conduct the experiments on a proper scale, and in big engineering works the necessary instruments of precision were not available. It was not sufficient to convince the managers of engineering works of the importance of research. Many of them were fully alive to it, and were quite sympathetic. The important thing was to establish more firmly the determination to carry out experiments on a large scale. There should be a larger number of men in the factories whose energy was directed to experimental work. Small manufacturers could not keep an experimenter, and the research institutions should be in a position to lend out to them men with the proper training. Manchester University had been able to lend such men to manufacturers, and some important developments in apparatus had resulted. More of that sort of thing could be done.

Principal J. C. M. Garnett (Manchester School of Technology) said he agreed with Dr. Fleming that the only way to secure the permanent pre-eminence of British industry was by changing the British attitude towards research. Natural science should be more extensively taught in all schools. Different subjects were taught by too many different teachers. Pupils should be taught at least half their time by one teacher. Everybody ought to know some science, but we must not confuse that with the question of men occupying leading positions in the scientific world, who had to carry their knowledge of natural science to a high standard. He joined Dr. Fleming in hoping that all apprentices would have to continue at continuation schools until 17 or 18 years of age. The instruction should be both vocational and social. The Government could do a great deal of advising and assisting in organising industrial and engineering research, and could come for advice to the technical societies, but the initiative must come from the British firms themselves, and the money must come from the industries directly. The Engineers' Club of Manchester recently produced a report on this subject, and a Council of Engineers had been established to foster it. Nearly all the largest firms in the Manchester district had joined the Association. Engineering firms in London, the Midlands and other districts were to be asked to co-operate. About 200 firms had joined. The Report advocated the inclusion in the Association of representatives of concerns in all branches of engineering, as such an Association would speak with a powerful and collective voice, and assist the Government in industrial and commercial questions. He hoped the present research laboratories would not be forgotten. When those were used there might be need for additional ones. The men who were doing original work had a profound influence on students, and any attempt to dissociate research from engineering work would be bad.

Mr. A. P. M. Fleming (Manchester) said he did not think Dr. Fleming had put it forcibly enough that the real crux of the whole problem lay with the manufacturers. The manufacturer could use the new knowledge in making apparatus better, and if he was not learned enough to use such new knowledge its value from an engineering point of view was gone. The manufacturer was slightly sceptical as to the real value of research, and rather conservative about investing money without an obvious and immediate return, and it would be years before the industry would be so permeated by scientific men as to automatically remove that obstacle. Apart from the Association described by Mr. Garnett, and the work they were doing, any channel by which the employer and manufacturer could be educated should not be neglected. He suggested that the technical press, trade associations, scientific institutions and others should impress the economic importance of this subject upon the manufacturer—the weapon which is put in his hands to compete with the foreign competitor—and they could also point out the wonderful work that was being done by national efforts. The most efficient way of applying the research was where the works and the laboratory were co-ordinated. When the manufacturer was educated as to the need for research, many would institute their own laboratories, but they could not be expected to go much further and devote attention to researches for developing new materials and methods. The time was never so ripe for such co-operation. The manufacturer should realise that a disaster for one firm was a disaster for the whole industry, and any advancement in methods by one firm should assist the success of the whole industry. That was the first step. With regard to pure science work, he thought that this must be independent of the individual concerns. Research work would always have to be done in connection with universities, and it was the best means of preparing young men for industrial life. It was only at the universities that the facilities already existed for the work. However, we had to conceive a magnitude of research which would make the present facilities like small sub-stations compared to big power-producing plant. In the U.S.A. there were over 50 research laboratories connected with individual corporations who were each spending from £10,000 to £100,000 a year on them. From the manufacturers' point of view he thought it was necessary that a great part of the practical training should come after the completed college course. A great deal of good could be done by instructing the young men in the economics of manufacture and the principles of works organisation. Much was being done by the universities and technical schools, but not enough. There was an increasing need in engineering works for young men who could follow up the work on organisation side. Those who showed themselves capable of doing so should be helped to rise to the higher positions, but it would be a mistake to try to educate the whole of them for higher positions.

Mr. Durance said it would be a waste to educate everybody to the highest standard. The chaff should be continually winnowed out from the corn. Youths should not only be taught how to make a machine, but how to make it to time. Boys from technical colleges were taught to ask three times the wage of a boy straight from school, but they knew nothing of the economical side of the business. People were too much inclined to say our scientific people were vastly inferior to the Germans. The Germans had forged ahead because the Government, through the banks and enormous concerns like the A.E.G. working together on a new system of Socialism, was really the only employer. If that was to be the future of commerce it would be the solution of socialism, because each Government would be the only employer, and individualism would suffer a great setback.

Lord Headley said he was doubtful whether classical education should be abolished, although at the public schools too much attention was devoted to Latin and Greek, which would not help to build aeroplanes and so forth, and enough attention was not given to science. He did not think the Germans were more intelligent than the British, but they had more methodical thoroughness and determination. He was convinced that State-controlled intelligence was bound to lead to mental atrophy. It did away with originality and prevented discoveries. Scientific effort should be encouraged, but not dictated by the Government. He thought it would be difficult to adopt Col. Crompton's suggestion of making three sons out of four engineers, if they showed no aptitude for it.

Dr. Hele-Shaw said he would contribute to the discussion in writing, but he would quote one instance of the advantage of scientific over empirical methods of discovery. Prof. Coker at the Royal Institution recently gave a beautiful lecture on his method of polarised light in investigating stresses. By his method it was shown that the stresses in an eye and bolt were very great. Finally Prof. Coker showed something in the shape of a long oval—something like a fish equal at both ends—which was almost perfect, putting the stress on the straight. The editor of "Engineering" told him (the speaker) that that was the exact shape of eye adopted by an American company after spending £30,000 or £40,000 in experiments. Prof. Coker said he had discovered it in his laboratory, and that he knew nothing of the American experiments.

Col. C. E. Cassal said he represented the chemists, who were a hopelessly disorganised body in this country, and not to be compared to the engineers for managing their own affairs. They would continue to be in the background until they invited the members of other professions to their discussions, and absorbed their ideas. Chemists and engineers could be of great value to each other. Few chemists knew enough of engineering to carry out chemical schemes involving such knowledge. He agreed with Lord Headley that the great superiority generally attributed to the Germans in science was a mistake. In the last 50 or 60 years Germany had produced nothing brilliant in science, but our educational and political systems had militated against working for the position which would have enabled us to stand against the organised villainy of the Teuton. Our system of education did not develop scientific thought. Our political system placed at the top a large number of persons whose ignorance of science was monumental. The 23 gentlemen proposed to direct industrial concerns which this country required in order to defend itself were not well selected. He agreed that the bookish spirit was too prevalent in schoolmasters. The schoolmasters was not concerned in works, and the works chemist was absolutely outside the field of the schoolmaster. He blamed our patent system for the lack of complete success in our dye manufacture. The Germans took out patents here, but left out crucial points in their specifications. He believed the war had come in time to save us from the destruction to which we were hurrying under the ridiculous system we had followed of managing the country.

Dr. W. H. Eccles said the main point in the Paper was that this was an epoch of time when the relations of pure science to industrial research had a better chance of being put on a satisfactory basis than they had hitherto had in this country. Those relations had been accidental, and go-as-you-please, and they should be on a method quite the reverse of that. In

putting before them suggestions for producing the necessary co-ordination Dr. Fleming was rendering a very useful national service. It was necessary to form and develop public opinion about these matters' especially among manufacturers, and public opinion ought to be developed so as to bring some influence to bear on Government circles. The Government method would be to establish a bureau, but he thought their method should be to develop public opinion by the continuance of such meetings as that, and in that way call attention to the opportunity that awaited them. Everyone realised by this time that any nation that neglected to apply science to guns, ships, armour, &c., would go to the wall, or take a subordinate place amongst the Powers. If the application of science was so necessary in the present war it ought to be easy to convince people that it would be equally necessary in the industrial war that was to follow.

The PRESIDENT invited other intending speakers to send in their contributions in writing, and announced that Dr. Fleming would reply to the discussion in writing.

This concluded the meeting.

CORRESPONDENCE.

SPEEDING UP IN AN ENGINEERING FACTORY."

TO THE EDITORS OF THE ELECTRICIAN.

The Paper recently read by Mr. Rankin is a timely contribution to a subject which must be henceforth of the most vital importance, not only in the preservation of British supremacy in world industry and commerce, but in the economic expansion of the Empire. The author has attacked his problem on sound scientific lines, and appears to have applied the principles of the American investigators with a nice discrimination and a sense of the probable limits of accuracy. Nevertheless, his Paper bristles with contentious points, with a few of which I propose to deal. It is to be hoped that others will take up the discussion, for there is no more pressing problem awaiting us on the restoration of peace than the remuneration of labour and the employment of each worker at his (or her) maximum capacity in that particular sphere for which Nature has endowed him. Although the necessity of largely increasing the nation's output is generally recognised, the end is being sought simply by ostensibly non-party political means. Yet the question is essentially a social one, demanding practical systematic research on scientific lines in fields hitherto almost entirely unexplored. It is from such a position as that reached in Mr. Rankin's Paper that an excursion into these fields can best be made.

What most impresses one on reading through the Paper is the author's mental attitude towards the worker, as shown by his choice of words when referring to the men and in describing the passive opposition which he encountered. Thus, if the man who took 4·9 minutes to do work which he had previously done in 2·25 minutes, it is stated "he was malingering." But the circumstances rather show that the man, so far from being dishonest, was really acting in accord with what he conceived to be the best interests of his class, even at his own personal loss, and from that aspect his action was highly moral and commendable.

Mr. Rankin, like the majority of men who take up time study, appears to lack that close sympathy with the labourer's viewpoint which is essential to success. My first experiments in the analysis of complex processes with a view to increasing the output per man were carried out towards the close of 1905, whilst engaged in positioning and calibrating movements for electrical instruments. I early learned from the attitude of my fellow-workers (technically educated men) the importance of sympathy when approaching the man on the bench with a demand for more work. Experience has shown me that driving methods—such as Mr. Rankin employed—do not pay, and, indeed, should not be necessary with proper management. Labour to-day is what a century's training by misguided employers has made it, and in general, in its dealings with Capital, it acts upon those same economic fallacies which inspire the policy of most industrial concerns. Lack of appreciation of the broader aspects of cost accounts has led to price-cutting and the exploitation of the labourer, who, in consequence, has sought to prevent the employer "dishonestly" obtaining extra units of his physical and nervous energy without metering them on the pay roll and supplying on pay day the wherewithal to replace them. If the employer's attitude has been a mistaken one, who shall blame the labourer, with his imperfect education and narrow outlook on life, for the wrong methods he has used in retaliation? Each side has fallen into grievous error because it has had no training in economics, and has chosen to regulate its product by a train of fallacious reasoning. So the employer has his theory of "Scarcity" and the employé his theory of the "Lump" of labour, each restrictive of output and prejudicial to the true interests of both sides. At various times during the past 10 years I have had to split up processes into their component parts, cheapening production with an increased output per worker and higher wages. I have always begun by explaining my case to the workers and enlisting their co-operation. I have employed straight piecework with a guarantee against price cutting so long as the process remained unchanged. This method has inspired confidence and produced contented and therefore efficient workers, contrasting with the disturbance due to stop watches and driving methods. Mr. Rankin's troubles should not have arisen; they were clearly due to wholesale changes, made rapidly, without a frank and satisfactory explanation of the position to labour beforehand.

To the worker it is his "price" or "rate" which is everything, but to the employer this is only one factor in manufacturing expense. Overhead charges are largely a function of the number of hands employed, and are almost independent of output. Consequently increasing the output per worker effects a reduction in the proportion of overhead charges which each unit produced should bear. This gain is so great that there seems little need for the various systems invented to cut piece rates automatically, without the knowledge of the man (as Mr. Rankin's plan does in spite of his clause 1). The straight piecework system is understood by the men, and they can calculate their earnings themselves; this gives them confidence. There should be no "in debt" workers—it does not pay to keep them; neither should newcomers be expected immediately to make full money at standard rates.

Mr. Rankin thinks it is absolutely wrong in principle that the men should sell pieces to their employers rather than their ability to work. In setting a "task" (unhappy word), however, the employer waives his right to ability, except as expressed in the piece in hand, and he is, in fact, demanding pieces. In this democratic age the freer the labourer is left the better, and the principle of selling pieces suits him best. "Ability," in the sense of high output, it is not always in the man's power to give. I have looked in vain for any reference by Mr. Rankin to the important matter of fatigue and its effects on the ability to produce. This, again, is an instance where driving methods are less likely to produce high output than regulated working periods alternating with regulated periods of rest. There is the classic instance of F. W. Taylor and his wagon loader. Prof. Mosso's researches are also well known, and his ergograph, although difficult of application to industrial operations, has demonstrated the general laws of fatigue. Within the last few weeks the famous No. 2 report of the Ministry of Munitions Health Committee has been published, and it will become a milestone on the road to industrial efficiency in this country. It is not sufficient to set a task: efficient management should say how it can best be done with the equipment available. It does not follow because a man is away from his bench or is apparently idling that he is wasting time: he may be taking that period of rest which is essential to his continued high-speed output, and only his day's total will show this. Since every person has his own characteristic fatigue graph, and as, moreover, it varies with changes in his health and general condition, guidance only can be given to each man to enable him to select his own best working and resting periods. When I read "during this period the men never left their work," I know—assuming the men really worked all the time—that they were not working at the maximum efficiency possible. The logical method of remuneration would seem to be one in which fatigue is considered. We hear a lot about doing "a fair day's work for a fair day's pay,"

but what is a "fair day's work" and what is a fair price for it? Here is a field for scientific investigation by expert economists directed by a Government Committee composed equally of representatives of Labour and Capital. Some such investigation, producing conclusive results satisfactory to both sides, is essential to a lasting industrial peace.

Labour is now scarce, but what is to become of all the surplus when the war is over? Restricted output per man cannot be contemplated if the Empire is to replace the capital which has been destroyed. The only course seems to be to train to the highest efficiency every man (or woman) now employed in that line of work best adapted to his natural characteristics. The new armies should be disbanded through civil reserves, where every man would be trained in high-efficiency methods in that branch of industry for which he possessed the greatest capacity. The State should continue to pay at least as much to each man during training as for Army service. In this way additions to the present labour force would be regulated and the greater productive power of each fully utilised. This would be equivalent in effect to a doubling or trebling of our industrial population. Work to fully absorb all this supply should be coming into sight now, if ever; when peace is declared will be too late. Neutral markets will be the only ones rich enough to buy largely, and there German competition will be severe on the old basis of cheapness and long credit. This brings us to low prices as the principal requirement in the future, and it demands the permanent abolition of all restrictions on output.

Mr. Rankin deserves the thanks of the engineering community for bringing forward a Paper raising such important questions.

Manchester, April 28. H. Ambrose Carney.

TO THE EDITORS OF THE ELECTRICIAN.

Mr. Rankin's Paper has come at an opportune moment. We have heard much during the past months concerning the need for stimulating the activity of British manufacturers with a view to maintaining the industrial and commercial supremacy of this country. The system he outlines, while attaining the results most urgently required by the nation, viz., decreased cost price of the manufactured article, increased return to capital and higher remuneration to labour, yet encounters such difficulties as to make the wisdom of the system's widespread application doubtful.

The foundation of his system is the determination of the "recognised rate," which entails taking actual time records in order to determine the time an operation should normally occupy. If this value is a true one, and so a measure of the man's average maximum ability, all would be well. But, as Mr. Rankin explains, it was just here that most difficulty was experienced, for "soldiering" during the taking of time records was common. This result is to be little wondered at, for the true nature of the system appears to have been veiled from the men, they so kept in ignorance of the method by which their wages were calculated as to cause them to suspect the whole system. At the outset the men do not appear to have been taken into the confidence of the employers, and so that mutual understanding which recognises that the interests of both masters and men are undoubtedly the same, was not initially obtained.

Now it is generally agreed that a change in our industrial system is rendered necessary on two accounts:—

1. In order to produce a low cost article so that British manufacturers shall be able to offset the effects of Germany's accumulated stocks flooding the markets, when peace is restored, at exceptionally low prices, and also that they might continuously and successfully compete with German manufacturers in foreign markets.

2. In order to preserve the unity and harmony of the British labour world.

Mr. Rankin's system undoubtedly attains the first result, but it is very doubtful whether it will accomplish the second. Financial authorities have stated that after the war almost certainly will there be a great monetary stringency. How will Labour, now habituated to a very much higher standard of living, accommodate itself to such reduced conditions? If upon the restoration of peace the relations subsisting between Labour and Capital are to be resumed it is certain that very urgent and forcible demands will be made for better rates. Refusal to meet such demands will result in the most mischievous and deplorable conflicts between these two essential forces of production. It thus appears that if industrial peace within the nation is to be maintained almost certainly must higher wages be given to Labour after the war. No return to the old rates, whether now agreed to or not, will be acceptable to the men in the altered circumstances.

While higher wages do ultimately accrue to the workers upon the application of Mr. Rankin's methods, yet the real possibility of engendering strikes during the introduction of a system that is to make for industrial harmony is an irony that cannot be entertained. The weakness of the system has already been indicated, for any system that relies for its success upon a "recognised rate," or upon the withholding of the true facts and methods from the men, is inherently defective.

Furthermore, while under certain conditions the overhead charges by this system are lower than under a straight piecework system, yet I have worked out a number of cases and find that their reduction is so inconsiderable as to make it appear doubtful as to whether this saving is not outweighed by the loss entailed in the creation of an undesirable Labour attitude.

Liverpool, May 1. Harold J. Brocklehurst.

TO THE EDITORS OF THE ELECTRICIAN.

I have read with considerable interest the article by Mr. R. Rankin, B.Sc., in the issues of The Electrician for April 21st and 28th, and should be glad if you could find space in your columns for the following remarks. Mr. Rankin condemns straight piecework as being altogether unsatisfactory.

I am is disagreement with him, and think that the success or failure attending the system lies not in the system itself, but in the manner in which it is applied.

In a factory with which I am connected straight piecework has been employed for a considerable time, and on the outbreak of war it became necessary that the output should be increased, in face of decreasing labour.

The adoption of several methods was considered, and finally it was decided that the piecework system be retained and that slight modifications on existing conditions be made. Before the change the task to which my remarks refer, was done throughout by one worker and 1s. 3d. was paid for each complete task so turned out, the normal speed of each worker being five jobs per day. The alteration consisted in sub-dividing the task into five operations, each to be done by a separate worker who became skilled in that operation, a piecework price being allotted to each operation, such that the total cost of the task remained unchanged. This was proposed to the workers who, with very little reasoning, gave their *unanimous consent*, after an agreement had been drawn out whereby it was promised that no price reduction should take place on increased outputs.

The effect of this was well marked as the workers gained confidence (without which no system is a success), and the output of each worker rose to 13 complete jobs per day. The following figures show that, although the labour cost did not alter, a saving was effected:—

Output—5 pieces per day.		Output—13 pieces per day.	
Labour—1s. 3d. × 5	= 75d.	Labour—1s. 3d. × 13.....	= 195d.
Overhead charges taken as 100 per cent.	= 75d.	Overhead charges	= 75d.
Total cost	= 150d.	Total cost	= 270d.
Piece cost	= 30d.	Piece cost	= 20 7/13d.
		Saving = 44⅓ per cent.	

The assumption made that the overhead charges are the same is justified, as no increase in the supervision was necessary.

In the method adopted by Mr. Rankin the price per piece is reduced as the output increases, showing that the employer gains both by the reduction in price and by the reduced overhead charges, while the worker gains only by his harder working,

which is, in my opinion, not quite fair, and by the cutting of prices automatically rather suggests hoodwinking the worker.

It is my opinion that rather than *reduce* the prices on increase of work it pays to *increase* them with increasing outputs, and I think Mr. Rankin will agree that such a system would be more readily accepted by the workers and lead to less trouble than that which he has adopted.

Manchester, April 30. G. C. STEVENS.

LEGAL INTELLIGENCE.

Storage Battery Contract.

Mr. Justice Sargant recently heard an action by Pritchett & Gold and Electrical Power Storage Co. (Ltd.) to recover the price of a battery supplied to Mrs. Currie, of Upham House, Aldbourne, the defendants being Hamble, River, Luke & Co., Ltd., the contractors for an electrical installation at Upham House, to whom plaintiffs were sub-contractors for the battery. Plaintiffs said the materials for the battery had been supplied, but the erection was not completed before defendant company went bankrupt, and they contended that in these circumstances the contract had not been performed, and they were therefore entitled to the value of the materials supplied, and not merely to a dividend of the price. Mrs. Currie was originally a defendant, but she paid £255 into Court and withdrew from the action under an order of the Master.

Mr. ROMER, K.C., who appeared (with Mr. H. E. Wright) for defendants, argued that plaintiffs had tendered for a battery, and had not incurred the responsibility of erecting it. It was not a case analagous to that of a man contracting to build a motor car on a buyer's premises; it was a contract to supply the component parts of a battery, and the moment the articles were delivered the property passed from plaintiffs to defendants.

Mr. GRANT, K.C., appearing (with Mr. Merlin) for plaintiffs, said, in reply, that there was no completed contract until the battery was erected.

His LORDSHIP, in giving judgment, said the real question was: When did the property in the goods pass? If the property in the materials for the battery passed to defendants, as was alleged, at or about the time of the delivery of the materials, free on rail for the railway destination, then of course the plaintiff company were only entitled to prove in the liquidation for the amount due to them. If, on the other hand, the property in the materials did not pass then the plaintiffs were entitled to the materials, and under the arrangement made by the order of the Master, to have paid out to them the sum paid into Court by Mrs. Currie. In his judgment all the difference was made by the special terms of the actual contract between the parties which seemed to him on their true interpretation to amount to a contract for the sale and purchase of a battery as one complete and entire whole in situ, and in working order, with its first charge included. The legal consequences were that the property still remained in their original owners, *i.e.*, plaintiff company, and they were entitled to have paid out to them the sum paid into Court, and to have the costs of the action against the defendant company.

A stay was granted with a view to an appeal.

NEW BOOKS AND NEW EDITIONS.

[Copies of the new books mentioned below can be obtained *post free* from THE ELECTRICIAN Offices on payment of the prices indicated in parentheses. It is only necessary to specify the number when sending remittance.]

657. "The Structure and Properties of the More Common Materials of Construction." By G. B. Upton. 10s. 6d. net (11s. 3d.)

658. "A Text Book of Practical Physics." By Dr. H. S. Allen and H. Moore. 8s. 6d. net (9s. 3d.)

659. "A Handbook of Colloid Chemistry." By Dr. W. Ostwald. Translated by Prof. W. M. Fischer. 12s. 6d. net (13s. 3d.)

660. "A System of Physical Chemistry." By Prof. W. C. McC. Lewis. Vols. I. and II. 9s. each net (9s. 9d. each).

661. "Notes on Screw Gauges." (National Physical Laboratory.) (Enlarged issue.) 1s. 6d. (1s. 9d.)

662. "Elementary Physical Science, Mechanics and Heat." By C. H. Draper. 2s. 6d. (2s. 9d.)

663. "Galvanizing and Tinning." By W. T. Flanders. 12s. 6d. net (13s. 3d.)

664. "Automobile Repairing Made Easy." By V. W. Page. 12s. 6d. net (13s. 3d.)

665. "Examples in Magnetism." By Prof. E. Austin. $1.10 (5s. 3d.)

667. "Electrical Apparatus Making for Beginners." By A. V. Ballhatchet. 2s. net (2s. 3d.)

668. "Telegraph Engineering." By Erich Hausmann, Sc.D. 12s. 6d. net (13s. 3d.)

669. "The Value of Science in the Smithy and Forge." By W. H. Catheart. 4s. net (4s. 3d.)

670. "Electrical Measurements and Testing." By C. L. Dawes. 3s. net (3s. 3d.)

671. "Mechanical Drafting." By C. B. Howe. 7s. 6d. net (8s.)

672. "Elementary Strength of Materials." By E. S. Andrews. 4s. 6d. net (5s.)

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 SPECIFICATIONS.

3,364 RICHARDS. Manufacture of electric insulating materials and the like.

5,007 LANDIS & GYR AKT.-GES. Spring arrangement, especially for use in electric making and breaking devices. (2/4/14.)

5,083 SHIBKO. Relays, especially for metering in telephone systems.

5,200 MURRAY & SHOTTER. Electromagnetically operated devices.

5,260 B.T.-H. CO., SHUTTLEWORTH & BROWN. Dynamo-electric machines.
Consists in automatically abruptly increasing the excitation of a series commutator machine connected in cascade to the induction motor when a predetermined load is exceeded.

5,741 B.T.-H. Co. (G.E. Co., U.S.) Devices for the discharge of electricity through a vacuum, gases or vapours.
An electric discharge device having a cathode adapted to operate at incandescence, said cathode having a conducting shield, such as a sleeve or spiral, interposed between the region of the cathode subject to erosion and the anode, said shield being spaced away from the cathode and electrically connected to its supporting conducter.

5,028 WEST. Electrical measuring instruments.

8,204 HOPPIE. Electrical batteries.

9,003 PATTERSON. Miners' electric safety lamps.

9,706 ELECTRIC & ORDNANCE ACCESSORIES CO., LANGLEY & HOWDEN. Spring return mechanism for electric motor controllers and for other purposes.

9,903 KENNEDY-MCGREGOR. Electrical connections, particularly applicable to the sparking plugs of internal-combustion engines.

10,325 HAMILTON. Electrically-driven luggage truck.

10,422 WOOD, FURLONG & FERRANTI LIMITED. Connection and insulation of taps on electric transformers and similar apparatus.

10,518 GLANDINOTO & SEUDERI SEUDERI. Apparatus for converting electrical currents (21/7/14.)

10,598 ROOTHAAN & FERRANTI LIMITED. Rheostat switches and the like.

11,050 CLOYNE. Perpetual magnetic power wheel.

15,761 SMITH. Replenishing electrolytic cells. (3/6/15.)

17,455 BELLINI. Installations and apparatus for use in wireless telegraphy and telephony.
The circuit of the ordinary or directive aerial of the station is combined with two other oscillatory circuits, each having the same frequency of oscillation as the circuit of the aerial, one of these two circuits comprising, when used for transmission, the spark-gap or arc or alternator, and when used for receiving, the detector, whilst the other circuit comprises a capacity which is preferably greater than that of the circuit of the aerial, these two circuits being connected together in series in such a manner as to form a closed loop which is connected with the circuit of the aerial, so that the three circuits will have two points in common; the three circuits being, in addition, constructed and arranged in such a manner as not to have any electric or magnetic effect upon one another, except that which results from the fact that they have two points in common.

17,512 ROBERT BOSCH (firm of). Projector lamp for use with incandescent filaments. (18/2/15.)

17,713 THYNNE. Electrically-heated stoke or open fire.

1916 SPECIFICATIONS.

2,266 O'DONNELL, J.P. Electrically-operated or controlled indicating apparatus for use with signalling apparatus on railways. (15/2/16.) 100,215.

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

April 10, 1916.

5,237 FORBES. Automatically-controlled electric heater for water, &c.

5,238 GRONDIN. Train-stopping apparatus.

5,240 LAMKIN. Sparking plugs.

April 11, 1916.

5,257 BACK. Sparking plugs for internal-combustion engines.

5,259 GORDON. Motor-driven vehicles whereof the motor may be utilized for driving the vehicle or dynamo carried thereon.

5,262 BROWN. Electrical alternating-current machines.

5,279 SUTTON. Apparatus for cutting wires or cables under water.

5,289 BLACKSTONE, CARTER & CARTER & WATTS. Electric cable-laying machine.

5,293 SUCHOSTAWER. Dynamo-electric machines.

5,300 CARBONE. Arc lamps.

5,319 PONS. Sparking plugs. (14/5/15, France.)

5,325 DEAKIN, POLINKOWSKY & WESTERN ELECTRIC CO. Semi-automatic telephone exchange systems.

April 12, 1916.

5,337 CHARLTON. Electrical aim corrector and teacher.

5,341 ASTLEY & BRITISH INSULATED & HELSBY CABLES. Insulators for supporting electricity conductors or appliances.

5,343 RUTHERFORD. Electric lamp holders.

5,377 B.T.-H. Co. (G.E. Co.) Dynamo-electric machines.

5,385 SEARLE. Illumination.

5,391 ALLMÄNNA SVENSKA ELEKTRISKA AKTIEBOLAGET. Continuous-current generators. (5/5/15, Sweden.)

5,398 ANDERSEN & SOBERG. Insulating compositions for electrical purposes, &c.

April 13, 1916.

5,422 DUNGEY & KERSTING. Portable military telephones.

5,442 FOLEY. Electro-thermic induction furnaces.

5,445 MARKS. (Goldberg.) Electrical controlling apparatus.

5,458, 5,466, 5,471 SOC. FRANCAISE RADIO-ELECTRIQUE. Wireless telegraphy and telephony. (28/12/14, France. 1/3/15, France. 9/3/15, France.)

April 14, 1916.

5,497 MCROSTIE & WILLOWS & WILLOWS. Electric wire-cutting device.

5,498 STEVENS. Shunting device for windings of electromagnets.

5,501 BURGE. Field or portable telephones.

5,524 PLANIAWERKE AKT-GES. FUR KOHLENFABRIKATION. Arc light electrode with capillary passages. (13/9/15, Germany.)

5,526 NEULAND. Dynamo-electric machines.

April 15, 1916.

5,532 DIXON. Processes for separating sulphates of barium, strontium and calcium and producing carbonate of strontium.

5,546 FAIRWEATHER. (Singer Mfg. Co.) Adjustable hangers for power transmitters.

5,559 MARTIN. Machines for laying cables and wires underground.

5,567 FRANCE. Concentrating or intensifying light of electric filament lamps.

5,569 FRANCE. Electric incandescent lamps.

5,570 CROWDUS. Storage batteries. (22/4/15, U.S.)

5,573 FRANCE. Reflectors and shades of electric lamps, gas lights, &c.

5,577 MARKT. Electric switch.

5,579 MCBERTY, POLINKOWSKY & WESTERN ELECTRIC CO. Special service system for machine telephone switching exchanges.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	163	The Plexsim Electric Still. Illustrated	23
Imports and Exports of Electrical Manufactures	164	The "Easy-Clip" Shade Carrier. Illustrated	29
Educational Notes	164	Battery Zincs. Illustrated	30
Business Notices	164	The Servantless Flat	30
Bankruptcies, Liquidations, &c.	164	High-Priced "Gasoline" the Electric's Opportunity	32
Electricity Supply	165	"Fluvent" Switch-Fuses for Heavy Duty	32
Traction Notes	165		
Telegraph and Telephone Notes	165	Miscellaneous Notes	167
Empire Notes	166	Tenders Invited	167
		Tenders Received & Accepted	167
The Round Table	27	Companies' Meetings and Reports	163
Electric Light Switching Exam. Results	28	City Notes	169
Electric Drills and Grinders. Illustrated	28	Electrical Companies' Share List	170

COMMERCIAL TOPICS.

The "Servantless Flat."

If the electricity undertakings in the country are to benefit by the present difficulties in obtaining domestic labour, some organised effort must be made to bring the advantages of domestic electrical appliances prominently to the notice of the general public. It is not sufficient to assume that because the supply authority runs a showroom in the town or that electrical contractors have attractive shopfronts, the public truly realises what the full commercial value of numerous inexpensive electrical appliances means to them. Probably at no other time has the average householder and his wife been more willing to bestir themselves in the conduct of the affairs of the household than at present under war conditions. From the domestic electric service point of view, this attitude is surely most favourable for the introduction of such apparatus as irons, table utensils, vacuum cleaners and small fires. It is fallacious to be influenced by the opinion that the increased cost of electrical energy will tend to check the purchase of these appliances by the public. If the case for domestic electric utensils is put forward in the right way—that is, if it is demonstrated that such appliances are in the nature of a useful investment—then the public will come into line. This argument is proved up to the hilt by the "servantless flat" which the Brighton Corporation electricity department has been conducting at a Patriotic Housekeeping Exhibition recently held in the town. Within a comparatively small exhibition space a model flat, comprising dining-sitting room, bedroom, bathroom and kitchen, was fitted up, and every domestic operation performed by electrical means. The exhibition was visited by thousands of townspeople, and also, we understand, by many from neighbouring districts, and the attendance was in no way impaired by the small charge for admission. At a time when the British Commercial Gas Association is trumpeting its wares throughout the length and breadth of the land, some voice should be raised on behalf of domestic electrical appliances, if only in the interests of national economy. We doubt whether the electricity undertakings will again have so favourable an opportunity of bringing the merits of the domestic electric service to the notice of the public.

* * * *

Municipal Employees' Annual Holidays.

An interesting point as to annual holidays was raised in a case which recently came before a Divisional Court on appeal from a decision of the Sheffield County Court. A tramcar driver named Hurt, who had been in the service of the Corporation tramways department, had recovered judgment for £1. 16s. 10d., which he had claimed as one week's wages in lieu of holidays, or, alternatively, as damages for breach of contract. The man had been a driver in the service of the Corporation for many years, and was dismissed in August, 1915. It appeared that in 1906 the Corporation passed a resolution that all workmen who had been in their service "for more than 12 months should have one week's holiday in each year"; and in each year after that Hurt had had a holiday in accordance with the resolution. His last holiday was at the end of June, 1914. It had been the practice of the Corporation, in which the employees acquiesced, to give the holidays at some time in each year from April to October, so that an employee who had had his holiday early in one year could not object to being required to wait until a late period in the following year, although more than 12 months might have elapsed since his last holiday. For the Corporation it was contended that the resolution of the Corporation was only a private resolution, and was not a term of its contract with its workmen. The fact that it had been the practice to give a holiday was no proof that the practice had become a term of the contract; and even if there was a binding contract to give a holiday the Corporation still retained the right to dismiss a man at a week's notice, and they had exercised that right in the case of the respondent. The man could not (on his own contention) have claimed a holiday before October, 1915. For Hurt it was submitted that the granting of the holiday was a term of the contract; it was an equivalent to an advance of wages, and was accepted as such by the men and their union. A man who did 12 months' work was entitled to a week's holiday. The Court (Lush and Rowlatt, JJ.) allowed the appeal. Mr. Justice Lush said respondent contended that, owing to his having worked for more than 12 months since his last holiday in June, 1914, he had earned the right to be paid for a week's holiday at the time when he was dismissed. The County Court Judge had accepted that contention, which he thought was wrong. Even assuming that, as the terms of the resolution had been communicated to the employee's union, those terms had created a contractual obligation, it only meant that in each *calendar* year—not in each year of a man's service—an employee who had been with the Corporation for more than a year should be entitled to a holiday. But that only applied while the employment lasted, and if it was brought to an end in a legal manner there was no breach of contract in not paying for a holiday. Mr. Justice Rowlatt thought there was no evidence of the assumption of the County Court judge that a man who had served for 51 weeks was entitled to 52 weeks' pay.

We are sorry to see a great Corporation like Sheffield wasting the rates in litigation over such a trivial sum as that involved in this case. The point raised by counsel that the resolution passed by the Corporation was only a private resolution, and not a term of the contract of service, seeing that it had been acted upon for eight years, is, in our opinion, quite unworthy of any public body in this country. Whether there was or was not a right to a holiday under the circumstances must depend upon the terms (expressed and implied) of the contract, although Mr. Justice Lush's opinion may be right that a *calendar* year was meant. That this was so understood by one of the parties we do not doubt, but it is more than likely that the driver did not understand it in the same sense. Government departments, local authorities and other public bodies should be model employers, and set a good example to others in their dealings with their servants. Ambiguous terms in contracts of service are frequent sources of industrial disputes; and as it is advisable to avoid all possible causes of friction just now, we are sorry that Sheffield Corporation did not pay the small amount claimed in the present case, and at the same time define more clearly their position as to future holidays for their employees.

* * * *

The Allies' Economic Conference.

At the close of the inter-Parliamentary Commercial Conference at Paris on Saturday the meeting unanimously adopted resolutions regarding the establishment of preferential postal, telegraphic and telephonic rates between the Allied nations, the constitution of a permanent body charged with determining the conditions of the transport of merchandise and the introduction of a tariff on enemy goods, so as to avoid delays in the transport of goods from Allied States; the reduction of freight rates, with recourse (if necessary) to general requisition of merchant vessels, with indemnification in order to assure victory by the economic solidarity of the Allies.

* * * *

Electrical Manufacturers in the U.S.A.

It is reported that the American electrical manufacturers are deluged with orders at present. The General Electric Co. continues to book contracts at the rate of $150,000,000 a year, or $3,000,000 a week.

If orders continue to be booked at this rate the company will conclude 1916 with the greatest volume of untilled orders in its history. To the

amount of new business must be added the approximately $20,000,000 of contracts unfilled at the end of 1915. In 1913 the company executed about $106,500,000 of orders, but its bookings were nearly $5,500,000 higher. A feature of the many new contracts being received by the company is the fact that by far the greater part is small orders—less than $25,000 each. The smallness of the orders is stated to be indicative of the general prosperity of the country, especially as it is corroborated by the testimony of the other electrical companies throughout the United States. Notwithstanding the high price of raw materials, the margin of profit is expected to be larger than in recent years. There has not been for months past the competition among the electrical manufacturing concerns for business that marked 1914 while there have been advances in quotations for goods due to the higher cost of materials and manufacturing costs which are covered fully in the higher prices. A few more weeks of heavy orders will leave the books of the General Electric and Westinghouse Electric Cos. glutted with orders for electrical goods, but it is reported that the General Electric Co. will not show as large earnings on its stock as the Westinghouse Co., on account of the huge war contracts of the latter.

* * * *

Maximum Prices for Steel, Iron and Coke. In the "London Gazette" of May 2 maximum prices fixed by the Ministry of Munitions are set out:—

The prices for high-speed tool steel are, 14 per cent. tungsten 2s. 10d. per lb. basis, and 18 per cent. tungsten 3s. 10d. per lb. basis. Other kinds of steel vary from £10. 7s. 6d. to £12. 10s. per ton. Scrap: Millings and turnings, 5d. per lb. net; bar ends, 6d. per lb. net. Bar iron from £13. 15s. net to £15, less 2½ per cent.; pig iron from £4. 2s. 6d. to £8. 17s. 6d. Furnace and foundry coke, from £1. 4s. to £1. 10s. 6d.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From April 22, 1916, *to* April 29, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

FOLKESTONE.—*France:* Elec. carbons, 10 pkgs.
GRIMSBY.—*Denmark:* Electrodes, 70 pkgs. *France:* Unenumerated, 22 pkgs.
HULL.—*Norway:* Elec. machinery, 5 pkgs.
LONDON. *U.S.A.:* Elec. machinery, £3,853; elec. lamps, £765; telephone material, £84; elec. carbons, £744; unenumerated, £7,068. *Holland:* Elec. lamps, £551; incandescent elec. lamps, 40 pkgs.; unenumerated, £1,521. *France:* Unenumerated, £114—50 pkgs. *Switzerland:* Elec. lamps, £148; unenumerated, £106. *Italy:* Elec. lamps, £3,661; wire and cable, £1,198; unenumerated, £36. *Norway:* Elec. machinery, £500. *Canada:* Unenumerated, £50. *New Zealand:* Elec. machinery, £38.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Unenumerated, £285. *Melbourne:* Elec. machinery, £954; elec. glow lamps, £404; wire and cable, £1,400; unenumerated, £1,389. *Sydney:* Elec. machinery, £657; wire and cable, £1,400; unenumerated, £2,690. *Wellington:* Unenumerated, £24. *Perth:* Unenumerated, £40. *Christchurch:* Unenumerated, £281. *Dunedin:* Wire and cable, £891; unenumerated, £32. *Lyttelton:* Elec. machinery, £195; unenumerated, £109. *Brisbane:* Unenumerated, £2,395. *Fremantle:* Unenumerated, £29. *Hobart:* Unenumerated, £32. *Invercargill:* Unenumerated, £20. *Wellington:* Unenumerated, £24.
AFRICA. *Durban:* Elec. machinery, £171; unenumerated, £731. *Cape Town:* Wire and cable, £1,435; unenumerated, £641. *Port Elizabeth:* Unenumerated, £167. *East London:* Unenumerated, £240.
EGYPT.—*Alexandria:* Unenumerated, £1,062. *Port Said:* Elec. machinery, £90. *Suez:* Elec. cable, £315.
GIBRALTAR. Elec. machinery, £29; wire and cable, £294; unenumerated, £17.
MALTA. Telegraph material, £455.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Wire and cable, £3,706; unenumerated, £1,042. *Calcutta:* Elec. machinery, £137; unenumerated, £2,850. *Ceylon:* Wire and cable, £23; unenumerated, £175. *Madras:* Unenumerated, £561. *Bangkok:* Unenumerated, £55. *Karachi:* Elec. machinery, £190. *Singapore:* Unenumerated, £263. *Port Swettenham:* Elec. machinery, £44; unenumerated, £169. *Malacca:* Unenumerated, £92.
JAPAN. *Yokohama:* Unenumerated, £86. *Dalny:* Unenumerated, £270.
CHINA. *Canton:* Unenumerated, £27. *Hong Kong:* Wire and cable, £339; unenumerated, £353. *Shanghai:* Elec. machinery, £133; wire and cable, £120; unenumerated, £1,141.
ITALY. *Genoa:* Unenumerated, £858.
U.S.A. *New York:* Unenumerated, £581.
SOUTH AND CENTRAL AMERICA. *Buenos Ayres:* Wire and cable, £338; unenumerated, £2,762. *Monte Video:* Unenumerated, £46.
HOLLAND. *Amsterdam:* Wire and cable, £803; unenumerated, £1,301. *Rotterdam:* Wire and cable, £240; unenumerated, £122. *Haarlem:* Wire and cable, £102.
FRANCE.—*Paris:* Elec. machinery, £1,230; unenumerated, £128. *Dieppe:* Elec. machinery, £86; unenumerated, £97. *Boulogne:* Elec. machinery, £21; unenumerated, £1,074. *Bordeaux:* Unenumerated, £217.
SPAIN. *Barcelona:* Unenumerated, £174. *Bilbao:* Telegraph material, £45; unenumerated, £334.
PORTUGAL.—*Oporto:* Unenumerated, £71.
RUSSIA. *Vladivostock:* Unenumerated, £1,350. *Petrograd:* Elec. machinery, £240; unenumerated, £141.

FOREIGN GOODS (duty paid and free).

Melbourne: Unenumerated, £27. *Amsterdam:* Unenumerated, £74. *Calcutta:* Unenumerated, £65. *Paris:* Unenumerated, £86. *Bilbao:* Unenumerated, £25. *Sydney:* Unenumerated, £54. *Bordeaux:* Elec. machinery, £20. *Boulogne:* Unenumerated, £508. *Cadiz:* Unenumerated, £36. *Barcelona:* Unenumerated, £35. *Dieppe:* Unenumerated, £75. *Hankow:* Unenumerated, £71. *Havana:* Unenumerated, £18. *Shanghai:* Elec. lamps, £867. *Singapore:* Elec. glow lamps, £334. *Hamburg:* Unenumerated, £57.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

EDUCATIONAL NOTES.

Heriot-Watt Technical College.—At the last meeting of George Heriot's Trust Councillor Harrison moved that in view of the great developments which must take place in technical colleges after the war, a special committee be appointed to consider the whole position of the Heriot-Watt College.

He said there was a vast field for the technical colleges, either in conjunction with the Universities, or separate from them. Scientific research would also have to be part of the work of the college. Prof. Darroch, in seconding, said that technical colleges had at present no standing in the country. A man should be able to go to a technical college and say: "Here is a problem arising in my business which I cannot solve. What can you do to help me to solve it for the sake of the industry of the country?"

The motion was adopted and a special committee was appointed to consider the matter.

Welsh College Grants.—At last week's meeting of the Court of Governors of Bangor University College the registrar (Prof. J. E. Lloyd) read a communication from the Treasury to the effect that an additional grant of £1,125 would be made to Bangor and Aberystwyth Colleges, and £2,250 to Cardiff College and £1,000 to the University, for the years 1916-17.

He said that no condition would be attached to the increased grant during the war, but afterwards it would be expected that aid from the rates to an equivalent amount should be contributed by the Welsh county and local authorities, under which conditions the total grant might rise to £11,000.

On the motion of Mr. WILLIAM GEORGE, the Court passed a hearty vote of thanks to the Government for the increased grant, and pledged itself to do all in its power to further the Government's objects.

The REGISTRAR also reported that the Drapers' Company had decided to continue its grant of £200 per annum for the maintenance of the electrical engineering department of the college for another two years, as an expression of the company's appreciation of the work done in the past.

BUSINESS NOTICES.

Plant for Sale.—The Metropolitan Railway Co. advertise for sale the electric generating plant until recently employed by the Great Northern & City Railway, including four 800 kw. d.c. generators, with Corliss engines, 10 boilers, four condensing plant, auxiliary engine and generator, coal handling plant, feed pumps, &c.

The Metropolitan Electric Supply Co. (Ltd.), 16, Stratford-place, London, W., advertise for sale an enclosed vertical compound marine type engine, direct coupled to two-phase a.c. Westinghouse generator of 1,500 kw. at 500 volts, with exciter, condenser, steam driven air and circulating pumps, oil and steam separators, &c.

Messrs. Walker & Homfrays (Ltd.), 76, Deansgate, Manchester, advertise for sale a National gas engine, a Lancashire dynamo (100-110 volt, 10 amperes), auto-switchboard, Hart battery and motor-generator.

Patent Development.—The proprietors of patent No. 13,991/1910, relating to a "Method of and means for controlling from a distance electric apparatus and especially telegraph apparatus and the like," desire to dispose of same, or to grant licences thereunder. Applications to Messrs. Cruikshank & Fairweather (Ltd.), Patent Agents, 65 and 66, Chancery-lane, London, W.C.

Restoration of Lapsed Patent.—The Controller-General of Patents on April 26 made an order restoring to Nathaniel Baldwin letters patent No. 10,771/1910 for "Improvements in sound-reproducing devices of the telephone receiver type."

BANKRUPTCIES, LIQUIDATIONS, &c.

A second and final dividend (1½d.) is payable at Bankruptcy-buildings, London, E.C., to creditors of Jas. Wm. and Tom Whitaker Tattersall, electrical engineers, Kimberley-road, Willesden-lane, London, N.W.

A first and final dividend of 7d. is payable at 33, Carey-street, London, W.C., in the winding up of the Stolz Electrophone Co., 1913 (Ltd.).

The Excelsior Aluminium Solder Co. (Ltd.) is being wound up voluntarily. Claims by June 16 to the liquidator, Mr. J. R. Atkins, at whose office (14, St. Ann's-square, Manchester), a meeting of creditors will be held on May 12.

Another half-yearly statement by the liquidator of the Consolidated Diesel Engine Manufacturers (Ltd.) has been issued, bringing the accounts up to Jan. 6 last.

In the interval the whole of the unsecured creditors have been paid off, leaving £52,800 in hand, so that the contributories are likely to receive a small portion of their capital back, but there are still some uncom-

pleted contracts in hand, and the cost of these may have to be set against the value of the remaining assets. For the past six months the costs amounted to £3,200, while the total receipts were only £1,700. The collection of book debts has been disappointing, only £10,400 having been yet got in out of £28,100 marked "good" in the original statement, and £69,300 scheduled as "doubtful."

ELECTRICITY SUPPLY.

EXTENSIONS.

Accrington.—The Corporation have received the sanction of the L.G. Board to the proposed extension of the electric generating plant and the erection of a chimney and flues in connection with the destructor. The total cost is £21,000, of which the plant will cost £14,000.

Greenock.—The Corporation have decided to apply to the Scottish Office for power to borrow £45,000 additional capital for the electricity supply department.

At the meeting last week, Provost W. B. M'Millan regretted that they had been unsuccessful in their endeavour to get the Admiralty to agree to pay any share of the money required. The Admiralty had, however, agreed to a coal clause being inserted in their agreement. He was satisfied that even after the war there would be plenty of work in the town of Greenock for many years, and they were only acting in a prudent and businesslike way in making application for that capital to keep the electricity works up to date.

Heston and Isleworth.—The Council is to apply for sanction to borrow £787 for laying feeder cables in addition to the £3,569 sanctioned before the war.

Sanction has been received to the borrowing of £175 for extending the main in Wellington-road.

GENERAL.

Aberdeen.—The Electricity Committee has increased the charge for the supply of electricity to the Caledonian and Great North of Scotland Railway Companies by 20 per cent.

Edinburgh.—The estimates were considered at the meeting of the Electric Lighting Committee last week.

It was shown that there was a considerable deficit in the revenue this year, caused by the lighting restrictions, and the Committee recommended the Council to increase the rate for electric current for lighting by ¼d. per unit, raising the charge to 3⅛d. They have also agreed to charge 5 per cent. in addition to the present power rate where there is no contract.

Gravesend.—The charges for electric current were increased by 10 per cent. in March, 1915, and now they have been increased by a further 15 per cent. as from the end of the March quarter.

Ingleton.—The wardens of St. Mary's have been instructed to obtain an estimate of the cost of wiring the church.

Leicester.—The following members of the staff of the electricity department have been granted increases in wages as under:—

W. E. Barton, superintendent of Aylestone station, from £300 to £325 per annum; G. Morris, car-shed superintendent, from £260 to £285; E. J. Riley, chief clerk, from £200 to £215; H. E. Rogers, mains superintendent, from £190 to £225; G. E. Purdy, draughtsman, from 40s. 6d. to 50s. per week; B. Calvert, chief motor inspector, from 52s. 6d. to 55s.; J. B. Blackwell, foreman meter fitter, from 66s. 6d. to 69s.; A. Pritchard, rental clerk, from 41s. to 43s. 6d.

Mansfield.—Friday last was budget day with the Town Council.

Mr. J. H. Collins pointed out that the Electricity Committee had not only promised £1,000 to the relief of the rates, but had defrayed the expenditure of certain machinery and cable laying out of revenue, and had reduced the lighting account by £100.

Mr. J. P. Houfton thought the Electricity Committee might have contributed £1,600 to relief of rates, as it did last year, instead of £1,000. Had it contributed the larger sum the rate might have been reduced by 1d. The Government had promised to pay the cost of laying the electric cables and the Committee was bound to make more profit than ever in the coming year.

In reply Mr. Collins said if the Committee could afford it, and the town needed it, his Committee would be glad to contribute £1,600 again.

Marylebone (London).—The dispute between the Council and the members of the "running staff" of the electric supply department, arising out of the demand for an increase of wages, was referred to arbitration, and representatives of the parties were heard on April 11.

The award has now been issued, and finds that the men's claim has not been established. It appeared that prior to the war the Electric Supply Committee had established a scheme of bonus payment dependent upon the cost of production per unit, and under the scheme the rates of wages of the men at the generating station were enhanced. The cost of production per unit had now increased to such an extent that no bonus payment accrued under the scheme, and the earnings of the men had consequently been reduced. The Electric Supply Committee, however, undertook certain munition work on which the men in question were employed, partly in their spare time, and an opportunity for increased earnings was thereby afforded. In addition, the majority of the men had received since the war began advances of wages amounting in most instances to ½d. per hour (2s. 3d. per week).

Newquay.—The Newquay Electric Light & Power Co. has now received an order from the Board of Trade empowering it to charge the following rates for electrical energy supplied for lighting: For any amount up to 17 units 9s. 11d., and for each unit over 17 units 7d.

Ross.—The Council have decided, on the recommendations of the Streets Committee, to inform the Ross Electric Light Co. that if by May 15 the overhead wires are not removed, or the agreement sent on July 1 last is not returned sealed by the company, the Council will engage a competent electrician to remove the wires, as provided by sec. 14 of the Electric Lighting Act, 1882, and sec. 10 of the Electric Lighting (Clauses) Act, 1899.

Salford.—The Electricity Committee is to enter into agreements with two firms for the supply of current at tariff rates, also with the General Electric Co. for the supply of energy to their showrooms on the usual contract terms, except that the price to be paid by the company is to be at a flat rate of 1¼d. per unit, plus 15 per cent. increase.

The Committee recommends the Council to vary so much of the resolution agreed to in February last, relative to the terms and conditions of the supply to the Corporation of electricity in bulk, by agreeing not to require the Lancashire Electric Power Co. to supply a demand of over 2,000 kw. unless the company have the necessary plant available, and subject to reasonable notice being given.

Stoke-on-Trent.—Last week the Estates, Public Works and Tramways Committee reported that they were discontinuing the use of nine telephone instruments, but the Electricity Supply Committee reported that, with the increased load and number of consumers it was undesirable to diminish the telephone facilities in the department.

Ald. H. Leese pointed out that the revenue was about £40,000, and the expenditure on telephones for the department some £100. There were five stations, and one central office. Each of those stations had to be connected with the power house, from which it obtained its supply, and also with the central office. If the instruments were done away with the cost would be three or four times more in messengers, for it was absolutely necessary that the central office should know what was going on.

The Mayor said there were times when they had no such things as telephones, and businesses were carried on just as well. He was quite certain that if the committee only "looked the matter in the face" they would see that some of the telephones could be done away with. If he were a betting man he would be prepared to lay heavily that the instruments in officials' houses were much more used for private business than anything else.

The question was referred back.

TRACTION NOTES.

Electric Delivery Drays.—The Midland Railway Co. is making an experiment in the use of electrically-operated drays for delivering goods in the outlying districts of Sheffield. At present three storage battery vehicles are being used, and are (it is stated) giving every satisfaction.

One vehicle carries goods to the Firth Park and Pitsmoor district; another, to Crookes and Walkley; and the third to Ecclesall, Fulwood and Ranmoor. The great advantage of the vehicles is that they cover the preliminary part of the journey very quickly, and get into the delivery area in much less time than a horse and dray would take. The chassis of the vehicles are American, but the railway company built the bodies of the drays themselves.

Halifax.—It is proposed to extend the Skircoat tramway depot, at a cost of £2,700.

Heywood.—There was a deficiency of £518 on the past year's working of the Corporation tramways, compared with a loss of £1,042 in 1914-15.

The Electricity and Tramways Committee have decided to ask for a rate of 4d. in the pound to meet the deficiency on the electric supply department, and 1d. for the tramways department.

Manchester District Electric Railway Service.—The electric service is now running with smoothness and regularity on the Manchester-Prestwich branch line of the Lancashire & Yorkshire Co., and it is expected that there will be a complete electric service by July.

There is a saving of time by the electric trains, the journey to Prestwich occupying 13 minutes compared with 18 minutes by the steam trains, and the journey to Bury occupying 24 minutes against 32 minutes. The standard five-car electric train is 326 ft. in length, providing seats for 72 first-class and 317 third-class passengers.

Walthamstow.—The Board of Trade has approved the proposal to construct a double end at Ferry-lane tramway terminus.

Women Tramcar Drivers.—At the meeting of York Council on Tuesday the chairman of the Tramways Committee (Ald. S. W. Meyer) explained the position as to the training of women as tramcar drivers.

What had really happened in regard to the matter was that they put off employing women on the tramcars at all as long as they could, knowing the difficulty in regard to the temporary employment of women when the men came back claiming reinstatement. They would soon be opening the extension to Hull-road, and in view of the possible calling up of more drivers, they thought it wise to experiment with women drivers. He, therefore, agreed with the manager to train one woman, and that seemed to have occasioned some misunderstanding among the men, who thought the Committee were trying to drive men into the Army. That was quite incorrect, and the committee had had an interview with the men's union representative, who urged the committee to retain the men as long as possible, and that it was decided to do by the committee on his casting vote.

There are now about 1,200 women acting as conductors of the Glasgow Corporation tramcars, and 70 as drivers of cars.

TELEGRAPH & TELEPHONE NOTES.

Australian Radio Service.—The Australian Minister for the Navy states that the Cabinet has decided that the whole of the wireless telegraph stations should be under the control of the Navy Department, and the new service will be called the Royal Australian Navy Radio Service.

Those employed on shore will wear uniforms similar to the naval uniforms with a slight difference in badges. It is proposed later on to appoint an engineer for radio telegraphy, and in the meantime arrangements have been made to retain Mr. J. G. Balsillie, who recently resigned his position as head of the wireless service, as consulting engineer.

Cheaper Telegraph Service.—At a recent meeting of the London Telegraph and Telephone Society, Mr. John Lee, chief traffic manager to the Post Office, lectured on "Telegraph Tariffs and Economic Needs," and advocated a cheaper and improved telegraph service.

Mr. Lee said they had to discover in what way the thousands who never sent a telegram might be raised suddenly to the class who might find it just worth while to do so. He was of opinion that a local telegram at 4d. would be popular. It was beyond question that in urban districts generally such a tariff would meet the people's needs. A 4d. tariff would not meet the cost of production if it included the whole of Great Britain and Ireland. What, therefore, should be the extra urban tariff? He doubted if it would be possible to differentiate at 100 miles. They had learned much from the 9d. tariff; it was too dear, and had hit the small trader very badly. To find the marginal figure they should need to come below 9d., but not much below it, since they were providing a local service for 4d. Hence all indications pointed to 8d. as the marginal value. It was quite possible that in normal times they would be able to give something more for 8d. than they now gave for 9d. They should be able to give a quicker service. A differentiated tariff on those lines would give an advantage to the local trader. With a 4d. London tariff one would rather give an order in London than in Aberdeen. Local trading was to be encouraged, and a uniform telegraph tariff suffered from an additional disadvantage in failing to realise the fact. And while it failed to realise the fact the telephones staked their very existence upon it. He contended that a great many of the administrative difficulties would be overcome if, in addition to the telegraph traffic at 8d. for a minimum of 12 words, which would be the primary care, there was a secondary tariff at 4d. for a minimum of 12 words, the further charge of ½d. a word applying to both classes. Telegrams of the secondary class could be handed in at any time, but he thought it likely that they would not be telegraphed until after the morning pressure, while they would be delivered, either by messenger or by postman, as circumstances permitted. It might be desirable to fix a time limit, say, 30 minutes, at which in the afternoon the 4d. telegram would be handled in sequence with the 8d. telegram. An urgent telegram at 2 p.m. would take turn with a non-urgent at 1:30 p.m. Dealing with economic waste in the telegraphs, Mr. Lee said that he saw no chance of a remedy for the vast amount of idle and insufficiently-used plant which they had other than the remedy which every railway company had had to adopt, and that was to cultivate secondary traffic at a lower cost. They needed to fill up their wires and to extend the productivity of their plant by catering for traffic which would only stand a low charge. They had reached therefore a fundamental basis for our telegraph tariff. There were to be two kinds of telegrams—the major class at 8d. for 12 words plus ½d. a word, the minor class at 4d. for 12 words plus ½d. a word. These two classes would also represent a difference in quality. The former would be dealt with urgently throughout; it would be the "limited express" of telegraphy. The latter would fill up the lines, and would be the ordinary "third-class Parliamentary" telegram. It was obvious that the longer the telegram the smaller proportionately would be the difference in charge, so that for very long telegrams the sender would be tempted to pass the marginal limits and to pay the additional 4d. for speed in transit. The 4d. message, the secondary class, in its aspect of a local telegram, would be handled as a primary class telegram in London and in other large urban districts. He also proposed that the secondary class should take the place of the night telegraph letter, and that the concession be extended to all telegraph offices instead of limiting the privilege to a small number of towns. After 8 p.m. the secondary-class telegram could be held over for delivery by post the next morning. On Sundays and official holidays he would give the primary service only. In that direction they would need to proceed, if the telegraphic service after the war were to take their proper place in the machinery of transport, and if the charges were to be based on something more nearly like sound economic doctrine. There were already certain ocean cable rates governed by very complicated tariffs. Between England and New York there were eight different tariffs. Compared with those charges the differentiation which he had in mind for the British service was simplicity itself. He was perfectly sure that if, after the war, our industrial organism were to be put swiftly to the arts of peace, it could only be done by the assistance of a swift, energetic and efficient telegraph system. No one who had seen the working of the "urgent" tariff in Germany could deny its usefulness. Our telegraph service would need to face the possibility of doing something more than transmitting messages at the demand of isolated individuals. It would have to become a public service, including in its mission the dissemination of officially-gathered information as regards market prices, demands for goods, supplies of foodstuffs and raw materials and other information, too, which would go to the enlightenment of the community in respect of civic and national duty. It would set out to break down the isolation of outlying districts and the separateness of individuals. It would emphasise the possibility of closer communion between man and man, no longer held apart by space or sundered by time. In this binding and welding and healing a telegraph service which should meet the different needs intelligently and enterprisingly would possibly assume something of leadership in the making of a firmer and worthier social state.

Inland Telegraph Service.—It is announced that on account of the depletion of the Post Office staff by the withdrawal of men for service with the Colours, the hours of public telegraph business at many post offices have been curtailed.

Some of the larger telegraph offices and a number of the smaller offices, both in town and country, now open at 9 a.m. and close at 7 p.m. for the collection and delivery of telegrams, and senders are warned that telegrams handed in after 6 p.m. may not reach their destination until the following morning.

Portsmouth.—An automatic telephone exchange was opened on Saturday last. This is the largest automatic exchange in this country. It has been equipped by the Automatic Telephone Mfg. Co., and has a capacity of 7,000 lines.

Western Union Cable System.—The centralising of the London wires of the Western Union Telegraph Cable System was effected on Monday, and in future the eight Atlantic cables of the system will run direct into one office at Western Union House, Great Winchester-street, E.C., where all the latest telegraphic instruments and appliances have been installed.

When the Western Union Co. leased the cables of the Anglo-American Telegraph Co., and of the Direct United States Cable Co., eight Atlantic cables were brought under one system of control. The full facilities of those eight cables, however, could not be realised while each of the three companies had a separate "station" in London.

EMPIRE NOTES.

Australasia.—The report on the working of the Melbourne electricity undertaking during 1915 was recently submitted to the Council.

Revenue was £182,594, an increase of £17,806 compared with the previous year, while expenditure was £82,745, increase £2,754, and a gross profit £99,849, compared with £84,797, the increase being 17¾ per cent. Net profit was £35,659.

The chairman of the Electric Supply Committee (Ald. Cahena) informed the Council that it was desirable to form a reserve fund for contingencies such as the necessity for disposing of machinery, &c., before the end of its normal life, and meeting non-remunerative expenditure, such as storage of coal. It seemed absurd to place £73,300 to credit of depreciation and renewals fund during the last two years, while writing off only £15,500. Unless it could be shown that those funds were required there would be a demand for a reduction, and for decreased charges for current. The Council's rates for lighting were the lowest in Australia, and lower than those of many large undertakings in England. A proposal to set apart £5,000 as a nucleus for a reserve fund was lost, but it was decided to carry that sum forward as a credit balance.

Ontario Hydro-Electric Commission.—The "Electrical News," of Canada, states that the first audit of the operations of the Commission took place recently.

In his report the provincial auditor (Mr. James Clancy) criticises the attitude of the Commission in assuming authority not conferred upon them by the Hydro-Electric Act. While the province had authorised to the end of 1915 an expenditure of $13,169,000, the Commission had expended $17,359,000. It is not suggested that this money has been misused in any way, and a Bill has been introduced to enlarge the powers of the Commission. The extra expenditure had been used chiefly to

finance smaller municipalities, which were under obligation to repay the money over a fixed term of years.

South Africa.—A report has been issued by the Development of Resources Committee of the South African Institute of Electrical Engineers on the possibilities of establishing in South Africa on a commercial basis certain electro-chemical industries.

The report is confined to agriculture and mining. These industries require annually more than £2,000,000 worth of chemicals, all of which are imported in the form of fertilisers, cyanides and nitrates. The essential elements for their manufacture—cheap electricity, coal and limestone—are available in South Africa, and the market is to a considerable extent protected from competition by high cost of transport for imported articles and by Customs duties. The committee is of opinion that calcium carbide and cyanamide and derivatives of cyanamide can be profitably manufactured in South Africa, provided the necessary raw materials are available at reasonable cost, and urges that an early investigation should be undertaken with regard to the location, quality and cost of production of these raw materials.

A factory has been established at Vryheid (Natal) for the production of ammonium sulphate. Plant capable of producing 5,000 tons a year has been laid down at a cost of £350,000.

MISCELLANEOUS NOTES.

Controlled Establishments.—The Minister of Munitions announces that he has made a further order under the Munitions of War Act, 1915, under which 156 additional establishments have been declared controlled establishments, making a total of 3,493 controlled establishments.

Conversion Table, &c.—We have received from the Caxton Translations Institute (Caxton House, Westminster), a hanging card which gives metric and English equivalent weights and measures, and a table for the conversion of [illegible]; also particulars of population, coinage, weights and measures, &c., of the various countries of the world. The price of the card is 6d. (post free 8d.).

Enemy Firms Wound Up.—The Board of Trade have now ordered the winding up of 125 business controlled by alien enemies.

During the past week the winding up of the Alpine Concrete Chimney Construction Co. (Ltd.), 119, Victoria street, London, S.W., was ordered. (Controller: Mr. D. H. Allen, 20, Copthall-avenue, London, E.C.) Pneumatas Co. (Ltd.), sanitary system of cleaning telephones, 125, High Holborn, London, W.C. (Controller: Mr. A. Hartley, 9, Bassishaw Gate, London, E.C.)

Exports to China and Siam.—The "London Gazette" of May 2 contains further lists of firms in China and Siam to whom goods may be consigned. Amongst the firms mentioned in the May 2 list are: Shanghai Export & Import Co., Shanghai.

Trading With the Enemy.—Further additions to the statutory list of firms with whom trading by firms in the United Kingdom is prohibited appear in the "London Gazette" of May 2.

Amongst the firms mentioned are:—*Norway*.—Allgemeine Elektricitäts Gesellschaft (Christiania). *Spain*.—Cia Sevillana de Electricidad (San Pablo 39, Avenida San Sebastian, Seville), Arturo Koppel (Carrera San Jeronimo, Madrid).

Tribunal Case.—At Blackpool Tribunal, on April 27, three single young men, engaged in munition work at Blackpool electricity works, came under review.

The borough electrical engineer (Mr. Furness) said the men were not certificated or badged under the Government. Badges had been abused particularly in Blackpool, by non-qualified tradesmen who had got hold of badges somehow. These men had not gone on munitions with the idea of avoiding military service. If it was more important the men should be in military service than on munitions then it was for them to say they must go into military service. He said he would apply for certificates and badges, and let the Tribunal know the result.

TENDERS INVITED.

Electric Generator, Gas Producer Plant, Transformers, Mains, &c.

Wanganui (N.Z.) Borough Council require tenders by noon May 9 for the supply and erection of Additional Plant at their tramway power house, including Pressure-type Gas Producer Plant, Gas Engine, Electric Generator and Switchgear. Specification, &c., from the Town Clerk.

The Victorian Railway Commissioners require tenders by 11 a.m. May 31 for supply of Transformers, with Terminal and Fuse Boxes during five years. The first order will be for 220 transformers to be delivered in six months. Specifications, &c., from the Commissioners' Offices, Spencer-street, Melbourne.

Oamaru (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1. 1s. for each contract.

Tramway Construction, Tramcars, &c.

The Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, require tenders by May 19 for the construction and working, for 60 years, of an electric Tramway in Bilbao, connecting the existing system with the Irala-Barri district. Minimum rolling stock required to commence is one motor and one trailer coach for passengers, and one motor goods coach and two trailer goods wagons. An option on the concession is held by the Sociedad Tranvia Urbano de Bilbao.

Dunedin (N.Z.) City Council require tenders by 5 p.m. May 17 for six Electric Tramcars and sections of Cars (Bodies, Electrical Equipments and Trucks). Specifications, &c., from the Town Hall, Dunedin.

Johannesburg (Transvaal) Council require tenders by noon June 6 for supply of two Manganese Steel Crossings, and for the supply of 500 c.i. Joint Boxes and 200 Hanks of Trolley Rope (contract No. 112). Specifications, &c., from the municipal offices, Johannesburg.

The Public Works Dept., Madrid, will receive tenders until noon May 30 for the Construction and Working, for 60 years, of an Electric Tramway in Melilla (North Africa). The minimum rolling stock required is 16 coaches, with motors and accessories. An option is held by Don Felipe Ezquerro.

Telegraph Material.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the Australian Commonwealth Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

Motor Generator, &c.

The Victorian Railway Commissioners require tenders by 11 a.m. May 10 for Motor Generator and Accessories for Battery Charging of Baggage Trucks, also Switchboard and Connections (contract No. 29,796).

Steam Pipes, &c.

Salford Corporation want tenders by noon May 8 for high pressure Steel Steam Pipes and Separator; and c.i. Pipes and Valves. Specifications from the Borough Electrical Engineer.

Electric Cable, Cranes, &c.

The Victorian Railway Commissioners require tenders by 11 a.m. May 17 for the supply and erection of a 2-ton Electrically operated Goods Elevator at the Jolimont car shed. Specifications from the Commissioners' Office, Spencer-street, Melbourne

TENDERS RECEIVED AND ACCEPTED.

Johannesburg.—The Tramway and Lighting Committee has accepted the tender of Sykes & Co. (at £26,395) for two 3,000 kw. turbo-alternator sets, with Parsons condensing plant, switchgear, &c.

Salford.—The following tenders have been accepted by the Electricity Committee:—

British Westinghouse Co., transformers, £1,088; Underfeed Stoker Co., two underfeed mechanical stokers, £1,335; J. Gerrard & Sons, alterations and additions to buildings and foundations for a 5,000 kw. turbo-alternator, £1,650; extensions to h.t. switch house, &c. £1,060; Albion Motor Car Co., 4-ton petrol motor wagon £896; W. & T. Avery, examination of weighing machines for one year, £20.

Walthamstow.—The Council has placed an order with P. R. Jackson & Co. for 24 commutators for the tramways department, at £5. 5s. each.

The tender of W. T. Henley's Telegraph Works Co. has been accepted for the supply of cables for the coming year.

FINANCIAL MATTERS.

COMPANIES' MEETINGS AND REPORTS.

Direct United States Cable Co. (Ltd.)

The ordinary general meeting was held at the Company's offices, 238, Winchester House, Old Broad-street, on Tuesday, under the presidency of Sir JAMES PENDER, Bart., the Chairman.

The SECRETARY (Mr. William Miles, F.C.I.S.) having read the notice convening the meeting and the report of the auditors,

The CHAIRMAN said: Gentlemen, you will have had a copy of the Directors' report and accounts for the year ended March 31 last, and I presume, as usual, you will take them as read. The accounts are, I think you will agree, set out in such clear form that very few words are needed from me in submitting a resolution that they be now received and adopted. We have received the rental from the Western Union Co. provided for in our agreement with that Company, and this sum, with interest and dividends on our investments, has produced a total revenue of £74,125. After providing for income tax, Directors' fees and the consulting electrician's fees, and paying a dividend at the rate of 4 per cent. per annum, a balance remains on the revenue account of £26,797, which is credited to the reserve fund. Out of that fund we have had to pay for the cost of repairing and maintaining our cables, and there is also debited to it a loss of a little under £2,000 incurred in the realisation of certain securities during the past year that your Directors deemed it wise to dispose of. After giving effect to these charges a balance remains to credit of reserve fund of £487,704, compared with £476,986 a year ago. When I last had the pleasure of meeting you I expressed a hope that in 12 months' time the war would be over, and we might then be in a position to declare a bonus. Unfortunately, the progress of events has been much slower than any of us anticipated, and we must, I think, all feel that while we can see the beginning of the end, the ultimate cessation of warfare is not yet in sight. As things are at present, the depreciation in the value of the securities that represent the greater part of your reserve fund has not been lessened, but has increased during the year, so that the provision of £50,600 made on account of that depreciation is, I fear, at this time wholly insufficient. It must, however, be remembered in this connection that we are in the happy position of holding a large stock of cable, which we purchased on very favourable terms, which appears in the balance-sheet at its cost of £77,661, but is worth now quite £140,000. We are, therefore, prepared for any emergency that can be foreseen in regard to the repair of our cables without the necessity of realising our investments at the very low prices now ruling. At the same time, it must be borne in mind that the cost of ship hire and labour in connection with the repair of cables has very materially increased, and, viewing all the circumstances under which we meet to-day, I feel sure you will agree that your Directors have been acting in the best interests of the Company in maintaining the 4 per cent. dividend that you have received during the past two or three years. We can only hope that the war will end more speedily than we anticipate, that in the meantime the good fortune that has attended us for the past two years in regard to the cost of maintaining our cables may be continued, and that with a rise in the value of our securities, we may next year be in a position to pay a bonus that will reward the shareholders for their patience during these trying times. The Chairman concluded by moving that the audited accounts for the year to March 31, 1916, and the report of the Directors thereon be received and adopted.

Mr. JOHN VARLEY seconded the resolution which was carried unanimously.

Colonel the Hon. T. H. A. E. Cochrane and Mr. C. E. Gunther were unanimously re-elected as Directors of the Company, and Messrs. Deloitte, Plender, Griffiths & Co., were also re-elected auditors of the Company. A vote of thanks to the Chairman terminated the proceedings.

Cuba Submarine Telegraph Co. (Ltd.)

The ordinary general meeting was held on Wednesday, Mr. GEORGE KEITH (the Chairman of the Company) presiding.

The SECRETARY (Mr. A. C. Austin) read the notice convening the meeting and the report of the auditors upon the accounts.

The CHAIRMAN said: Gentlemen, I have now to propose the adoption of the report and accounts, which I presume you will take as read. You will be pleased to see the year's earnings compare very favourably with what they were in 1914. The large increase shown may be attributed partly to the generally prosperous conditions of Cuba and the other West Indian Islands, and partly to interruptions of competing lines bringing additional traffic to our cables. You will see by the comparative statement attached to the accounts the traffic increase during the first nine months of the year more than covers the loss due to the reduction of rates which took place on Oct. 1, 1914. The August and September decreases are fully compensated by the very abnormal increases during April, May and June, due to the interruption of competing lines, and the satisfactory increase during the last three months shows the expansion of the business under the lower rates. The traffic receipts of the whole year have increased £6,508. Interest on investments shows an increase of £560, and with the transfer fees the total revenue amounts to £45,310, or £7,066 more than it was in 1914. On the other hand, the year's expenditure does not compare favourably in consequence of the heavy cost of cable repairs. The London expenses are £97 more while station expenses are £1,679 less, as they do not include, as they did last year, the cost of the shallow water repairs, which is this year embraced in the separate charge against revenue for cable repairs. The large amount of cable used in the year's repairs has lessened the cable in stock, and the depreciation on stores and cable comes out £189 less. The heavier rate now charged has increased the income tax balance by £713, and there is the subscription of £100 voted to the Red Cross Funds at our meeting last year. Altogether the total expenses, excluding the cable repairs figures, amounts to £15,466

The duplicate Santiago cable, which I mentioned at our meeting last year, had been repaired in March, was again interrupted during the cyclone last August, and was repaired in the following November. Both repairs necessitated hiring a cable steamer for the work, and were very difficult and costly to carry out in consequence of the great depth of water, and the large amount of cable used. Both these interruptions were caused by earthquakes in the sea-bottom, and the cyclone in August badly damaged the cable but in the Morro Inlet at Santiago, and the harbour cables there. The duplicate Batabano cable which was repaired near Batabano in May last year was again interrupted and repaired last September. These repairs being in shallow water were carried out locally by our electrician at comparatively small cost. Altogether the cost of the year's cable repairs amount to £13,654, which brings up the total expenditure to £29,120 or £12,418 more than it was in 1914.

The result of the year's working shows a profit balance of £16,189, out of which interim dividends amounting to £7,600 were paid in October last, and after carrying £2,500 to the Pension Fund, the Directors now recommend the payment of a final dividend of the same amount, making a total distribution for the year of 10 per cent., subject to income tax, on the preference shares, and 5 per cent., free of income tax, on the ordinary shares, and reducing the balance brought forward by £311 to £7,580 carried forward to next year's account. The general reserve fund remains the same as last year, at £160,000, while the pension fund now stands, with interest accrued, at £13,108. The £10,660 2½ per cent. Consols, and the £5,000 3½ per cent. War Loan Stock have been converted into 4½ per cent. War Loan Stock, which, with an additional amount purchased, makes £21,100 invested in that Loan. The conversion entailed a loss of capital-value of £3,447, which has been taken from the reserve against loss by depreciation on investments, but has resulted in largely increasing the interest on the year's investments which I think may be considered satisfactory. The investments at cost, less reserve for depreciation, stand at £115,811, or £9,650 more than they were last year.

As regards the current year, business generally continues good and active. The sugar crop now being harvested is a record one and prices are very high. All this is increasing the prosperous condition of trade generally in Cuba. Our cables are all working well, and giving an efficient service, and up to the present the traffic passing over our cables compares very favourably with what it was last year. I beg to move that the report and accounts for the year ended Dec. 31 last be received and adopted.

Mr. ALEXANDER G. LOW seconded, and after the Chairman had answered a few questions, the resolution was carried unanimously, and the final dividends for the year were then declared.

Mr. Charles Woodbyne Parish was re-elected a Director, and Messrs. Gane, Jackson, Jefferys & Freeman were re-elected auditors to the Company.

A vote of thanks to the Chairman terminated the proceedings.

Indo-European Telegraph Co. (Ltd.)

The ordinary general meeting was held on the 27th ult.

The SECRETARY (Mr. John I. Bethell) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the notice which you have just heard read summoning this meeting was forwarded to each shareholder with a circular letter signed by our Secretary with reference to the decision of the Directors to declare an interim dividend. From this circular letter you will have observed that owing to the continuance of the War all the documents of the Company have not yet been received from abroad. In these circumstances it has not been possible to prepare the balance sheet for the year ended Dec. 31, 1915. Having regard, however, to the fact that it has been customary to hold a general meeting of the Company at this time of the year, the directors, reluctant to depart from precedent, decided to convene the meeting, in order that shareholders might have an opportunity of hearing that the directors, in view of the inconvenience likely to be caused by the postponement of the full dividend for the year, have declared a dividend, by way of further interim dividend, equivalent in amount to the usual final dividend and distribution—that is to say, £2. 12s. 6d. per share, free of income tax. This they have every reason to believe the accounts, when presented, will be found to justify. It is hoped that it will be possible to issue the directors' report and accounts towards the end of next month, and I propose now to move the adjournment of this meeting until

it is possible to present such report and accounts. Due notice will be given of the adjourned meeting. I desire, with the consent of my colleagues, to ask the shareholders if they will be good enough to authorise the Board to make a further contribution to Russian Red Cross Funds, or funds in any way connected with the disabled soldiers of Russia, our Ally during this war. It would be a graceful act on our part as a company, and would, I have reason to know—and you may well know—be much appreciated. We have already contributed certain substantial sums, but I think that, having received now such a very handsome dividend under circumstances which would not have led any of you to expect it, we shall be more than justified to our own consciences if we make a further contribution to our Ally's wearied and wounded soldiers. I would, therefore, ask you to make a contribution of £1,000, to be used by the directors at their discretion for these purposes.

Mr. CHARLES HOLLAND seconded the motion, which was carried unanimously, and the proceedings then terminated.

BABCOCK & WILCOX (LTD.)—The net profit during 1915 amounts to £396,551, and with £69,492 brought forward, the total is £466,043. The interim dividends (paid in October, 1915) of 3 per cent. on the preference shares, 2½ per cent. on the second preference shares, and of 6 per cent. on the ordinary shares absorbed £107,059, leaving £358,984, from which the directors recommend that the following dividends be paid for the half-year ending December 31, 1915, viz., 3 per cent. on the preference shares and 2½ per cent. on the second preference shares (less tax), and dividend of 9 per cent. on the ordinary shares (tax free) which absorb £156,859. A sum of £150,000 has been placed to reserve, and £10,000 has been granted to the staff pension fund, leaving to be carried forward £42,125. The company's works are largely engaged in the manufacture of boilers and munitions for the Government. During the year the directors acquired additional premises adjoining the Renfrew works and carried out other extensions. The company is short of men, and female labour is being introduced in some of the departments. Such a large proportion of the staff have joined H.M. Forces that additional work has been thrown on the remainder. The extra demand on the staff has been met with a spirit of enthusiasm.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—During the past year 21,081,928 units of electrical energy were sold, compared with 15,387,471 units in 1914. The number of houses connected at Dec. 31 last was 8,768, compared with 8,180. The gross revenue was £224,206 (against £202,455) and net revenue was £162,922 (against £140,609). With balance brought forward and interest received on money deposit the available total is £176,602. 10s. 7d. After deducting the interim dividend of 3½ per cent. paid on the ordinary shares in November last, the dividends paid and accrued on the preference shares, &c., there remains £122,177. 8s. 4d. The directors recommend that £52,000 be placed to credit of depreciation and renewals account, that £10,000 be added to reserve, and that a final dividend be paid on the ordinary shares for the second half-year at the rate of 5½ per cent., actual (making 9 per cent. for the year), which will leave about £30,000 to be carried forward, after providing for the directors' extra remuneration of £2,500, and a bonus of £1,629 payable to the staff in India. The capital expenditure last year amounted to £122,343. 12s. 4d., the total outlay to Dec. 31 last being £1,380,827. 7s. 10d. The demand for electrical energy continues to increase steadily, and the result of the working for the year must be considered satisfactory.

JOHNSON & PHILLIPS (LTD.)—Mr. Robt. W. Blackwell, who presided at the annual meeting last week, said that the trading profit for 1915 was £69,076. 18s. 9d., after setting aside £9,420. 15s. 2d. for maintenance of buildings, plant, &c. After paying debentures interest, &c., and providing for depreciation on machinery and plant, &c., the available balance was £34,050. 6s. 7d. It was proposed to pay a dividend of 5 per cent. (tax free) on the ordinary shares, leaving to be carried forward £25,300. 6s. 7d. In the opinion of the board the conditions under which the business must be carried on for a considerable period to come did not admit of a larger distribution. They must carry very heavy stocks of material, and at present work practically filled their shops. The balance-sheet showed that the position of the company was thoroughly sound and steadily improving. The original £175,000 first debentures had been reduced to £110,887. During 1915 they had spent on additions to buildings and plant £8,413. 17s. 2d., and spent out of revenue £9,000 for the maintenance of their property. Generally, he considered that, under existing conditions, they had good reason to be satisfied with both the present position and the future prospects of the concern. It was more than probable that a large part of their plant would run at full pressure, but a considerable proportion of their machinery and plant which was not susceptible of adaptation to present requirements might have to lie idle until normal conditions were again reached. He did not believe that the company had been either advantaged or injured financially by the war to any special extent. Their turnover might be somewhat higher than they might reasonably have expected, but the difficulties of doing business, prices and costs of all kinds, had greatly increased and their margin of net profit decreased. It was only during the year under consideration that they had seriously felt the pressure upon them. They had strained their resources to the utmost, and should continue so to do. With that end in view they had developed and built a considerable amount of new machinery. It was his opinion that at least a part of that new plant would be of real utility to them. The whole of their property had been well maintained, and the board proposed to continue in its endeavour to bring every part of the works and plant up to the best modern standard. It was but fair that he should express on behalf of the board its high appreciation of the energy and ability with which the active management and staff had grappled with the situation and met the demands upon them. Their thanks were due to them, one and all, and in no small measure.

A. REYROLLE & CO. (LTD.)—The accounts for 1915 show a profit, after providing for depreciation, &c., of £11,853. Dividends of 10½ per cent. on the preference and 18½ per cent. on the ordinary shares have been declared, £5,009 being placed to reserve and £3,387 carried forward (compared with £2,843 in previous year).

SHROPSHIRE, WORCESTERSHIRE & STAFFORDSHIRE ELECTRIC POWER CO.—The chairman (Mr. W. L. Madgen) stated at the meeting last week that the units sold in 1915 showed an increase of 10 per cent. compared with the previous year, and there had also been a continued increase in the number of consumers for industrial purposes. The price of fuel and the difficulties of obtaining regular deliveries required constant attention and adjustments had had to be made in the prices of supply to consumers, but they were in hopes that those circumstances would not have any serious retarding effect upon the natural development of the business. Compared with electric supply undertakings which relied chiefly upon the supply of current for lighting, they, in common with other power companies, had an advantage which was not so generally appreciated as perhaps it might be. It was, he considered, an undoubted advantage that the greater part of their own output was used for driving machinery and for other industrial purposes. As the years had gone by the efficiency of the incandescent lamp had continued to increase in a somewhat disconcerting manner until the lamp now in common use consumed less than one-third of the current taken by a lamp of similar candle power some seven years ago. In other words, three times the lighting was now given for the same money, and lamps of still higher efficiency were now available in the larger sizes. It was true that cheapness encouraged consumption, but there soon came a limit to that, and in very many cases the electric lighting consumer was now getting too much the best of it at any rate upon the usual method of making up his bill. In the case of power supply, however, the relation between the current supplied to the consumer and the work done by it for him was practically constant, so they need not apprehend that his consumption and their revenue from him would diminish. Then again, in dealing with large buyers there were advantages in respect of service expenses, collections, &c., which were familiar in many trades, and to all business men. It appeared to follow from these and other considerations that the smaller undertakings and those which chiefly relied upon the leaner demands such as electric lighting must inevitably be led to buying their requirements in bulk from the main power stations which were equipped on the great scale adequate to furnishing the current necessary for the industrial and transport requirements of large areas. In conclusion, he expressed, on behalf of the Board, their acknowledgment of the services rendered to the company by their general manager (Mr. Bond), their chief engineer (Mr. Legge), the secretary and other members of the staff who have "carried on" successfully in most difficult times.

WILLANS & ROBINSON (LTD.)—Mr. J. C. Peache, who presided at the meeting on Friday last, said that the net profit for the past year was £16,726, of which £7,800 was absorbed by the payment of dividend on "A" and "B" preference stock and interest on funding certificates. It was proposed to pay a dividend of 10 per cent. on the small ordinary capital, and after carrying £7,098. 19s. to reserve to pay a bonus of 2s. 6d. per £100 "B" stock, and 1s. per share on the ordinary shares. It was gratifying to be able to state that the prospects for the current year were good, while for the year under review, after providing for distribution mentioned above, £7,099 had been added to the reserve fund, bringing that fund up to the satisfactory sum of £24,313. In the course of the year the Queensferry premises had been sold to the Government. An important transaction arising since the close of the year under review was the proposed transfer of large interests in ordinary shares, which the directors were satisfied would materially consolidate the standing of the company. The payments made to dependents of men who enlisted in the early period of the war amounted to between £7,000 and £8,000 for the year under review. Over 200 of the company's original staff were still serving with the forces, of whom 16 held commissioned rank, and 13 of various ranks had given their lives in the service.

CITY NOTES.

MEMORANDA (May 3).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 56⅞. Consols Pay Day, June 1. Stocks and Shares Ticket Days, May 11 and 30. Pay Days, May 12 and 31. Price of silver, 37¼d.

CALCUTTA TRAMWAYS CO. (LTD.)—The receipts for 1915 (including interest on investments, &c., and balance brought forward of £7,566) were £116,736. A final dividend of 6s. 6d. per share is proposed (making 9½ per cent. for the year); a sum of £15,000 is to be transferred to reserve, £1,309 to staff provident fund, leaving to be carried forward £6,812.

CITY OF BUENOS AYRES TRAMWAYS CO. (LTD.)—A dividend of 1s. 3d. per share (being at rate of 5 per cent. per annum), less tax, has been declared for the quarter ended March 31 last.

HINDHEAD & DISTRICT ELECTRIC LIGHT CO. (LTD.)—The net profit for 1915, after making provision for depreciation, was £2,077. A final dividend of 3 per cent., making 6 per cent. for the year, has been declared, and £803 carried forward.

METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)—The ordinary general meeting, which was adjourned until May 2 or such later date as the Committee might agree, will not be held on May 2. Notice will be given when a date is fixed.

NORTH OF SCOTLAND. ELECTRIC LIGHT & POWER CO. (LTD.—The gross profit for 1915 (including £2,420 brought forward) was £9,458, and after meeting interest on debentures and loans and writing off £56 from suspense account, the net profit is £6,546. A dividend at rate of 3 per cent. for the year was declared, £2,000 placed to renewal reserve, £1,000 to general reserve and £2,046 carried forward.

SUBMARINE CABLES' TRUST.—Notice is given in an advertisement in another column that, in accordance with the terms of the trust deed, 37 certificates (for £120 each) of this Trust were drawn on the 1st inst. for payment out of surplus income on and after that date by Messrs. Glyn, Mills & Co., 67, Lombard-street, London, E.C.

TELEPHONE CO. OF EGYPT (LTD.)—Including £164,276 brought forward, the profits for 1915 were £232,143. Further dividends of 6 per cent. are recommended on the preferred and deferred shares, making 10 per cent. for the year, and carrying forward £193,469.

TRAMWAYS & GENERAL WORKS CO. (LTD.)—The report for 1915 states that (including balance brought forward) the profit is £540, out of which the directors recommend a dividend at rate of 4d. per share (less tax), which will absorb £333, and leave £206 to carry forward.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date May 3, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17¼d.
Solid Drawn Copper Tubes	19d.
Brazed Copper Tubes	19d.
Brazed Brass Tubes	19¼d.
Brass Wire	16¾d.
Copper Wire	19d.
Rolled Brass	16¾d.
Brass Sheets	17¼d.

	per ton.
Copper Sheets	£152 0 0
Spelter	£103 0 0
English Lead	£35 10 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£108 0 0
Clean Brass Scrap	£71 0 0
Braziery Copper Scrap	£95 0 0
Old Lead	£31 0 0
Old Zinc	£80 0 0
Hollow Pewter	£125 0 0
Black Pewter	£85 0 0
Gun Metal	£85 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date May 2, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£72 0 0
Clean Copper	£110 0 0
Braziery Copper	£95 0 0
Gun Metal	£85 0 0
Old Lead	£30 0 0
Tea Lead	£28 0 0
Old Zinc	£72 0 0
Hollow Pewter	£135 0 0
Shaped Black Pewter	£95 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £90; Commercial Tinman's Solder, £115; Blowpipe Solder, £125.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, May 2. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., May 2.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅝	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	9⅛	4 15 8	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	9¼	6 3 1	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅞	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. C. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	80½	4 19 5	Jan, July
5	2/3	Do. 4½% Pref.	3½	6 18 6	..
5	5%	Do. Ord.	3⅛	6 19 6	Aug, Feb
5	4½%	Do. City Pref.	2¾	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅛	6 5 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	11⅞	6 15 5	Feb, Aug
10	6/0	Do. 6% Pref.	10	6 0	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10⅜	6 15 11	Mar, Sept
10	6%	Do. 6% Pref.	10½	5 17 1	Feb, Aug
St.	4½%	Do. 1st Deb.	86†	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	97†	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	76½	5 17 8	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6/-	London Elec. Supp. 6% Pref.	4⅜	7 3 3	..
St.	4%	Do. 4% Mort. Debs.	80	5 0 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅛	6 4 8	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	91½	5 9 3	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1⅛	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	3⅜	6 10 7	Mar, Sept

† Ex dividend or Interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., May 2.	Rate per cent, Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5⅛	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅛	6 0 3	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp 4½% Db. St.	83	5 8 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅜	7 6 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅛	5 17 11	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4⅜	5 11 7	Jan, July
		Electric Railways & Tramways.			
22	5%	British Elec. Traction 5% Debs.	79	6 6 7	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	71	8 9 0	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	66½	6 0 4	..
St.	4%	Do. do. Assented Def. Ord.	64½	6 4 0	..
St.	4½%	Do. 4½% Pref.	99½	4 10 3	Jan, July
St.	4%	Do. 4% Deb. St.	93½	4 5 9	Jan, July
St.	4%	City & S. London Deb.	72†	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	62½	8 0 0	Feb, Aug
10	11%	London Electric Ry. Ord.	2⅜	5 19 6	Jan, July
St.	4%	Do. 4% Pref.	64⅝	6 3 6	Mar. Sept.
St.	4%	Do. 4% Debs.	85	4 14 4	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25½	3 18 5	Feb, Aug
St.	3½%	Do. 3½% Pref.	77½	4 10 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	74½	4 13 9	Feb, Aug
St.	3½%	Do. 3½% A Debs.	82½	4 4 6	Jan, July
St.	3½%	Do. 3½% Debs.	83½	4 4 1	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18⅝	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	92	4 7 0	May, Nov
St.	4½%	Do. 4½% First Pref.	71⅞	6 5 5	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 7	Jan, July
St.	4%	Do. 4% Debs.	71	5 12 8	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	68	5 17 7	Mar, Sept
		Electric Manufacturing, &c.			
1	14%	Babcock & Wilcox Ord.	2⅜	5 3 0	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅛	6 4 5	Mar
100	5%	Do. Prior Lien Debs.	89½	5 11 8	Jan, July
1	6%	Do. 6% Pref.	⅞	6 17 2	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10½	7 2 10	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref.	⅞	6 17 2	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅝	7 3 3	April
100	6%	Do. 6% Prior Lien Debs.	100⅛	5 19 8	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65⅞	6 1 8	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	11⅜	6 9 9	Jan, July
5	5%	Do. 5% Pref.	4½	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	93	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅜	7 13 8	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	⅛	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	⅛	7 7 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	72	5 11 1	Jan, July
50	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9⅜	6 4 8	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14½	6 15 7	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4½	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	10	10 0 0	Feb, Aug
10	5%	Do. Pref.	7½	6 13 4	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	37	6 9 9	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1½	5 11 8	May, Aug
1	6d.	Do. 5% Pref.	⅝	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 8	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jun, Dec
St.	4%	Willans & Robinson B. Cum. Pref.	41½	9 12 9	..
St.	4%	Do. 1st Mt. Deb. St.	50½	7 18 5	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	96½†	6 2 2	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	21⅞	6 19 11	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69½	5 11 8	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7⅜	6 1 8	May, Nov
10	10%	Do. 10% Pref.	14	7 2 10	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	5⅛	7 0 8	Ja,Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	141	4 17 3	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	63½	5 11 1	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	79†	5 1 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77½	5 3 3	Feb, Aug
10	7%	Do. Ord.	14⅜	4 17 10	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co.	36†	6 1 10	Ja, My, Jly
25	13%	Indo-European	43½†	6 14 9	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2⅜	4 12 9	April
1	7%	Do. 7% Pref.	1⅝	3 13 5	July
10	1%	West India & Panama Ord.	1⅜	8 13 9	May, Nov
10	6%	Do. 1st Pref.	7⅞	7 12 11	May, Nov
10	8%	Western Telegh. Co.	14⅜	5 13 9	Mr, Jly, O, Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½	4 10 3	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	5⅞†	6 12 5	Nov.
1	10%	Oriental Telephone Ord.	1⅜†	5 8 6	Apl, Oct
St.	4%	Do. Db. St.	73½	5 1 5	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	5⅛	6 4 3	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4½	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	91½	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	11⅛	5 2 8	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10½	5 14 3	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	82½	6 1 9	Ja, Apl, Jly,O
..	4%	Do. $100 Pref	82⅜	5 14 6	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs	124	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅛	6 10 8	Mar, Sept
St.	5%	Do. 5% Debs.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10½	5 19 6	..
St.	4½%	Do. 4½% Debs.	87½	5 2 10	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6⅞	7 2 7	May, Nov
5	5%	Do. 5% Pref	4½	5 14 3	Mar, Sept

† Ex dividend or Interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,982. [Vol. LXXVII. No. 6.] FRIDAY, MAY 12, 1916. PRICE SIXPENCE

Abroad 9d., or 20 cents. or 1 fr., or 90 pf.

CONTENTS OF THE CURRENT NUMBER.

NOTES 171
Arrangements for the Week .. 174
The Present Position of Electricity Supply in the United Kingdom and the Steps to be Taken to Improve and Strengthen It.—*Discussion* 175
Experiments with Filaments Heated Electrically in Volatile Liquids. By S. W. J. Smith, F.R.S. Illustrated. 177
Shipyard Cranes of the Rotterdam Dockyard Company. By M. G. De Gelder. Illustrated 178
Transformer Design. By F. M. Denton, A.C.G.I. Illustrated. *Concluded* 181
Hire and Maintenance of Continuous-Current Motors. By Henry Joseph 185
THE HIRING AND MAINTENANCE OF MOTORS 188
Automatic Protective Devices for Direct Current Systems. By M. Rosebourne, B.Sc., and F. A. Couse. Illus. .. 189
CORRESPONDENCE 193
"Speeding Up in an Engineering Factory" (R. Rankin, H. Stuart and H. Ambrose Carney).
Technical Education (A. W. Ashton).
Generation of High-Tension Continuous Current (L. Bouthillon).
Sir William Beardmore on Science and Industry 195
PARLIAMENTARY INTELLIGENCE 196
Educational 196
The "Electrician" Commercial and Industrial Section .. 197-204

NOTES.

Daylight Saving.

FOR years we have heard of the Daylight Saving Bill, originated by the late Mr. WILLIAM WILLETT. The subject has been frequently discussed, and has been opposed more by scientific men than by any other class. As far as we are aware, the opposition of the scientist is chiefly based upon the idea that by means of any such measure we should be living in artificial fashion according to a time which was obviously incorrect. No doubt this would in a sense be the case; but, on the other hand, this is already equally true of every person in Great Britain who does not happen to live on the longitude of Greenwich. There does not, therefore, seem to be any particular force in such an argument. It is really a matter of practical utility. In the evidence which was given before a Select Committee, the General Manager of the London & North-Western Railway is reported to have stated that his company would save £92,000 per annum by such a measure, and the Chief Officer of the London County Council tramways stated that the saving to the Council would be at least £10,000 a year. Having regard to the letter which we published last week from the Board of Trade, requesting gas and electric lighting consumers to reduce their lighting by 10 per cent., it seems to us that it is only reasonable that the Daylight Saving Bill should be adopted. It is quite true that the same thing might be effected by other means, such as joint individual effort on the part of banks, railways and other bodies, but the fact remains that a Bill is far the easiest way of securing the change. The idea of daylight saving seems to have originated in this country, but we have waited to adopt the expedient until other countries have moved in this direction, thus displaying a national policy that is only too characteristic. As to the effect which will be produced upon electric lighting undertakings, there is no doubt that they will suffer to some extent. At the same time, it must be remembered that the lighting part of the load of an electricity works is far less important than it was years ago. Power is what is important in these days, and in this category we should, of course, include electric heating, cooking and other domestic applications. If these applications have been properly pushed, most electricity undertakings will not feel the effect of the new Bill to any serious extent.

Accelerating Production.

IN our opinion little good is likely to result from giving wide publicity to the so-called deficiencies of thoroughly trained mechanics as munition workers. We deplore the comparison that was made between male and female labour by Sir WILLIAM BEARDMORE last week in his Inaugural Address to the Iron and Steel Institute. Not only do we deplore the comparison, but we feel that the suggestion that "the men who thus limited the output could only be regarded as unworthy of the privileges of citizenship" should not have been made. Without belittling in any way the splendid work that is being done by our women, we believe that all in good time the men will be able to answer the charge. Moreover, the conditions on the Clyde do not necessarily represent the conditions in other parts of the country. It is fairly well known that many of the engineers on the Clyde feel that they have a grievance, and if this be the case it is likely that the output will be small. But for one side to accuse the other as being unworthy of the privileges of citizenship is not the best way of settling the grievance. As we have said, it may be that the men have a complete answer to the charge, and till such time as the men state their case we advise readers to keep an open mind on the question. Were we large employers of labour, and were we given to speaking in public, references to employees in our speeches would be conciliatory rather than aggressive at the present time when output means so much to us. Better than either side vilifying the other would be for the two again to meet and to thresh out the whole business from beginning to end, and to Committee neither side would object to bald truths and plain speaking. Till we have full knowledge of the whole of the facts we are not prepared to admit that our working engineers are less patriotic than their employers.

The Handling of Materials.

IN his recently published book on "The Economical Handling and Storing of Material," Mr. G. F. ZIMMER states that "The national economy of the civilised world cannot do without the mechanical handling and storing of material, and . . . the toll claimed from the ranks of labour by the European War, and the consequent shortage of hands, will force even those who are slowest to adopt modern means to replace the man by the machine wherever possible." This is a view which we have long held. Even in countries where

unskilled labour is cheap, to use man as a mere weight-lifting machine is to degrade him. Had man been intended for any such purpose we may take it for granted that his general arrangement would have been different. But, altogether apart from the misusing of manual labour, there is no place, nor should there be any place, in society for unskilled men. We believe that the present century will see their liberation. Almost without exception, those who have installed modern plant for the mechanical handling and storing of material find that such plant yields a very high return on the capital expended, and this applies to small installations as well as to large. Not only is the yield high, but from the works, or the warehouse, is removed the curse both of employer and employé, and, in fact, of the whole community—namely, the presence of a relatively high percentage of unproductive labour which impoverishes the country. If for no other reason, our successors will be grateful to us for the introduction of electrical energy as a motive power on machines intended for the handling of material. In our time it is not unlikely that thousands of millions of tons of material will be handled annually in this country by electrically-driven machinery.

Local Government Guidance.

NOTES of some cases decided by the Central Tribunal have recently been circulated for the information of Local Tribunals. Of the five cases given, two have a direct bearing on the question of higher education. On the first case the Central Tribunal gave a decision with respect to a specific question raised by the Appeal Tribunal—viz., "That it does not appear to them that the teaching of mathematics in a secondary school is of itself a work of national importance at this time which would justify exemption." In our opinion, sound common sense has been shown in this case, for, although the teaching of mathematics in secondary schools is work of national importance, it is unquestionably work that can be performed for the time being by women. We do not doubt that equally sound decisions would be given in other cases of the kind coming before the Central Tribunal, but few of the cases we have in mind are likely to come before them, and having got the idea that there are to be no exemptions for teachers, Local Tribunals will be liable not to discriminate. It is an easy matter for the Local Government Board to issue a further list of "starred branches" of the teaching profession. We refer more particularly to those engaged in technical education. The second case is that of an attested man, 19 years of age, applying for temporary exemption until August to enable him to complete a year's training for his teacher's certificate, and to take the inter.B.Sc. examination. It was stated that the parents had made sacrifices for their son's education. The Local Government Board puts the whole matter into a nutshell in the following words: "The Local Tribunal dismissed the application. The Appeal Tribunal granted the postponement requested. The Military representative appealed against this decision. The Central Tribunal decided that the man was not to be exempt." On this decision we shall not trust ourselves to make any comment.

City and Guilds Examinations.

LITTLE fault can be found, by those suitably prepared, with the questions set at the examinations held last week by the City & Guilds of London Institute in Grades I. and II. of electrical engineering. The candidate being expected to attempt seven questions out of 12 in the Grade I. examination is at liberty to pass by the questions on the branches of the subject of which he has no knowledge, and the only criticism we have to offer on the Paper is that the range of the questions appears to be too narrow. This can be easily remedied. We suggest that a paper, of about the same standard, on alternating-current work would be welcomed by those who, to begin with, find the present examination in alternating currents too advanced for them. The relatively small number of successes in past years in this branch of the subject leads one to the conclusion that there are many such men, and it is for these that we would hold an elementary examination. Equally satisfactory are the questions in the Grade II. examinations, although those who learn only from books, without thinking for themselves, will find some of the questions intractable. Of the two papers, that on alternating currents gives one the idea of being the more practical, and a man who can answer, in a workmanlike manner, the questions in this paper should be useful in the engineering office or on the test bed. We may have occasion later to refer to the final examination. All students of electrical engineering should endeavour to sit for these examinations, which are the only ones open to the rank and file of the electrical engineering industry. The medals and prizes offered each year by the City Companies, apart from their value, are the best of testimonials for young electrical engineers.

Coal-Cutting by Electrical Plant.—Under the auspices of the West of Scotland Branch of the Association of Mining Electrical Engineers, a successful coal-cutting demonstration was held at Bredisholm Colliery, near Uddingston. Mr. A. B. Muirhead, president, explained that the branch was anxious to continue the pioneer work which it had already inaugurated amongst machine men and other underground workers who were called upon to handle and operate electrical plant.

Magnetic Survey—It is announced by the United States Department of Terrestrial Magnetism that the "Carnegie," under the command of Mr. J. P. Ault, arrived at Port Lyttelton, New Zealand, on April 1st, having successfully completed the circumnavigation of the globe between the parallels 55 deg. south and 60 deg. south. Errors in the existing magnetic charts to the extent of 12 deg. to 16 deg. were found.

Silicon-Bronze Wires of 1,000 ft. Span.—In connection with the electric-power distribution in Pommerania, a strait of the Baltic has been spanned by stranded conductors of a length of 1,000 ft.

On each bank an iron mast, 50 metres high, has been erected. The ground on both banks is marshy, and ferro-concrete foundations had to be sunk to a depth of 6 metres into the moor, in which they rest on piles. Four concrete piers have been fixed at the corners of a square of 6 metres side; on, and in, these piers rests the concrete base proper of the mast. It was originally intended to build each mast in three sections, and to join up the sections while the mast was lying on the ground before erection. There was, however, an accident, states J. C. Bohnenberger, in the "E.T.Z." The bottom section, therefore, was fixed first, and the two other sections were then raised on it and fitted in position. Each mast weighs 67·5 tons. The masts support three stranded conductors of 25 millimetres square; the width of the channel is 304·5 metres, and the wires sag by 16·5 metres, leaving a clear height of 35 metres (117 ft.) above mean water-level.

Life Testing of Incandescent Lamps.—A Paper on this subject, by Messrs. G. W. Middlekauff, B. Mulligan and J. F. Skogland, has recently been published. The authors outline the method employed by the Bureau of Standards in the inspection and life testing of incandescent lamps for the U.S. Government, and describe the power plant, the life racks and the photometer. Particular attention is directed to the special equipment of the photometer. This includes watts-per-candle computor and a recording device by which observed values of candle-power, watts, watts-per-candle, and actual life are recorded on a separate card for each lamp. These records are made in such a way that life at forced efficiency is corrected to life at normal without computation or reference to tables of factors. The procedure in actual measurement and testing is described in considerable detail.

Electric Steels at Sheffield.—Since 1915, according to "Machinery," the erection at Sheffield of at least 15 additional electric furnaces has resulted in an increased output of steel alloy for automobiles, aeroplanes and small castings. Melting high-speed tool steel by the electric furnace is stated not to be so successful as by the crucible process, one of the reasons alleged being that the size of melt is too great. Better results are said to be obtained with the smaller quantities dealt with in the crucible process.

Restoration of the Fanning Island Cable.—The "Telegraph and Telephone Age" reports an interesting incident in connection with the cutting of the British cable at that island last year by the German cruiser "Nürnberg." Hugh Gregg, an operator in the station there, dived at the risk of his life into the shark-infested waters and recovered the lost end of the cable soon after the "Nürnberg" completed its work of destroying the station. After the cutting of the cable the "Nürnberg" towed the sea end off shore and dropped it in deep water. Gregg devised a glass-bottom boat, and after cruising around for several days located the lost end in 40 ft. of water. Gregg dived repeatedly until he succeeded in attaching a line to the cable.

Post Office Electrical Engineers' "Journal."—Of the articles in the current issue may be mentioned the following :—

"Long-distance and Cable Telephony," by B. S. Cohen and J. G. Hill; "Notes on the Design of the Crystal Receiver," by L. B. Turner; "Home-grown Telegraph Poles," by G. Morgan; "Selecting of Telegraph Poles in the Forest of Enzie," by T. Sharpe. There is also an interesting article on the "Bridge Megger."

From the editorial pages we notice that last November, when the carrying on or temporary suspension of the "Journal" was considered by the Council of the Institution of Post Office Electrical Engineers, it was decided that the magazine should be continued. The Council is to be congratulated on what we consider to be a wise decision. We regard the cessation of the publication of any magazine, which is written with the object of disseminating useful professional knowledge, as an irreparable loss.

Corrosion Resistance of Copper Steel.—To the "Journal of Industrial and Engineering Chemistry," Messrs. D. M. Buck and J. O. Handy contribute a Paper on this subject. It appears that steel and iron containing copper show greatly-increased corrosion resistance when exposed to atmospheric conditions. The most effective amount of copper to be used for this purpose is approximately 0·25 per cent. Smaller amounts of copper down to as little as 0·04 per cent. have a considerable influence in lessening corrosion, but the results are not so good as with the higher amount. Previous investigation has indicated that 0·15 per cent. copper is in nearly all cases as efficient as 0·25 per cent. Higher amounts of copper up to 2 per cent. give little or no added benefit. Copper is as necessary in the so-called "pure irons" to insure corrosion resistance as it is in normal open-hearth and Bessemer steels.

Grain Elevators.—"The Times" Engineering Supplement referred recently to the use of these in Australia and America. The elevators are of two main types, "country" and terminal. In the former the grain is first tipped into the dump hopper of the elevator, then it runs by gravity to the boot of the elevator leg, and thence raised to the head by an endless band carrying buckets or scoops. From the head it passes to bins either by means of screws, belt conveyors or direct spouting. The terminal elevators are on a much larger scale, their mechanical equipment and storage capacity being much greater. The grain is generally removed by power shovels from the railway wagons, and after being raised to the head distributed to the storage bins with intermediate, cleaning, drying, and grading operations. The bins are huge receptacles of circular, or other sections, with bottoms in the form of an inverted cone, or pyramid, from which the grain can be delivered. The elevator built for the Armour Co., of Chicago, has a bin capacity of 1,000,000 bushels, and can take 360,000 bushels in 10 hours, and despatch them at the same rate. Arrangements for bleaching 9,000 bushels of grain and 24,000 bushels of oats in an hour are made. The main tower enables grain to be received at the rate of 20,000 bushels an hour, and the river house will be equipped to ship 120,000 bushels an hour to boats. All the mechanical apparatus is driven by electric motors, the power house having 4,700 h.p. and is equipped with turbo-generators.

Science in Examinations.—On the 3rd inst. a meeting was held by the Committee of the Neglect of Science, of which Sir E. Ray Lankester is chairman.

Lord Rayleigh presided, and among those present were: Lord Ispswich, Lord Montagu, Sir Hugh Bell, Colonel R. E. Crompton, Prof. Turner and Sir Ray Lankester.

Lord Rayleigh said that the ignorance of natural science was deplorable, and the time for the teaching of science must be found by engineering classics from the privileged position they now occupied.

Sir Ray Lankester remarked that the movement started by the feeling that mistakes in various administrative quarters were due to defective scientific knowledge. He called attention to the memorandum recently published by 36 prominent scientific men and representatives of educational institutions, pointing out that our educational system was unsatisfactory, and that more general and practical knowledge of natural science should be taught in colleges and universities. The object of the present meeting was to formulate resolutions for presentation to the Government.

Sir E. Schafer moved the following resolution:

"That in the opinion of this meeting it is a matter of urgency, in order to promote national efficiency in the near future, that the natural sciences should be made an integral part of the educational course in all the great schools of this country, and should form part of the entrance examination of the universities of Oxford and Cambridge, as well as of the newer universities."

After support by a number of speakers, the resolution was carried unanimously.

Sir H. Johnston then moved:

"That it is in the highest degree desirable that the Government should exercise the large power which it possesses of encouraging the study of the natural sciences and thereby increasing the efficiency of our public servants (1) by assigning capital importance to the natural sciences in the competitive examinations for the home, Indian, foreign, and Colonial Civil Service; (2) by requiring some knowledge of the natural sciences from all candidates for admission to Sandhurst."

This resolution was adopted, and it was decided to bring the matter before the Government.

OBITUARY.

Admiral Lord John Hay.—We regret to have to record the death of Admiral of the Fleet Lord John Hay, G.C.B., fourth son of the eighth Marquis of Tweeddale and uncle of the present peer, which took place at Fulmer, Bucks, on the 4th inst. The deceased had a distinguished and eventful career in the Naval Service, and he was also a Member of Parliament for nearly 20 years, representing Wick and Ripon. After holding various important Naval appointments he became First Sea Lord in 1886; and then from May, 1887, to Dec. 15, 1888, filled the post of Commander-in-Chief at Devonport, and attained the rank of Admiral of the Fleet, retiring in 1897. In 1881 he was made a K.C.B., and G.C.B. five years later. Admiral Lord John Hay was a director of the Metropolitan Electric Supply Co. for many years.

R. S. Blackburn.—The death is announced of Mr. Richard S. Blackburn, well known as an electrical engineer and contractor, of Hebden Bridge.

PERSONAL.

It is stated that Sir William Maxwell, Director-General of Indian Posts and Telegraphs, is expected back in India at the end of the present month.

Mr. P. J. Pringle has been appointed consulting engineer and assessor to the Melbourne Tramway Board formed to take over and develop the undertaking of the Melbourne Tramway & Omnibus Co. Mr. Pringle will continue as general manager and chief engineer of the Electric Supply Co. of Victoria.

Mr. Mostyn Rosenbaum, of Manchester, has, by deed poll, taken the name of Mostyn Rosebourne.

Royal Engineers (T.F.)—The following appointments have been made:—

London Electrical Engineers: Temporary Second-Lieut. T. S. Wallis (from R.E.) to be second lieutenant. Second-Lieuts. G. F. Wood, A. Blackie, I. S. Dalgleish, J. W. Mason, T. C. Mann, K. L. Wood and G. B. Adeney, and Second-Lieut. (temp. captain) A. R. Z. Porter (from London Regiment) to be temporary lieutenants.

APPOINTMENTS VACANT.

An advertisement announces that there are vacancies for two practical physicists at manufacturing works in London, for service at the conclusion of the war. Commencing salaries £500 per annum.

Bedford Corporation require an engineer-in-charge. Wages £2 to £2. 5s., with 1s. 6d. war bonus. Applications by May 25.

Belfast Corporation invite applications for the appointment of general manager of their tramways Salary £800, rising to £1,000. Applications to the Town Clerk (on forms supplied) by May 13.

INSTITUTIONS AND SOCIETIES.

Institution of Electrical Engineers.—*Enemy Members.*—At the informal meeting of corporate members, held on March 8, 1916, it was decided to invite the corporate members to express, by means of reply-cards, their approval or disapproval of each of the four proposals adopted by the meeting, which are set out below. The replies received have been examined by two scrutineers (Messrs. C. A. Baker and F. B. O. Hawes), who have reported that the result is as follows: Number of cards issued, 3,244; number of cards returned, 1,470.

Proposal.	In favour of proposal.	Against proposal.
(*a*) To expel members who are subjects of enemy countries or States	1,320 ...	88
(*b*) To expel members who, being naturalised British subjects have retained enemy nationality	1,307 ...	79
(*c*) *Not* to expel members who are naturalised British subjects and were formerly subjects of a country or State now at war with Great Britain and Ireland, but who have under the laws of such country or State definitely lost their alien nationality, provided they are able to prove this to the complete satisfaction of the Council	1,081 ...	264
(*d*) That no person shall after the .....day of.....19....., be eligible for election as a member of the Institution who is a subject of any country or State with which the United Kingdom of Great Britain and Ireland is or shall have been at war on or after the date mentioned	1,120 ...	200

A resolution has been drafted to carry out the objects proposed, and has been submitted to two counsel. The necessary meetings of corporate members has been called for May 25, at 5 p.m.

Yorkshire Mining Electrical Engineers.—A meeting of the Yorkshire branch of this Association was held at Wakefield on Saturday, under the presidency of Mr. A. R. Chaytor. The following officers were elected for 1916-17: *Branch President*, Mr. Roslyn Holiday, Ackton Hall Colliery; *Vice-Presidents*, Messrs. A. L. Flint (H.M. Assistant Inspector of Mines) and F. Marsland (Barrow Colliery); *Joint Hon. Secretaries*, Messrs. J. A. McLay and H. Elliott. A Paper was read by Mr. J. W. Harbottle (Wheldale Colliery) on "The Winhey Detector," a protective device for ensuring safety on electric power circuits.

Association of Supervising Electricians.—We are informed that the meeting for May 16th will not take place, Mr. F. C. Raphael having accepted a commission in the Royal Engineers. Other arrangements are being made, of which notice will be given in due course.

Royal Institution.—The President has nominated the following Vice-Presidents for the ensuing year: Sir Thomas Barlow, Bart., Sir William P. Beale, Bart., Mr. Charles Hawksley, the Hon. R. C. Parsons, Sir James Reid, Bart., the Right Hon. Lord Wrenbury, Sir James Crichton-Browne (Treasurer), and Colonel E. H. Hills (Secretary).

Electric Vehicle Committee.—The Society of Motor Manufacturers and Traders have appointed Mr. T. C. Pullinger, of Arrol-Johnston (Ltd.), to represent this Society on the Electric Vehicle Committee.

Electrical Wholesalers' Federation.—The annual general meeting took place on the 26th ult.

The chairman (Mr. R. W. Smith), in presenting the report of the Committee and reviewing the work of the year, said that many questions affecting the wholesale electrical trade had arisen which the E.W.F. had been able to negotiate successfully. He appealed for more support from bona-fide wholesale firms, so that the Federation should be thoroughly representative. Wholesale electrical firms desirous of becoming members can obtain all information from the Secretary, Amberley House, Norfolk-street, London, W.C.

Royal Meteorological Society.—Mr. L. C. W. Bonacina will read a Paper on the 17th inst., at 4.30 p.m., "On the Readjustment of Pressure Differences: Two Species of Atmospheric Circulation and their Connection." The author will present a résumé of our knowledge relating to cyclonic and thunderstorm circulation. He considers that storm action must be in either case initiated by slight variations of density, the disturbances being of a cyclonic or of a thunderstorm type, according to whether they are mainly in a horizontal or in a vertical direction. An attempt will be made to explain the conditions which determine the type of disturbance, and to advance a theory of wave transmission which it is hoped to test by application to observed facts.

The Aeronautical Institute of Great Britain.—Sir Hiram Maxim has accepted the invitation of the Aeronautical Institute of Great Britain to become its first president. The Institute is the youngest of our aeronautical bodies, having been formed on September 30th last, at a meeting presided over by Sir William M. Ramsay.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 12th (to-day).

PHYSICAL SOCIETY.

5 p.m. At Imperial College of Science, South Kensington. Papers on "The Latent Heats of Fusion of Metals and the Quantum-Theory," by Dr. H. S. Allen, M.A.; "Lenses for Light Distribution," by Mr. T. Smith, B.A.; "The Choice of Glass for Cemented Objectives," by Mr. T. Smith, B.A.

SATURDAY, May 13th.

ROYAL INSTITUTION.

3 p.m. At Albemarle-street, W. Lecture by Prof. W. H. Bragg, M.A., D.Sc., F.R.S., on "X-rays and Crystals." (Lecture II.)

MONDAY, May 15th.

SOCIETY OF ARTS.

4.30 p.m. At John-street, Adelphi, W.C. Lecture by Dr. J. Erskine Murray, F.R.S.E., on "Vibrations, Waves and Resonance." (Lecture III.)

UNIVERSITY COLLEGE.

5.30 p.m. At Gower-street. Lecture by Mr. E. Kilburn Scott on "The Manufacture of Nitrates from Air by Electric Power."

TUESDAY, May 16th.

ROYAL TECHNICAL COLLEGE, GLASGOW.

2.15 p.m. Under the auspices of the Institution of Engineers and Shipbuilders in Scotland, the West of Scotland Iron and Steel Institute and Glasgow Chamber of Commerce. An Address on "Engineering Industry in the Economic War," by Mr. T. C. Elder, of the British Electrical and Allied Manufacturers' Association, to be followed by a Discussion.

UNIVERSITY OF LONDON.

5 p.m. At University College, Gower-street. Lecture by Prof. F. G. Donnan, M.A., Ph.D., F.R.S., on "The Rôle of Chemical Science in Civilisation."

WEDNESDAY, May 17th.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. At 20, Hanover-square, W. Paper by Mr. J. W. Purkiss on "Some Suggestions regarding Visual Efficiency in the Use of the Microscope and other Optical Instruments."

FRIDAY, May 19th.

INSTITUTION OF MECHANICAL ENGINEERS.

6 p.m. At the Institution of Civil Engineers, Great George-street, S.W. Paper by Mr. D. Adamson on "Spur Gearing."

1st LONDON ENGINEER VOLUNTEERS.

Orders for the week by Lieut.-Col. C. B. Clay, V.D., Commanding.

Officer for the Week.—Platoon Commander N. E. Brown.

Next for Duty.—Platoon Commander C. H. C. Bond.

Appointments.—The provisional appointment of Sergt. H. A. N. Medd as Sergt. Instructor of Musketry is hereby cancelled. Mr. R. H. Bryan to be Sergt.-Instructor of Musketry.

Friday, May 12.—Technical at 46, Regency-street, S.W., for Sections 3 and 4 No. 3 Company; Squad and Platoon Drill Sections 1 and 2, No. 3 Company, at Chester House; Signalling Class and Recruits No. 3 Company at Chester House.

Saturday, May 13.—Company Commander E. G. Fleming's Instruction Class at 2:30.

Musketry.—*See* notice and Tables A and B at Headquarters.

Sunday, May 14.—Major-General Sir Francis Lloyd, K.C.B. (G.O.C. London District) will make an inspection of the Corps at work on the sections of the South London Defences allotted to them. *Every member should make special efforts to attend.* Parade Victoria (S.E. & C. Railway Booking Office) at 9 a.m. sharp. Uniform, haversacks and water bottles. Midday ration to be carried. Railway vouchers will be provided.

NOTICE.—The parade for Richmond Park on Sunday, May 21, is cancelled.

THE PRESENT POSITION OF ELECTRICITY SUPPLY IN THE UNITED KINGDOM AND THE STEPS TO BE TAKEN TO IMPROVE AND STRENGTHEN IT.

The following is a report of the discussion on Mr. E. T. Williams's Paper which took place at the Manchester meeting of the Institution of Electrical Engineers on the 18th ult. An abstract of the Paper appeared in our issue of the 14th ult, page 48.

Mr. J. A. Robertson, in opening the discussion, said: The present position of electricity supply business in this country calls for serious and careful consideration in view of the steps which will require to be taken at the end of the war to re-organise and re-establish our national industries. The restrictions placed by the Local Government Board last year on new capital expenditure, coupled with the largely increased output of energy for war munition purposes, have reduced the reserve plant capacity in most central stations to a margin which would have been considered totally inadequate in normal times. The problem of how to utilise to the very best advantage the existing capacity of plant in central stations is, therefore, one that should receive the immediate and careful attention of all interested in electricity supply. The most serious difficulty with which central stations have had to cope during the last year has been the high price and the shortage of fuel supplies. The position was so serious last year as to call for Government legislation, and the Prices of Coal (Limitation) Act was passed in July, 1915. While the Act conferred an immediate benefit in restricting the inflated prices which were then demanded, I am afraid that the intention of the Act is not being fulfilled at present and that large quantities of coal are being sold at prices considerably above the maximum increase of 4s. per ton. The existing conditions call for thorough investigation, and if found necessary the Act should be amended to carry out what was undoubtedly the intention of Parliament in passing it. Indirectly the difficulties under which central stations have been operating will do much good. Manufacturers who are still generating from private plants or using steam or gas power have found their power costs increasing by 30 to 40 per cent., while the central station consumer has not been called upon to pay more than 10 or 15 per cent. increase in the rates for electricity. We have, therefore, the unique position of manufacturers applying for power supplies who were previously convinced they could produce more cheaply with their own plants, while central station engineers are refusing applications for supply which no amount of canvassing could formerly obtain. The ultimate effect is bound to be beneficial to the electrical industry, and the time is, therefore, opportune to consider steps for improving and strengthening our position after the war.

In a Paper read by Mr. Williams at the Institution in London last week, we have Dr. Ferranti's splendid idea for centralising electricity supply put in the form of a concrete proposal. Mr. Williams believes that the time has arrived when a national scheme of bulk supply from large central stations might be introduced which would gradually supersede the inefficient and, in some cases, obsolete stations now in operation. The bulk supply undertaking would be owned and operated by the State through a Central Board. The board is to consist of 11 members, six being engineers, each responsible for electricity supply in one of the six districts into which the country is to be divided for supply purposes. The board would be empowered to erect and build large generating stations and to supply in bulk to existing authorities. Incidentally the board would also take over the functions now exercised by the Local Government Board, the Board of Trade and the Home Office. All central station engineers will agree that centralisation is desirable, but there are certain stages of development to be passed and difficulties to be overcome which are overlooked in the Paper. The technical difficulties cannot be set aside, particularly the differences in periodicities in various districts. For instance, while the large system at Newcastle has a 40 periods supply, most Yorkshire and Lancashire towns have adopted 50 periods. In Birmingham 50 periods is a standard, but the South Wales Power Co.'s supply is at 25 periods, although the supply in Cardiff is 50 periods. In the Glasgow district, both the power company and the Corporation have adopted 25 periods. Every one will also agree that the present Government control of electricity undertakings by three departments is unsatisfactory, but to set up a board which will operate electrical undertakings on such a large scale and to give the board powers now exercised by three Government departments is a proposal which is open to severe criticism. I think also that to place the control of a district comprising, say, the Midlands or the North-west of England, in the hands of one engineer manager will not commend itself either to engineers or local authorities. It will be noted that the scheme does not propose to interfere with existing undertakings, but simply to act as a trading concern selling electricity in bulk. The power companies have been trying to do this for years and have made little headway because they found in most cases that bulk supply cannot be given to central stations at a price which will pay the standing charges on the necessary cables converting and transforming plant and also the standing charges on the superseded generating plant. Again, the Central Board would have no powers to compel a local authority to shut down its generating station or to fix the price which the existing authorities are to charge for current. A local authority might, therefore, continue to operate its own plant and even to pay its extensions out of revenue, or it could purchase current from the State system in bulk, and resell it at prices which were deliberately fixed high to ensure large profits for the benefit of the district rates. In either case the object of a bulk supply scheme, i.e., the provision of cheaper electricity for all industrial and domestic purposes would be defeated. The principle of State ownership of public utilities has provoked much controversy and the question of electricity supply on the Bill will prove a further bone of contention. On the one hand it will be argued that the State can provide the necessary capital cheaper than a private company, and that the business would be conducted for the public good instead of for private profit. On the other hand it will be charged that State administration is lax and inefficient compared with private company ownership, and that commercial development is often subordinated to political considerations. If it is necessary to consolidate electricity generation on national lines, the only alternative to State ownership appears to be ownership and operation by a private company under State control, or State ownership with operation by a private company on the lines recommended to the London County Council in Messrs. Merz and McLellan's report. These questions will require ample consideration, and care must be taken that in putting by one mistake we do not make another by rushing to the other extreme. My point is that the present is not an opportune time for central station engineers to discuss questions of this magnitude. State ownership may be the *ultimate* solution of the all-electric problem, but we will be faced with an enormous difficulty, probably in a few months, or at most in a year or two, to meet the demand for a cheap power supply which is vitally essential for increasing the productive capacity of our manufacturers after the war. Our task for the present is to ascertain what steps can be taken to utilise our *existing* facilities to the fullest extent, taking care only to make extensions or adopt methods which could be worked in as part of a larger scheme, when the time is ripe for it. The policy of linking up existing undertakings, which has been adopted in one or two London boroughs, ought, I think, to be seriously considered. You will find that the country for electrical purposes divides itself into some 10 or 11 areas. These areas all represent the important industrial districts and to a very large extent the coal mining districts of the country. Starting with London as the first and largest area, there is an area, which we will call No. 2, around Birmingham. South Wales is No. 3. The Midlands might be divided into two areas, one (No. 4) including the Sheffield district, and the other (No. 5), taking in Derby, Nottingham and Leicester, with the smaller towns surrounding them. Lancashire would provide two areas, the first and largest being the Manchester district (No. 6) and the other (No. 7) the Liverpool district. The central area of Yorkshire would be No. 8, and the North-east district, including the Newcastle Company's supply area, would be No. 9 area. Scotland would be divided into two areas, one taking in the industrial area (No. 10) for about 15 miles round Glasgow, and the other, which would couple up Edinburgh and several small stations in the neighbourhood, would be No. 11. Each of these districts would provide an area of supply with the existing central stations which could be linked up at a moderate cost for supply purposes. Later on when times are normal it would be a simple matter to supply the network thus formed from one or two large modern stations. About 220 generating stations out of a total of 364 in the whole country would be included in those areas. Most of the remainder are in residential districts and it would not be commercially profitable to connect them to any system of high-tension networks.

As an instance of what linking up might do, the Manchester district is a striking example. There are situated within the Manchester area 15 generating stations with an aggregate generating capacity of 170,000 kw. Nine of these stations are generating three-phase energy at 50 periods, and there are no technical difficulties to prevent them being linked up immediately. The result would be an enormous benefit all round. In place of each station requiring to maintain a complete equipment of reserve plant, the stations would act as reserves to each other, and the aggregate demand on the whole of the stations could be increased by 30 to 40 per cent. with perfect safety. The risk of interruption would be greatly diminished and by running the most efficient plant on the system continuously at full load, leaving the less efficient plant for peak loads, the cost of operation would be greatly reduced. A number of stations could be shut down entirely at week-ends. The smaller generating stations with direct-current plant would gradually instal transforming and converting plant and so receive the benefit of the combination. This linking up would offer at least a partial solution and serve as a stepping stone to a bigger centralisation scheme. There appears to be no insurmountable difficulty in putting this scheme in operation. Hitherto the chief obstacle to any co-operation between existing authorities has been local jealousy, but if machinery was put in motion to combine these authorities for a common object this jealousy, which is largly due to misunderstanding, would probably disappear. I would propose the formation of joint boards for each district consisting of representatives elected by the supply authorities along with a certain number of independent members appointed from the local manufacturers, who are, after all, the parties most interested in the question of cheap power supply. With regard to the cost of linking up, this might be borne by the local authorities in proportions which could be determined either by the use made of the bulk supply, *i.e.*, the standing charges on the capital cost could be allocated in terms of the electrical energy purchased in bulk, or considering the general all-round advantage of such a scheme there would be no serious injustice if the cost was borne in equal proportions by each of the undertakings. As the joint board would require to raise capital, Parliamentary powers would be necessary, and these powers might be limited at first to the raising of capital for the consolidation of existing undertakings. If, as I believe, however, the system works satisfactorily, the powers might be enlarged later to include the extension of existing undertakings and the building of new stations. By this means we should obtain uniformity in administration, and other benefits, such as standardisation of rates for

supply, would naturally follow. It is not suggested that this proposal would provide a complete solution to the problem, but it would at least prove more workable than any nationalising scheme could possibly be at this stage: it could be put into operation with the minimum of cost and, what is more important at present, with the minimum delay. I thoroughly agree with the suggestion that the powers now vested in the Local Government Board, the Board of Trade, and the Home Office should be combined in a central electricity board. This board, which would be mainly composed of electrical engineering experts, would be the sanctioning authority for loans, and would, therefore, be able to exercise technical supervision over the proposals of the district boards. There is another question so closely bound up with the centralisation of electricity supply which, unless dealt with on national lines, will prove a serious hindrance to the object we are aiming at. Although poorer in natural resources than other countries, we have an abundant supply of high quality coal. The only possible competitor is oil fuel which may be left out of account while we are dependent on foreign markets for our supplies, and in any case all the available supply will be required for many years for naval and mercantile marine purposes where it offers special advantages. We are, therefore, absolutely dependent for our production of power which is essential to our industrial needs, on the supply of coal. Coal getting and coal distribution are an outstanding example of our haphazard methods in dealing with matters of vital importance. The colliery owner is left free to extract the coal, to sell it to the highest bidder, even though he be the agent of a foreign Government not too friendly to this country. There is no attempt to grade or classify coal from particular districts for industrial purposes. Prices vary within wide limits, and at one time we are threatened with interruption of supplies through workmen's strikes, while at another stocks are held up in order to artificially inflate prices. In past years competition was the consumers' only protection, but with the demand overtaking the supply we can hardly blame the proprietors for eliminating competition in order to increase their profits. I would suggest that the time has arrived when a Commission should be appointed by the Government to report on our national supply of fuel with the object of utilising it to the best advantage for the various chemical, metallurgical and other purposes for which it is required.

The question of transport should also be dealt with so that we should not witness the anomaly of coals being shipped from Newcastle to Manchester district, whilst collieries within a 20-mile radius of Manchester are actually sending consignments of coal to Newcastle for export. The Limitation of Prices Act will require to be strengthened and compulsory arbitration introduced to prevent an interruption of coal supplies through strikes of workmen. To avoid such strikes some form of profit-sharing might be established which would give the worker a direct interest in the concern for which he works. These proposals may seem somewhat daring, but if we are to make good the wastage caused by the war and to retain our commercial supremacy the problem must be dealt with on broad lines. The ideal to aim at is to convert our natural resources, fuel and labour into power, light and heat so as to achieve the highest individual and national efficiency. If the war causes us to scrap our old methods and to reorganise existing systems with the view of attaining higher standards, the enormous sacrifices which it has entailed will not have been in vain. In the meantime, while we are expending all our skill and energy in assisting to bring the war to a successful conclusion, let us also at the same time commence to set our house in order and utilise our existing powers so that electricity may take its proper share in the re-organisation of industry, which will inevitably take place when peace returns.

Mr. J. S. Highfield said the author, in dealing with the fuel difficulty, contemplated that after the war ended the price would still continue high. Personally, he hoped it would, because as suppliers of power it was their business to save coal. One of the reasons for the success of electric supply undertakings was the possibility of working with less coal than the individual manufacturer. Speaking on the subject of the granting of powers to public companies, Mr. Highfield thought it was a mistake originally to grant powers with terminable concessions, as during the last few years preceding the termination it would be difficult to raise capital for so short a period, and they would not like to invest their reserve funds so freely in the business because of the doubt as to what they would get for the undertaking when it was sold. When the power Acts were granted in 1900 that fault in the original legislation was realised and power companies were formed without compulsory purchase clauses. He therefore looked forward to considerable success for these companies, having regard to the fact that the large towns were, in the main, kept out of the area, with the exception of the Cornwall and South Wales companies. There was no question the electrification of England under the powers created had been most successfully carried out, and he agreed with Mr. Robertson that the work which municipal bodies had done was successful. In order to make more progress it might be necessary and advisable to establish such a board as Mr. Robertson had suggested. Even without such a board a great deal might be done. In this part of Lancashire, besides the large and medium-sized municipal stations, there was the Lancashire Electric Power Company, which practically covered the balance of the area. Between them something more could be done in regard to linking up so that the small stations should not be unnecessarily extended. The electrical industry in this matter had suffered from professional jealousy. There had not been that assistance given between managers of supply authorities which would have made connections possible. Difficulties were often due to the action of the authorities who controlled the works; much could be done if human nature could be somewhat altered. It was a large job and he had not much belief in Government control because it was not possible to alter human nature by legislation. The war was going to do a lot for us and it was making people see that the success of one's neighbour was in a very large measure one's own success.

Alderman W. Walker, dealing with the subject of cheap sites, said he placed little or no value on the question of the price of a site when putting down a large station. What did it matter if the site cost £500 or £1,000 per acre. The sinking fund and interest on that amount was so small that it could be all thrown away by a slight advantage in the water supply, or an additional fraction of a penny on the carriage of coal. An adequate supply of fuel drawn from more than one area was one of the main considerations combined with a good supply of condensing water. The question of linking up was one which everyone would agree to. In principle the linking up of stations within the area described by Mr. Robertson would be a good thing for the community. When, however, details came to be discussed, a new factor entered into the matter and that was the human element when dealing with representatives of public bodies and directors of private companies with their professional and technical staffs. One immediately found conflicting views as to which was the main concern. At present we were handicapped by the existing system of having to go to Parliament for permission before a step could be taken to improve the conditions in a given area. There might be just outside an area places which had not been developed electrically, and those who had the controlling influence did not seem to desire to do anything. Yet whenever there was an attempt to introduce a scheme by which the owner would be put in a position of having a supply of electricity the public bodies were able to bring pressure to bear—out of local sentiment only—they could get the scheme turned down by a Parliamentary Committee which did not wish to bring itself into conflict with the political bodies. In that connection there ought to be somebody to whom an appeal could be made, and who would consider these questions solely on their merits and not with sentimental or political motives. Personally he would welcome such a body constituted on the lines by Mr. Williams and Mr. Robertson which should have power to control the area concerned, though he favoured Mr. Robertson's geographical areas.

Mr. A. E. McKenzie agreed with Mr. Highfield that the high prices for coal were not unfavourable to the electric undertakings of the country. In Manchester, for instance, the price of gas had been approximately increased 24 per cent. in the last 12 months, as against 10 per cent. to 15 per cent. for electricity. With regard to Mr. Robertson's suggestion that the proposed board should fix the selling price, he was afraid that would involve considerable difficulty, as each municipality had its own ideas as to the amount that the electricity department should contribute in favour of the rates. The Manchester electricity department had for some years contributed a sum of £30,000 per annum in relief of the rates. If it were proposed that the department should be State-controlled he was sure the inhabitants of the city would present great opposition to the scheme unless this rate-aid was continued. He considered that great economies would be effected if the linking up of stations was brought about. It was absurd to think that municipal boundaries should be insurmountable barriers against such a scheme. Professional jealousy also tended against its adoption. He did not think it necessary that further powers should be obtained to link up stations as it had been done in several London boroughs with very great saving. In Lancashire it could easily be arranged by the engineers of the various undertakings, and a great step forward would have been made and undoubtedly good would result.

Mr. S. J. Watson was particularly interested in the question of joint boards. It was not in itself a novelty, as it had been adopted in other public works, viz., water supply, sewage, hospitals, &c., also the case of the Stalybridge Joint Tramways and Electricity Board. One of the great difficulties of such a board would be that of finance. He suggested that the capital might be found partly by municipal bodies and partly by private enterprise. A further step might be taken to appoint representatives from the local boards to a Central Board in London, which should possess very wide powers. Not the least matter which such a board would have to deal with would be the conservation of coal supply. It would have power to stop the establishment of any further small generating stations and also consider the advisability of continuing existing stations or forcing them to take a supply from some other larger undertaking in the district. When Chairman of the Manchester Section some five or six years ago he went carefully into the question of linking up the different stations and found that if all the supply undertakings within an 8 or 10-mile radius of the city were coupled up it would set at liberty for use spare plant to the value of approximately half a million of money. With the regard to the establishment of large super stations, there must be a limit beyond which a power station could not become a practical problem, principally because of the enormous responsibility which would rest upon the supply authority operating these huge stations. The standardisation of prices was also a problem which required tackling. Would-be consumers did not always understand why in one town they were charged on one basis and at one price and in another town the charges were at a different price and on a different basis. He also deprecated the adoption of freak charges as it was not good for the supply business. What with rateable values, maximum demands, telephone system, standing and running charges, &c., people were simply befogged. He agreed with Mr. Highfield on the question of perpetuity of tenure. If an order was limited it was obvious that higher prices must be charged than would be the case if the time was unlimited owing to the uncertainty as to what would happen at the end of the term.

Mr. C. C. Atchison said he agreed that there should be a Central Electricity Board in London, but its functions should be mainly in the direction of finance and general guidance. There should be some standardisation of systems throughout the whole country. At the

present time systems were very varied and it would be difficult to link up the stations in certain areas owing to the difference in frequencies and so on. He doubted whether it would be possible even for a local board to standardise prices. Mr. Robertson had mentioned oil fuel as compared with coal. If we could rely on satisfactory deliveries of oil that fuel would be much more easily handled and save a great deal of apparatus now employed for dealing with coal and ashes. The point to consider was that whereas we had coal in our own country we should have to buy oil from other countries who might not always be friendly towards us. With regard to the profits from municipal stations he thought that the ratepayers were entitled to a reasonable return from their trading undertakings, but not to the extent some of them had contributed in the past. The friction which might exist between undertakings in connection with the linking up of systems did not in his opinion arise from engineers, but was purely a question of local Councils. No doubt in the future it would be necessary to link up certain stations, and the engineers were quite willing to consider such a scheme with interchange of supplies regulated in a manner like the railway clearing house.

Mr. J. H. Wood thought the time was ripe to consider the question of linking up. This could be done without a board, by a meeting of the different authorities. Many of the smaller undertakings had found it necessary to limit their undertakings because they could not enter upon any additional capital expenditure until there was some revenue from the capital already expended. Many consumers were lost in this matter. With regard to coal supplies a board on the lines suggested by Mr. Robertson could both control prices and quality. Large undertakings, owing to their large orders for coal would possibly obtain better prices than the smaller, but if they were represented by a board this would be able to control prices to some extent. A point which had not been touched upon was that of labour. There had been a good deal of trouble caused by men leaving smaller stations to go to larger stations because of the better wages in the latter case. He suggested that a board might regulate the amount to be paid for labour.

Mr. R. Blackmore thought there was no good reason why the suggested board should be formed. It would be unworkable as far as prices were concerned. It had not yet been shown that super-stations could generate cheaper than a medium-sized station. He considered the question of linking up was a good one, but it was not necessary to bring in Parliament to do it. Tramways had already been linked up. Running powers existed between towns and an interchange of traffic existed under workable conditions and why should not electricity stations be linked up similarly? A great deal had been seen during the war of Government administration. An example of what could be done to ruin a public utility service had been seen in connection with the Government management of telephones. If electricity undertakings in this country were to be affected in the same way as the telephone undertakings then let us have nothing to do with it.

Mr. J. Drummond Paton said there had been numerous complaints made in the meeting of trouble with coal and colliery owners, and if the trouble was coming from that source a movement should be made to meet it. It was necessary that engineers should not confine themselves to pure technical electrical engineering, but study mining engineering in order to deal with the waste coals and future supplies of coal for electric power. Colliery interests would welcome the movement of the Institution to solve the future problem of power production. Reference had also been made to the use of oil and the impossibility of its becoming an important factor in the future of electrical engineering. He might say that the supply of oil in this country would not come from abroad. We had millions of tons of waste coal which yielded 40 or 50 gallons of oil to the ton, but the colliery owners could not produce this material till it was demanded. Place the vital centre of power production in the middle of the fields controlled by these men, and use the gas, waste power or coke, which necessarily must be originated in the production of coal oil. If necessary to maintain the existing stations feed this oil, or the residual coke or preferably the gas from the processes on to them. This was the pathway he would suggest for engineers to travel along. In one field not far from where he was stationed there were 90 million tons of coal about 5 ft. thick, which would show 40 or 50 gallons of crude oil per ton. Take the Wigan cannel from which we had been able to get 90 gallons per ton, and at the moment realise that this was worth 5d. to 6d. in a crude form per gallon. The coal which was now estimated as valuable coal would in the near future, be relegated to a position of secondary importance. Coal fired for a thermal value only would become a thing of the past and take secondary place to coal which would yield a high oil and by-product return.

Mr. Robertson said there had been a great many points raised but some, fortunately, cancelled each other out and he need not refer to them. Mr. Highfield took the view that the electricity supply ought to be dealt with in much the same way as the railways, and that concessions should be granted in perpetuity. Mr. Robertson took leave to join issue with Mr. Highfield on that point. He had held for some time, and thought he was right, that if there was an example of inefficiency in this country it was our railway system. A system which overlapped, wasted hundreds of thousands of pounds each year in unnecessary competition, gave worse trading facilities and travelling conditions than prevailed on the Continent, was not something to hold up as an example for the organisation of the electricity supply. Even in such small matters as automatic signalling this country was very much behind other countries, although we had railway companies which were practically unfettered by legislation of any kind. The high price of coal, as Mr. Highfield said, supported by Mr. McKenzie, was, of course, a good thing for electricity undertakings for the time being and even if it continued. But a broader view should be taken. He looked at the subject from the point of view of supplying a cheap power for the benefit of our manufacturers, and to re-establish our position, after the war, in the world of commerce. To do that we must have cheap power, and if we were going to have cheap power we must have cheap fuel. He did not think it right or proper to console ourselves even for the high price of coal by saying it was a good thing for electricity, because the gas departments had to put up the price more than we had and because private plant was going to cost more in proportion. Several speakers had made a strong point of the human element and one gentleman had asked "Why go to Parliament at all? You can meet together and get your linking up schemes carried out without going to Parliament." Then the human element was brought forward as the element which would prevent any efficient system of linking up. It was just because of the human element that it would be necessary, in his opinion, to go to Parliament to obtain powers to override those local Councils which might not be prepared to come voluntarily into a local linking-up scheme. It had been stated that he had proposed that uniform prices should be charged in one district or in one undertaking. He had not made any such proposal. He had simply said the local board should be the authority that would fix the prices for each area or portion of an area. He thought that was a very necessary thing, because if you were introducing a bulk supply to a group, one local authority might fix prices without any reference to the actual cost, or the actual value to the consumer. Mr. McKenzie had mentioned that if any system of prices were fixed by a board Manchester people would object, because the electricity undertaking paid £30,000 a year towards the rates. Mr. Aitchison had said that was a very right and proper thing to do. He did not agree. He did not think an electricity undertaking existed for the purpose of making money to be handed over to the ratepayers who were not possible consumers of electricity and who would never be called upon to make good any deficiency that might arise. Any surplus or profits should be transferred to the reserve fund and so prevent the possibility of the ratepayers being asked to make good any deficiency. With regard to the fixing of prices, Mr. Blackmore had said "Fix prices just a little bit above what the private consumer could make it for himself." In some cases that might be a very good thing, but in others he was afraid it might mean something like financial disaster. We could not fix prices, as an engineer put it some years ago, to suit competition and let the cost of production take care of itself. The linking-up arrangement he suggested was only a temporary one to meet the difficulty. His own view was that the powers possessed by these boards should go much further later on and would ultimately result, he believed, in the nationalisation both of generation and distribution. We had heard examples of Government mismanagement, and the telephones had been spoken about. With all due deference he thought much of the criticism which had been levelled against the telephone department was unfair and unjustified. The Government took over the telephones and the staff to operate them, under circumstances of very great difficulty. In any case he was not going to believe that the same staff which, on March 31st, or whatever date it was, were so efficient when working the telephones for the telegraph company suddenly became inefficient and useless on April 1st. On the other hand, we had a Government created and organised within 12 months turning out munitions on a scale that would have been considered a miracle if it had been prophesied. He thought the Ministry of Munitions offered a splendid example of what organisation could do. If a Ministry could be got comprising the best brains in the country to organise a department in time of war in the businesslike way in which that department had been conducted, he saw no reason why the same brains could not be get together and the same public spirit shown in time of peace, in order to organise and develop our electricity supply.

EXPERIMENTS WITH FILAMENTS HEATED ELECTRICALLY IN VOLATILE LIQUIDS.*

BY S. W. J. SMITH, F.R.S.

Summary.—The author, repeating some experiments by Mr. Addenbrooke and Mr. Crawley, discovered a striking phenomenon, viz., a bubble is formed on a wire immersed in liquid which moves along the wire to and fro, and if there are loops in the wire it "loops the loop" in a curious way. He discusses this phenomenon.

I was led to perform these experiments by a statement made to me by Mr. C. W. S. Crawley to the effect that, when a 100-volt lamp filled with paraffin oil is used as a resistance in a 200-volt circuit, the bubbles of gas which form on the filament, instead of rising at once, run down the legs of the filament before they escape to the surface of the liquid.

Attempting to reproduce this phenomenon, I found that if the voltage applied to the lamp were reduced below 100, so that no bubbles formed, it was possible (by momentarily increasing the voltage) to obtain a single bubble upon the wire.

The behaviour of this bubble was most fascinating to watch; it ran backwards and forwards from one terminal to the other, "looping the loops" of the filament many times before escaping from the wire! Many other liquids, besides paraffin oil, yield the same

* Abstract of Paper read before the Physical Society of London.

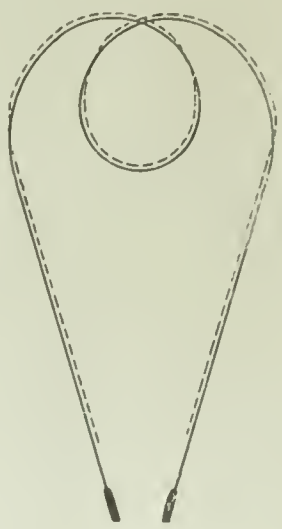
result. Benzene, turpentine and aniline may be mentioned as examples.

The currents necessary for the production of the bubble and for its maintenance are higher the higher the boiling point of the liquid. This suggests that the bubble consists of vapour of the liquid, and the inference is, in fact, usually correct except during the first heatings soon after the liquid is poured into the lamp. Then there will be a certain amount of entrapped air which may provide the nuclei of the earlier bubbles. Indeed, if a very viscous liquid of high boiling point (such as machine oil) is used it is possible by means of a fine pipette to project a minute bubble of air upon the heated wire. This bubble then moves in the same manner as those formed spontaneously.

With turpentine, for example, it is easy to adjust the current so that a fairly large bubble circulates to and fro for a long time (a quarter of an hour, for instance) without appreciable change in size. Reducing the current, a similar steady state can be reached with a bubble of reduced size. If the current be reduced below a certain limit, however, the bubble disappears.

These facts suggest that the contents of the bubble are continually changing, the constant size under any particular gradient being the result of a balance between the increase due to evaporation into the bubble and decrease due to condensation from it.

It appears from a variety of considerations that the bubble exists in a region of which the temperature changes rapidly in the direction perpendicular to the wire. At first sight it seems possible that the movements of the bubble are due to electrical forces; but, except that these may play some part in causing the bubble to cling to the wire, it is unlikely that they are appreciable.



The motion of the bubble is not affected by altering the direction of the current. It is produced equally well by alternating current. It is thus apparently of thermal origin, and seems to be determined only by the temperatures to which the current is capable of raising the wire and its environment. Keeping the current as low as possible, so that the motion of the bubble is comparatively slow, and the convection currents from the heated wire are not very pronounced, it is possible to observe fairly easily the track which the bubble follows. This track is represented by the dotted curves in the figure, the continuous curves denoting the filament of the lamp. The bubble may be said to pass along the "upper" side of each element of the filament. In other words, it runs along the region in which the convection of heated liquid from the filament is a minimum.

The author next examines the forces acting on the bubble, and considers that possibly the sudden heating and expansion of the liquid would provide the necessary impetus. At the same time he does not exclude an explanation based on differences of surface tension due to differences of temperatures between the two sides of the bubble.

The results of some additional experiments on the temperature of wire and currents are given below:—

Amperes.	Volts.	Resistance.	Temperature.
2·85	2·20 (no bubble)	0·772	104·0° C.
	2·17 (bubble)	0·761	99·0°
2·95	2·31 (no bubble)	0·783	109·5°
	2·26 (bubble)	0·766	101·5°

The numbers in the first and second columns are currents and corresponding voltages (mean values) obtained. The numbers in the third column are the resistances obtained by dividing the volts by the amperes in each case.

To obtain the numbers in the fourth column the liquid was heated by an external source to about 130°C. It was then allowed to cool slowly, being kept stirred meanwhile. The resistance and temperature of the wire were measured from time to time. The numbers in the fourth column give the temperatures at which the wire had the resistances shown in the third column.

SHIPYARD CRANES OF THE ROTTERDAM DOCK-YARD COMPANY.*

BY M. G. DE GELDER.

Summary.—The author briefly describes the several crane systems for the handling of material over the building slips at shipyards and gives a detailed description of an electric crane which may be considered a combination of the travelling tower crane and the cantilever crane. These cranes have been installed at a shipyard in Rotterdam and full particulars of their performance are given.

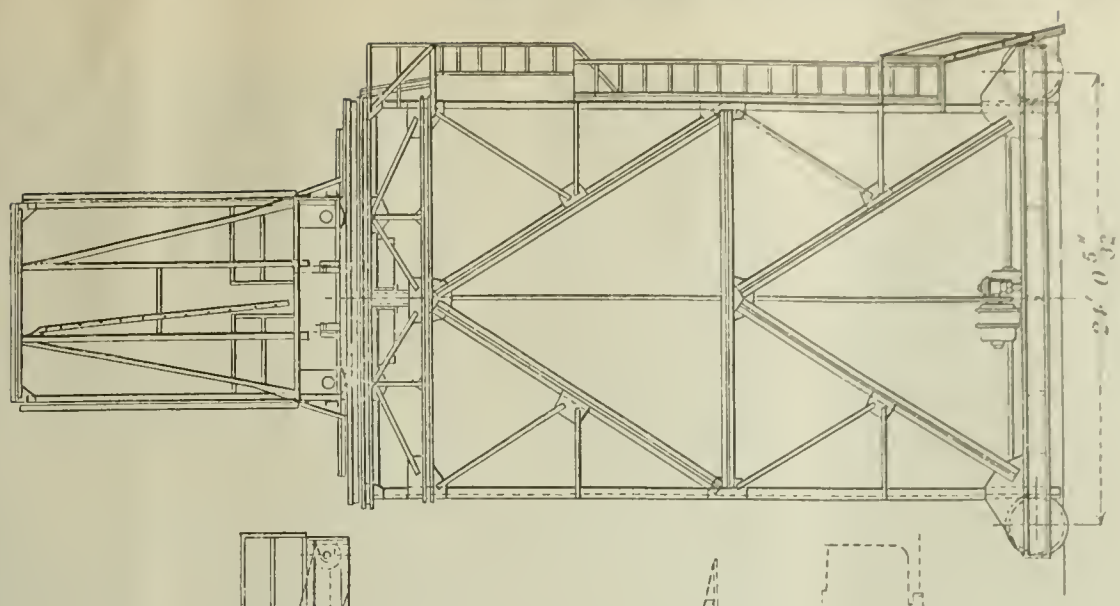
Originally the shipyard used the ordinary electric derrick masts, but it was thought advisable to adopt a more efficient arrangement, because the size of steamers to be built was constantly growing, and quick handling of material was absolutely necessary in order to arrive at a large output with the limited number of workmen available in the Rotterdam port.

Various systems of shipyard cranes are already in use, and in the Papers read on this subject interesting particulars have been published regarding them. In some of the larger British and German shipyards overhead cranes have been adopted, combined with roofed building sheds, but this system is only possible in exceptional cases, such as in the building of the largest vessels. On the other hand, many British yards are still adhering to the system of derrick masts already referred to. In view of these facts, shipbuilders are obliged to study the problem carefully before taking a decision as to the system of shipyard cranes to be fitted. It is, of course, rather difficult to design a satisfactory arrangement between the two extremes referred to. In this respect each shipbuilder should be guided by his own personal views or experience, by special requirements and local circumstances. As a rule, any modern arrangement of shipyard cranes will lead to wider spacing of the building berths than ordinary derrick masts would require. It is often claimed as an important advantage of such derrick masts fitted between the uprights that they do not take up much space. It is doubtful, however, whether nowadays a large number of narrow spaced berths really are an essential advantage. The amount of money wasted owing to want of space is not always realised, for surely in modern industrial works plenty of clear ground means a good deal of saving. From an economical point of view it may be better to build eight steamers per year on three berths than to turn out the same number of vessels on four berths, laid down more closely on the same ground space. Therefore, even if the fitting of shipyard cranes requires a strip of ground to be left open between the berths, thereby reducing the number of berths possible over a certain river frontage, it does not follow that valuable ground is really lost.

It must be borne in mind that ship material cannot always be put in place immediately when ready for erection. Every shipbuilder now tries to rivet mechanically on the ground as many floors, brackets, girders, bulkheads, &c., as possible to avoid the expense and delay due to riveting-up after erection. Apart from this, on account of the laying-off system now adopted more and more in Continental yards, large numbers of deck, shell and double-bottom plates, &c., are punched and machined before the keel of a vessel is actually laid. Under these circumstances large quantities of ready material have to be removed from the shops to somewhere in the yard near the building berth before being put up in position. To avoid shifting such material more than once sufficient ground space must be available either in front of or between the berths. As it is always cheaper to transport material by trucks alongside the berth (on which it is already loaded) than by cranes over the top of the vessel, open ground space alongside the berth is certainly useful. On the other hand, ground space is kept available in most yards in front of the berths in anticipation of the building of larger ships in the future. Under these circumstances, it seems advisable to design the shipyard cranes in such a manner that they can lift material as well from the ground in front as from alongside the ships, and so that they can deposit this material without further handling to the position where it is to be fitted.

In this respect derricks or masts forming fixed electric tower cranes are quite unsatisfactory for the following reasons: (*a*) To

* Abstract of a Paper read at the Spring Meeting of the Institution of Naval Architects.



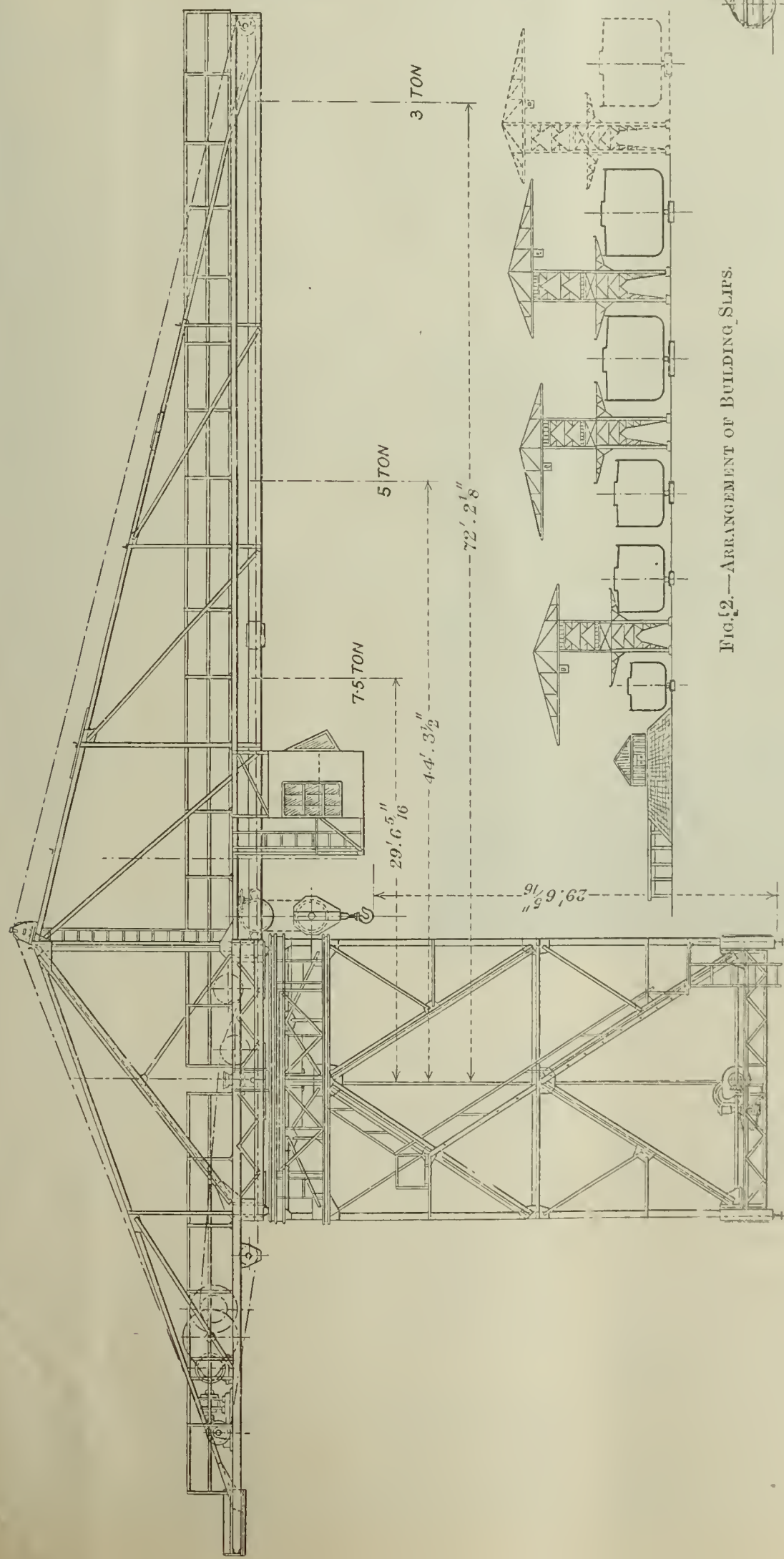


Fig. 2.—Arrangement of Building Slips.

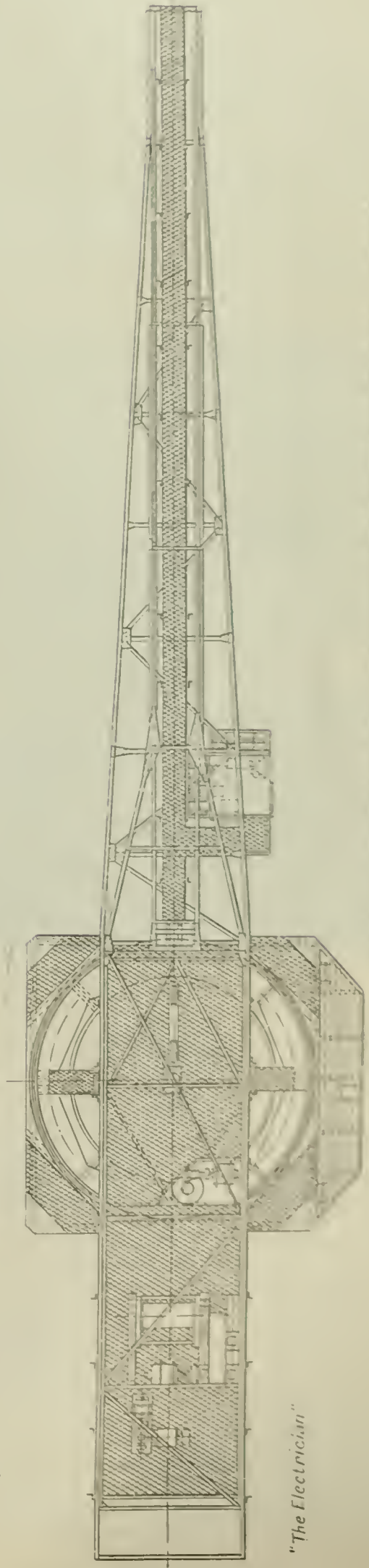


Fig. 1.—Cantilever Crane at the Works of the Rotterdam Dockyard Company.

"The Electrician"

avoid more than one lift of material when ready, the material has to be transported at once in way of the crane overreaching the part of the vessel where such material is to be fitted, which in practice may often cause much trouble ; (*b*) if such cranes are used alternatively for two berths next to these cranes, the ground space which must be kept open between the two berths for the material referred to reduces the working radius of the cranes on one side by at least the width of this open ground space ; and (*c*) several cranes overlapping each other are necessary to enable the cranes to bring the material to the part of the ship where it is required. Two berths for vessels of about 360 ft. length would require four cranes with long jibs, and the cost of these cranes, including foundations, would amount to £8,000, which would be still far from satisfactory.

Although such cranes have been fitted in several yards, the idea of adopting this principle was rejected at once on account of the above considerations. Complete plans and estimates were, however, made for overhead travelling cranes covering not only the full width of the berth, but also 20 ft. of ground space reserved for depositing material alongside the berth ; but the cost of this arrangement was found to be much in excess of the cost of cranes as finally adopted.

Transportable tower cranes running alongside the berths were also considered, but found not quite suitable. In the first place, the berths at the Rotterdam company's shipyard are purposely made sloping over a distance of about 300 ft. from the ordinary low-water level on the river side up to the ground level of the shops, which is above the highest spring tide, so as to reduce the height of the keel blocks at the fore end of the vessels building. On this sloping part the tower cranes could not travel safely if the rails were simply laid on the ground.

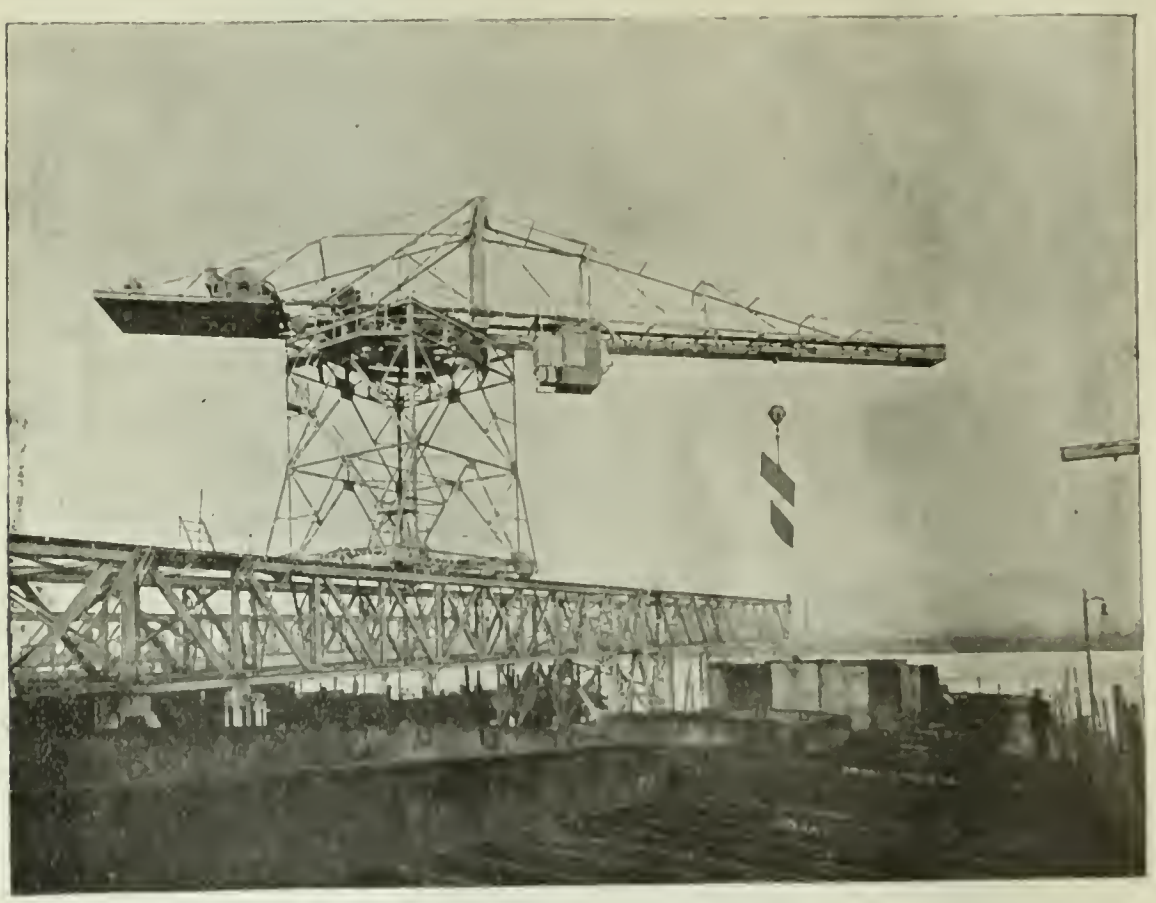


Fig. 3.—Crane and Elevated Runway.

The weight of such cranes, when of sufficient dimensions and capacity, is about 80 to 100 tons, whilst the weights to be handled are mostly only 1 to 2 tons, and it is not economical to have such heavy cranes constantly running for shifting light material. Cranes of the cantilever type are more satisfactory : but it must be a serious disadvantage of this system that it is necessary to shift the entire crane for the slightest adjustment in the position of the material which has to be put in place.

The above considerations guided the author in designing a system of shipyard cranes, which may be considered a combination of the ideas embodied in the travelling tower crane and the cantilever crane. The cranes, supplied by the Haarlemsche Machinefabriek, of Haarlem, are of the all-round swinging type, and run alongside the berths on top of lattice girders supported by columns. The cranes can lift 3 tons at the extreme end of the arm—i.e., with a radius of 22 metres (72 ft.) from the centre, 7½ tons with a radius of 9 metres (29 ft. 6 in.), and intermediate weights between these limits. These intermediate weights—for instance, 5 tons at a radius of 13·5 metres (44 ft. 3½ in.)—are painted on the arms at the corresponding radius, and in the operator's cabin a special meter is placed marking the weight lifted (instead of the amperes used), so that the operator may notice at a glance whether it is safe to lift a certain load at the required radius. This safety check was considered necessary, as ordinary shipyard men are often far out when estimating weights of certain material to be lifted. The cranes were tested with 10 per cent. overload. The hoisting speed is ½ metre (20 in.) per second for 3 tons, ⅓ metre (13 in.) for 5 tons, and ¼ metre (10 in.) for a load of 7½ tons. The horizontal travelling speed is 1 metre (39 in.) per second, and the swinging of the crane through 360 deg. requires only 35 seconds. The travelling speed of the trolley on the arm is ½ metre (20 in.) per second. The motors for hoisting, travelling, receiving and traversing are all designed for 440-volt continuous current, and have a capacity of 27, 15, 15, 4 H.P. respectively. The crane gauge is 6·25 metres (21 ft.), and the weight of the unloaded crane, including ballast, is 34 tons, equal to 8·5 tons per wheel. The pressure of the wheels on the girders may, however, be considerably increased by the wind pressure on the cranes. Plan and elevations of the cranes themselves are shown in Fig. 1 and the arrangement of the building slips is shown inset in Figs. 2 and 3.

It was assumed that the cranes should be capable of working with a wind pressure not exceeding 10 lb. per square foot, as heavy storms would make it in any case impossible to use the cranes. Even with such a wind pressure it is not practicable to use cranes of any description owing to the great danger with the material swinging about. The wheel pressures have been carefully calculated in various positions of the crane, with the maximum load combined with wind pressure of 10 lb. per square foot, and also in a certain position of the unloaded crane with a wind pressure of 40 lb. per square foot (the maximum which may possibly be expected). The author found that in the most unfavourable position of the loaded crane, with a wind pressure of 10 lb. per square foot, the pressure on the two wheels running on the same girder would be 11·5 and 17·6 tons respectively. When the wind pressure rises to 40 lb. per square foot the wheel pressure will be 17 tons on each of the two wheels, but in this case the cranes are always standing above the columns. The steel structure has been calculated to carry two cranes working as close to each other as possible, in any position between two columns under the most unfavourable circumstances, as referred to above. As long as the wind pressure does not exceed 10 lb. per square foot, the two cranes can consequently lift in any position required a total weight of 6 tons with a radius of 22 metres (72 ft.), and at smaller radii weights up to 15 tons. Taking into account the length of the crane arms when they extend beyond the ends of the girder path, there is a length respectively of about 418 ft. and 593 ft. within reach of the cranes. The arms of 72 ft. working radius project 63 ft. outside the columns. Allowing 9 ft. for the uprights and free space between shell and uprights, the crane on the shortest girder can entirely overreach a vessel of about 370 ft. in length and 54 in width, or, say, of 6,300 tons dead weight.

If two cranes are running on the same girder, it is essential that the railway on the ground space should extend at least about half-way down the berths, so as to avoid the one crane interfering with the working of the other. In this case the crane on the riverside is, of course, to be used chiefly for the after part of the vessel, and the material for this part must be deposited as far down the berth as possible. To discharge such material from the trucks, small cranes have been fitted on the columns of the steel structure, the hoisting ropes of which can be worked by electric winches fitted between the berths. Up to the present these cranes have practically never been used, as the electric shipyard cranes have had time available for discharging the trucks also.

After a year's experience it was found that one crane as described is quite sufficient to transport all the material required for the building of a 6,000-ton steamer, about 360 ft. long, and that such a steamer can be launched practically complete for delivery within four months after laying the keel : this compares favourably with any foreign records. To build two such steamers simultaneously on two adjoining berths, one steel structure with two cranes would be quite sufficient. If a yard had to be laid out for building steamers of this size only, it would, consequently, be advisable to adopt the following arrangement—viz., *one* berth, one steel structure with two cranes ; for *two* berths, one steel structure with two cranes, and so on. For two such berths the approximate cost will be £5,750 complete. This initial cost compares favourably with other systems

of shipyard cranes of similar efficiency. The general arrangement adopted, as shown in Fig. 2, is somewhat different from the arrangement as suggested above. This is due to the fact that the berths are made for various sizes of vessels.

Taking into consideration the possible width of 70 ft. of steamers which are 550 ft. long, the arms of such cranes would have to be much longer than those of the crane as described above. The weight of such cranes and of the steel structure would have to be increased considerably, and the cranes would be more difficult to handle. For this larger type of vessel the author preferred to adopt the arrangement of a steel structure next to each berth, with two cranes of the type as described above running on the same structure. These cranes will not fully overreach the berth, but, of course, the part of the ship not covered by the cranes of the one structure will be covered by the cranes of the next structure, as the cranes of the two adjoining structures will then overlap each other. With reference to this overlapping, it is advisable to make the cranes on different structures of different heights above the ground level, and the height of the various crane hooks, arranged to suit the size of the vessels to be built on the various berths, are given by the author.

Of course, it may be possible that the height would not be above the highest point of the vessel on the berth, especially of large passenger ships; but it is not absolutely necessary that the highest parts of light superstructures should be erected by the cranes. It would not seriously affect the price to increase the height of the cranes, but for the sake of easy handling it is inadvisable to make the crane heavier than is absolutely necessary.

The author has had a fair opportunity of ascertaining the direct saving in wages due to the shipyard cranes by building two sister vessels of about 6,000 tons on the same berth and under exactly the same circumstances, with this difference only, that the first ship was built previous to fitting the cranes and the second ship immediately after. The direct saving obtained amounted to 6 per cent. At first sight this saving may not look very important, but, of course, apart from this direct saving, there are indirect savings which are rather difficult to estimate. Although the piecework rates for riveting are not changed, the cost of riveting is reduced on account of the fact that the cranes allow parts to be riveted up hydraulically on the ground before being lifted in place. Another important factor is that the engineers can now put in place all their auxiliaries and shafting previous to the vessel being launched, thus obviating great delay and inconvenience in completing the vessels at the finishing berth.

Finally, there is the important saving in time of building. For the 6,000-ton vessels referred to above, built under similar circumstances, the time for the second ship was reduced from five to four months, which means an increase of output of 25 per cent. and a considerable reduction of the amount of the general expenses to be charged up to each vessel, apart from the fact that the time of delivery which may be quoted often affects the contract price which may be obtained.

As an actual fact, it may be mentioned that within 18 ordinary working days after the first keelplate was laid down, all the remaining keelplates, the bottom plating in way of double bottom, the entire double bottom, including centre girder, intercostal floors, margin plates, tank-top plating, all the frames from collision bulkhead to after peak bulkhead, two complete side stringers, and all bulkhead wing plates, also 60 shell plates and various strong beams, all for a 6,200-ton deadweight cargo steamer, have been erected in place by the use of two cranes as described above.

As a practical result of the increased output due to the shipyard cranes, the pneumatic and hydraulic riveting plant had to be enlarged, additional shipyard machines and frame bending furnaces had to be added, and finally the engineering department, which had previously been always ahead of the shipbuilding department with reference to delivery, required a good many new machines to keep pace with the shipbuilding after the installation of the cranes. These extra requirements of practically all the branches of the works afford the best evidence of the efficiency of the shipyard cranes. This in itself is very satisfactory, but it clearly proves that when making an important improvement in a certain branch of his works a manager cannot reap the full benefits unless he can also afford the additional expense of the consequential improvements required in all the other branches.

Engineering Institutions Volunteer Engineer Corps.—We are informed that, as desired by General Sir O'Moore Creagh, the corps has now joined with the 4th Battalion Central London Regiment (Architect's Corps) to form the 1st London Engineer Volunteer Corps. The identity of the corps will be preserved, and the funds will also remain separate.

TRANSFORMER DESIGN.

(*Concluded from p. 149.*)

BY F. M. DENTON, A.C.G.I.

Summary.—A general discussion is given of the nature of the problem of transformer design, and the author sets out Arnold's method of design for constant potential transformers. He then deals with the conditions ensuring maximum electrical and commercial efficiencies, and discusses the advisability of designing power transformers for minimum cost. A rule is developed by the aid of which designs of power transformers may be based upon commercial efficiency rather than upon minimum cost. The author then gives an outline of the method of design proposed by Arnold in 1910 and a comparison of Arnold's later and earlier methods. Comparative designs are worked out and a schedule is given, based upon Arnold's method of 1904.

Design of a 500-KVA 50-cycle 6,600/440-volt Star-connected Three-phase Transformer.—The transformer will be in oil, and water-cooled, a corrugated iron container being used.

The line voltages being 6,600 and 440 volts, the transformer must be designed for 3,810 and 254 volts per limb, whilst the primary and secondary currents on full-load will be about 44 amperes and 660 amperes respectively.

As a *Power Transformer* the design is as follows :—

Using stalloy 18 mils thick, let $B=13{,}000$ lines per square centimetre. $B=13{,}000$

For this density the loss in the iron at 50 cycles will be $w_i=2{\cdot}88$ watts per kilogramme, and the magnetising ampere-turns per centimetre 9·76. $w_i=2{\cdot}88$, $At/cm.=9{\cdot}76$

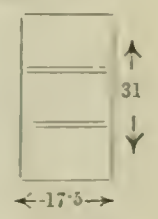
Assume $\frac{£_k}{£_i}=4$ and let s be 1·54 amperes/sq. mm. $£_i=4$, $s=1{\cdot}54$

$$C=\frac{1}{\gamma}\frac{B}{s}\frac{£_k}{£_e}=483.\quad \text{Assume } \gamma=70$$ $C=483$, $\gamma=70$

$$\Phi=10^6\sqrt{\frac{KVA\times C}{44{\cdot}4\times f\times m}}=6{\cdot}02\times10^6$$ $\Phi=6{\cdot}02\times10^6$

$$Q=\Phi/B=463 \text{ sq. cm.}$$ $Q=463$

Use a rectangular section of core and rectangular coils. With two ducts each 1 cm. wide, the cross-section of the core may be made 31 cm. deep by 17·5 cm. wide



$$(31-2)\ 0{\cdot}9\times17{\cdot}5=463$$

$$\text{Specific cooling surface}=\frac{128Ui}{Q\times W_i}=12{\cdot}3 \text{ sq. cm./watt.}$$

$$\text{Ampere-turns per phase}=I_1t_1=\frac{\Phi}{C}=12{,}500.$$ $I_1t_1=12{,}500$

Ampere-turns per centimetre. Assume $AS=370$. $AS=370$

$$\text{Height of window: } h=\frac{2I_1t_1}{AS}=67{\cdot}6 \text{ cm.}$$ $h=67{\cdot}6$

$$\text{Specific cooling surface of coils}=\frac{6{,}000 \text{ to } 7{,}000}{AS\times s}=12$$

$$\text{Width of window}=a=\frac{4I_1t_1}{100shf_s}=14{\cdot}1 \text{ cm.}$$ $a=14{\cdot}1$

Flux density in yoke $=B=13{,}000$

Weight of iron :

Cores $=3\times7{\cdot}8\times6{\cdot}76\times4{\cdot}63=730$ kg.
Yokes $=2\times7{\cdot}8\times8{\cdot}67\times4{\cdot}63=625$ kg.

$G_i=1{,}355$ kg., $E_i=2{\cdot}71$

$$G_i=1{,}355 \text{ kg.}$$

$$E_i=\frac{1{,}355}{500}=2{\cdot}71 \text{ kg./KVA.}$$

Total iron loss : $1{,}355\times2{\cdot}88=3{,}900$ watts. $W_i=3{,}900$

Method of winding : Rectangular coils; primary outside.

Primary turns per phase : $t_1=\frac{\Phi}{CI_1}=287.$

Secondary turns : $t_2=\frac{440}{6{,}600}\times287=19{\cdot}1=19$ $t_2=19$

$$t_1=19\times\frac{6{,}600}{440}=285.$$ $t_1=285$

Current densities : Try $s_1=1{\cdot}5$ and $s_2=1{\cdot}6$

$$q_1=\frac{I_1}{s_1}=29{\cdot}33=(1\times29) \text{ sq. mm.}$$ $q_1=29$, $s_1=1{\cdot}52$

$$q_2=\frac{I_2}{s_2}=413=4(3{\cdot}5\times30) \text{ sq. mm.}$$ $q_2=420$, $s_2=1{\cdot}57$

Secondary winding : $\left(\frac{440}{\sqrt{3}} \text{ volts.}\right)$

Use $2\times2\,(3{\cdot}5\times30)$ sq. mm. bare copper tape, arranging the tape concentrically, and insulating with $\frac{1}{4}$ mm. presspahn tape between the paralleled turns. Separate adjacent turns by a 3 mm. air space.

Mean length of secondary turns :

$$l_2=2\times31+2\times17{\cdot}5+2\pi\times2{\cdot}25=111 \text{ cm.} \qquad l_2=111$$

$$\text{Voltage between adjacent turns}=\frac{440}{\sqrt{3}\times19}=13{\cdot}4 \text{ volts.}$$

Between primary and secondary windings leave 15 mm. air space, and let the primary be wound upon a paper cylinder 7 mm. thick.

Primary winding : $\left(\dfrac{6{,}600}{\sqrt{3}} \text{ volts.}\right)$

Wind the 285 turns in bare copper tape 1 mm. $\times$ 29 mm., separating the turns with $\frac{1}{4}$ mm. presspahn strip. Wind in 16 coils, 13 having each 18 turns, and 3 having 17 turns. Overwind each coil with three layers of half-overlapped cotton tape. Between coils place a 5 mm. ring of presspahn. At the top of the winding have a ring of presspahn 9 mm. thick, and at the bottom a ring of wood 34 mm. thick.

Mean length of primary turns : $l_2=111$

$$2\times31+2\times17{\cdot}5+2\pi\times6{\cdot}4=137 \text{ cm.} \qquad l_1=137$$

$$\text{Voltage between adjacent turns}=\frac{6{,}600}{\sqrt{3}\times285}=13{\cdot}4 \text{ volts}$$

$$\text{Check } AS=\frac{44\times285+660\times19}{67{\cdot}6}=370 \qquad AS=370$$

$$\text{Check } f_k=\frac{2\{(285\times29)+(19\times420)\}}{14{\cdot}1\times67{\cdot}6}=0{\cdot}34 \qquad {}_k=0{\cdot}34$$

At this point the actual value of $\gamma\left(=44\dfrac{L_i}{L_k}\right)$ should be compared with the value (70) assumed at the outset. We have

$$L_i=\frac{\text{volume of iron}}{m\times Q}=\frac{1{,}355}{7{\cdot}8\times3\times463}=125 \text{ cm.} \qquad L_i=125$$

$$L_k=\frac{l_1+l_2}{2}=124 \qquad L_k=124$$

$$\gamma=44\times\frac{125}{124}=44{\cdot}4 \qquad \gamma=44{\cdot}4$$

This differs so greatly from 70 that the design will surely fail to prove the best possible, and the designer should begin all over again, choosing a much lower value for AS or, probably better still, choosing lower values both for γ and for AS. The figures given in column (3) of the parallel columns summarising this design show the result of giving γ the value 44, and AS the value 300. It will be noticed that the transformer thus obtained has better regulation than the first one, and has about the same price and efficiency.

The figures in columns (2) and (3) illustrate an important point. It will be noted that in each of these two designs the actual value of γ is approximately the same as the assumed value, and that in each case the condition for minimum cost $\dfrac{E_i}{K_u}=\dfrac{£_k}{£_i}$ has been approximately fulfilled. Similar current and flux densities have been used, and approximately equal electrical efficiencies have been obtained, yet the transformer of column (3) is cheaper than that of column (2). As both designs have been logically worked out, following Arnold's method which is supposed to lead to the cheapest possible design, how does it come that the transformer of column (3) costs less than that of column (2) ? The answer is that Arnold's method, like all practicable methods, leaves the choice of the type and shape of the transformer to the discretion of the designer. In column (2) a tall, narrow type has been chosen, leading to an excessive amount of iron, whilst column (3) refers to a type having better relative proportions.

The first design, in which γ was assumed equal to 70 will now be completed, both as an example of the method and for comparison with the alternative designs, of which the results only are given.

Effective resistance per phase :

$$r_1=\frac{k_p(1+0{\cdot}0017T)\,l_1t_1}{5{,}700\,q_1}=\frac{1{\cdot}15\times2\times10^{-4}\times137\times285}{29}$$

$$=0{\cdot}309 \text{ ohm.} \qquad r_1=0{\cdot}31$$

$$r_2=\frac{1{\cdot}15\times2\times10^{-4}\times111\times19}{420}=0{\cdot}00116 \text{ ohm.} \qquad r_2=0{\cdot}00116$$

Primary copper loss per phase $=I_1^2r_1=598$ watts.
Secondary copper loss per phase $=I_2^2r_2=502$ ..

Total copper loss per phase 1,100 ..
Total copper loss 3,300 watts. $\qquad W_k=3{,}300$

Weights of copper :

$G_{k1}=8{\cdot}9\times10^{-5}\times285\times137\times29=$ 101·0 kg.
$G_{k2}=8{\cdot}9\times10^{-5}\times19\times420\times111=$ 78·7 ,,

Total $G_k=3\times179{\cdot}7$,, $\qquad G_k=540$
$=$ 540·0 ,,

$$K_u=\frac{540}{500}=1{\cdot}08 \text{ kg. per } KVA. \qquad K_u=1{\cdot}08$$

Cooling method : Use a corrugated-iron case.
Use 2·75 kg. of oil per $KVA=1{,}375$ kg. oil.
S.G. of oil 0·89. Volume of oil 1,550 litres.
Volume of transformer : about 350 litres.
Try total oil depth of 2 metres.
Length of water pipe :

$$L=\frac{W_i+W_k}{\pi d}a=\frac{3{,}900+3{,}300}{\pi\times3{\cdot}0}=4{,}200 \text{ cm.}$$

taking for "a" 5·5 sq. cm. per watt, and using copper tube 1·25 mm. wall, and 27·5 mm. bore. Volume of tube will be about 30 litres.

Area of oil surface will be about 8,800 sq. cm.

Water required :

$$=\frac{50 \text{ to } 80(W_i+W_k)10^{-3}}{T}=75\frac{7{\cdot}2}{45}=12 \text{ litres per min.}$$

Losses and efficiency : At full load ($\cos\Phi$=unity) the sum of the losses will be

$W_i+W_k=7{,}200=1{\cdot}44$ per cent. of 500 kw.,
and the efficiency will be $100-1{\cdot}44=98{\cdot}56$ per cent. $\qquad N=98{\cdot}56$ per cent.

No-load current : The iron of the two-window type of three-phase transformer being unsymmetrical, two of the three phases require different no-load current from the third. As this difference is usually small the following method of taking an average of the currents for the three phases is sufficiently accurate for ordinary purposes.

There are three magnetic circuits, one embracing each window and the third passing around both windows ; these will be called the short path and the long path respectively.

The ampere-turns for the short path are :
For the iron $224{\cdot}4\times9{\cdot}76=2{,}190$ ampere-turns.
For four butted joints $=0{\cdot}8\delta$ $B=0{\cdot}8\times0{\cdot}02\times13{,}000$ $=208$ ampere-turns. Four butted joints are here reckoned equivalent to an air-gap 0·02 cm. long

$2{,}190+208=2{,}398$ ampere-turns.

The primary susceptance (defining susceptance as the quadrature component of the no-load current due to 1 volt applied) will be

$$b_0=\frac{2{,}398}{\frac{3}{2}\sqrt{2E_1l_1}}=1{\cdot}042\times10^{-3} \text{ mho.} \qquad b_0=1{\cdot}042\times10^{-3}$$

whilst the primary conductance is

$$g_0=\frac{W_1}{mE_1^2}=\frac{3{,}900}{3\times(3{,}810)^2}=0{\cdot}897\times10^{-4} \text{ mho.} \qquad g_0=0{\cdot}897\times10^{-4}$$

whence, if all the paths were short ones the no-load current would be

$$I_0=E_1\sqrt{b_0^2+g_0^2}=3{\cdot}98 \text{ amperes.}$$

The ampere-turns for the long path are :
For the iron $281{\cdot}6\times9{\cdot}76=2{,}740$
For the joints 208

Total 2,948 ampere-turns.

Whence $b_0=1{\cdot}28\times10^{-3}$ mho., whilst g_0 is, as before, $0{\cdot}897\times10^{-4}$, and if all the paths were long ones the no-load current would be

$$I_0=3{,}810\sqrt{(1{\cdot}28\times10^{-3})^2+(0{\cdot}897\times10^{-4})^2}=4{\cdot}89 \text{ amperes.}$$

There are, however, two short paths and one long one, so that the average no-load current will be about

$$I_0=\frac{2\times3{\cdot}98+4{\cdot}89}{3}=4{\cdot}3 \text{ amperes.} \qquad I_0=4{\cdot}3$$

$$\frac{4{\cdot}3}{44}=9{\cdot}8 \text{ per cent. of full-load current.}$$

Voltage drop : *See* Kapp : "Transformers."

$$\text{Percentage inductive drop}=0{\cdot}1\,\frac{N}{\Phi_{\text{meg.}}}\left(b+\frac{a_1+a_2}{3}\right)\frac{p}{l}.$$

$N=285\times44\times10^{-3}=12{\cdot}5$
$\Phi_{\text{meg.}}=6{\cdot}02$, $b=2{\cdot}2$, $a_2=1{\cdot}48$, $a_1=2{\cdot}35$,

$$p=\frac{l_1+l_2}{2}=124,\quad l=63{\cdot}5.$$

Per cent. inductive drop $=1{\cdot}41$ per cent.

$$\text{Leakage reactance}=\frac{V_L}{I_1}=\frac{1{\cdot}41\times3{,}810}{44\times100}=1{\cdot}23 \text{ ohms.} \qquad x_s=1{\cdot}23$$

Short-circuit resistance, $R_s = \left\{0{\cdot}31 + 0{\cdot}0016\left(\frac{285}{19}\right)^2\right\}$ $R_s = 0{\cdot}571$
$= 0{\cdot}571$ ohm.

Impedance voltage $= I_1\sqrt{R_s^2 + x_s^2} = 59{\cdot}4$ volts.

Percentage reactance drop $= 100\frac{I_1 x_s}{E_1} = 1{\cdot}41$ per cent.

Percentage resistance drop $= 100\frac{I_1 R_s}{E_1} = 0{\cdot}66$ per cent.

Percentage impedance drop $= \frac{100 I_1\sqrt{R_s^2 + x_s^2}}{E_1}$
$= 1{\cdot}56$ per cent.

As a *lighting transformer* the design would be :—

Specified efficiency about 98½ per cent., the iron loss not to exceed 0·5 per cent. $\eta = 98{\cdot}5\%$ $W_i = 0{\cdot}5\%$

Using stalloy 18 mils thick, let $B = 8{,}000$. For this density the loss at 50 cycles will be $w_i = 1{\cdot}19$ watts/kg., and the magnetising ampere-turns per centimetre 1·6. $B = 8{,}000$ $w_i = 1{\cdot}19$ $At/cm. = 1{\cdot}6$

Weight of iron, $E_u = \frac{10 p_i}{w_i} = \frac{10 \times 0{\cdot}5}{1{\cdot}19} = 4{\cdot}2$ kg./*KVA* $E_i = 4{\cdot}2$

Weight of copper, $K_u = \frac{E_i}{0{\cdot}46\frac{£_k}{£_i}} = \frac{4{\cdot}2}{0{\cdot}46 \times 4} = 2{\cdot}28$kg./*KVA* $K_u = 2{\cdot}28$

$s = 1{\cdot}3$

Current density, $s = 1{\cdot}96\sqrt{\frac{p_k}{K_u}} = 1{\cdot}3$,

$f_k = 0{\cdot}34$
$\beta = 35$

$C = \frac{\Phi}{I_1 t_1} = \frac{1}{\beta}\left(\frac{E_i}{K_u}\right)^2 \frac{B f_k}{s} = \frac{1 \times 3{\cdot}38 \times 8{,}000 \times 0{\cdot}34}{35 \times 1{\cdot}3} = 202.$ $C = 202$

Flux, $\Phi = 10^6\sqrt{\frac{KVA \times C}{44{\cdot}4 \times f \times m}} = 3{\cdot}96 \times 10^6.$ $\Phi = 3{\cdot}9 \times 10^6$

From this point the steps in the design are similar to those for the power transformer. For the purpose of comparison corresponding dimensions in the power and lighting designs are shown in parallel columns in Table III.

Figs. 1, 2, 3 and 4 show the relative proportions of the transformers dimensioned in columns 1, 2, 3 and 4 respectively.

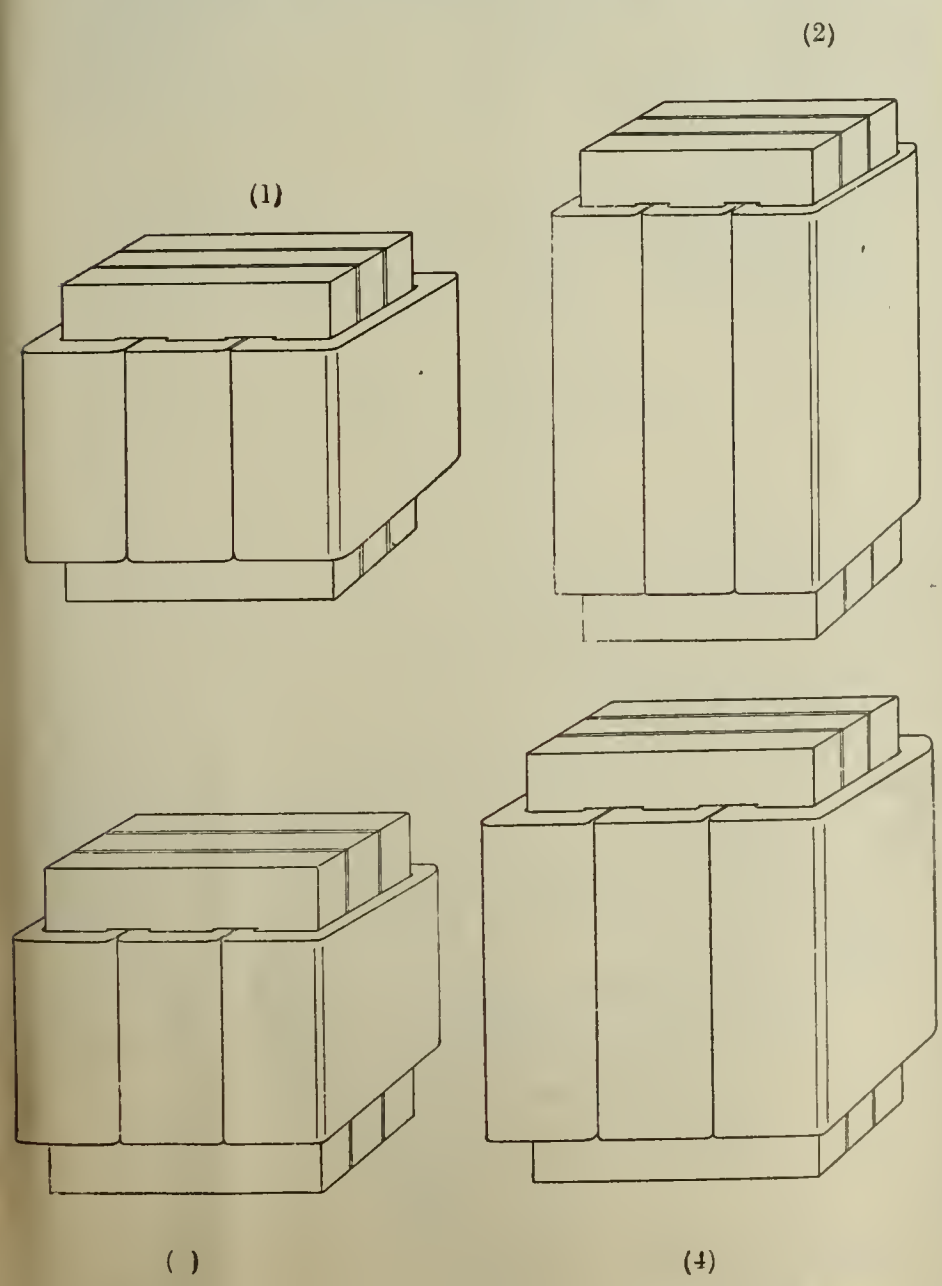


Table III.—*500 KVA 50 cs 6,600/440 volt Three-phase Transformer*

Quantity.	Symbol	Power. 7—70 18—370 (1)	Power. 7—70 18—200 (2)	Power. 7—44 18—300 (3)	Lighting. (4)
Flux density in lines per sq. centimetre	B	13,000	13,000	13,000	8,000
Total iron loss in watts per kilogramme	W_i	2·88	2·88	2·88	1·19
Ampere-turns per centimetre	$At/cm.$	9·76	9·76	9·76	1·6
Current density in amperes per sq. millimetre	s	1·54	1·54	1·54	1·3
Flux per ampere-turn	C	483	483	705	202
Total flux in core	Φ	$6{\cdot}02 \times 10^6$	$6{\cdot}02 \times 10^6$	$7{\cdot}02 \times 10^6$	$3{\cdot}9 \times 10^6$
Cross-section of iron of core in sq. centimetres	Q	463	463	580	488
Primary ampere-turns per phase	$I_1 t_1$	12,500	12,500	10,000	10,000
Ampere-turns per cm. of height of window	AS	370	200	300	370
Height of window in cms.	h	67·6	125	67	104
Overall width in a window occupied by winding in cm	a	14·1	7·63	11·4	16·8
Total iron weight in kgs.	Gi	1,355	1,880	1,730	1,901
Total watts iron loss	Wi	3,900	5,410	4,980	2,262
Primary turns per phase	t_1	285	285	225	435
Secondary turns per phase	t_2	19	19	15	29
Cross-section of primary conductor in sq. mms.	q_1	29	29	29	35
Cross-section of secondary conductor in sq. mms.	q_2	420	420	420	480
Current density in primary	s_1	1·52	1·52	1·52	1·25
Current density, secondary	s_2	1·57	1·57	1·57	1·37
Mean length of primary turn in centimetres	l_1	137	128	147	142
Mean length of secondary turn in centimetres	l_2	111	109	123	115
Copper space factor	fk	0·34	0·34	0·34	0·34
Resistance of primary per phase in ohms	r_1	0·31	0·29	0·262	0·4
Resistance of secondary per phase	r_2	0·00116	0·00114	0·001	0·0016
Total watts copper loss	Wk	3,300	3,180	2,844	4,410
Weight of copper in kgs.	Gk	540	515	464	1,000
Percentage elec. efficiency	η	98·56%	98·28%	98·44%	98·67%
No-load current in amperes	I_0	4·3	5·9	5·5	0·82
Short-circuit reactance, ohms	X_s	1·23	0·5	0·81	0·88
Short-circuit resistance, ohms	R_s	0·57	0·55	0·49	0·76
Percentage impedance drop on full load	$Z_s I_1$	1·56%	0·87%	1·09%	1·35%
Constant depending on type of transformer	γ	Assumed 70 Actual 44	70 65	44 41	... ...
Constant depending on type and rating of transformer	β	Assumed. Actual.	... ...	... ...	35 34
Ratio of cost of copper to cost of iron per kg.	$£_k/£_i$	4	4	4	4
Ratio Ei/Ku	.	2·5	3·7	3·7	1·9
Total cost of transformer in arbitrary units	...	100	114	102	168

Table *Showing Values of* γ $(=44 l_i' l_k)$ *for Transformers Constructed with Alloyed Iron.*

KVA	*f*	*m*	Type.	V_1 V_2	γ
21	50	3	Core	2,100 250	60
200	42	3	Core	13,200 208	45
420	50	3	Core	40,500 550	60
700	42	3	Core	30,000 545	70
1,100	42	3	Core	34,600 510	42
3,060	50	3	Core	55,000 5,000	32

SCHEDULE FOR TRANSFORMER DESIGN.

According to the method given in "Die Wechselstromtechnik" by P. Arnold and J. L. la Cour (1904 edition).

Given :

.....phase transformer .....*KVA*, ...cycles per sec.
...../.....volts per phase ...../.....amps. per phase.
P.F. of load..... Type..... η =.....per cent.

Lighting Transformer.

Given :

.....per cent. iron loss (p_i).
$\therefore$ per cent. copper loss (p_k) =

Choose B, suitable values of *B* for lighting transformers :—
Air cooled, 10 to 60 *KVA*, 40 to 60 ~, *B*..... 4,500 to 7,000 for Lohys iron, 7,000 to 9,000 for Stalloy.
Artificially cooled, larger, *B*..... up to 9,000 for Lohys, up to 11,000 for Stalloy.

Do not, as a rule, allow W_i (the watts iron loss per kilogramme of iron) to exceed 2.

Weight of iron per KVA $=\dfrac{10\,p_i}{w_i}=E_i=$.....

Weight of copper per KVA $=\dfrac{E_i}{(0{\cdot}36 \text{ to } 0{\cdot}46)\frac{£_k}{£_i}}=$.....

0·36 for laminations 0·35 mm. thick and 0·46 for those 0·5 mm. thick. For Stalloy this quantity approaches unity.

Space factor for the copper $=f_k=$.....

Refer to curve, or sketch out coil and insulation intended and measure f_k from the sketch.

Mean current density, $s=1{\cdot}96\sqrt{\dfrac{p_k}{K_u}}$ amperes per square millimetre.

$$C=\frac{\Phi}{I_1t_1}=\frac{1}{\beta}\left(\frac{E_i}{K_u}\right)^2\frac{Bf_k}{s}=\text{.....}$$

Values of β :

Core type :	Single phase	40 to 75
	Three phase	25 to 50
Shell type :	.....	18 to 30

Power Transformers.

Choose B.—B....., 8,000 to 13,000 lines per square centimetre for Lohys iron, 10,000 to 14,000 for Stalloy.

Choose s.—s....., 1·2 to 1·8 amperes per square millimetre, or, when specially ventilated, up to 2·5 amperes per square millimetre.

Discover $\dfrac{£_k}{£_i}$ (which often lies between 3 : 1 and 5 : 1).

$$C=\frac{\Phi}{I_1t_1}=\frac{1}{\gamma}\frac{B}{S}\frac{£_k}{£_i}.$$

Values of γ, using ordinary iron :—

Core type :	.....	100 to 125
	Three phase	60 to 100
Shell type :	.....	50

For alloyed iron the values may be much lower.

Then proceed for *either Lighting or Power Transformers* :—

Check by working out a to see whether its value falls within the usual limits found in successful designs.

$$a=\left(\frac{B\times S\times f}{10^6}\right)^{1\cdot5}(\sqrt{KVA\times f_k})E_iK_n$$

Values of a :

Core type :	Single phase	23 to 35
	Three phase	35 to 48
Shell type :	.....	22 to 28

Dimensions of the cores :

$\Phi=\left(\sqrt{\dfrac{KVA\times C}{44{\cdot}4fm}}\right)10^6$, where m=number of phases.

Iron loss in core per kilogramme (total eddy plus hysteresis from curve) $=w_i$.

Cross-section of core, $Q=\dfrac{\Phi}{B}$ sq. cms.

Choose form (shape) of cross-section (cross or rectangular or stepped).

Find periphery of cross-section of core in centimetres $=U_i$, including *one wall* of each ventilating duct, having chosen the number and width of ventilating ducts.

Specific cooling surface of core $=\dfrac{128\,U_i}{Q\times w_i}$ sq. cm. per watt iron loss.

Values of sq. cm./watt :

	Air cooled	≥ 13 to 15
	Artificially cooled	8 to 10.

Ampere-turns per phase $=I_1t_1=\dfrac{\Phi}{C}=$.....

Ampere-turns per limb $=1$ or $2\,I_1t_1$, according to the number of phases per window.

Ampere-turns per centimetre of height of core $=AS$.

Values of AS :

Air cooled	150 to 230
Oil cooled	220 to 300
Water cooled	300 to 400.

Specific cooling surface of coils (neglecting ends) $=\dfrac{6{,}000 \text{ to } 7{,}000}{AS\times s}$.

Values of $\dfrac{6{,}000 \text{ to } 7{,}000}{AS\times s}$:

Air cooled	≥ 25 to 30
Oil cooled	20 to 25
Water cooled	8 to 15.

Width of window (minimum allowable) $=\dfrac{2 \text{ or } 4\,I_1t_1}{100\,shf_k}=a$, where h is the height of a window in centimetres.

Flux in yoke : $=\dfrac{\Phi}{1 \text{ or } 2 \text{ or } \sqrt{3}}$

Choose B_{yoke} (usually equal to or less than B_{core}).

Iron loss per kilogramme for yoke (from curve).

$Q_y=\Phi_y/B_y$.

Total weight of iron : .....

Weight of iron per KVA $=E_i$ (often of the order of 4 to 10).

Dimensions of yoke : Height ..... cm. ; breadth ..... cm. length ..... cm.

Thickness of laminations, 0·35 mm. to 0·5 mm.

Weight of cores ..... kg.	*Weight of yokes* ..... kg.
Losses in cores ..... watts.	*Losses in yokes*..... watts.
Total iron loss W_i watts	*Percentage iron loss*..... per cent.

Method of winding, e.g., cylindrical coils, rectangular coils, high-voltage coils outside.

High-voltage winding :

$$\text{Turns per phase } t_1=\frac{\Phi}{CI_1}=\text{.....}$$

Choose current-densities s_1 and s_2.

Values of s : s_1, which is usually for the *outer* coil, for which cooling conditions are good, often lies between 1·2 and 1·8 amperes per square millimetre, whilst s_2 may be between 0·8 and 1·8.

Section of conductor : $\dfrac{\text{diam. bare}}{\text{diam. insulated}}=$ .....

Number of coils per limb ..... Turns per coil, ... each coil consisting of ..... layers of ..... turns, plus ..... layers of ..... turns.

Maximum voltage between adjacent turns = ...

As a rule this should lie below 100 or 150 volts, though in large high-voltage transformers it may go to 250. Note that the maximum voltage between adjacent turns is usually between the first turn of one layer and the last turn of the next layer.

Maximum voltage between adjacent coils = ...

This often lies between 500 and 2,500 volts.

Insulation of the coils .....

For instance, for 500 volts per coil might use the following : Each coil to be given three layers of half-overlapped oiled cotton tape, the complete coil to be boiled under vacuum in insulating varnish. Between coils use a 3 mm. disc of presspahn. Between second and third, fourth and fifth, sixth and seventh, &c., layers of a coil put one layer of impregnated paper.

Mean length of one turn of the high-voltage winding .....

Effective resistance per phase .....

$$=k_r\left(\frac{1+0{\cdot}004T}{5{,}700}\right)\frac{l_1t_1}{q_1}=r_1,$$

where T is the temperature rise (often 40°C.) above the room temperature. k_r is a factor (often about 1·15) to allow for the fact that, on account of the effect of eddy E.M.F.s in the copper, the effective resistance to alternating current is greater than the resistance as measured by continuous current. In a particular case of a 150 *KVA* 30.000 230 volt 5/653 amperes 50-cycle transformer, in which the low-voltage winding was made up of eight copper strips in parallel, each having a section 13 mm. × 3·5 mm. (the total cross-section being 45·5 sq. mm., the current-density 1·8 amperes per square millimetre), the value of k_r was as high as 1·54.

Copper loss per phase $=I_1^2r_1=W_{k_1}$ ..... watts.

Weight of copper per phase $=8{\cdot}9\times10^{-5}t_1l_1q_1=G_{k_1}$..... kg.

Total weight of copper $=m\,(G_{k_1}+G_{k_2})$ ..... kg.

Weight of copper per KVA $=K_u=$..... kg./*KVA*.

Low-voltage Winding.

Turns per phase $=t_2=t_1\dfrac{E_2}{E_1}=$ ..... turns.

$s_2=$.....

Cross-section of copper $=\dfrac{I_2}{s_2}=q_2$ ..... sq. mm.

Section of conductor (bare) = ... mm. × ..... mm.

Coils per limb = ... coils.

Turns per coil = ... turns.

Maximum voltage between adjacent turns = ... volts.

Insulation of the coils.....

For instance, a 120-volt winding consisting of 39 turns of copper tape, two strips 3·5 mm. × 27·8 mm. in parallel, wound in two layers of 20 and 19 turns respectively was insulated as follows : The two parallel d.c.c. strips, wound together with cotton tape (one layer 0·25 mm. thick) were made into a cylindrical coil which then was completely over-wound with three layers of half-overlapped tape, making a thickness of 2 mm. for the three layers together, and then boiled under vacuum in insulating varnish.

Mean length of a turn $=l_2=$ ..... cms.

Effective resistance per phase $=r_2$ ..... ohms.

Copper loss per phase $=I_2^2r_2=W_{k_2}$..... watts.

Weight of copper per phase $=G_{k_2}$..... kg.

Total copper loss $=m\,(W_{k_1}+W_{k_2})=W_k=$..... watts.

Per cent. copper loss $p_k=\dfrac{W_k}{10\,KVA.}=$ ..... per cent.

Cooling Method.

Weight of oil per KVA ..... kg./*KVA*.

For simple oil-cooled transformers the following rough rules may be used: Transformers 10 to 300 *KVA.*, 30 to 60 cycles; core type, 40 to 60 cycles, voltages up to 6,000, using corrugated or ribbed container.

$$\frac{\text{Weight of oil}}{KVA} = \left\{\frac{30}{KVA} + 2{\cdot}5\right\} \text{ kg. for single phase,}$$

$$\text{or} \qquad = \left\{\frac{40}{KVA} + 3{\cdot}6\right\} \text{ kg. for three phase.}$$

For small transformers, say up to 40 *KVA*, using smooth container, take $\left\{\frac{50}{KVA} + 8\right\}$ kg. per *KVA*.

The oil used should be a mineral oil or an oxidised resin oil, free from acid, having specific gravity 0·895 to 0·88. The oil before being used should be filtered and then kept near its boiling point for several hours to drive out all water. The boiling point of such oils is usually about 160°C. and flash point 185°C.

Total weight of oil ..... kg.
Volume of oil ..... cubic decimetres.
Volume of container ..... cubic decimetres.
Profile of corrugation or rib (give sketch).

FOR WATER-COOLED TRANSFORMERS.

Litres per minute, cooling water,

$$= 50 \text{ to } 80 \left(\frac{W_i + W_k}{T}\right) 10^{-3},$$

where T is the excess in degrees Centigrade of the temperature of the transformer above room temperature T may often be about 50°C.

Length of cooling tube for water ..... cm.

Inside diameter ....., outside diameter ....., thickness of wall of tube .....

FOR AIR-BLAST TRANSFORMERS.

Cubic metres of air per second $= 1{\cdot}2 \text{ to } 2{\cdot}5 \left(\frac{W_i + W_k}{T}\right) 10^{-3}$ .....m^3/sec.

Power of blower required $= (18 \text{ to } 22) \frac{(m^2/\text{sec.})h}{\eta_{\text{blower}}} =$ ..... watts,

where h is the air pressure required in millimetres of water, and is often 20 mm. to 30 mm., and η_{blower}, the efficiency of the blower usually lies between 0·3 and 0·5.

Cooling surface of the transformer $A_T =$ ..... sq. cm.

A_T is the total surface of the core plus one wall of each air duct, plus the total outer cylindrical surface of the outer coils.

Cooling surface of the container $A_{\text{cont.}} =$ ..... sq. cm.

$A_{\text{cont.}}$ is the surface actually in contact with the oil.

Outer surface of the cooling pipes $A_{\text{pipes}} =$ ..... sq. cm.

The pipes to be totally immersed in the oil.

Then work out,

$$a_T = \frac{A_T}{W_i + W_k} = \text{..... sq. cm./watt.}$$

$$a_{\text{cont}} = \frac{A_{\text{cont.}}}{W_i + W_k} \text{ and } a_{\text{pipes}} = \frac{A_{\text{pipes}}}{W_i + W_k}.$$

The maximum temperature rise of the transformer will be

$$T_T = \frac{1{,}600 \text{ to } 2{,}000}{a_T}$$

$$T_T - T_{\text{oil}} = \frac{800 \text{ to } 1{,}200}{a_T},$$

where T_{oil} is the maximum rise of the oil temperature.

$$T_{\text{oil}} = \frac{1{,}300 \text{ to } 1{,}700}{a_{\text{cont.}}}.$$

The following facts bear upon the choice of the value allowable for T_T: Cotton will stand a working temperature of, say, 85°C., that is to say, a rise of about 60°C. above room temperature; paper, 95°C.; and mica, asbestos, &c., 115°C. Iron cores, unless a non-ageing alloy be used, should not run at a higher temperature than 70°C. or 80°C. For safety, therefore, the final temperature of the transformer should not much exceed 70°C., or T_T (the rise) should not exceed 45°C. to 50°C.

LOSSES AND EFFICIENCY.

At full load ($\cos\phi = 1$) the sum of the losses $W_i + W_k + W_{\text{blower}} =$ ... watts
η full load = ... per cent.; $\frac{3}{4}$ load .....per cent.; $\frac{1}{2}$ load .....per cent.; $\frac{1}{4}$ load ..... per cent.

NO-LOAD CURRENT.

Mean length of a line of force = ... cm.
Ampere-turns from the iron curve = ... $At_{\text{iron}} =$ .....
Ampere-turns for the joints $= 0{\cdot}8 d B_{\text{core}} =$ ..... $= At_{\text{joints}} =$ .....

Four butted joints are together about equivalent to 0·02 cm. of air; that is, $d = 0{\cdot}02$ in the equation just given.

Magnetising component of no-load current

$$= \frac{At_{\text{iron}} + At_{\text{joints}}}{\sqrt{2}t_1} \text{ for single phase.}$$

$$= \frac{At_{\text{iron}} + At_{\text{joints}}}{\frac{3}{2}\sqrt{2}t_1} \text{ for three phase.}$$

Power component of no-load current $= \frac{W_i}{mV_1}$,

whence I_0 the no-load current

$$= \sqrt{(\text{magnetising component})^2 + (\text{power component})^2}$$

VOLTAGE DROP (Kapp's method).

Percentage inductive drop $= 0{\cdot}19 \frac{X}{\Phi_{\text{meg.}}} \left(b + \frac{a_1 + a_2}{3}\right) \frac{p}{l}$, where X = effective ampere-turns in one coil on one limb in units of one thousand; $\Phi_{\text{meg.}}$ = megalines of useful flux in the core; b = radial space (copper to copper) between primary and secondary coils; p = length of a mean turn in centimetres; a_1 and a_2 = radial depths of the coils in centimetres; l = axial lengths of the coils in centimetres.

Thus get full-load reactance drop $V_L =$ ..... volts

Leakage reactance $= \frac{V_L}{I_1} - x_s =$ ..... ohms.

Short-circuit resistance (referred to the primary)

$$= R_s = \left\{r_1 + r_2 \left(\frac{t_1}{t_2}\right)^2\right\} = \text{..... ohms.}$$

Short-circuit voltage (to send full-load current through the primary when the secondary is short-circuited)

$$= I_1 \sqrt{R_s^2 + x_s^2} = \text{..... volts}$$

Percentage reactance drop on full load $= 100 \frac{I_1 x_1}{V_1} =$ ..... per cent.

Percentage resistance drop on full load $= 100 \frac{I_1 R_s}{V_1} =$ ..... per cent.

Percentage impedance drop on full load $= \frac{100 I_1 \sqrt{R_s^2 + x_s^2}}{V_1} =$ ...per cent.

HIRE AND MAINTENANCE OF CONTINUOUS-CURRENT MOTORS.*

BY HENRY JOSEPH.

The electricity-supply undertaking of which the author has charge having carried on a small but successful business in the hire of motors for the past 14 years, it may be of interest to members if some particulars are published.

The company supplies continuous-current, principally for textile driving, in the town of Hawick, in Roxburghshire, the main industries of the district being the manufacture of tweed and hosiery. Table I. shows the proportion of motors on hire at the end of 1915 in mills and for various industrial purposes.

Table I.

——	No. of motors.	Total H.P.	Average H.P.
Consumers' own motors	174	1,096	6·3
Motors on hire-purchase	10	451	45·1
Motors on hire	116	731	6·3
Totals	300	2,278	7·6

Practically the whole of the above motors are maintained by the author's staff; and most of those owned by consumers have been supplied through the company and the drive arranged under their supervision.

Particulars are given of the hire rates, which vary from 9s. per quarter for a $\frac{1}{4}$ H.P. motor up to £6. 5s. for one of 50 H.P. The rates have been considerably increased from those of the early days, since the original terms were found to be inadequate. At first quotations were given for the hire of motors after the cost of each installation had been calculated. During the past four or five years it has been found more convenient to adopt a definite rate per horse-power for standard motors. Special motors, such as low-speed or geared ones, are not let on hire unless they happen to be in stock. The hire rate includes the motor complete with pulley, starter, main switch, cut-outs, shunt regulator and slide rails, if these are required, all fixed and connected up. The hirer pays for belting and the cost of mains from the service (or from the nearest available point of supply) to the motor and starter. The result is that practically the whole of the material is returnable on dismantling, and only the cost of labour is lost.

The rental covers the cost of all maintenance and renewals. New brushes are fitted when required, and no question as to whether the company is liable ever arises in the event of a breakdown. Damage occasionally occurs as the result of carelessness or negligence on the part of the hirer's employés, but it has not been considered good policy to raise the question of liability in such cases. They do not

* Abstract of a Paper read before the Yorkshire and Western Local Sections of the Institution of Electrical Engineers.

often occur, and the inconvenience caused to the user by a breakdown is quite sufficient incentive as a rule for him to urge his employés to treat the motor carefully.

It is to this policy, coupled with prompt attention to repairs, that the success of the hire system is largely due. Consequently consumers are quite willing to pay in most cases rentals which are admittedly high in comparison with the purchase price of the motors.

The company safeguards itself against loss due to a motor being hired for a short period and then returned by inserting a clause in the hire agreement by which the hirer undertakes to pay an agreed sum to cover the cost of installation and removal in the event of a motor being returned before the expiration of a stated period.

One might reasonably expect that motors would only be hired by small firms with limited capial, but this is by no means the case. Nearly all the hosiery mills, among them some of the largest in Scotland, hire their motors. They prefer to confine their attention to their business and to hand over the whole responsibility of their electric drive to the supply company.

In the event of a minor breakdown, a man is promptly on the spot to carry out repairs on site if possible. If the trouble cannot be quickly remedied, another motor is fixed as quickly as possible. For mill work these are important considerations.

Financial Results.

Table II. shows the number and horse-power of motors let on hire each year since 1902, with the corresponding capital cost and rental per horse-power.

Table II.

Year.	Added in year.		Total to date.		Average H.P.	Per horse-power.	
	No.	H.P.	No.	H.P.		Capital cost.	Yearly rental.
						£	s.
1902	5	16	5	16	3·2	14·0	12·1
1903	26	56	31	72	2·3	15·3	20·6
1904	10	101	41	173	4·2	10·5	15·8
1905	10	56	51	229	4·5	10·7	17·1
1906	8	39	59	268	4·5	10·5	22·5
1907	9	44	68	312	4·6	10·2	22·4
1908	5	31	73	343	4·7	9·3	22·0
1909	14	58	87	401	4·6	8·5	23·4
1910	6	20	93	421	4·5	8·1	29·5
1911	10	126	103	547	5·3	7·0	24·0
1912	3	—5	106	542	5·1	7·0	25·0
1913	4	92	110	634	5·7	6·2	22·0
1914	—5	9	105	643	6·1	6·0	23·2
1915	7	78	112	721	6·4	5·4	22·2

The former shows a steady fall owing to the lower prices of motors, the higher average horse-power, and the fact that as time goes on some motors are in use which have been hired out before, and consequently have had their cost written down. Mains and other incidental charges were included in some of the earlier installations, thus further enhancing the capital cost.

Table III.

Year.	Capital cost to date £	Gross rentals.		Maintenance.		Net rentals.	
		£	Per cent.	£	Per cent.	£	Per cent.
1902	232	10	4·2	...	...	10	4·2
1903	1,100	74	6·8	2	0·2	72	6·6
1904	1,824	137	7·5	14	0·8	123	6·7
1905	2,432	196	8·1	34	1·4	162	6·7
1906	2,807	301	10·7	52	1·8	250	8·9
1907	3,171	350	11·0	137	4·3	213	6·7
1908	3,197	378	11·8	122	3·8	256	8·0
1909	3,431	469	13·7	116	3·4	353	10·3
1910	3,425	621	18·1	146	4·3	476	13·8
1911	3,820	655	17·1	274	7·2	381	9·9
1912	3,779	680	18·0	205	5·4	477	12·6
1913	3,930	697	17·7	250	6·4	447	11·3
1914	3,861	745	19·3	214	5·5	540	13·8
1915	3,881	802	20·6	243	6·2	559	14·4

Table III. gives the total capital cost to date, with the corresponding maintenance costs and gross and net rentals for each year since 1902. It will be noticed that, ignoring occasional years when exceptional conditions may have prevailed, there is a gradual increase in the percentage cost of maintenance due to the ageing of the bulk of the motors. This figure will probably settle down to an average of about 6 per cent. on the capital cost.

During the last five years the gross rentals amounted to about 18 per cent. of the capital outlay, the lower rates received from the earlier motors having reduced this from about 25 per cent., which is the average rental obtained on the total cost with new motors during this period. Taking the former figure and deducting 6 per cent. for maintenance, we are left with a net rental of about 12 per cent., part of which is allocated to revenue and the balance set aside to a redemption fund for writing down the value of the motors when returned from hire.

Particulars are given on the equipment of the repair shop and the general system adopted.

Breakdowns.

Before describing the procedure in the event of a breakdown, it is well to point out that the company act as wiring contractors, and always have a staff of wiremen available. The permanent wiremen and mains staff are all trained for motor work, and one man in particular spends most of his time on motor repairs, and is as often as not in the works and readily available for emergency calls. If a report of a breakdown is received, a man is sent out at once and reports by telephone if the failure is such that it cannot be repaired quickly on site. In that case he sets to work to get the faulty motor disconnected and removed from its bed. Particulars of the drive at the same time are ascertained at the works and a suitable motor selected from stock. Sometimes one can be found, perhaps larger than is necessary, but which is already fitted with a pulley near enough to the right size. If a little too small, a temporary shunt regulator may be fitted.

Of course, it is impossible to stock all possible varieties of pulleys of various diameters and bores, consequently it frequently happens that a stock pulley has to be bored out or bushed and a new key-way cut. If this is necessary it is put in hand at once and fitted after the motor is in place.

A motor or horse lorry is ordered, preferably the former, several being available for hire in the town, and the motor is slung up and very little time lost in getting it on site. Battens are taken to the job with it, and as the old bolt centres are probably wrong, it may be necessary to screw battens down with the old foundation bolts (if these are set in concrete), recessing the heads below the surface of the battens and coach-screwing the motor down to them. Usually, however, motors are already fixed on battens wide enough to allow of considerable variation in bolt centres, so that little time is lost in fixing down another motor to them.

As a motor is often fixed in a room which can only be reached by taking it up two or three flights of stairs, a good deal of experience and some ingenuity is needed in handling it quickly and safely. For this purpose a U-shaped clamp with a set screw is used to fix a chain block to a joist, or else a hole is bored through a floor and an eye bolt with a large washer fixed. If the staircase is an open one, it is easy to "sling" a motor from floor to floor, otherwise a pair of long battens are laid down on the stairs and the motor slid up them by hauling with a chain block. Sometimes in the case of small motors, up to, say, 5 H.P., it is quickest to remove both end shields and take out the armature, when the motor can be carried up in pieces.

Great delay has often occurred in the past in removing pulleys These are sometimes made to fit the shaft too tightly and are driven on hard. They are best shifted with a pair of screw pulley drawers. Keys also are a fruitful source of delay, and to obviate this they are now always fitted with gib heads. One or two types of key drawer have been tried, but with varying success. If keys and pulleys are only fitted properly in the first place, and a film of oil put on the shaft, very little trouble is likely to be found in removing them again.

In many cases—*e.g.*, where pulleys, &c., give no trouble, a small motor up to, say, 5 H.P. can be changed in an hour and a-half from the time of the breakdown, but possibly a more usual period from the notification of stoppage to the time a new motor is running is double this.

Repairs on Site.—A man having been called to a motor sets to work at once to find if the trouble is due to the starter or any part of the switchgear, or to the armature, field, brush-gear or wiring. The majority of stoppages are due to starter troubles, and of these the bulk are caused by burnt-out resistances or open-circuited hold-over coils, these fairly frequently failing at the leading-in wires. Most starter defects can be remedied, at any rate temporarily, on site. If not, a fresh starter is telephoned for. In the case of a large motor it is usually quicker to repair a fault on a field coil on site than to change the motor. If means, of course, removing one end, taking out the armature, and perhaps removing a pole-piece to get the coil out. By cutting away the outer tape before dismantling one can usually judge as to whether the trouble is sufficiently near the surface for a fairly quick repair to be possible. If the breakdown occurs in the afternoon, a large motor is never changed for a field-coil repair unless it is a genuine burn out.

In the case of armature faults it is often possible to make a temporary repair on site which will keep the motor running until a week-end. The commonest fault, especially in small armatures wound with fine-gauge conductors, is a break at the point where one of the ends bends away from the coil. One can frequently get over this in lap-wound armatures by soldering across the commutator lugs.

Repairs.

The surest way to keep down the cost of repairs is to educate one of the hirer's employés to keep the motor clean and the armature and field coils blown free from dust, to see that brushes do not wear down too far, and to keep a proper level of clean oil in the bearings. As a breakdown entails interruption of the user's business, he will usually see that one man is made responsible for a particular motor, and that he gives it 10 minutes or so of attention, say, once a week. It was at one time thought that periodic inspection would lead to a diminution of breakdowns, but this after being tried was abandoned.

When a re-wind is necessary it used to be the practice to send the armature away, but now the repair is usually done at the works, the necessary coils being bought from the makers. The question frequently arises as to whether in a particular case it pays to re-wind rather than replace one or two faulty coils. It is very annoying after fitting a couple of coils to find that another has been damaged in lifting. It is still more provoking if the second failure does not occur until the armature has been belted and the motor re-assembled and tested. If the original faulty coils have been overheated to such an extent as to be useless as a guide to the condition of the rest, it is probably a good plan to scrap an additional coil and bend the wire to see if the cotton is perished and breaks easily. If so, it should certainly be re-wound, because the coils which have to be lifted are almost certain to be damaged during the process. The exact point at which one may feel justified in confining the repair to the replacement of a few coils can only be judged by experience.

Armatures should, of course, have a preliminary fall of potential test before the ends are sweated into the commutator. In connection with voltage-drop tests generally, the author would draw attention to what he believes is a fairly common error—namely, putting the current leads on opposite ends of a diameter or separated by an angle corresponding to the brush positions. If this is done, and there are equalising connections, confusion is apt to arise, especially if, as is sometimes the case, one or more equalising wires are broken. If the current leads as well as the millivoltmeter leads are both applied to adjacent bars, the effect of possible trouble with equalising connections is eliminated.

Quite successful repairs have been carried out to shunt field coils that have started to burn out but have been detected before very serious damage has been done. A number of turns may be entirely taken off to eliminate the fault. If the quantity of wire removed is an appreciable proportion of the total, a new length is wound on and jointed by means of a sleeve with binding screws.

While on the subject of repairs, one cannot lay too much stress on the importance of recessing the mica below the surface of the copper on the commutator. The saving in brushes is most marked, and in a few instances in particular it is little short of astonishing. Motors which have been known to consume a set of brushes in three weeks will go for 12 months without a single new one. The wear on the commutator in such cases before this treatment is, of course, excessive. Table IV. gives the annual cost of carbon brushes for the past 10 years, together with the corresponding percentage of capital to date and the cost per horse-power and per motor. Mica cutting started in 1911 and took till 1914 to complete. Part of this saving, but certainly not the major portion, is due to buying direct from the brush manufacturers instead of from the motor makers, this change having taken place in 1912.

Table IV.—*Annual Cost of Brushes.*

Year.	Cost of brushes.	Percentage of capital to date.	Cost per horse-power.	Cost per motor.
	£ s. d.		s. d.	s. d.
1906	16 11 1	0·59	1 3	5 7
1907	22 3 9	0·70	1 5	7 6
1908	19 2 6	0·60	1 1	5 3
1909	23 19 7	0·70	1 2	5 6
1910	27 18 7	0·81	1 4	6 0
1911	37 0 9	0·97	1 4	7 2
1912	27 2 2	0·71	1 0	5 1
1913	25 11 11	0·65	0 10	4 9
1914	18 18 4	0·49	0 7	3 7
1915	20 2 1	0·52	0 7	3 7

Choice of a Motor and Starter.

An effort has been made in recent years to adopt a standard motor, past experience having shown up a number of defects in various makes. The principal points looked for are a liberal rating without undue weight and bulkiness, ease of dismantling, larger bearings, and an accessible commutator. Suitable brush-gear is also a consideration. No brushholder, except of a positive radial type, should be fitted to a motor. Old motors with obsolete brush-gear have been wonderfully improved by changing the holders. Ball bearings should be avoided, for they are most unsatisfactory. Narrow pole gaps are also a great source of trouble. The small saving in efficiency is certainly outweighed by the greater risk of armature breakdown caused by a faulty bearing. Bearings inevitably wear; therefore, such breakdowns are inseparable from motors with narrow air-gaps.

Needless to say, price is the least consideration when one has to be responsible for the upkeep of the motors. Hence cut prices and extra high speeds are avoided. On the other hand, very low-speed motors are unsuitable on account of their size for general hire work. British motors are obtainable which fulfil most if not all of the above conditions.

It is unfortunately a fact that motor starters have not yet reached a very high state of perfection. There are, however, some fairly good carbon-resistance starters on the market, and some of these look like developing on the right lines; but among starters that have been in use long enough for all their faults to develop, the author has not yet been able to find one which combines a good resistance element with sound switchgear. Undoubtedly carbon with its negative temperature coefficient is the right material for starting a large motor.

Drum starters are unfortunately so cramped with blow-out coils, supplementary resistances, and various connections, that the author would prefer lever starters, if it were not for the great difficulty in so making them that the handle can be relied on to fly back against the very considerable friction due to the pressure required to ensure contact for heavy currents.

The author, in conclusion, deals briefly with the character of drive that should be adopted.

DISCUSSION.

In what follows we are only able to deal with a few of the remarks.

Mr. T. Roles mentioned the hiring scheme in Bradford, now in its twentieth year, where the prime cost of motors—both continuous and alternating—let out on hire at the present time was about £53,000. He thought that the annual charge should not be less than 15 per cent. of the total cost of the motor, with slide rails and starter. At Hawick the rental covered the cost of all maintenance and renewals. At Bradford such was not the case. Again, any other damage than that due to fair wear and tear had to be paid for by the hirer. Probably at Hawick most of the machines are used for textile work, and consequently there was little risk of damage, but at Bradford the conditions were very different.

Mr. C. E. Allsopp stated that in connection with the Bradford hiring department, in March, 1915, the number of continuous and alternating-current motors on circuit was 2,551, equivalent to 10,309 kw.; of these approximately 1,100 were on hire, representing 4,139 kw. The latest returns (February, 1916) show 1,262 motors on hire, representing 7,337 kw., an increase of 162 motors, or 3,198 kw. in less than 12 months. It was highly necessary to have a very vigilant repair staff, and the men should possess intimate knowledge of general motor windings and rewinding, and should have sufficient technical knowledge for minor calculations. Generally speaking, they found that coils could be easily made in their own shops at a very much lower cost than if purchased, and to give equal satisfaction. Their experience had been that the number of breakdowns was in direct proportion to the number of men they took off inspection. In regard to reducing the mica on commutators, he would like to give a word of warning from his own experience that this must be carried out very cautiously; if effected too deeply, it caused lodgment of carbon dust and dirt, and resulted in short-circuits. With reference to the use of ball bearings and roller bearings on hired motors, they had every reason to be perfectly satisfied with their experience at Bradford with the numerous machines so fitted up to 150 h.p. Ball bearings were satisfactory if treated and mounted correctly, the great fault with the early patterns being that the manufacturers did not realise that they were fitting them to a machine that had different characteristics from those which they had experienced previously—viz., that the heating first took place in the shaft from the armature and that the clearance adopted did not allow for the resultant expansion of the inner races. Greater clearances were now allowed, and if the bearings were properly mounted there was every reason to believe that they would give satisfaction. The bearing manufacturers advocated that, up to 30 h.p., balls of the medium type should be used, and over that size the short roller bearing with thrust washers on motors over 7 h.p. to take the end-thrust that is experienced due to belt fasteners and other causes. In considering air-gaps of electric motors one had to take into consideration magnetic leakage and the usual rise of speed of continuous-current motors, and also what became a very vital matter in the case of alternating-current machines—viz., the efficiency and power-factor. By adopting ball bearings the air-gap could be considerably reduced with very good results. They had had considerable trouble with white-metal bearings and they had decided in many cases to change them for gunmetal bearings of a known mixture. One had to consider that the consumer was apt to run the belt of a hired motor too tightly and put undue stress and strain on the bearings, with the result that white-metal bearings soon ran out. The cost of brush renewals at Bradford, for the number of motors already stated, was only in the neighbourhood of £16 a year. The mica was cut down on only a few machines which would not otherwise operate well, but he considered the low cost of brushes to be due to the use of the box-type of brushholder with brushes of extra bearing depth. His experience was that the radial brush was a thing of the past.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone: City 4698 & 4699. *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*

Advertisement Rates, &c., forwarded on application.

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 8d. nett.

INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.

ELECTRICITY METERS: THEIR CONSTRUCTION AND MANAGEMENT. By C. H W. Gerhardt. Profusely illustrated. Price 9s. nett. [Price 10s. 6d.

MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.

SIGNALLING ACROSS SPACE WITHOUT WIRES: THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.

BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By G. M. Baines. Price 7s. 6d. nett.

THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol. I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.

THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. *New Edition.* Bound cloth, 2s. 6d. nett, post free 2s. 9d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone 9s. nett, post free 9s. 4d.

STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett

ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S Heather, M.I.E.E. 9s. nett.

AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.

WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.

ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.

LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.

ELECTRIC BLASTING APPARATUS AND EXPLOSIVES: With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.

THE SHOT-FIRER'S GUIDE: A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.

THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.

THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*

BOILER FEED WATER. By F. A. Anderson. Price 6s. nett.

LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.

Further portions of this list of "THE ELECTRICIAN" SERIES OF BOOKS appear each week.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

THE HIRING AND MAINTENANCE OF MOTORS.

The advantage to be gained by hiring out electrical apparatus is appreciated by many of our large electricity undertakings, but we doubt if it is realised that this means of increasing revenue may be equally beneficial and practicable in small undertakings. At the moment we have in mind the electric motor rather than domestic appliances. It must be remembered that every motor is not only a consumer of energy, but also an advertisement to the undertaking, and that the greater the number of motors on the mains, the greater the development of power is likely to be up to a certain point.

In considering a matter of this kind several questions arise. The more important of these are : Is it difficult to make a satisfactory beginning ? And what will it cost ? The latter of these two questions is, perhaps, the more essential, and it is surprising to us that full information on this point is not already available. In other words, why does not every central station engineer already know precisely how much it costs on the average to maintain an electric motor in service ? The costs are certainly known to some of our engineers, but they are not generally available, whereas for the good of the industry such information should be at the disposal of all who are interested.

As to the more general question whether it is difficult to make a beginning in the hiring of motors in a small undertaking, we would call attention to the results obtained at Hawick by Mr. H. JOSEPH, who, in a recent Paper before the Institution of Electrical Engineers, described what has been done. An abstract of the Paper appears elsewhere. It should be noted that the population of Hawick, which is largely engaged in the textile industry, is under 17,000, and the total plant at the station is only 1,280 kw. We are dealing, therefore, with an essentially small undertaking, but nevertheless, owing to the development of the motor load, the output last year amounted to over three-million units.

It appears to us that in any scheme of this kind there are several essentials to success. To start with, the basis must, of course, be financially sound, but there are many other points equally important which are dependent upon the personal attitude of the consumer. In other words, there is the human point of view. The consumer may well be attracted by the convenience of a service and may regard the cost as of secondary importance, more particularly if the policy that is followed is broad-minded. The policy seems to be particularly enlightened at Hawick, where the charge made includes complete maintenance of the motor, and where no inquiries are made as to the cause of any breakdown. In other words, the supply company takes the risks of negligence on the part of the hirer. This prevents the raising of vexatious questions, and although there may be some risk of expense that should not be borne, the consumer is likely to see that the motors are not negligently treated, for the simple reason that a breakdown necessarily means some loss to him in his business. Further, the charge that is made includes the supply of brushes, so that the consumer has nothing to trouble about; and, lastly, there is the question of the prompt attention to breakdowns so as to make the service as certain as possible. At Hawick, breakdowns seem to be handled with the least possible

delay, so that very little time is lost to the user in the event of anything going wrong. For example, 1½–3 hours is mentioned as the time that is required. Taking all this into consideration, we are not surprised that this particular service has developed rapidly, notwithstanding that the charges made are higher than those in some other districts. The higher charges carry with them corresponding advantages, and the consumer is therefore willing to pay.

In looking over the list of motors that are kept in stock we are struck with the small differences in power between some of the motors. It would seem to us that the list might be somewhat shorter, with the obvious advantage that the number of parts to be stocked would be reduced. No doubt it is important not to supply consumers with motors really larger than necessary, as an unduly large motor means increased cost to the consumer; but, on the other hand, standardisation should be sought as far as possible, not only for the benefit of the supply undertaking, but for the advantage also of the manufacturer. A large range of sizes militates against cheap production.

Generally speaking, the experience gained with motors at Hawick has been satisfactory, or, at least, it may be said, that makes of motors are to be obtained which give perfectly good results. We regret to see, however, that the same cannot be said of motor starters. It is surely time that our manufacturers should be able to turn out motor starters having a good life and giving satisfaction in their operation. In this branch of business there is evidently a tendency still to cut things too fine.

In conclusion, we would urge once more that full information on the maintenance of electric motors should be collected and made available to engineers generally. This subject might very well be taken up by the Development Committee of the Incorporated Municipal Electrical Association; or, indeed, we do not think it should be beyond the scope of the Institution of Electrical Engineers, which has the advantage of numbering among its members both company and municipal engineers, as well as designers and manufacturers and the engineers attached to the several large insurance companies, and is, therefore, more completely representative.

AUTOMATIC PROTECTIVE DEVICES FOR DIRECT-CURRENT SYSTEMS.

BY M. ROSEBOURNE, B.SC., AND F. A. COUSE.

Summary.—The following article relates to automatic devices for cutting out faulty feeders on two-wire and three-wire direct-current systems due to faults to earth.

The question of automatic protection against earths on direct-current systems has up to the present been neglected, due probably to the lesser importance of low-tension direct current compared with high-tension alternating-current systems. In the latter, where the kilovolt-ampere capacity of each feeder is high, it is of importance to localise any fault which might occur, so as to limit any shut-down to a minimum without interrupting the supply through healthy feeders. Recent practice has developed along these lines, and all modern installations are fitted with these selective devices.

The importance of preventing shut-downs in the case of high-tension mains has led to the adoption of ring or duplicate supplies, and the selective devices here adopted are chosen with a view to preventing any failure of supply due to faults on the feeder system.

In all systems earth faults develop into total or partial short-circuits, which, in the absence of any leakage protection, bring out the overload circuit-breakers, connected to the affected area, and may, where automatic overload circuit breakers without time discriminations are connected to the generating plant, cause a complete shut-down.

In any case, these momentary short-circuits create a disturbance throughout the whole system, which is enhanced in the case of the alternating-current mains due to the reactance of the feeders and the possibility of synchronous apparatus falling out of step.

The following advantages may be claimed for the installation of automatic selective leakage devices in direct-current systems:

1. Where overload circuit-breakers only are installed earth currents and consequently electrolysis and corrosion may arise, which would flow continuously if below the value of the circuit-breaker setting.

2. Where overload circuit-breakers are installed faults are only automatically cleared by the excessive current necessary to open these breakers, resulting in practically short-circuits which disturb the whole system. Furthermore, the overload breakers in the generating circuits are liable to open, and thus result in a complete shut-down.

3. If leakage indicators be adopted a complete or partial shut-down of the system becomes necessary, in order to localise the fault, unless the fault is left on the system until it can be tested under dead conditions.

In many cases the financial loss consequent on these unnecessary shut-downs more than neutralises the extra expenditure of protective devices, as mentioned in this article.

Regulation 124 of the Coal Mines Act (1911) calls for sufficient means for indicating any defect in the insulation of a system, and the present methods employed, although indicating a faulty system, do not actually localise the fault, with the result that the fault remains on the system until each feeder can be systematically examined or the whole plant shut down.

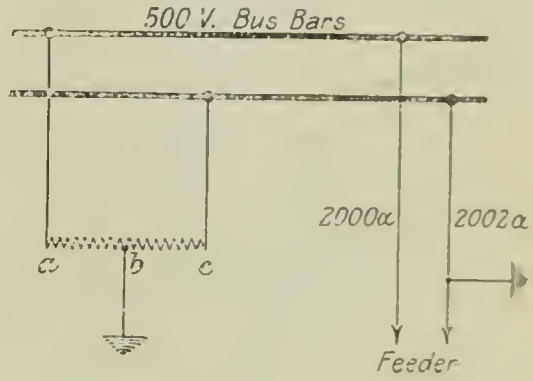


Fig. 1.

The following devices ensure that a fault on a two or three-wire system is immediately cleared without any disturbing currents flowing through the system. (Patent No. 16,053 Nov. 13, 1915.) It necessitates the introduction of a resistance inserted between the 'bus bars at the source of supply, the mid-point of which is normally connected to earth.

Two-wire Systems.

In a perfectly healthy system, the currents in the positive and negative circuit of any feeder are equal, but should a fault develop on one pole, and a return circuit be available for the current passing through this fault, this balance is upset and this fact is made use of to isolate the faulty feeder.

In order to reduce the loss of energy absorbed by the resistance permanently connected across the 'bus bars, and at the same time render the system sensitive to faults, it is proposed to make use of what may be termed "economy resistances," which permit of the introduction of a high resistance between the 'bus bars under healthy and normal conditions of the system, thereby reducing the loss in this resistance, which becomes automatically reduced in value when a fault develops, thus making the system more sensitive to earth faults.

The following example may be cited:

Voltage of system	500 volts.
Resistance inserted between the 'bus bars	500 ohms.
Watts absorbed by resistance	500 watts.
Normal current in resistance	1 ampere.

Assume full-load of feeder to be 2,000 amperes and a dead earth on the positive pole. The current in one section of the resistance *bc* (Fig. 1) becomes zero, while that in *ac* increases

to 2 amperes. Thus, the out-of-balance equals 2 amperes, which equals 0·1 per cent. of the full-load current; this requires an extremely sensitive relay to operate with such a small percentage out-of-balance.

It is proposed to utilise the fact that a current flows in the mid-point earth wire, to short-circuit part of this resistance during the faulty conditions, and thus make the system more sensitive to earth faults.

The same effect may also be produced by shifting the point of connection to earth on this resistance nearer the pole opposite to that on which a fault develops, thereby reducing the resistance in the path of the earth current.

In the previous example, if the resistance of the section *bc* is reduced to, say, 5 ohms, when a fault occurs on the positive main, the momentary current in this section becomes 100 amperes, and this the full load out-of-balance current is increased to 5 per cent., which is sufficient to operate the relay. Since the increased current in the resistance *ab* is only momentary, this resistance may be rated extremely highly, and does not entail a large and expensive resistance.

Figs. 2 and 3 show two methods of accomplishing this, where in Fig. 2 the relay operates a double-pole contactor switch, which short-circuits the total economy resistance, an auxiliary switch being provided on the contactor, so as to avoid breaking circuit on the relay contacts.

The relay is designed to operate when a current flows through it in either direction, and in order to make this relay more sensitive it can be short-circuited by the contactor

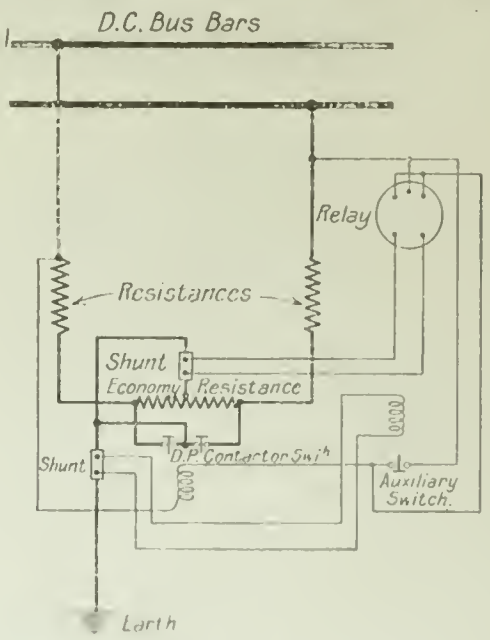


Fig. 2.

switches when a fault occurs, so that it will not have to carry the larger fault current as a result of the resistance being cut out.

In Fig. 3 the economy resistance is only short-circuited in the faulty section opposite to the fault, this method possessing the advantage that during fault conditions a larger resistance is left inserted between the bus bars, and thus the demand on the generating system is reduced.

Fig. 3A shows an alternative arrangement to Figs. 2 and 3, which possesses the following advantages:

1. Only one resistance, outside the economy resistances, is employed, which is automatically connected to the pole opposite to that on which the fault occurs, thereby momentarily increasing the earth current and operating the differential relay in the faulty feeder circuit.

2. The economy resistances mentioned in Figs. 2 and 3 are replaced by indicating lamps placed permanently across the bus bars, and which serve to indicate visually the condition of the system with regard to faults to earth. The resistance is normally coupled between the mid-point of these lamps and earth.

3. Since a fault to earth on the generator circuits, which is not intended to be automatically isolated, also operates the contactors and thus allows the full-fault current to flow continuously through the resistance, it will be necessary to cut out the automatic gear, should this resistance be rated for only a momentary flow of this full-fault current. With this object in view, a fuse or time relay with hand resetting is inserted in this fault circuit, which would automatically break circuit should the fault current flow for a time in excess of that necessary to complete the isolating operation in case of a fault on a feeder circuit. When this takes place the lamps, which light up on one side and darken on the other, would indicate that a fault exists on the generator circuits.

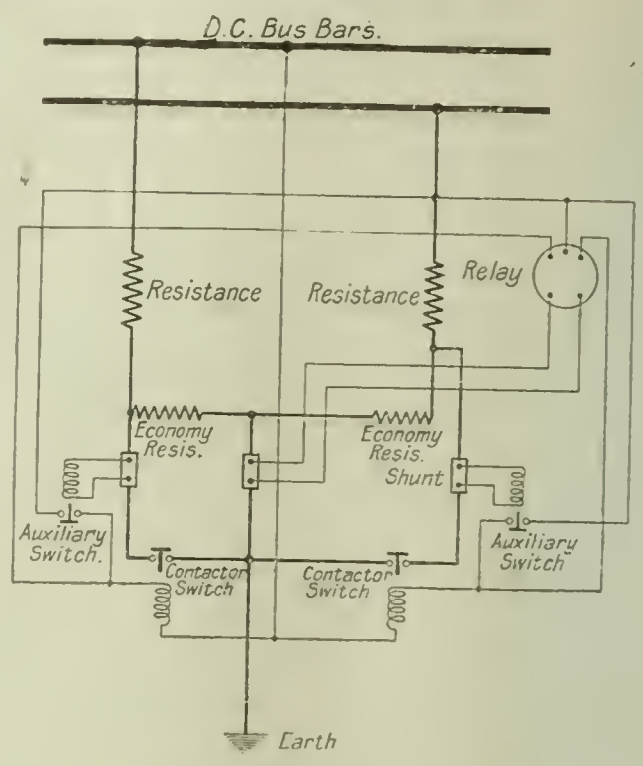


Fig. 3.

The advantage of these methods is that faults are cut out in their incipient stages, thereby reducing the extent of the damage and preventing disturbances over the rest of the system.

Fig. 4 gives the diagram of connections for a single and independent two-wire feeder showing one type of relay for operating the double-pole switch in case of earth faults, thereby cutting out the faulty feeder.

The relay shown here is of the electromagnetic type, possessing two coils, wound in opposition to it, the armature of which is attracted, due to the out-of-balance current in these coils when a fault develops.

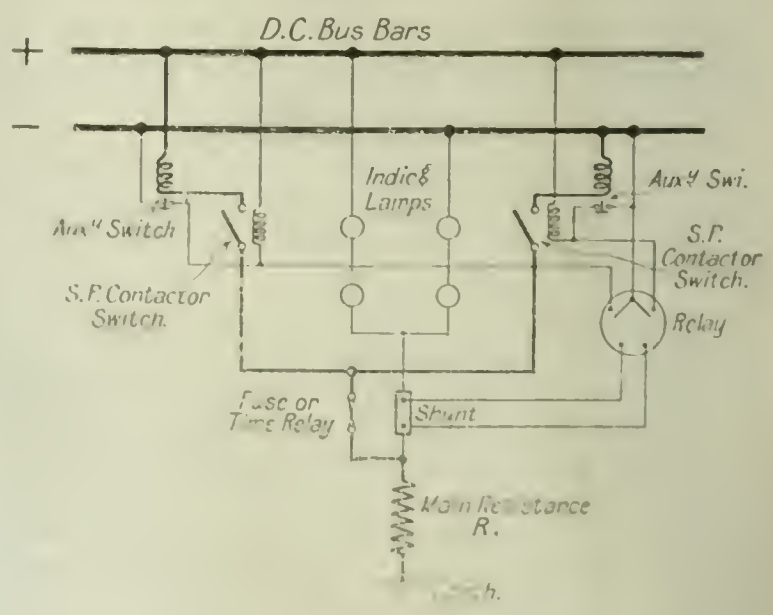


Fig. 3A.

In a two-wire direct-current network where a feeder may be fed from both ends, the split conductor system as shown in Fig. 5 may be employed, which, in case of a fault on any feeder, isolates that feeder only, while maintaining the rest of the system intact, assuming that a fault occurs on one split only, or on the two splits of the same pole unequally. In this case the methods as shown in Figs. 2 and 3 are retained.

The principle involved here is that normally the currents in both splits of one feeder are proportional at all loads, a fault on any split, however, upsets this proportionality on the

faulty feeder, which is cut out at both ends automatically as before. The sound feeders, however, do not lose this proportionality since both splits of these sound feeders feed equally into this fault, and are, therefore, not cut out.

The relay shown in this figure is of the moving coil type, in which two coils are wound on the moving system, whose torques are normally equal and opposed, and, therefore, the moving element is at rest. Should a fault develop, the system becomes unbalanced and the relay acts.

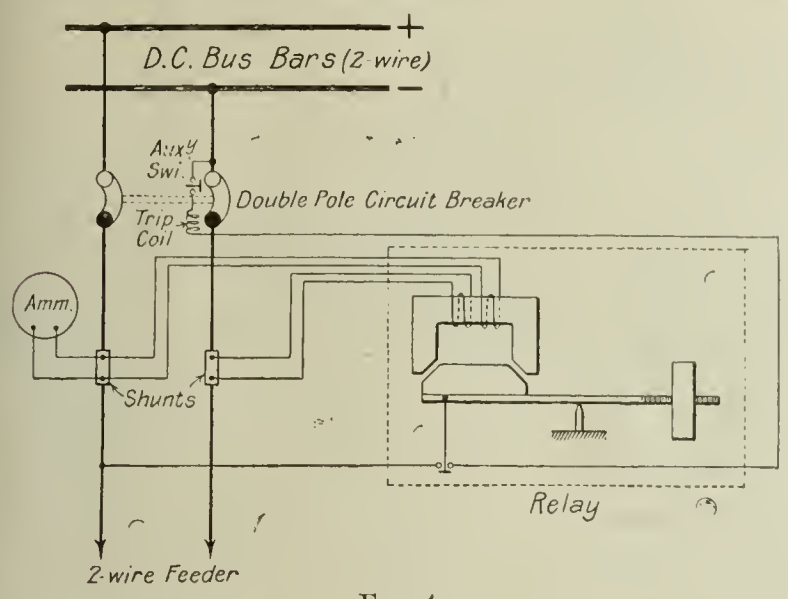


Fig. 4.

Three-wire Systems.—In the case of three-wire systems, it is proposed to insert a resistance between the outer 'bus bars at the source of supply as before, and normally to earth a point on this resistance slightly removed from the neutral point in potential, so that a difference of potential exists between the middle wire and the point connected to earth, as shown in Fig. 8. Should a fault to earth occur on any of the three poles of any feeder, a current will flow in the earth

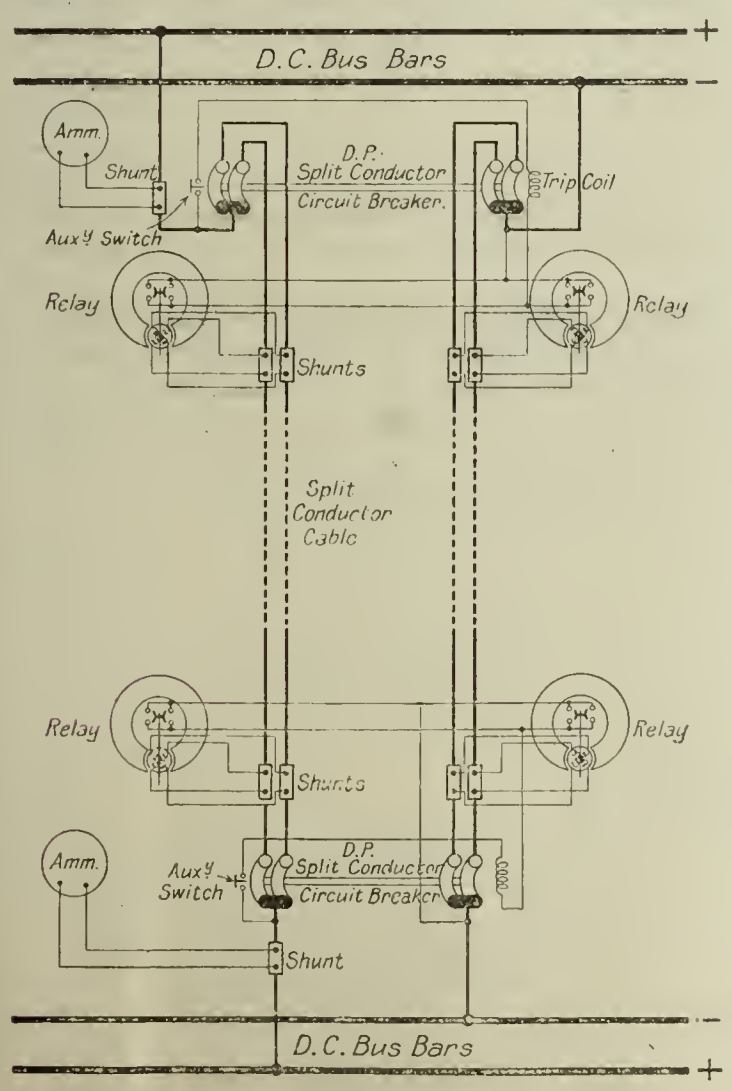


Fig. 5.

connection, which operates the relay placed in this circuit. This relay is made to operate the contactor switches and to short-circuit part of the resistance opposite in potential to the pole on which a fault develops, which results in a momentary increase in the earth current, sufficient only to create an unbalanced condition between the currents in the three poles, which are normally balanced and as shown in Fig. 6, and thus by means of the differential relay operate the circuit-breaker in the faulty section and clear the fault. Immediately the fault is cleared the circuit is automatically changed to its normal condition.

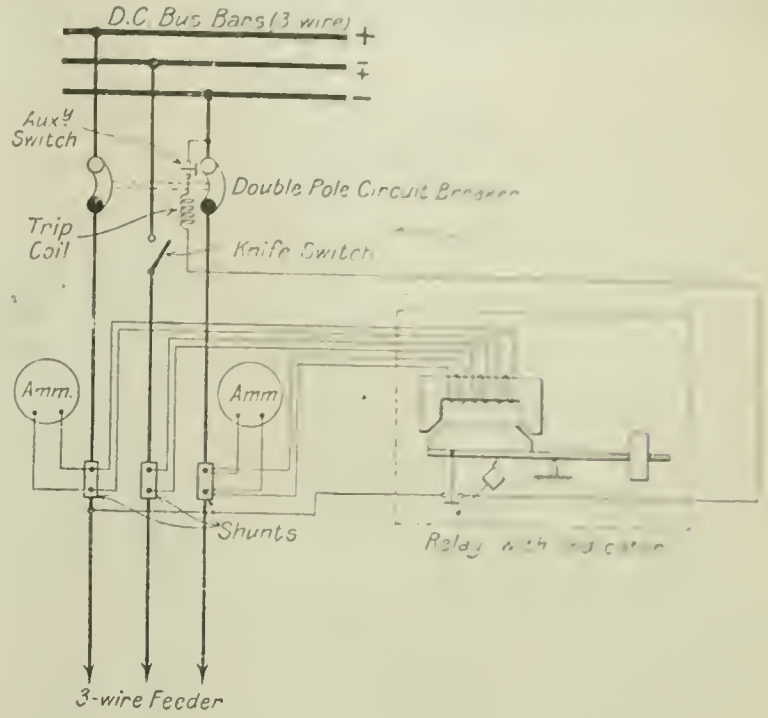


Fig. 6.

The same effect may also be produced by automatically shifting the position of the earth point on the resistance to a point nearer the pole adjacent to the faulty pole as before, thus reducing the resistance in the circuit of the earth current.

The point chosen for earthing the resistance must be within the limits that the potential between the outers and earth does not exceed that required by the Board of Trade rules.

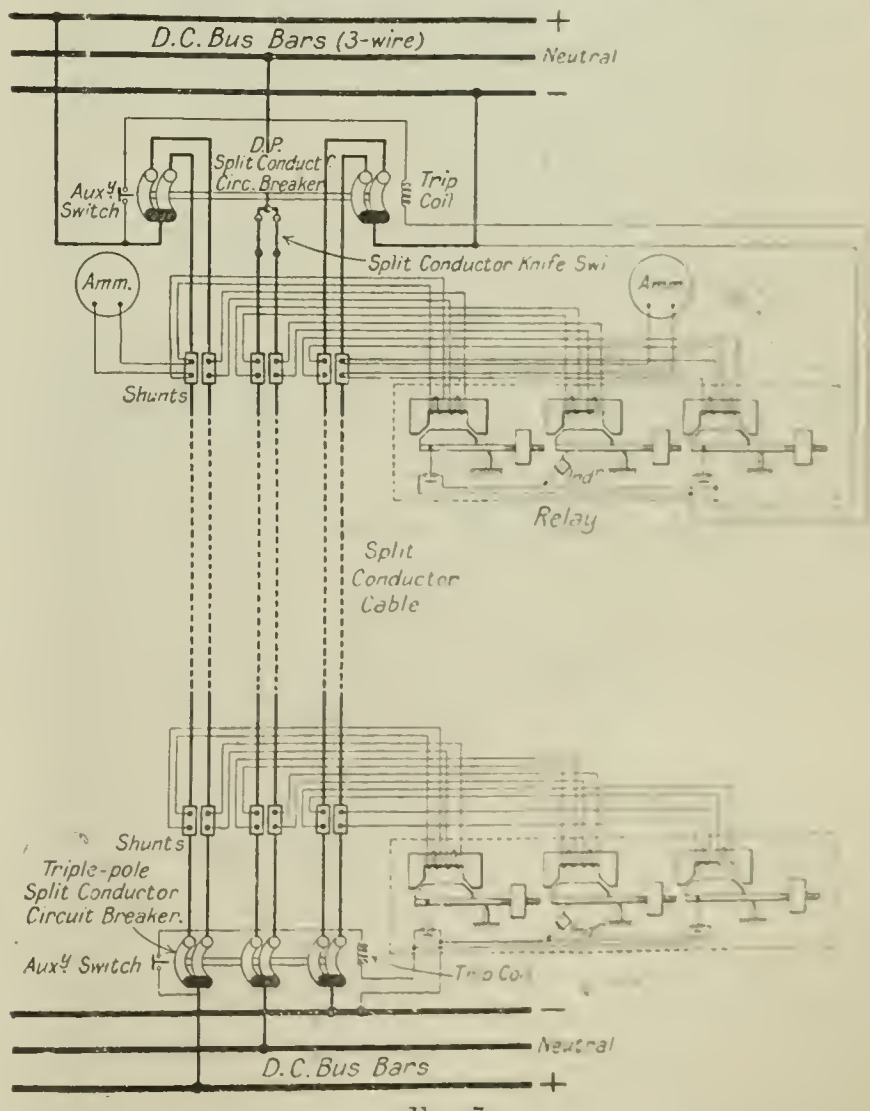


Fig. 7.

At the moment of tripping this value would be exceeded, but this is justifiable so long as it is only momentarily in circuit.

This system may be applied to the split-conductor system, where a feeder may be energised from both ends, as shown in Fig. 7. In this case a resistance is inserted between the outers at the source as before, the conditions of earthing, &c., remain-

ing unchanged. A fault on any split to earth produces a current in the earth connection, and thus upsets the balance in the faulty feeder as before, and trips the switch at both ends,

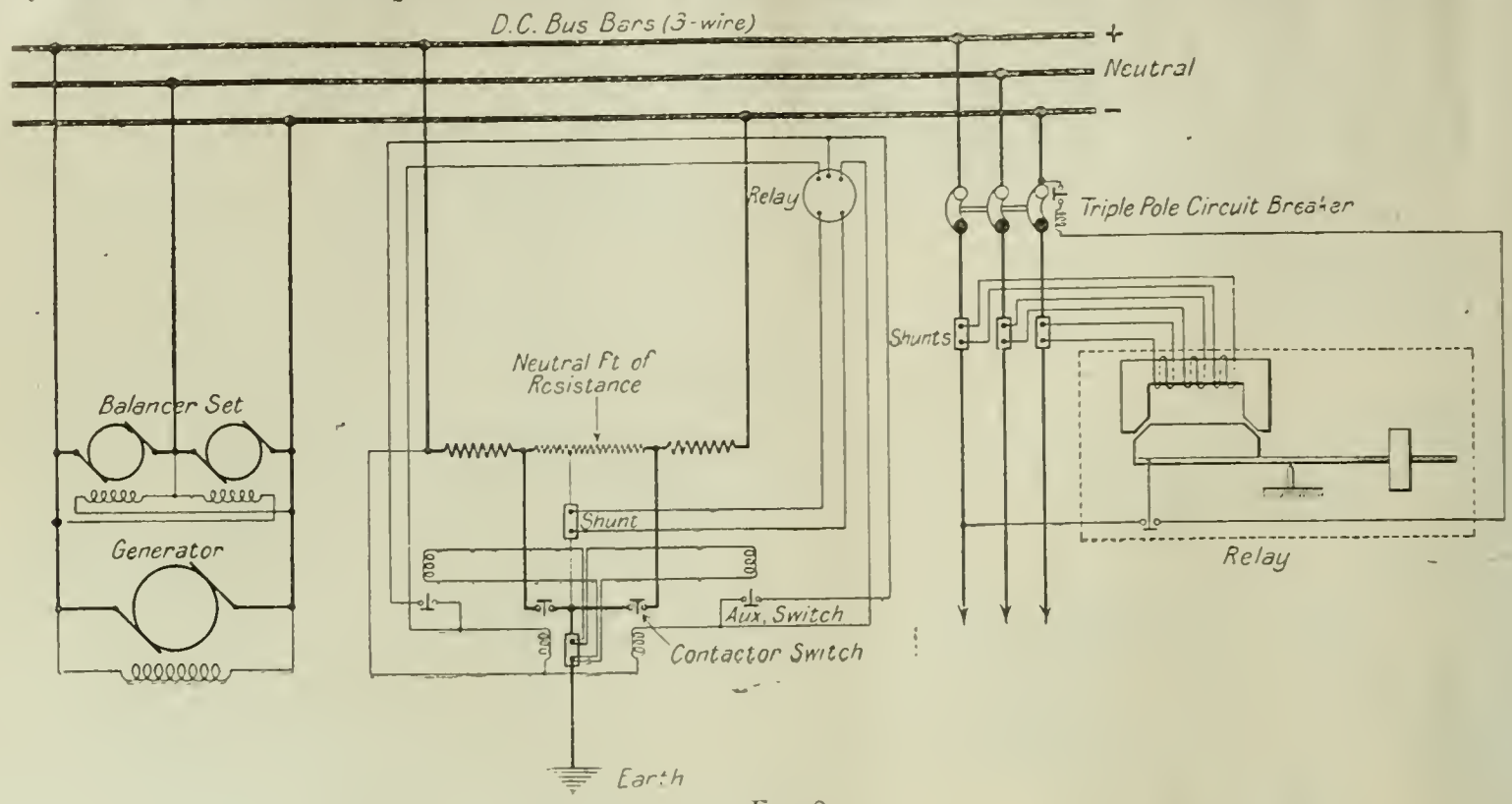


Fig. 8.

the remaining part of the system being kept intact, since the balance is upset only in the faulty feeder section.

Common Relay Operating Contactors.—This relay is of the moving coil type, and will operate down to 5 per cent. of the

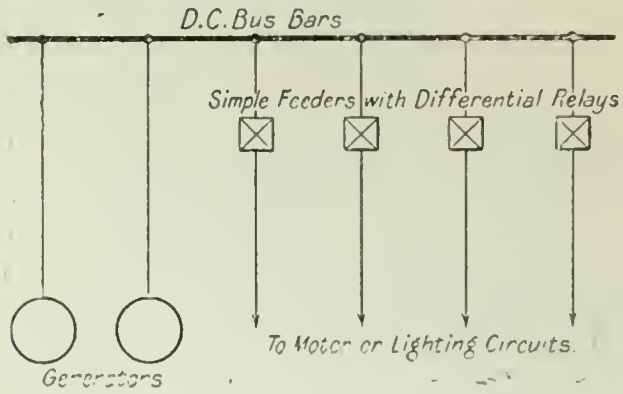


Fig. 9.

maximum current in either direction. Assuming the maximum current passing through this relay to be 2 amperes, as in the example cited before, this relay will operate with 0·1 ampere, which is equivalent to an earth resistance on one pole of

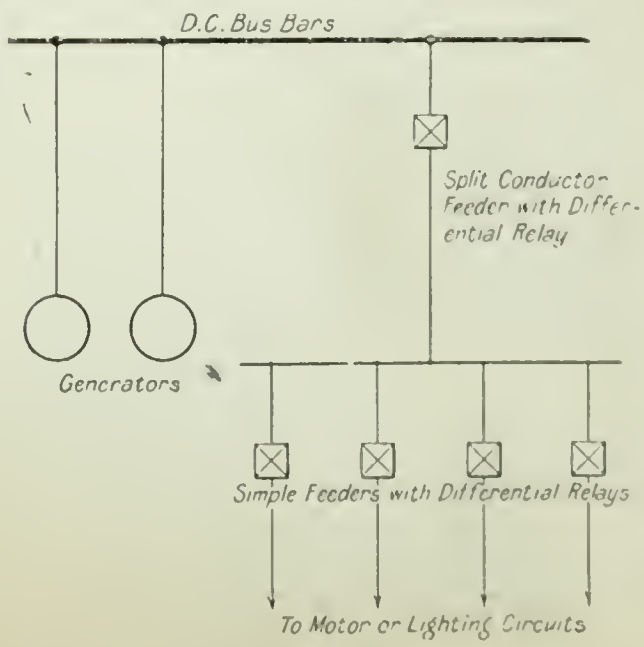


Fig. 10.

4,750 ohms. This, of course, is much too sensitive a setting, and in practice should be set for a value approaching the maximum current *i.e.*, 2 amperes—so that the sensibility of this relay is of the same order as the sensibility of the differential feeder relays.

Feeder Relays.—These relays are also capable of operation down to 5 per cent. of the full-load current, and the following table gives the values of the maximum fault resistance which will operate the relay for different-sized feeders on a particular system, assuming the voltage of the system to be 500 volts, the permanent resistance across the bars 500 ohms and the relay to operate at 5 per cent. of the feeder full-load current :—

Feeder full-load current.	Minimum out-of-balance current required to operate.	Maximum fault resistance to earth.
2,000 amperes	100 amperes	0 ohms.
1,000 ,,	50 ,,	5 ,,
500 ,,	25 ,,	20 ,,
200 ,,	10 ,,	45 ,,
100 ,,	5 ,,	95 ,,
50 ,,	2·5 ,,	195 ,,

Thus, an earth fault of 195 ohms on a 50-ampere feeder could be, if desired, automatically cut off in such a system as the above.

Applications.—Figs. 9, 10 and 11 show various applications where this system of protection can with advantage be applied, these figures being self-explanatory and referring to both 2 and 3-wire systems. It will be observed that various types

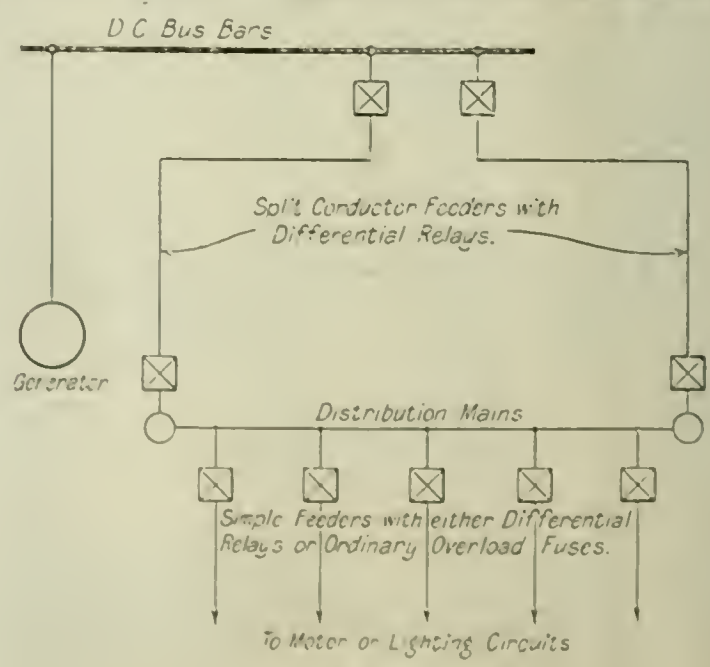


Fig. 11.

of relays and switching arrangements have been indicated, but the most suitable type will vary with each installation.

This method of protection can also be adapted to alternating-current systems, where the resistances mentioned could be replaced by reactances.

CORRESPONDENCE.

"SPEEDING UP IN AN ENGINEERING FACTORY."

TO THE EDITORS OF THE ELECTRICIAN.

In replying to the correspondence in last week's ELECTRICIAN, I would like to say that my Paper being published in an abstract only, a wrong impression may easily be produced of some points dealt with more fully in the Paper itself.

Unlike you, I cannot say I am in agreement with much of Mr. Carney's letter. He seems altogether prejudiced against the case for the employer, and, from the impression his letter gives me, I should say likely to be satisfied with mediocre results provided the men profess contentment.

Although it is true that it does not necessarily follow that a man is loafing who takes 4·9 minutes to do a job which he himself previously did in 2·25 minutes, it almost invariably follows, and, in the particular case mentioned, it certainly was the case. The man may have thought that he was doing the best for himself—in this he was most certainly wrong—but he was nevertheless acting dishonestly, and that I am not going to any pains to excuse. Condoning deception of this sort, or indulging in self-deception, is not likely to lead to any good for anybody.

Mr. Carney thinks I lack the close sympathy with the labourer's view point which, he considers, is essential to success. The work I described certainly was successful—the results prove it—so he is wrong. I may say at once, as one who for many years was engaged in manual work, that, while I have every sympathy with the labourer, I have grave doubts about the soundness of many of his views. I am in sympathy with both men and employers, and I consider both their cases from my own point of view, which, in work of this sort, is of some importance. Sympathy does not imply agreement. There is a course which, if followed, should satisfy both employer and employé.

Driving methods were not employed by me. The farthest I went in this direction was to stand up for a reasonable thing and resist attempted driving tactics of disaffected men, and experience has shown me, much as it may surprise Mr. Carney, that such methods do pay. I do not agree that the attitude of labour is due to that of the employers; Mr. Carney's assumption that the latter are ignorant of economics is a debatable point, at least as far as their own work is affected.

Mr. Carney may be satisfied with the results he obtained by his methods—that is a personal matter—but my experience has shown that the use of the stop watch, which does not by any means imply driving methods, is far and away superior to any other method for the obtaining of increased outputs. Part of the Paper, omitted in the abstract, shows that, without the rigid analysis rendered possible by the plain figures obtained by the use of the stop-watch, the same results could not have been expected. Some of the men whose work was timed, and reorganised, were, I think, genuinely astonished at the difference made. Manual work, like some forms of athletics, can only be properly studied by means of a stop-watch. The employer who believes in driving will drive without seeking the aid of any such instrument, and without offering higher wages.

Mr. Carney makes a great point of contentment amongst the workers. The workers referred to in the Paper are fairly well satisfied, but very little of their contentment is due to their seeing that I am satisfied with anything far removed from an effort on their part to do their best, although such a thing is frequently a reason for self-satisfaction amongst workmen. A full explanation of the system was made to the men before its application. Nothing was hidden from them. The simpler aspect of the system mentioned in the Paper was not noticed at first, but, when it was, there was no reason why it should be enlarged upon; it is only a matter of interest and does not affect the actual figures. The men were given outputs and figures for rates of pay to compare: their satisfaction or otherwise was their own affair largely; only experience could show definitely the advantages they would gain. This experience they were unwilling to obtain. In the Paper, I have mentioned that, far from driving being the rule, considerable pains were taken to find an excuse for the men when turning out greater outputs, and I believe that part of the reluctance of the men causing the strikes was due to honest blame that, in some cases, they were going to be shown to have been deliberately restricting output.

With the men personally, with few exceptions, I was always on very good terms, and took their artifices and dodges in a sporting spirit, while insisting on what I knew to be right and refusing to be deceived.

I still hold that an employer pays for a man's abilities in the workshops as much as in the office. In setting a task on this system the employer, who is responsible for the methods of work, and the facilities for turning it out, is really fixing a minimum standard of ability. Pieces per hour form the only available measure of this in the kind of work under consideration.

Mr. Carney might have noticed in his search through the Paper that six minutes in the hour, that is 10 per cent., was allowed for rest to the workers, in addition to certain other allowances. This was principally on account of fatigue. Had there been years to spare, fatigue studies *might* have been undertaken, but I expect that when they are the stop-watch will be necessary, and there will be a great deal more trouble than I have had; they will touch the workman much more personally than my methods. There was no time for delay, however, and the thing had to be settled quickly and reasonably on the somewhat common engineering lines, the lines which may be inferred from the definition of an engineer, which I have heard several times at meetings lately, as being a man who can do in a day what most others would take a week to do. I state in the Paper that had more elaborate analyses been possible, better results would doubtless have been obtained.

As regards Mr. F. W. Taylor's work, as I read his books, this was spread over many years for comparatively small results to begin with, and, had I resorted to his tactics of dismissal and so on, in the tense labour situation created by the war, I should have held myself to blame, but in no single instance was driving, in any shape, resorted to. It must not be forgotten that two sections of men fell in with the system without the slightest trouble, other than the "soldiering" during timing, all of which was duly noted and discounted.

Mr. Brocklehurst, like Mr. Carney has, owing to the Paper being in abstract, formed a wrong impression as to the way in which the men were approached in the first instance. As I have said, nothing was hidden from them. In setting the task I was prepared to back my judgment even in spite of attempts at "soldiering." Any mistakes I made in setting the task low I stood by, but they were few, and not of much moment. I cannot enter into the German question, although it may be argued that Germany's accumulated stocks are more likely to be mythical than real, but there is no reason why the introduction of the system I have described should lead to any trouble whatever if men are willing to give it a fair trial. There were strikes all over the country at the time dealt with in the Paper, and in places where there was no attempt to introduce any changes in method of payment, and where it has been shown absolutely that men were deliberately keeping down the output. In normal times I believe the changes would have been made with much less difficulty.*

The system was not devised by me, but I cannot see that the setting of a proper normal output, with a 33⅓ per cent. margin of time allowed for its completion, and a guaranteed minimum wage, leaves any loophole for such weakness as Mr. Brocklehurst implies. It relies in no way on withholding anything from the men. The latter were told that provided I was sure that the task was reasonable—and I would see to that—the more money they earned the better I would be pleased, as the labour cost decreased somewhat. That still holds, and they are satisfied.

In reply to Mr. Stevens, I do not condemn straight piecework

* In an address to the Iron and Steel Institute last week Sir William Beardmore gave some examples of restricted output in his own works in Glasgow. He mentioned cases in which girls turned out 100 per cent. and 120 per cent. more work than skilled men. Where such things are possible and where, owing to a war there is a shortage of labour, it would be almost a miracle if strikes were not caused by any attempt, however reasonable, to speed up and obtain an honest output.

as altogether unsatisfactory. If a stop-watch is employed in the fixing of the prices, in the hands of a competent engineer observer, the results need not be altogether unsatisfactory. It was a failure in the works dealt with, and the fact that leading engineers have been forced to drop it, shows that I am in good company in holding the opinions I have expressed. At least one prominent labour leader has, I believe, declared that straight piecework is, in his opinion, a failure.

From Mr. Stevens' description of the alterations he made I am inclined to think that they have had only a small direct influence on the increase in output. A consent of the workers so spontaneously unanimous as to be italicised makes me somewhat suspicious. If each worker, without any alteration in methods, and paid in the same way, received 16s. 3d. per day as against 6s. 3d. previously, the inference would seem to be that they had a soft job in the first instance. The division of labour saved their faces and provided the excuse for them to go on, even as the excuses I had to provide, served the same purpose.

I am sorry to point out to Mr. Stevens that his saving is approximately 30·7 per cent., not 41¼ per cent.

I consider it quite fair to arrange for the labour costs to fall with increasing output. The employer, in my opinion, is entitled, in some degree at least, to reap a direct benefit from the system and facilities for which he has been responsible to give the men an opportunity of earning higher wages up to the limit of their ability. In any case, neither this part of the saving, nor that in overhead charges, goes wholly to the employer. They have their effect in reducing the price to the purchaser and increasing the market, to the lasting benefit of both employer and employee.

There was, as I repeat, no hoodwinking of the worker. If your correspondents refer to the curves in the Paper they will see that they have been straining at a gnat; when one hour's task is done in half an hour, as may happen with a very smart man, his rate of pay increases over 83 per cent., while the reduction in labour cost is only 7·5 per cent.

I am very well satisfied with the results of the system I have adopted, and, from my experience of the results of ordinary straight piecework, I am convinced that they never would have been obtained by that means.

London, May 9. R. Rankin.

TO THE EDITORS OF THE ELECTRICIAN.

I have followed with interest the articles by Mr. R. Rankin, B.Sc., in your issues of The Electrician for April 21st and 28th, as well as the correspondence in the following issue, and I agree with Mr. H. Ambrose Carney that Mr. Rankin deserves our best thanks for bringing forward a subject of such vital importance to the welfare of the nation.

At the present time, in the manufacture of an article which, in pre-war days, was assembled by one skilled person, I have found it necessary, owing to the dilution of skilled with semi and unskilled labour, to split up the assembling into separate processes, giving a single process to each person, with the result that that process became purely mechanical to that particular person. It was in determining what the cost of each process ought to be that I met my greatest difficulty. The processes were considered by the workers to be a new means of cutting the prices, and I think they had at the back of their minds a vague notion that it was some new "States" trick, for even after carefully explaining the cause of splitting up the processes and the whole scheme they seemed to distrust it. As there were no fixed prices the workers for the first few weeks took as long as they possibly dare over each piece in an attempt to make the piecework price as high as possible, and Mr. Rankin will, no doubt, see that with fixed dates for Government orders, stop watches were out of the question. I continued to give the prices I had calculated in the first case and which, when added, gave the same total price as that for all the processes combined, and in time several of the workers saw that they could take away more money per week in the new scheme than they could before, so that gradually the whole shop developed the same idea. I afterwards found that it was not the fact that the processes became mechanical which struck the workers, but the fact that they did not waste time changing from one process to another as they had done previously. It is, of course, the former which is the more important of the two; the latter is practically negligible for a good worker. By means of this scheme I obtained a greater output from my diluted labour, which was what I was aiming at, and, as Mr. G. C. Stevens pointed out in The Electrician for May 5th, the actual cost of the articles was reduced.

The carrying out of this scheme has made me very much of the same mind as Mr. Carney—that is, the average British workman must be humoured and carefully handled if he is to be used to the full extent of his powers. I have found it better policy to treat those under me with a firm hand, but as human beings, and not as mere machines, as Mr. Rankin's article seems to suggest they should be treated.

I do not agree with Mr. Carney's system of "State Aid" for soldiers after the war, but I certainly think something should be done to see that the right man gets the right job; by this I mean that the skilled man should not be put on labouring, while the unskilled man gets his job because he got there first. It is only by having every man in his right position after the war that we shall obtain a maximum output from the nation.

Manchester, May 6. H. Stuart.

TO THE EDITORS OF THE ELECTRICIAN.

In commenting upon my remarks anent Mr. Rankin's Paper you have apparently misunderstood my proposals for an industrial reserve. The term "reserve" is, perhaps, unhappily chosen, since with the various species of military service now extant, the word has acquired an almost exclusively military connotation. Yet it exactly expresses my meaning if it be shorn entirely of its military sense. Every one now agrees that this country can no longer afford to handicap itself in the race with other nations by the inefficient utilisation of its labour forces. Undoubtedly the war has shaken up the haphazard arrangement of these forces into a far better distribution. Production is in consequence generally more efficient now than in pre-war days, if due allowance be made for the other factors which we experience. So that already we have advanced on the road to industrial efficiency. My point is that we should not shake out the round pegs from the round holes they have recently found, and drive them back into the square holes they occupied before the war. The nation cannot afford to do it. Even if we could, it would be impolitic to do so; every round peg would chafe in the square hole re-assigned to it, having experienced life in its proper position, and would become a potent source of labour unrest. This position seems to me perfectly sound.

But we are bound to see that those now under arms do not lose by this arrangement, and, therefore, my proposal is that these men, too, should be given the opportunity and the training to find and fill each his proper niche. This the Industrial Reserve would do. Your statement that "when peace is proclaimed the men who have been fighting for us will be allowed to return at once to their former occupations in order to begin to earn the wherewithal to provide homes for their families," postulates the existence of industries to absorb all these men, fully and efficiently, the day peace is signed. Can anyone say this would be so were hostilities to end to-morrow?

It is not a question of economy in the maintenance of the men, but a question of taking the greatest opportunity this country has ever had of reconstructing, on a sound basis, its industrial and commercial structure. It is a practical step in the performance of "that national duty which sees that the fit survive," instead of throwing them into the ranks of the unemployed. As to the State payments during training in the Industrial Reserve, they and the training itself are but the modern counterparts of the rewards which the generous ancients bestowed upon their warriors. Shall we in this enlightened age be less generous?

Manchester, May 8. H. Ambrose Carney.

[In our correspondent's letter last week, "No. 2 report of the Ministry of Munitions Health Committee" should read "No. 7 report."—Eds. *E.*]

TECHNICAL EDUCATION.

TO THE EDITORS OF THE ELECTRICIAN.

As a member of the Council of the Association of Teachers in Technical Institutions, I should like to thank you for your strong leading article on the present position of technical education. Although your castigation of all parties concerned may not be quite just, the situation appears to be so serious that it is not the time to exercise a nice discrimination in apportioning the blame. The A.T.T.I. have given long and serious consideration to the question, and have endeavoured with a certain amount of success to arouse public opinion in the Press; they have approached the more important educational authorities, the Board of Education and certain M.P.s interested in education; they have also co-operated with other associations in holding meetings and reading Papers which have been reported in the Press. The public utterances of ministers when questioned have been all that one could desire, but nothing has actually been done, and we are at the present moment faced with the complete emptying of all technical colleges doing advanced work owing to the extension of the military service age down to 18, which will be further intensified in the case of electrical engineering by its removal from the list of reserved occupations. The men whose courses have been interrupted will, in the majority of cases, not return to college, and at the end of the war we shall wake up to find ourselves technically in a position infinitely worse than before the war.

It appears to me that only one course is open to the Government, viz., to decree that tribunals must regard advanced full-time students of proved ability as exempt from military service (except in technical corps) until the end of their course and so long afterwards as they may be required by manufacturers for important technical work. At the instance of the A.T.T.I. this concession was obtained from Lord Derby by the B.O.E. in the case of students who attested under his scheme, and has been put in operation in a few cases but has now lapsed. Of my own students four have come under its operation, and these have been engaged by a large electrical works who, on appealing to the county tribunal for their exemption, had their case decided against them without being given a hearing.

The first Military Service Act recognised as grounds for exemption the fact that the man was in training for some work of national importance; if this clause remains in the new Act and if tribunals are compelled to respect its provisions there may be some hope of saving the situation; otherwise we may look forward to our manufacturers after the war being more severely handicapped than ever.

Battersea, May 9. A. W. ASHTON.

[We appreciate Dr. Ashton's letter. As for our castigation of all parties not being quite just, we would state that we judge by results. The exercising of a nice discrimination in apportioning the blame was intentionally avoided.—EDS. *E.*]

GENERATION OF HIGH-TENSION CONTINUOUS CURRENT.

TO THE EDITORS OF THE ELECTRICIAN.

Referring to the article by Mr. A. W. W. Linke on a "Direct-current Generator for 10,000 volts," in THE ELECTRICIAN of the 17th ult., p. 842, I beg to inform you that to my knowledge a certain number of machines generating continuous current at a P.D. of 10,000 volts have been built, and have been in service for several years.

Makers of such machines in addition to the Allgemeine Elektricitäts Gesellschaft are notably the Compagnie de l'Industrie Electrique et Mécanique, and the firm of Cuénod, of Geneva. One of these machines, giving 10,000 volts and 0·2 ampere, constructed by the Cuénod firm, has been used by me since the exhibition of 1912.

A series of machines giving 8,000 volts and 2 amperes, have been built at the same time by the Compagnie de l'Industrie Electrique et Mécanique. In 1914 the French administration of Posts and Telegraphs put a machine, built by this company, into service in a wireless telegraph station working at 10,000 volts and 1 ampere, and a series of similar machines is about to be installed. Dynamos giving 12,500 volts and 1 ampere are about to be built.

All such machines have a [illegible] commutator, some of them even for a voltage of 12,500 volts, are built in such a way that a certain point of the winding can be put to earth. They are built for lower currents than those of the A.E.G., but the difficulty in such types of construction is not so much a question of current, but of voltage.

Postes and Télégraphes, Paris, May 1. L. BOUTHILLON.

SIR WILLIAM BEARDMORE ON SCIENCE AND INDUSTRY.

In his presidential address to the Iron and Steel Institute Sir William Beardmore made some interesting remarks on the position of science. After referring to the fact that the war had taught us ethical, political and industrial lessons, which were urgently needed, Sir William stated the industrial lessons were those involving economy of production and the relation of employer and employee.

Regarding science, this came first, and there must be co-operation between laboratory research and manufacturing development. There was a great need for the extension of research and experiment, and his experience was that much of this work was highly remunerative, either positively, in improved processes of manufacture, or negatively by eliminating errors. Much of it was unremunerative, and all of it required money. The narrow margin of profit obtained by the manufacturer left little for such work, and manufacturers had difficulty in finding means to carry it on properly. In addition, the refusal of workers to utilise to the greatest advantage the improved methods evolved by experimental research discouraged industrialists in evolution and application of such methods. When a charge of lack of enterprise was made against manufacturers, blame should also be laid on the workers, who did not realise that their interests were primarily affected by the attitude they displayed in such cases. It was not enough for the State to encourage research; the nation was equally concerned with the application, and the question was a national one.

A great export trade was necessary, since the people depended on plenty of work. Research was a charge on the selling price, and to counterbalance this it was essential that the volume of output should be increased. Consequently the bed rock was reached when they found that unless restrictions and limitations of workers' associations were abolished much of the gain from research would be lost.

Owing to the output from the machines at Parkhead not being great enough, girls were employed in the projectile factory, and they in all cases produced more than double the output produced by thoroughly trained mechanics. In shell bodies it was double, in boring it was double and in curving it was 120 per cent. greater.

The speaker referred to the indigo problem, and the fact that two German firms spent £1,000,000 on it and worked 16 years on it. Then the partnership was dissolved, and within a few weeks one of the firms claimed to have solved the problem. Incidentally, it was a good example of German business methods, and the firm in question held the monopoly of the indigo market for five years. During the whole progress of these experiments nothing was divulged.

Sir William referred to the limitations of our educational system, only four colleges at Cambridge, none at Oxford, were presided over by scientific men, and of 35 of our public schools 34 had classical head masters.

It would benefit the State if the heads of Government departments were scientific men, since these departments were necessarily connected with scientific work. Yet no scientific man had ever been entrusted with the head of a department as a Cabinet Minister.

The engineer was calling for metals of higher quality and greater range of purposes, and everyone was clamouring for reduction in cost. Every industrial process should be examined constantly and methodically, and responsibility rested on employers to make such research work part of their productive methods.

In the discussion which followed, Mr. B. Talbot, of Middlesbrough, asked the Council if they would call a special meeting of the Institute to discuss the duty of the State to trade. He considered they were in a position to advise the Government, especially as their leaders in the Cabinet were not scientific men.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"The Mechanical Handling and Storing of Material." By G. F. Zimmer. (London: Crosby, Lockwood & Son.) Pp. xiv. + 732. 42s.

"Mechanical Engineers' Pocket Book." By William Kent, M.E., Se.D. (London: Chapman & Hall, Ltd.) 9th edition. Pp. xliv. + 1526. 21s.

PARLIAMENTARY INTELLIGENCE.

DAYLIGHT SAVING.

In the House of Commons on Monday the following resolution (moved by Sir Hy. Norman and seconded by Mr. B. Peto) was carried by 170 votes to 2: "That in view especially of the economy in fuel and transport that would be effected by shortening the hours of artificial lighting, this House would welcome a measure for the advancement of clock time by one hour during the summer months of this year."

In the course of the discussion Mr. H. SAMUEL, Home Secretary, said that the Government would not have dreamt of favouring that measure or inviting the House to consider it unless they had reason to think it was essentially advantageous for war purposes. The question of our coal supply was giving the Government serious concern. A large number of miners in the early part of the war were enlisted in the Army, and although the output per man had increased owing to the greater regularity of labour, the working of the best seams of coal and other causes, the fact remained that the output was declining, and had declined considerably during the war. Our Allies were in urgent need of increased supplies of British coal, and we were casting about in every direction to increase our coal supply. When a proposal was made which they were convinced would lead to economy of many hundreds of thousands of tons of coal in the course of the year, they could not regard that as a matter of indifference. That was a prime reason why the Government looked with a favourable eye upon the motion. Further, there would be a distinct economy to the nation if, as they believed, expenditure upon the fuel necessary to provide artificial light for something approaching 150 hours would be saved. It was difficult to estimate the amount of the saving, but it was more likely to be a question of millions than of hundreds of thousands of pounds. It was true the measure would give better opportunities for recreation to large numbers of working people, but it was true, on the other hand, that in these days none of them was much disposed to trouble about recreation. It was to be remembered that healthfulness and cheerfulness had their value in maintaining the moral of the nation. He was asked what would be the position of gas and electric light works, which would lose part of their revenue. Those undertakings existed for the service of men; men did not exist in order to be customers of such undertakings. If the scheme was a good and practicable one, the interests which depended for their income on the supply of artificial light must adapt themselves to the changed circumstances. At the present moment, when the price of coal was high and the supply restricted, gas and electric light companies would be rather glad to be relieved of the obligation to maintain their usual coal supply. Clock time was a purely artificial thing. Most people's clocks and watches did not correspond with sun time at all, and in travelling extensively one's watch had to be frequently altered. The proposal had the support of many of the leading scientists of the world, though the present Astronomer Royal did not favour it. There would be no penalty imposed on individuals who refused to conform to the alteration. It was proposed that notices of the change should be exhibited in Post Offices and other places. The local authorities and churches would be invited to alter their clocks, and the assistance of the Press would be invoked to impress on the whole nation that on a specified night the clock would be altered. The Government were unwilling to make the change without the approval of the majority of the House. If the House approved the motion, it was thought advisable to seek the sanction of Parliament to a short Bill which could be introduced on the following day. It would be for the period of the war only. If the Bill passed that week, as he hoped it would, he proposed that the change should be effected on the night of Saturday and Sunday, May 20 and 21. He proposed that normal time should be restored on the night of September 30-October 1. He believed that was the moment when the greatest difficulties would arise. It was suggested that two o'clock in the morning should be the hour when the change should be made as the most convenient hour for the railway companies.

The Daylight Saving Bill was introduced into the House of Commons on Tuesday and read a first time.

LOCAL GOVERNMENT (EMERGENCY PROVISIONS) BILL.

Certain amendments were made in the House of Commons last week in the new clause dealing with the prohibition of the establishment of new omnibuses, and these amendments were agreed to by the House of Lords on Tuesday last.

LEGAL INTELLIGENCE.

A. C. Hands v. J. Davis & Co. (Southampton) (Ltd.)

On Friday last Mr. Justice Astbury granted plaintiff's application to enter judgment in default of defence in this action, and a declaration was made that plaintiff was entitled to a first charge on the Company's assets to secure the payment of debentures.

EDUCATIONAL.

Faraday House Electrical Engineering College.—The following awards have been made at the recent scholarship examinations:—

A Faraday scholarship of 50 guineas per annum, tenable for two years in college and one year in works, to F. I. Ray, of Bournemouth School; a Maxwell scholarship of 50 guineas per annum, tenable for one year in college and one year in works, to C. F. Fowler, of Brighton Grammar School; and an entrance exhibition of 20 guineas per annum, tenable for two years, to W. Parr-Dudley, of Cranbrook School.

Electrical Science Scholarships.—The late Mr. T. Taylor, of Blackpool, left £1,000 to the town of Ashton for the endowment of scholarships for the study of electrical science.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914 SPECIFICATIONS.

22,045 HOCHSTADTER. Arrangements for automatically switching off or indicating defective sections of electric distributing nets. (16/4/15.)

1,997 POTTS. Telegraph machines.

2,163 MARKS. (Delany Foreign Co.) System of telegraphy.

A tape-operated telegraph system in which each signal impulse is initiated by imparting to the line a recording current weakened by an opposing current, is continued by the recording current unopposed, and lastly is terminated by a stronger current of opposite polarity, this latter current finally remaining unopposed upon the line until the succeeding signal impulse is initiated.

5,168 CADETT & PERCY. Magneto ignition for internal-combustion engines.

5,201 MURRAY & SHOTTER. Circuit-breakers, current limiters, excessive current indicators and the like for electric circuits.

An apparatus for indicating the existence of an excessive current in an electric circuit in which the apparatus is connected, of the kind comprising an automatic switch device adapted to interrupt intermittently or reduce the flow of current in the circuit in the event of this current exceeding a predetermined value, in which an alternative path or circuit for the current traversing the apparatus to that including the automatic switch is provided, controlled by a second switch device, in such a manner that one or other of the alternative circuits is closed except when a permanent excessive current demand occurs.

5,323 PATTERSON. Miners' electric safety lamps.

5,533 KEAST. Coin-freed apparatus for testing manual strength of pull, and electric-circuit endurance.

5,557 B.T.-H. Co. (G.E. Co.) Electric rectifiers and methods of operating the same.

Comprises a vitreous envelope containing a cathode of highly refractory material, such as tungsten adapted to be heated to incandescence, one or more anodes of considerable heat dissipating capacity, and a filling of inert gas or vapour at a pressure sufficiently high to prevent electrical disintegration of the cathode.

5,596 SAVIN & AUTOMATIC TELEPHONE MFG. CO. Electrical relays.

5,623 SIEMENS & HALSKE AKT.-GES. Electrical alarm systems. (16/4/14.)

5,731 ELLIOT & SOLECTRIC CO. Portable primary batteries or cells.

5,783 MARCONI'S WIRELESS TELEGRAPH CO. & FRANKLIN. Aerial conductors for wireless telegraphy.

Consists in the combination at a wireless station of two similar aerials, each consisting of two vertical frames at right angles to one another, an adjacent transmitting station at equal distances from the two aerials, two radiogoniometers connected to the two aerials, each to each, and a common receiver.

6,991 LANDIS & GYR. AKT.-GES. Short-time electric switch. (23/5/14.)

7,826 DE FERRANTI & FERRANTI (LTD.). Electrical transformers.

7,827 DE FERRANTI, ROOTHAAN & FERRANTI (LTD.). Electrical apparatus employing oil insulation.

7,840 BROWN. Vibrating make-and-break devices for use in electric signalling.

7,987 B.T.-H. Co. (G.E. Co.) Rotary electric converters.

An arrangement for regulating the commutating field of a rotary converter mechanically coupled to a booster, comprising a commutating field winding in series with the converter armature and an auxiliary commutating field winding impressed with a voltage controlled by a contact making wattmeter in accordance with the load on the booster and sense in which the booster acts on the converter voltage.

8,516 ROBINSON. Electric fuse carriers.

9,584 ELMEN, SALISBURY & TALBOT. Electric water-heaters. (26/12/14.)

10,272 ROBERTS. Amplification of wireless signals.

11,033 CODD. Magnetos.

12,614 FRIED. KRUPP AKT.-GES. Electrical arrangements for distant control. (2/9/14.)

15,330 BACON. Switching devices for the low-tension induction circuit of automobile engines.

18,084 TURNER. Telephone systems. (20/6/14, divided application on 6,480/15. April 30.)

1916 SPECIFICATIONS.

503 BOOTHROYD, G. S., & CALLENDER'S CABLE & CONSTRUCTION CO. Cable clamps for electric wiring installations. (21/5/15, divided application on 7,647/15, 100,233.)

4,402 PUTT, L. M. Telegraph machines. (8/2/15, divided application on 1,997/15, 100,239.)

Hydro-Electric Works. A Bill has been brought into the Prussian Diet to authorise the Government to expend £310,000 on the establishment of hydro-electric works at the weirs which are being constructed at Mainkur, Kesselstadt and Gross-Krotzenburg in connection with the general scheme for the canalisation of the Main from Offenbach to Aschaffenburg. The result of a technical examination shows that if four turbo-generators are provided at each place it will be possible to obtain an average of 30,000,000 kw.-hours per annum, or 25,000,000 kw. hours after deducting losses in lines and transformers. It is proposed to erect a transmission line between these works and the Government hydro-electric works on the upper part of the Weser, so that an interchange of supply may be effected when necessary.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	197	Simplex Inspection Lamps. Illustrated	38
Imports and Exports of Electrical Manufactures	198	Osram-Atmos Lamp Not Affected by Atmosphere. Illustrated	38
Business Notices	198	Electrical Accessories Price List	40
Liquidations	198	"Hotpoint" at Brighton. Illustrated	40
Electricity Supply	198		
Traction Notes	199		
Telegraph and Telephone Notes	200		
Miscellaneous Notes	200		
Tenders Invited	200		
The Round Table	33	Tenders Received & Accepted	201
New "Igranic" Two-Coil Magnetic Lock-Out Switch. Illustrated	34	Municipal Accounts	201
Large Continuous-Current Switchboard. Illustrated	37	Companies' Meetings and Reports	202
		City Notes	204
		Electrical Companies' Share List	204

COMMERCIAL TOPICS.

Electrical Engineers and Public Policy. At a meeting of the directors of the Glasgow Chamber of Commerce on Monday last, the chairman (Mr. Jas. W. Murray) moved approval of the minutes of the President's Advisory Committee, which contained a letter from Mr. Sam Mavor, stating that the British Electrical and Allied Manufacturers' Association had taken the initiative in organising meetings of engineers and engineering manufacturers in the chief industrial centres in the hope of receiving the co-operation of technical institutions and commercial organisations for several purposes of vital public importance.

One of the objects of the B.E.A.M.A. was to impress on the public the permanent indispensability of the industry from the point of view of national security in future, and to discuss questions of national policy in regard to (*a*) some measure of Government support to the industry, (*b*) its better commercial organisation by collective effort on the part of manufacturers and engineers, (*c*) the closer alliance between science and industrial production, (*d*) patriotic preference throughout the Empire in purchasing British manufactures. A further letter announcing a forthcoming meeting in Glasgow, and stating that one of the points to be emphasised was the establishment of a Ministry of Commerce, was also read. The chairman said that the Advisory Committee thought it advisable that the Chamber should be associated in this important movement. The resolution was agreed to.

* * * *

Coal Output Restrictions. The Executive of the Mining Association of Great Britain and the Executive of the Miners' Federation of Great Britain will meet next week in order to discuss the question of coal output, and to devise measures to mitigate the loss in production owing to the depletion of labour.

Although the conference has been promoted by the Government, the coalowners and the men's representatives will meet without the presence of Government representatives, and the delegates will be invited to devise a scheme on their own initiative to secure the necessary production of coal during the war. The output for 1913 was 287,412,000 tons, for 1914, 265,643,000 tons; and for 1915, 253,188,000 tons. In 1914, 1,133846 men were employed in the coal mining industry, and last year there were 953,642. The question of the continuation of the eight hours rule will come up for consideration. Up to the present the workmen's representatives have deprecated suspension of the Act, and have appealed for a fair trial of the joint effort of owners and workmen to increase output, while the coalowners have recognised that suspension could not be usefully employed until the time had arrived when co-operation between the parties was possible. The time would appear to have arrived for a reconsideration of attitude on this matter. It has been estimated by the Coal Mining Organisation Committee that if there were no avoidable absenteeism the output would be increased by from 13 to 14 million tons per annum.

* * * *

French Trade with the U.S.A. It is reported that the leading manufacturing and exporting houses in the United States are preparing a systematic campaign for building up business with France.

A commission to be appointed by the American Manufacturers' Export Association will visit France in June and July. The commission will include men of known technical experience, whose business will be to investigate the industrial situation in France with a view to seeing just where American methods and facilities can be employed to advantage in extending that country's manufactures and trade. All the industries of the United States concerned in French trade will have representatives on the commission, and among those who will probably serve are Messrs. James A. Farrell (president of the United States Steel Corpn.), Alba Johnson (president of Baldwin Locomotive Works), E. M. Herr (president of Westinghouse Electric Co.), and George F. Randolph (vice-president of the Baltimore & Ohio Railroad Co.).

* * * *

American Trade with Australia. An interesting stage in the development of trade between America and Australia has been reached in the appointment of Prof. P. B. Kennedy, Director of the Department of Trade and Transportation at New York University School of Commerce, as Commercial Attaché from the United States, to Melbourne.

It is stated that the main object of Prof. Kennedy's work will be to foster a friendly spirit between the United States and Australia, and to help as much as possible to keep the commercial relations between the two on a sound footing.

* * * *

Electricity Supply in Shanghai. On another page we reproduce a very full abstract of Mr. T. H. U. Aldridge's report on the financial and technical progress of the undertaking over which he presides. In so far as the former is concerned, it will be gratifying to the municipality that the undertaking has made a net profit of considerably over £30,000 during the past year. Mr. Aldridge appears to have suffered considerably from breakdowns of turbine plant, and these have principally arisen from the use of defective material in the blading, but in spite of disconcerting breakdowns, the load-factor has been steadily improved and the sales of electrical energy have been increased by over 50 per cent. It is a tribute to the efforts of the turbine makers that by the installation of this class of plant, despite blading troubles, the cost of production during the past year has been reduced by over 20 per cent. Mr. Aldridge has succeeded remarkably well in the development of the Shanghai undertaking, and his success is doubtless attributable to the adoption of a bold policy not only in the ruthless scrapping of antiquated and uneconomical plant, but also in the adoption of a forceful commercial policy in regard to the use of subsidiary electrical appliances, such as radiators, fans, small motors, &c. Mr. Aldridge states that the sale of 680,000 units for heating and cooking has fully justified the adoption by the Council of a scheme for hiring out radiators and cookers. The extent of the power load may be gathered from the sale of 30,000,000 units for this purpose, exclusive of nearly 3½ million to the tramway company for traction purposes: indeed, the power units represent 62 per cent. of the total sales. The future progress of the undertaking is evidently well assured, judging by Mr. Aldridge's estimate that the profit for the coming year will be nearly £40,000, after setting aside a similar sum for depreciation. At one time Mr. Aldridge purchased German plant, but since the war the bulk of his orders have been British, though for reasons of policy some have been given to American firms. It is noteworthy that Mr. Aldridge is not content to sit in his office at Shanghai, but pays regular visits to Europe, and that these excursions prove profitable is evident from his courteous and grateful acknowledgments to various municipal and company electrical engineers in this country from whom he has obtained valuable technical, engineering and commercial advice. Mr. Aldridge has succeeded in setting a high standard of municipal electricity supply in the Far East, which we are hopeful will be emulated by engineers of other undertakings in that part of the world.

* * * *

Municipal Extravagance. Many of the County and Provincial Borough Councils expend large sums of money in promoting Parliamentary bills, schemes of extension, amalgamation, &c. Some of this legislation is of doubtful public utility, but it involves the expenditure of much money and

time on municipal experts, counsel, &c. We are glad to see that the Local Government Board is going to scrutinise more closely expenditure of this character, for, in connection with the recent application of the Plymouth Corporation for sanction to borrow £17,000 to defray the costs incurred in the promotion of and opposition to the scheme for amalgamating the three towns of Plymouth, Devonport and East Stonehouse the Board have refused to sanction, as part of the loan, £1,821, the costs of three counsel engaged in the case.

The Board, in refusing its sanction, points out that no fewer than nine counsel were employed by the three authorities to represent them at the local inquiry, and in the proceedings before Parliament, and it did not think it could possibly declare the whole of the expenditure so incurred to be reasonable. In regard to the other items of expenditure incurred in connection with the scheme, the Board states that it had had great difficulty in deciding that the cost of expert evidence paid for was, in fact, reasonable. It regards with great disfavour the lavish expenditure of the rates in these cases in procuring evidence of experts who have no particular claim to local knowledge on the subject of their evidence, and in the present instance the Board, for its part, would have been perfectly satisfied to decide the case with such evidence as to the financial position of the authorities concerned as could have been given by the local officials, and with similar evidence in regard to the medical and public health aspects of the case. In view of all the circumstances, however, the Board has decided to sanction the expenses incurred on this latter account.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From May 1, 1916, *to* May 6, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

GOOLE.—*France:* Elec. motors, 9 pkgs.
LIVERPOOL.—*U.S.A.:* Unenumerated, 46 pkgs.
LONDON. *U.S.A.:* Elec. machinery, £123; elec. lamps, £1,631; carbon candles £186; unenumerated, £912. *Holland:* Elec. lamps, £4,434 48 pkgs.; incandescent elec. lamps, 20 pkgs.; elec. lamps and caps, 77 pkgs; elec. machinery, £127; unenumerated, £504. *France:* Elec. machinery, £550; unenumerated, £351 13 pkgs. *Switzerland:* Elec. machinery, £307; unenumerated, £321. *Canada:* Wire and cable, £1,308. *Denmark:* Unenumerated, £80. *Egypt:* Unenumerated, £13.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Unenumerated, £100. *Melbourne:* Elec. machinery, £506; unenumerated, £1,132. *Sydney:* Elec. machinery, £430; wire and cable, £2,843; telegraph material, £380; unenumerated, £1,087. *Wellington:* Elec. machinery, £608; wire and cable, £186; unenumerated, £292 *Perth:* Unenumerated, £155. *Christchurch:* Wire and cable, £238; unenumerated, £77. *Lyttelton:* Unenumerated, £81. *Brisbane:* Unenumerated, £54. *Gisborne:* Unenumerated, £10. *Townsville:* Unenumerated, £97. *Napier:* Unenumerated, £69. *Launceston:* Unenumerated, £25. *Rockhampton:* Elec. machinery, £38.
AFRICA.—*Durban:* Elec. machinery, £130; wire and cable, £2,113; unenumerated, £1,135. *Cape Town:* Unenumerated, £203. *Port Elizabeth:* Unenumerated, £345. *East London:* Unenumerated, £105. *Oran:* Elec. machinery, £107.
EGYPT. *Alexandria:* Wire and cable, £27; unenumerated, £32. *Port Said:* Elec. machinery, £70. *Suez:* Unenumerated, £93. *Port Sudan:* Unenumerated, £153.
MAURITIUS.—Unenumerated, £33.
MALTA.—Unenumerated, £21.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Wire and cable, £56; elec. machinery, £80; unenumerated, £1,765. *Calcutta:* Elec. machinery, £35; wire and cable, £40; unenumerated, £1,944. *Ceylon:* Unenumerated, £450. *Madras:* Unenumerated, £84. *Bangkok:* Unenumerated, £517 *Karachi:* Unenumerated, £239. *Singapore:* Unenumerated, £612.
JAPAN. *Yokohama:* Unenumerated, £82. *Kobe:* Unenumerated, £450. *Tokio:* Unenumerated, £695.
CHINA.—*Hong Kong:* Unenumerated, £783. *Shanghai:* Elec. machinery, £1,021; wire and cable, £80; unenumerated, £789
ITALY. *Genoa:* Unenumerated, £3,177.
U.S.A. *New York:* Unenumerated, £70.
SOUTH AND CENTRAL AMERICA. *Buenos Ayres:* Wire and cable, £58, telephone material, £513; unenumerated, £765. *Valparaiso:* Unenumerated, £111. *Rosario:* Unenumerated, £27. *Santander:* Unenumerated, £111
HOLLAND. *Amsterdam:* Wire and cable, £62; unenumerated, £256. *Rotterdam:* Wire and cable, £47; unenumerated, £142
FRANCE. *Paris:* Unenumerated, £204 *Dieppe:* Elec. machinery, £8; unenumerated, £111. *Havre:* Elec. machinery, £35. *Nantes:* Elec. machinery £173. *Rouen* Elec. machinery, £60.
SPAIN.—*Malaga:* Unenumerated, £183 *Bilbao:* Unenumerated, £500.
CANADA. *Montreal:* Unenumerated, £25. *St John's:* Unenumerated, £39.
DENMARK. *Copenhagen:* Wire and cable, £434 unenumerated, £150.
NORWAY. *Christiana:* Unenumerated, £60.
RUSSIA.—*Petrograd:* Elec. machinery, £45.

FOREIGN GOODS (duty paid and free).

Cape Town: Unenumerated, £71. *Durban:* Unenumerated, £69. *Genoa:* Unenumerated, £121. *Launceston:* Unenumerated, £26 *Perth:* Unenumerated, £11. *Sydney:* Unenumerated, £173. *Rotterdam:* Unenumerated, £11 *New York:* Unenumerated, £153. *Shanghai:* Unenumerated, £350.

IN TRANSIT.

Auckland: Elec. lamps, £210. *Melbourne* Elec lamps, £1,680. *Sydney:* Elec. lamps, £583. *Wellington:* Elec. lamps, £250.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

Cecil John Heffer and Fras. E. Bayley (trading as Berners Electric Co.), 55, Berners-street, London, W., have dissolved partnership.

Mr. W. H. Vincent, M.I.E.E., has joined the staff of Messrs. Knox, Schlapp & Co. (Melbourne), and will take charge of their technical department.

Owing to increasing work in searchlights, and also in lamp-lowering gear, the London Electric Firm have been compelled to build new up-to-date works at Brighton-road, Croydon. Notice of the actual change will be given to the trade shortly.

Post Office Stores for Sale.—The Postmaster-General has for disposal for immediate delivery some c.i. and salt-glazed earthenware pipes, salt glazed earthenware multiple conduits, &c., which have become surplus owing to the war. Particulars from the Controller, Post Office Stores Dept., 17-19, Bedford-street, Strand, London, W.C. *See also an advertisement.*

Plant for Sale.—The Metropolitan Railway Co. advertise for sale the electric generating plant until recently employed by the Great Northern & City Railway, including four 800 kw. d.c. generators, with Corliss engines, 10 boilers, four condensing plant, auxiliary engine and generator, coal handling plant, feed pumps, &c.

The Metropolitan Electric Supply Co. (Ltd.), 16, Stratford-place, London, W., advertise for sale an enclosed vertical compound marine type engine direct coupled to two-phase a.c. Westinghouse generator of 1,500 kw. at 500 volts, with exciter, condenser, steam driven air and circulating pumps, oil and steam separators, &c.

Plant Wanted.—An advertiser wants generating plant of about 15 kw. at 230 volts.

Patent Development.—The proprietors of patent No. 13,991/1910, relating to a "Method of and means for controlling from a distance electric apparatus and especially telegraph apparatus and the like," desire to dispose of same, or to grant licences thereunder. Applications to Messrs. Cruikshank & Fairweather (Ltd.), Patent Agents, 65 and 66, Chancery-lane, London, W.C.

LIQUIDATIONS.

The first meetings of creditors and contributories of Cedes Electric Traction (Ltd.) will be held at 33, Carey-street, London, W.C., on May 19.

A meeting to receive an account of the winding up of the Ardwick Electric Regulator Co. (Ltd.) will be held at 67, Princess-street, Manchester, on June 9.

ELECTRICITY SUPPLY.

EXTENSIONS.

Battersea (London).—The Electricity Committee recommends the adoption of a scheme of the electrical engineer (Mr. F. A. Bond) for coping with the increase in the demand for energy in the Nine Elms and Church-road districts.

The scheme involves the erection of a sub-station adjoining the Nine Elms Baths, and the installation of a rotary converter, the extension of one of the e.h.t. mains from New-road to the sub-station, the provision of an additional transformer and switchgear in the New-road sub-station, and the provision of an additional concentric feeder cable to be drawn through ducts already provided from High-street to a point in Church-road. The total cost of the work is estimated at £5,178, and the Council is recommended to apply to the L.C.C. for sanction to a loan for this sum.

Bo'ness.—The Secretary for Scotland has sanctioned the borrowing of £12,000 for the extension of the electricity works, subject to the condition that 1-20th of any sums borrowed is paid off or set aside to a sinking fund annually.

The Council have approved of these terms, the borrowed money to be repaid by being equated over a period of 20 years. The Council have also agreed to ask the National Electric Construction Co. to submit the necessary modification of their original extension scheme.

Fulham (London). The Electricity Committee recommends an extension of the condensing water pipes for a further distance of from 100 ft. to 150 ft. to the river bed, and that a contract be entered into with John Cochrane & Sons to carry out the work at a cost of £1,500.

The Finance Committee also recommends application being made to the L.C.C. for sanction to borrow the above sum, and also £1,000 to cover the cost of extending the mains to the Townmead Works.

Greenock.—On the 2nd inst. the new 5,000 kw. Westinghouse Rateau steam turbo generating set at the Dellingburn electricity works was started.

The set is a duplicate of the one installed two years ago, and consists of a 6,700 H.P. steam turbine coupled to a 5,000 kw. 3,300-volt Westinghouse alternator of the totally-enclosed self-ventilated type with compensated windings.

Councillor DUNCAN M'CALLUM, convener of the Electricity Committee, presided, and in proposing "Success to the New Generating Set," said that in the first year's working of the department the total output was something less than 200,000 units. This went up rapidly, until in the year 1913-14 it reached 11,000,000 units, and it was expected that at the end of the present financial year they would have turned out about double that supply, or at any rate considerably over 20,000,000 units. They had now generating plant to meet their requirements for a number of years, but they were aware that the Corporation had just sought further borrowing powers for £45,000 for cables, &c., and for boilers.

Mr. W. J. POOLE, of the Westinghouse Co., replied, and handed to Mr. M'Callum, for Mrs. M'Callum, a handsome gift as a memento of the occasion; and Sir Hugh Shaw Stewart submitted the toast of "The Large Power Users," to which Mr. R. L. Scott responded; and Bailie Orr proposed "The Officials," to which Mr. Frank H. Whysall, electrical engineer, and Mr. Colin MacCulloch, town clerk, replied.

Halifax.—The Tramways and Electricity Committee will extend the h.t. mains to Messrs. Goodall's premises, at a cost of £1,120.

Hammersmith (London).—The electric supply mains are to be extended at a cost of £208 to Aldbourne and Wormholt-roads, and new switchboards are to be fixed at the Shepherd's Bush sub-station at a cost of £128.

The Council is recommended to agree to supply the Osram-Robertson Lamp Works with electrical energy for four years at 0·8d. per unit, the minimum guaranteed payment to be £5,000 per annum.

The Electricity Committee has decided not to accept any of the tenders received for the supply of coal, but has authorised the electrical engineer to continue his negotiations with the District Coal Supplies Committee for Derbyshire, Nottingham and Leicestershire, with a view of making arrangements for a continuance of adequate supplies at prices to be agreed, from those collieries, and has empowered him to purchase additional parcels of coal up to a total quantity of 1,000 tons.

Rochdale.—At the meeting of the Council last week there was some discussion on a proposal of the Gas and Electricity Committee to spend £60,900 on the extension of the electricity works.

It was urged by the Committee that the expenditure was necessary to meet the growing demands for current for power, and also to enable the Committee to work the plant at full capacity.

Ald. CUNLIFFE suggested that the question should be considered by the Council in committee. It was improbable that the Committee would get permission to borrow the money at the present time, and he was not certain that the scheme proposed was the best.

Sir J. E. JONES said that with the proposed outlay the Committee would be able to increase the output by 100 per cent., which was necessary to meet the growing demands.

It was, however, decided to call a special meeting of the Council to discuss the matter in committee.

Sheffield.—Mains extensions estimated to cost £1,769 have been authorised. Practically the whole of the amount will be spent in supplying Messrs. John Brown & Co. with current.

The Electric Supply Committee records its high appreciation of the valuable services rendered to the undertaking by the late Coun. Crowther during the many years he was a member of the Committee, he having held the positions of chairman and deputy-chairman.

Walsall.—Subject to satisfactory guarantees by intending consumers, the Electricity Committee proposes to extend mains in Wednesbury-road and the Paddock area at a cost of £680, including the necessary transformers and switchgear.

The Committee reports that satisfactory terms have been arranged with the Ministry of Munitions and the contractors concerned as to replacing plant for the new generating station which was commandeered.

Wigan.—Last week the Council adopted the recommendation of the Electricity Committee to apply for sanction to the borrowing of £53,920 for the extension of the electricity undertaking, on the basis of a scheme submitted by Mr. H. Dickinson, Liverpool.

Wolverhampton.—The L.G. Board has sanctioned the borrowing by the Council of £6,600 for mains and sub-station equipment.

GENERAL.

Bootle.—The Council have decided to increase all charges for electric light and power by 12½ per cent. from June 30.

Burnley.—The Electricity Committee have decided not to send delegates to the annual conference of the Incorporated Municipal Electrical Association in London on June 22 and 23.

Burton-on-Trent.—During the past month 219,419 units were sold for lighting, motors, heating, &c., and 35,870 for traction, increases of 70,479 and 8,143 respectively compared with the corresponding period last year.

Itchen. The Board of Trade have intimated to the Council that they have no power to grant an extension of the electric lighting order for three years after the war, but, under the circumstances, they will defer consideration of renewing the order for a year.

Newcastle (Staffs). The charges for electrical energy for power and lighting have been increased.

Nottingham.—The Corporation have voted £60,750 from the profits of the gas, tramways and electricity supply undertakings in aid of the district rate, reducing it by 5d. in the pound.

St. Anne's-on-the-Sea.—At last week's Council meeting the Electrical Engineer (Mr. J. H. Clothier), stated that the output for lighting purposes, for the first time, showed a decrease compared with previous years.

Industrial power demands showed a large increase, and heating and cooking also showed a satisfactory increase.

All electricity charges have been increased 15 per cent. as from the beginning of the current quarter.

Torquay. The Council have agreed, on the recommendation of the Electric Light Committee, to grant Mr. J. M. Keenan, deputy electrical engineer, a bonus of £5. 5s. per month during the absence of the borough electrical engineer (Mr. C. W. Salt) on war service.

Wimbledon.—The Electricity Committee of the Council has refused the request of the proprietor of a picture palace for an allowance to be made off the minimum amount charged for current supplied under agreement, on the ground that, owing to lighting restrictions, he is unable to consume the minimum quantity specified.

The electrical engineer (Mr. H. Tomlinson Lee) has drawn up a scheme for wiring the Council Chamber and providing two electric radiators.

TRACTION NOTES.

Bradford.—The Electricity Committee propose to purchase an electrically-propelled vehicle for conveying coal from the stations to the electricity works and ashes from the works to any tips available.

Gateshead-on-Tyne.—The Council have sanctioned the Gateshead & District Tramway Co.'s application for permission to double the tramways on the Bensham route, provided the company bear the cost of paving the strips of macadam on both sides of the road between the tram lines and the channels, to the satisfaction of the surveyor, at an estimated cost of £675.

Glasgow.—The tramways department have recently allowed a large number of the cleaning staff to join the colours and to engage upon munition work.

The places of these men are being filled by women. There are still several hundreds of men who will shortly be freed to start in munition factories, and women will also replace these.

Middlesex Tramways.—The Board of Trade has sanctioned the running of trailer cars on the tramways of the Metropolitan Electric Tramways (Ltd.).

Newcastle-on-Tyne.—Last week the Tramways Committee reported on the question of increasing the sources of revenue of the tramways department.

The chairman (Mr. R. MAYNE) said the difficulty was not want of traffic, but the need of more profitable traffic. The great difficulty was the increased expenditure. To keep those in the Army in the same financial position as when they enlisted would cost the system £12,000, the war bonuses cost £5,720, income tax was £8,000 more and coal cost £4,000 more. They were not making more than 1d. per car mile, and that was not enough for renewals and the other requirements; it meant they were running the matter too fine. The workmen's traffic ought to pay its way. A draper's assistant living in the extreme west, and working in the extreme east of the city, had to pay full fare. The ordinary worker would be the last to expect that the slight profit on that man's fare should be taken to make up what he (the munition worker) paid short. The loss on the workman's cars was 2d. per car mile. On the proposal to raise the charges for soldiers, he said they desired to be generous, but they ought not to be generous with other people's money.

Ald. FITZGERALD moved an amendment for the deletion of the proposals to raise the prices for soldiers, and this was carried, and the report as amended was then carried.

Salford.—The Tramway Committee have decided, notwithstanding that there is only a balance in hand on the past year's working of £18,400, to hand over £22,000 towards the relief of the rates.

Torquay.—The Electric Light Committee has deferred consideration of the proposed increase in the price of current to the tramways company until August next.

TELEGRAPH & TELEPHONE NOTES.

P.O. Telegraph and Telephone Administration.—The Post Office provincial superintendents and the headquarters staff of traffic managers have been amalgamated into one establishment, under the control of Mr. R. A. Dalzell, with the title of Chief Inspector of Telegraph and Telephone Traffic. His two principal assistants will be Mr. L. Harvey Lowe, late Deputy-Controller of the London Telephone Services, and Mr. J. Lee, with the title of Deputy Chief Inspector of Telegraph and Telephone Traffic. Mr. W. A. Valentine, late Provincial Superintendent, has been appointed Deputy-Controller of the London Telephone Service.

Atlantic Radio-Telegraph Service.—Marconi's Wireless Telegraph Co. announces the resumption of the Deferred Night and Week-end Letter Services, suspended recently owing to the trouble in Ireland, and their traffic can now be expeditiously handled, as their land line communication with the high power Trans-Atlantic wireless station in Ireland is restored.

Australian Government Radiotelegraph Service.—The Cabinet of the Australian Commonwealth Parliament has decided that the wireless system of the Commonwealth, created under the supervision of Mr. J. G. Balsillie, and hitherto attached to the Postmaster-General's department, shall henceforth be under control of the Navy department, and be called the Royal Australian Radio Navy Service. Employés on shore stations will wear a uniform similar to the naval uniform.

Wireless Telephony in U.S.A. Navy.—It is reported that Mr. Daniels, Secretary of U.S. Navy, has communicated by means of a wireless telephone with the commander of a battleship off the coast. This is claimed to be the first time communication by wireless telephone between ship and shore has been established.

Radiotelegraphy in Bolivia.—A correspondent of the "Chamber of Commerce Journal," referring to the legislative enactments of the Bolivian Congress in the past session, says these included one approving the Governments resolution rescinding the contract with Marconi's Wireless Telegraph Co. for the installation of a wireless telegraph service in Bolivia.

The rescission of the contract was due mainly to economic reasons. The erection of a new wireless station at Viacha, 29 km. from La Paz, is now under way in charge of Bolivian engineers. Aside from this station there are five wireless stations in Bolivia at present, the powerful Marconi station at Riberalta in the eastern provinces, and four smaller stations in the Gran Chaco, three Telefunken and one Marconi.

MISCELLANEOUS NOTES.

Enemy Firms to be Wound Up.—Claims against the United Berlin-Frankfort India Rubber Co. (Ltd.), 57, Carter-lane, E.C., are to be sent to the controller, Mr. P. D. Leake, 25, Abchurch-lane, E.C., by June 6.

The total number of orders made by the Board of Trade for the winding-up of businesses controlled by alien enemies is now 131. Amongst the latest firms in regard to which orders have been issued are: Coutinho, Caro & Co., 134, Fenchurch-street, London, E.C., metal merchants (Controller: N. W. Wild, 22-28, Broad-street-avenue, E.C.); Wolf Safety Lamp Co., Boston-street, Sheffield, engineers and lamp manufacturers (Controller: T. G. Shuttleworth, Royal Insurance-buildings, Church-street, Sheffield); E. M. Brinckman & Co., 99, Redeross-street, Southwark, London, S.E., merchants (electric lamps, batteries and gas mantles) (Controller: K. C. Fox, 45, London-wall, E.C.)

Exports to Liberia.—On April 26 H.M the King issued a Proclamation prohibiting the export of all articles from the United Kingdom to Liberia, unless consigned to a person or persons authorised by the Foreign Office or the Board of Trade.

A list of persons and companies in Liberia to whom goods may be consigned has been issued and includes H.M. Consular officials: American Legation, American Officers of Liberia Frontier Force (Monrovia); Cie des Cables Sud-Americains (Monrovia): Liberian Rubber Corpn, Ltd. (Monrovia); Spanish Consulate (Monrovia); Statian Radiotelegraphique Francaise (Monrovia), and others.

Royal Flying Corps.—The following Committee has been appointed to inquire into the administration of this corps: Mr. Justice Bailhache (chairman), Mr. J. G. Butcher, M.P., Mr. E. Shortt, M.P., Mr. J. H. Balfour Browne, K.C., the Hon. Sir C. Parsons, K.C.B., Mr. Charles Bright, F.R.S.E., M.I.E.E. It was intended to invite a military officer of high rank to join the Committee.

Trading With Enemy Firms.—Further additions to the lists of persons and firms with whom persons and firms in the United Kingdom are prohibited from trading appear in the "London Gazette" of May 9.

These include: *Denmark.*—Allgemeine Electricitäts Gesellschaft (Vestergade 23, Copenhagen); Anglo-Russian Trading Co. (Dron Vaerg 3, Copenhagen); Continental Caoutchouc & Gutta Percha Co. (Amaliegade, Copenhagen).

Japan.—Accumulatoren Fabrik Aktien Gesellschaft (32B, Tsukiji, Tokyo); Carlowitz & Co. (124, Higachi-mashi and 11, Isogami Dori 5, Nichome, Kobe); Siemens-Schuckert Denki Kabushika Kaisha (65, Bojima Hamadori, Osaka, 48 Akashicho Tsukiji, Tokyo; Kobe and Moji).

Wills.—The late Mr. Harold Faraday, electrical engineer, of Wardour-street, W., left property of the value of £29,495.

The late Sir Charles Rivers-Wilson, G.C.M.G., chairman of the British Electric Traction Co., left £10,097.

TENDERS INVITED.

Mechanical Stokers.

The Tramways and Electricity Committee of BELFAST Corporation invite tenders for the supply of Chain-grate Mechanical Stokers. Specification, with form of contract, from the city electrical engineer (Mr. T. W. Bloxam), East Bridge-street, Belfast. Tenders must be lodged at the Town Clerk's office, City Hall, Belfast, by 10 a.m. May 24. *See also an advertisement.*

Electric Lamps, Lamp-Holders, &c.

Tenders will be received until 11 a.m. June 14 by the VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, for the supply of 5,000 6 volt, and 1,000 110 volt Electric Lamps for signal system (Contract 29,912); 1,000 Lamp-holders (Contract 29,913); and 3,000 gals. of Wood Preservative (Contract 29,930). Specifications, &c., may be obtained from the offices of the Commissioners.

Transformers, Mains, Water Wheels, Alternators, &c.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. May 31 for supply of Transformers, with Terminal and Fuse Boxes during five years. The first order will be for 220 transformers to be delivered in six months. Specifications, &c., from the Commissioners' Offices, Spencer-street, Melbourne.

OAMARU (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1. 1s. for each contract.

Telegraph and Telephone Material.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, Perth (W. Australia) requires tenders by 3 p.m. June 7, for the supply of 15 tons of Galvanised Iron Wire (Schedule 508, W.A.), for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specifications from office of Deputy Postmaster-General, Perth, W.A.

The Secretary of the Department of Public Works, OTTAWA, will receive tenders until 4 p.m. May 15 for the supply and delivery at Halifax (N.S.) of 10 knots of Single Conductor Submarine Telegraph Cable (107 lb. copper and 150 lb. gutta percha per knot), with g.i. wire sheathing. Specifications from the General Superintendent, Canadian Government Telegraph Service, Ottawa.

Steam Generating Plant.

The NEW SOUTH WALES DEPARTMENT OF PUBLIC WORKS will receive tenders until 2 p.m. May 22, for the supply and erection of Steam Generating Plant for the power station at Port Kembla. Specification, &c., may be obtained from the Department of Public Works, Sydney.

Coal-Handling Plant.

MANCHESTER Corporation require tenders by 10 a.m May 17 for Automatic Coal-handling Plant for Stuart-street station.

Wiring.

KEIGHLEY AND BINGLEY Joint Hospital Board require tenders by May 22 for the wiring of the Fever Hospital and Sanatorium at Morton Banks. Specifications, &c., from the Borough Electrical Engineer.

Tramway Construction, Tramcars, &c.

DUNEDIN (N.Z.) City Council require tenders by 5 p.m. May 17 for six Electric Tramcars and sections of Cars (Bodies, Electrical Equipments and Trucks). Specifications, &c., from the Town Hall, Dunedin.

JOHANNESBURG (Transvaal) Council require tenders by noon June 6 for supply of two Manganese Steel Crossings, and for the supply of 500 c.i. Joint Boxes and 200 Hanks of Trolley Rope (contract No. 112). Specifications, &c., from the municipal offices, Johannesburg.

The Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, require tenders by May 19 for the construction and working, for 60 years, of an electric Tramway in BILBAO, connecting the existing system with the Irala-Barri district. Minimum rolling stock required to commence is one motor and one trailer coach for passengers, and one motor goods coach and two trailer goods wagons. An option on the concession is held by the Sociedad Tranvia Urbano de Bilbao.

The Public Works Dept., Madrid, will receive tenders until noon May 30 for the Construction and Working (for 60 years) of an Electric Tramway in MELILLA (North Africa). The minimum rolling stock required is 16 coaches, with motors and accessories. An option is held by Don Felipe Ezquerro.

TENDERS RECEIVED AND ACCEPTED.

ACCRINGTON.—The Electricity Committee has accepted the following tenders :—

Lancashire Water Cooler Co., water cooling tower ; British Thomson-Houston Co., 2,000 kw. turbo-alternator, with condenser, &c. ; J. P. Hall & Sons, boiler feed pumps ; Holden & Brook, feed water heater ; Ed. Bennis & Co., for modernising one set of mechanical stokers.

BOLTON.—The Electricity Committee have accepted the tender of J. & N. Dickinson (Ltd.) for the construction of a sub-station near Melrose Mill for supplying electricity to Lostock.

SHEFFIELD.—The Council have accepted the tender of Phœnix Dynamo Mfg. Co. for supply of a spare armature for pump motors at £67.

WOLVERHAMPTON.—The Electricity Committee recommends the Corporation to accept the tender of Strachan & Henshaw (at £515) for the installation of ash handling plant at the electricity works.

MELBOURNE (VICTORIA).—The Council have accepted the tender of the Australian Gen. Elec. Co. for 600 gas-filled metal filament lamps, £381. 15s.

SYDNEY (N.S.W.).—The Electric Lighting Committee recommend the City Council to accept the tender of Noyes Bros. for insulated wires and cables (specification 448), £7,181. 8s. 3d., the basis o

copper being taken at £110 per ton ; and that of R. Johnson, Clapman & Morris for g.i. steel and iron wire (specification 447), £522. 19s. 2d. The committee also recommended that the following be purchased under existing contracts : Lawrence & Hanson, service and fuse boxes (specification 397), £2,644. 15s. 10d. ; Australian Gen. Elec. Co., three-phase motors for Ipswich (specification 382, sec. D), estimated cost £1,100 ; Noyes Bros., meters, 10 200-ampere 240-v. d.c., 2,500 5-ampere 240-v. a.c., 500 10-ampere 240-v. a.c. 50 200-ampere 240-v. a.c.

Temperature Measurement Contracts.—The Cambridge Scientific Instrument Co., of Cambridge, inform us that they have received during the past month Government contracts for temperature measuring instruments from the Ministry of Munitions, Royal Naval Cordite Factory, Victorian Government railways, Small Arms Factory (at Lithgow, Australia), and the Russian Government Supply Committee.

Commonwealth Contracts.—The following tenders have been accepted by the Australian Government departments :—

Postmaster-General's Dept., Melbourne.—Western Electric Co., 500 resistance boxes 9s. 3d. each, ditto 9s. 6d. each, 150 ditto 9s. 11d. each ; J. Bartram & Son, 3,560 retardation coils 1s. 8d. each, 3,700 ditto 2s. each, 560 induction coils 2s. 8d. each, 500 generators 21s. 6d. each, 7,000 indicators 3s. 8d. each, 10,500 ditto 3s. 7d. each, 9,954 jacks 10½d. each, 2,700 listening and ringing keys 4s. 4d. each, 100 microphones 1s. 7d. each, 1,150 plugs 11½d. each, 100 switches 3s. 3d. each, 100 telephone meters 29s. 9d. each ; Automatic Telephones (Australasia), 240 telephones 51s. 9d. each, 60 ditto 60s. each.

Postmaster-General's Dept., Sydney.—Automatic Telephones (Australasia), 400 (reduced from 3,750) telephones, £2. 14s. 9d. each ; Jas. Paton, 300 telephones £1. 10s. 9d. each, 150 ditto £3. 2s. each, 50 ditto £3. 14s. 6d. each, 50 miles wire £9. 5s. per mile ; Colonial Rubber Co., 750 lb. sheet ebonite, 4s. per lb. ; Brit. Gen. Elec. Co., 9,740 protectors, 5s. each ; Western Elec. Co., 4,000 pole steps, £1. 19s. 1d. per 100 ; Lawrence & Hanson Co., single silk-covered annealed copper wire, 20 lb. 2s. 5d. per lb, 15 lb. 2s. 6d. per lb., 10 lb. 2s. 8½d. per lb., 10 lb. 3s. 2½d. per lb., 20 lb. 4s. per lb., 30 lb. 4s. 7½d. per lb., 30 lb. 5s. 8½d. per lb., 50 lb. 9s. 2½d. per lb., 20 lb. 16s. 9d. per lb., "Eureka" silk covered wire, 10 lb. 6s. 9½d. per lb., 10 lb. 7s. per lb., 10 lb. 7s. 7½d. per lb., 10 lb. 8s. 4¾d. per lb., 10 lb. 9s. per lb., 10 lb. 9s. 7d. per lb., 10 lb. 10s. 2½d. per lb., 10 lb. 10s. 9½d. per lb., 10 lb. 13s. 2½d. per lb., 10 lb. 15s. 7½d. per lb. ; British Insulated & Helsby Cables, double-coated silk covered annealed copper wire, 20 lb. 3s. 5d. per lb., 10 lb. 4s. per lb., 10 lb. 4s. 6d. per lb., 50 lb. 5s. 5d. per lb., 10 lb. 5s. 11d. per lb., 10 lb. 6s. 5d. per lb., 10 lb. 7s. 5d. per lb., 10 lb. 8s. 11d. per lb., 10 lb. 11s. 5d. per lb., 10 lb. 13s. 6d per lb., 10 lb. 16s. 6d. per lb. ; F. Holden, erection of telephone line between Marlee-Bobin line and Hyndman £56. 5s., supply and erection of 25 ft. wood poles 15s. per pole and 20 ft. poles at 10s. per pole, and erection of 500 lb. per mile g.i. wire, about 14 miles 7 chains, £85. 5s.

Postmaster-General's Dept., Adelaide.—British Insulated & Helsby Cables, 12 Morse sounders 11s. 6d. each, 11,000 copper tapes and insulators to specification 526, as per schedule 401, £46. 17s. 6d. ; Felton & Grimwade, 1,000 glass tubes for cells, £2. 14s. ; Firebrick Insulator & Pottery Co., 7,000 porcelain insulators, "A" to drawings C35, C36 and C37, sealed pattern, 6¾d. each.

Postmaster-General's Dept., Brisbane.—Western Elec. Co., 800 coils 1s. 6¾d each ; Moreland Metal Co., 5 tons 18 cwt. scrap copper £399. 14s. 6d., 5 tons ditto £410. 0s. 5d., 13 tons 18 cwt. bad scrap £286. 4s. 9d., 1 ton 1 qr. copper wire £75. 3s. 6d., also 10 cases 10s.

Victorian Railways.—J. G. Black telegraph wire, £22 per ton ; Noyes Bros., Ackley hand brakes at £8. 5s. each for new bogie cars, for St. Kilda-Brighton electric railway ; Australian Gen. Elec. Co., material for railway car lighting, at rates.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Blackburn.—The accounts of the tramways department for the year ended March 31 show total capital expenditure £336,258. The total amount placed to sinking fund is £107,800.

Revenue was £68,410 (compared with £68,302 for previous year), and working expenses were £46,964 (£46,928). Interest required £3,515, sinking fund instalments £9,711 and loan repayments £6,022, the net profit being £1,756 (against £1,572). Average fare charged per mile was 0·76d., average total revenue per car-mile was 14·20d., and working expenses (including power) were 9·74d. Passengers carried were 12,246,151 (against 12,223,569), car-miles run 1,091,050 (1,121,769), and units used 1,678,976.

In his report the general manager (Mr. J. H. Cowell) states that during the year 4 miles of trolley wire were renewed, another portion should be renewed this year, but as the wire cannot be purchased at present, he has had this portion anchored, so that there will be less danger of accident in case of breakage, by which means renewal can be deferred for another year. Renewals and repairs of permanent way have been carried out where necessary ; another portion should be renewed during the coming year, but, owing to the difficulty of obtaining rails, it is to be left over for the present, and Mr. Cowell has had renewed the really dangerous sections of the routes, and the portions held over for renewing occur on the straight and not on inclines, so that the result of a car leaving the rails will not be so serious. After allowing for the energy used for rail grinding, &c., the average consumption per car-mile is 1·53 (against 1·54) units. Female labour has been introduced, and will be extended as necessity arises. The venture has so far been successful. 119 of the employes are serving with the military and naval forces, and the amount paid to dependants of these for the year was £1,765.

Preston.—The accounts of the tramways department for the year ended March 31, 1915, which have just been issued, show gross capital expenditure £192,799, of which £111,495 was outstanding.

Revenue was £47,775 (against £45,946), working expenses were

£29,802 (£29,585), interest required £3,354 (£3,625), and sinking fund £5,189 (£5,038), leaving net balance (placed to reserve) £3,205 (£2,551). Revenue per car-mile was 10·35d. (10·54d.), and working expenses were 6·57d. (6·92d.). Passengers carried were 10,761,381 (10,340,688).

Shanghai.—The accounts of the municipal electricity undertaking for 1915 show gross capital outlay £754,735 (increase £74,047).

Revenue was £216,099, gross profit £67,180, and net profit £32,363.

In his report the engineer-in-chief (Mr. T. H. U. Aldridge) says the department's policy, financial stability and technical soundness had been vindicated in the opinion of Mr. A. H. Preece and the treasurer. An unsatisfactory feature of the year was the breakdown of the German built turbo-alternators at Riverside. At one critical period 66 per cent. of the turbine plant was unavailable for service owing to defects. Unsuitable material used in the manufacture was responsible for the trouble. Chemical analysis of the metal used for the turbine blading conclusively proved that a wrong selection was made in its choice. Two of the machines which developed blade trouble had been in commission only one year and nine months. Other mechanical defects had since shown up. An electrical breakdown also occurred necessitating re-winding part of one of the alternators. It may be asked why were these machines selected. Tenders were publicly invited. The selected ones were, theoretically, taking price, steam consumption and guaranteed efficiency into full consideration, the best offered, and it would at the time have been difficult to have passed them over. The two 2,000 kw. A.E.G. machines (which had been in commission 1 year and 9 months) have cost £318. 15s. and £267. 10s. per annum respectively for repairs and maintenance, while the British machines at Fearon-road, which had been in commission from 5 to 9 years, have varied from £17. 12s. 6d. to £52 per annum. Not only had the German turbines proved defective in Shanghai, but several transformers had also shown marked inferiority to either British or American ones in service. The year's working showed a further reduction in the costs of production of 22 per cent. from last year's figure. The greatest reduction was in coal, partly due to a cheaper price paid, partly to supervision and again to the lower steam consumption of one of the new 5,000 kw. turbines. Sales of electricity increased by 52 per cent. Those yearly reductions in works costs were indicative of what might be looked for when the new extensions in hand were completed; they brought nearer to realisation the hoped for reduction in the prices charged for lighting, heating and cooking. Coal cost 0·255d. per unit sold (against 0·306d. in previous year), and total working expenses were 0·534d. (against 0·684d.). The generating plant capacity of the two stations is 19,600 kw. Maximum load on the two stations was 14,400 kw. Shortly before the close of the year some of the large mills shut down temporarily, one accounting for 500 kw., while quite a number of small power users had also stopped operations, due to trade depression. Traction load was practically the same as last year. Load factor increased from 33·6 per cent. in 1914 to 40·8 per cent. During the year 119·20 miles of cable were erected for enlarging and extending the overhead mains and 0·65 miles of e.h.t., 2·13 miles of l.t., and 0·50 mile of pilot cable laid. Forty-three additional transformers were put into service totalling 11,606 kw., and the net increase in transformer capacity is 5,394 kw. The total capacity of transformers in service is 18,284 kw. Arrangements were concluded with the French Tramway & Lighting Co. for a bulk supply up to 400 kw., and the company's demand has so far averaged 228 kw. There are 44 arc lamps and 1,422 metal lamps for public lighting. Practically all the incandescent street lamps are now of the so-called half-watt or nitrogen type. The current consumption of these lamps is approximately 0·75 watt per candle, compared with 1·2 watts per candle consumed by the ordinary metal lamp formerly in use. There were 1,000 electricity meters issued. This figure represents the net increase in meters issued during the year after allowing for meters returned for cleaning and repair, and there were 16,992 meters in use at the end of the year and 1,092 current limiters. Service connections increased 3,119, making the total 18,104. Additional 30 watt (equivalent) lamps connected during the year were 92,331, a total of 621,078. These include fans, radiators and cookers, but neither street lamps nor motors. Motors connected were 299, aggregating 1,972 h.p., and disconnected 162 (= 2,607 h.p.), net increase 137 (= 2,365 h.p.) The total horse-power on the mains is 14,547. Indications justify a belief that there will be a large increase in small motors. With regard to larger power installations, negotiations have been concluded with 10 oil, cotton and flour mills for an aggregate prospective total of 6,210 h.p. Electric heating has become thoroughly established. The number of additional radiators connected during the year—practically all of which were hired out—increased by 345. This brings the total number of radiators to 1,216 = 2,432 kw. This form of heating has become popular amongst foreigners and Chinese alike. The absence of dirt, smell and fumes and also the portability of the electric radiator are all in its favour. The cheap heating rate of 2·5 candareens (0·75d.) per unit still further attracts consumers. Electric cooking has not had an opportunity of expanding, because the cooking ranges ordered to meet the demand could not be procured. These ranges, on order for over a year, were not delivered in Shanghai till January this year. Electricity for heating and cooking, not only in Shanghai but in other countries, will supersede other forms wherever the price charged for current is sufficiently low. In the earlier stages of development much disappointment was caused by the unreliability of the heating elements, but these initial difficulties, common to many innovations, have been steadily overcome, and at the present time the appliances obtainable from the manufacturers who have specialised in this class of work are very great improvements over the early products. Such firms as the Carron Co. and the Falkirk Iron Works, which have been engaged upon the manufacture of domestic and other cooking ranges for over a century, have laid out sections of their works for the manufacture of electric heating and cooking appliances. Total sales of electricity were 49,787,397 (an increase of 52·6 per cent.) The increases and decreases were: Private lighting, +14·2 per cent.; public lighting, −4·7; heating and cooking, +71·5; power, +101; traction −6·4; total, −52·6. 62,291,443 units were generated. Of the European staff 18 per cent. are serving with the Colours. The loss in action of Mr. Budd, the late chief clerk to the department, has to be recorded. The estimated net profit was £31,506. 7s. 6d., and that actually made was £32,363. 13s. 6d. At the Riverside works two turbine-driven 10,000 kw. generators and one of 5,000 kw. generator are to be installed, increasing the plant capacity of the station to 39,000 kw. The alternators are designed to generate at 6,600 volts, and by means of step-up transformers, connected directly to the generators, the pressure will be transformed up to 22,000 volts. The transformers are designed with an internal reactance of 5 per cent., so that by their use the employment of external reactances now usually regarded as necessary in big power stations will not be necessary. One of the 10,000 kw. turbines will be of the impulse type, such as those already installed, and the other 10,000 kw. set will be of the Parsons reaction type. These two machines will have to operate under identical conditions, thus there will be excellent opportunities for observing the merits of the two machines. The 22,000-volt switchgear is arranged as far as possible so that a breakdown to one part should not seriously affect the other sections. It occupies three separate floors, and the lay-out is designed to reduce the risk of fire to a minimum. The general lay-out of the switchgear is the result of the department's own ideas, together with improvements which have been suggested from observations made in some of the newest and most up-to-date power stations in Great Britain and the United States. The writer's particular thanks are due to Mr. Lackie (Glasgow) and Mr. P. V. Hunter (Newcastle-on-Tyne). There will be eight new boilers, all of Babcock & Wilcox water-tube marine-type, fitted with self-contained superheaters and feed water heaters. Each boiler is designed to evaporate 40,000 lb. of water per hour at a pressure of 200 lb. per square inch and at a temperature of 575° F. under normal conditions.

Mr. Aldridge informs us that the remarks in his report regarding the German turbo-alternators and transformers which have been installed are being made use of by the British Consular service at Shanghai, it being intended to distribute them throughout the various British Consulates in China, hoping that it may, to some extent, influence prospective buyers in favour of British manufacturers. The price per unit sold has been reduced to 0·534d., which figure Mr. Aldridge thinks compares favourably with the majority of stations in England, and is only equalled by a few. These works costs include repairs and maintenance of mains, and these are somewhat higher than is the case at home, owing to the enormous extent of the overhead system of distribution. It is found in practice that there is little use installing any radiators with a capacity of less than 2 kw., and 2 kw. has been made the minimum standard at Shanghai. Last year the department constructed several hundred radiators themselves, with satisfactory results. The luminous lamp type is not encouraged, and a great number of that type have been converted into the hot wire pattern. Practically all the electrical radiators in service are hired out by the department at 1s. 3d. a month. Had the council not undertaken to hire out radiators and cookers, it is certain that this application of electricity would never have made headway. The sale of 680,000 units for heating and cooking justifies the policy pursued by the department. Over 30,000,000 units were sold for power purposes, excluding 3,395,000 sold to the tramway company for traction. Units sold for power were 62 per cent. of the total sales, of which the higher load-factor and reduction in works costs is a direct reflection. The net profit of £32,363 was made after providing £27,877 on loan interest and providing £38,087 for depreciation. The return of profit on capital outlay increased to 8·91 per cent. The profit for 1916 is estimated at £39,567, and £11,573 will be set aside for depreciation. With regard to the 25,000 kw. extensions, the alternators which generate at 6,600 volts are to be tied to large transformer units for raising the pressure up to 22,000 volts, and the trunk cables are to be of the split conductor type. Whilst for reasons of policy some of the new plant will be American, the greater bulk of it is to be British.

COMPANIES' MEETINGS AND REPORTS.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—At the meeting on Friday last Sir H. S. Leon, who presided in the absence of the chairman (Mr. F. A. Bevan), stated that their relations with their lessees (the Western Union Telegraph Co.) continued to be most friendly. The directors recently inspected the new premises of that company in Great Winchester-street, where the whole of the London operating stations had been consolidated, and where the latest appliances for the transmission of messages and scientific methods of handling cable business had been installed. The war had, if anything, made the agreement with their lessees more secure, as there was every evidence that through it the receipts for cable business had largely increased. Moreover, the equipment of the Western Union Co.'s new premises at very considerable expense emphasised their determination to respect the lease and to continue their conduct of the cable business under the most up-to-date conditions. During the past year £14,846 was spent upon the renewal of cables. In order to provide the money necessary to pay for the new ship which had been built to replace the s.s. "Minia," they had to realise renewal fund investments, and though the operation was a loss of £7,505, they had the consolation

that the new ship, which had cost approximately £86,000, could not now be built and equipped for much, if anything, less than £140,000. The new vessel, which had been named the "Lord Kelvin," had been handed over to the service of the Western Union Co. in accordance with the terms of the lease.

ANGLO-PORTUGUESE TELEPHONE CO. (LTD.)—The gross revenue of the past year was £81,923. Expenses were £51,577 and royalties to Government £2,459, leaving a gross profit of £27,886. After payment of income tax (£1,349) and providing for debenture interest (£1,937) and sinking fund (£1,662), the amount available (including £5,471 brought forward) is £28,409. Of this amount £2,000 has been added to exchange fluctuation account and £10,000 to renewals fund. In November last an interim dividend of 3 per cent. was paid (less tax), and the directors now recommend a further dividend of 5 per cent. (less tax), making a total distribution of 8 per cent. for 1915, and leaving £4,409 to be carried forward.

BATH ELECTRIC TRAMWAYS (LTD.)—Sir James Sivewright, K.C.M.G., who presided at the recent meeting, said that the past year's traffic and other receipts showed a decrease of £5,558, compared with 1914. That was largely attributable to the reduction of their motors in the latter part of 1914. Economies had more than offset the diminution in receipts, so that they had actually a greater net revenue than in 1914. All their men of military age had offered themselves for service. Some were rejected, but 171 had joined the Naval and Military Forces, while 50 others had attested. After paying all expenses of operation and administration the balance was £16,553. After paying interest on the first mortgage debentures, the dividend on the preference shares, &c., the balance was £8,486. There was a promising future before the company.

CALCUTTA TRAMWAYS CO. (LTD.)—Sir Hy. Kimber, Bart., presided at the meeting last week, and said that the traffic receipts for the past year were £225,058, or only £1,313 less than in 1914. The working expenses were £118,189, a decrease of £2,693. The profit was £107,825. Capital expenditure during the year (£11,720) was incurred on completing the new Dalhousie-square sub-station and the new alternating-current set at the Nonopookur power station. Ten new motor cars had been ordered before the war, but not being immediately required for service they had remained incomplete. The final dividend was 6s. 6d. per share, making 9½ per cent. for the year, which will be paid (less tax), and the usual contributions of £15,000 to reserve and £1,309 to provident fund had been made. For the current year the aggregate receipts to date showed an increase of £4,721 over those for the same period last year, but they must expect that with the continuance of the war, the cost of all materials, freights, &c., would continue to advance, with the addition of increased import duties and income-tax to be levied in India.

INDIAN ELECTRIC SUPPLY & TRACTION CO. (LTD.)—The surplus on the working in Cawnpore during 1915 (including £144 interest accrued) was £15,932 (against £12,724 in 1914), and including further interest in England and transfer fees the net revenue account shows a credit of £15,993. After providing for debenture interest the net profit is £10,264. The directors have placed £2,000 to general reserve, £3,000 to reserve for depreciation and renewals, and £500 against expenses on debenture issue. They recommend a final dividend of 3½ per cent., making 6 per cent. for the year, and leaving £800 (against £717) to be carried forward. Mr. J. G. B. Stone stated at the meeting last week that the capital expenditure during the year was £2,488 for additions to engine-room machinery and mains. The increase in the number of units sold was 598,928, or 25 per cent., and the net profit in Cawnpore had risen from £12,724 to £15,931, or 25 per cent. increase. The actual price per unit was slightly lower, but that had been more than balanced by the lower cost of generating. The supply side continued to expand, and new districts were awaiting development as soon as conditions allowed. The short length of tramway still yielded no profit, although it was a convenience to the Indian population.

LISBON ELECTRIC TRAMWAYS (LTD.)—The result of the operations for 1915, after deducting interest and amortisation due on debentures of the Companhia Carris de Ferro de Lisboa, and after payment of £25,570 for interest on and redemption of debentures of that company, and also payment of London office expenses and directors' remuneration, shows a net profit of £59,917, which, added to £2,883 brought forward, gives a balance of £62,800. Out of this amount the usual 6 per cent. preference dividend (£25,533) has been paid. In November the directors also paid on the ordinary share capital an interim dividend of 2½ per cent. net (£15,851), and they now recommend payment of a final dividend of 2 per cent., making 4½ per cent. net for 1915. The balance of £8,736 will be carried forward. In order to meet this year's contribution to depreciation reserve £25,000 has been transferred to that account from the exchange reserve to represent this year's appropriation, it being considered that this sum would have been available out of profits for this purpose, had it not been for the heavy fall in the rate of exchange, and as the exchange reserve account was set aside for this purpose it now falls to be drawn upon. The tramways carried 67,101,249 passengers, earning Es. 2,022,142893,5, compared with 63,758,037 passengers and earning Es. 1,938,210 $79.3 in 1914. The traffic receipts and the number of passengers carried continue to expand, but the abnormal high price of coal and other supplies, as well as the cost of labour, have caused a considerable addition to the expenditure. The company has also suffered from the heavy depreciation in the Exchange, the average rate of which, during the year, has fallen from 43·43d. to 35·97d. With the exception of one small incline, which it is hoped will be completed during the current year, the remainder of the Ascensores lines have been electrified and re-opened to traffic.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—Sir Cecil Franklin, who presided at the recent annual meeting, said the income of the company was derived from two sources: from telephone exchanges actually owned and worked by the Oriental Co. at Madras, Mauritius, Singapore, Rangoon and Moulmein, and from investments in other telephone companies in different parts of the Empire. The gross revenue from subscriptions, rentals and sales amounted to £57,578, compared with £51,731 in 1914. The increase was mainly due to developments at Madras, Mauritius and Singapore. Dividends and interest from associated companies (£33,429) showed an increase of £1,698 due to larger dividends receivable from the Bombay and the China and Japan companies. The Bombay Co. paid 20 per cent. and the China and Japan Co. 10 per cent. The working expenses during the year amounted to £29,870, and to those should be added the London expenses (£3,076), an item which had largely increased by heavier income tax and excess profits duty. With the balance from 1914 of £56,136 there was a total of £115,063 for disposal. Deducting the interim dividends on the preference and ordinary shares, interest on debenture stock and the charge for the redemption fund, the net balance was £99,726, out of which it was proposed to pay a final 3 per cent. on the preference shares, and a final dividend on the ordinary shares of 6 per cent., transferring certain sums to reserves and staff pension fund £2,000, and carrying forward £15,197. With reference to the transfer to reserve, it should be borne in mind that telephone plant in tropical or semi-tropical countries was peculiarly liable to depreciation not merely from ordinary wear and tear, but from other causes, such as the substitution of underground for overhead construction, developments in the art, typhoon storms and many other contingencies of that kind. With regard to the Telephone Co. of Egypt, they had recently found it necessary to send out their consulting engineers to make a very careful investigation, and to report on the state of the plant and its value. Having done that with regard to Egypt, they thought it might be necessary to extend it a little further, and to consider how far it was desirable to gain similar information as to the value of their plant and the best means of developing other parts of the company's systems. With regard to the Oriental Co. they were proposing to earmark, for the first time, £40,000 to reserve for depreciation. They were transferring £70,000 to a reserve fund account. How much (if any) of that £70,000 was profit depended upon the investigation they were proposing to make.

SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO. (LTD.)—Mr. W. Gascoyne Dalziel, who presided at the meeting last week, said that one-third of their employés had joined H.M. forces, and four had been killed. Under the arrangement with the Treforest Electrical Consumers' Co., all working expenses were borne by that company. There had been a satisfactory expansion of the business during the year, the units sold amounting to 28,967,656, compared with 26,510,198 in 1914. After paying expenses and setting aside £5,079 for depreciation, the surplus was £6,756. 3s. 8d. That enabled payment of a half year's interest to Dec. 31 last on the old debenture stock, leaving £1,756 3s. 8d. to be carried to suspense account. As they had in hand £3,999 brought forward, there was a fair prospect that they would be able to pay the whole of the interest for the present year, and with important new business which they had in view they anticipated that the debenture interest would in future be earned. There could be no doubt that with the large increase in the number of units sold they would in normal times have earned a much larger surplus. During the past year additional connections to the system amounted to 2,415 h.p., and negotiations were concluded with new consumers which, together with the anticipated increased demands from existing consumers, would probably result in a substantial addition to the total horse-power connected to their mains.

WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)—The report for the half-year ended Dec. 31 states that the amount to credit of revenue is £33,553. 5s. 2d., compared with £39,935. 2s. 1d. in the corresponding half-year of 1914, and the expenses have been £22,987. 1s., against £31,251. 15s. 6d. The balance is £10,566. 4s. 2d., to which is added £1,845. 19s. 2d. interest on investments and £2,237. 15s. 1d. brought forward, making a total available of £14,649. 18s. 5d. The directors propose dividends for the half-year on the first and second preference shares at 6s. per share (£11,769. 12s.), leaving a balance of £2,880. 6s. 5d. The board have thought it well to recommend that the above balance be carried forward. The traffic receipts for the half year show a falling off of £16,529, compared with those of the corresponding period of 1914, when an abnormal volume of traffic was carried. Beyond the reduced traffics, the company also suffered from the hurricane. At the date of the last report it was not possible to gauge the effect of the severe hurricane that in August passed over the West Indies, extending from Cuba and Jamaica to Guadeloupe, to which disturbance the simultaneous interruption of our two main cables between Porto Rico and Jamaica is attributable. This interruption lasted for 12 days, and necessitated the use, at considerable cost, of alternative connecting lines for carrying our traffic during the emergency. It is many years since a similar disaster happened to those two cables. Consequent upon and as a direct result of war conditions, the working expenses, although on the whole less than those for the corresponding period, are above the average of the previous few years, and no immediate reduction can be hoped for. The value of cable used in repairs and renewals was particularly heavy during the half-year, and in the opinion of the board the amount properly chargeable on this account against reserve for depreciation is £5,451. 4s. 5d. In the report for the corresponding period of 1914 reference was made to the depreciation of the investments in respect of reserve funds. A valuation made under the conditions now prevailing can hardly be considered as a reliable standard of their real value but at present Stock Exchange quotations the amount of depreciation is about £22,600.

CITY NOTES.

MEMORANDA (May 10).—Bank rate 5 per cent. (since Aug. 8, 1914) Consols 56 15/16. Consols Pay Day, June 1. Stocks and Shares Ticket Days, May 30 and June 14. Pay Days, May 31 and June 15. Price of silver, 36½d.

CHLORIDE ELECTRICAL STORAGE CO. (LTD.)—A dividend of 10 per cent. for the year ended March 31 has been declared.

CRAIGPARK ELECTRIC CABLE CO. (LTD.)—The net profit for the year ended March 31 was £9,481 (after making provision for excess profits tax), which, with £1,147 brought forward, makes £10,628. The directors recommend placing to depreciation £2,500, reserve £1,000, dividend on ordinary shares at 6 per cent., leaving £2,028 to be carried forward.

EASTERN TELEGRAPH CO. (LTD.)—The company announce that, subject to final audit, the accounts for the year ended Dec. 31, 1915, show that after making a contribution to the general reserve fund, payment of interest on the 4 per cent. mortgage debenture stock, dividend on the 3½ per cent. preference stock, and three interim dividends of £1. 5s. per cent. each on the ordinary stock to Sept. 30 last, there is a balance available, out of which the directors recommend payment of a final dividend of £2. 5s. per cent., and a bonus of £2 per cent., both tax free, and payable on the 24th inst., making with previous payments on account a total distribution of 8 per cent. (tax free) on the ordinary stock for the year ended Dec. 31, 1915. The transfer books of the ordinary stock will be closed from May 17 to May 24, inclusive.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) In reference to the announcement made on the 12th ult. of a final dividend of 4s. 6d. per share, together with a bonus of 4s. per share, for the year 1915, the share register of the company will be closed from the 16th to the 23rd inst., inclusive.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date May 10, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17½d.
Solid Drawn Copper Tubes	19d.
Brazed Copper Tubes	19d.
Brazed Brass Tubes	19½d.
Brass Wire	16⅜d.
Copper Wire	19d.
Rolled Brass	16⅜d.
Brass Sheets	17½d.

	per ton.
Copper Sheets	£152 0 0
Spelter	£103 0 0
English Lead	£35 10 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£108 0 0
Clean Brass Scrap	£71 0 0
Braziery Copper Scrap	£95 0 0
Old Lead	£31 0 0
Old Zinc	£80 0 0
Hollow Pewter	£125 0 0
Black Pewter	£85 0 0
Gun Metal	£85 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date May 9, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£73 0 0
Clean Copper	£115 0 0
Braziery Copper	£100 0 0
Gun Metal	£86 0 0
Old Lead	£30 0 0
Tea Lead	£28 0 0
Old Zinc	£72 0 0
Hollow Pewter	£135 0 0
Shaped Black Pewter	£95 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £90; Commercial Tinman's Solder, £115; Blowpipe Solder, £125.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, May 9. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., May 9.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9 3/8	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	9 5/8	4 15 8	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	9¼	6 3 1	Feb Aug
5	10%	Brompton & Kensington Ord.	6 13/16	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	80	5 0 0	Jan, July
5	2/3	Do. 4½% Pref.	3¼	6 18 6	..
5	5%	Do. Ord.	3 1/16	7 12 5	Aug, Feb
5	4½%	Do. City Pref.	2 3/16	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3 1/16	6 5 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	11 11/16	6 15 5	Feb, Aug
10	6/0	Do. 6% Pref.	10	6 0	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10 1/16	6 15 11	Mar, Sept
10	6%	Do. 6% Pref.	10¼	5 15 8	Feb, Aug
St.	4½%	Do. 1st Deb.	86¼	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	97†	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	76½	5 17 8	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79¼	5 1 0	Jan, July
5	6/0	London Elec. Supp. 6% Pref.	4 1/16	7 3 3	..
St.	4%	Do. 4% Mort. Debs.	80	5 0 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2 1/16	6 4 8	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5%2d Mt. Db. St.	92	5 8 9	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1†	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	3 1/16	6 10 7	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., May 9.	Rate per cent, Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5 13/16	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5 13/16	6 0 3	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	83	5 8 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅛	7 2 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅛	5 19 2	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4	5 12 6	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	79	6 6 7	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	71	8 9 0	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	66½	6 0 4	..
St.	4%	Do. do. Assented Def. Ord.	64½	6 4 0	..
St.	4½%	Do. 4½% Pref.	99½	4 10 3	Jan, July
St.	4%	Do. 4% Deb. St.	93½	4 5 9	Jan, July
St.	4%	City & S. London Deb.	72†	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	62½	8 0 0	Feb, Aug
10	1½%	London Electric Ry. Ord.	2 3/32	5 19 6	Jan, July
St.	4%	Do. 4% Pref.	64½	6 3 7	Mar, Sept
St.	4%	Do. 4% Debs.	85	4 14 4	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25½	3 18 5	Feb, Aug
St.	3½%	Do. 3½% Pref.	77½	4 10 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	74½	4 13 9	Feb, Aug
St.	3½%	Do. 3½% A Debs.	82½	4 4 6	Jan, July
St.	3½%	Do. 3½% Debs.	83½	4 4 1	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18 5/8	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	92†	4 7 0	May, Nov
St.	4½%	Do. 4½% First Pref.	71	6 6 9	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 7	Jan, July
St.	4%	Do. 4% Debs.	71	5 12 8	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	68	5 17 7	Mar, Sept
		Electric Manufacturing, &c.			
1	14%	Babcock & Wilcox Ord.	2 3/4	5 5 5	Apl, Oct
1	6%	Do. 6% Pref.	1 1/4	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1 1/8	5 17 11	Mar
100	5%	Do. Prior Lien Debs.	89	5 12 4	Jan, July
1	6%	Do. 6% Pref.	2 9/16	6 12 5	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	101 7/16	7 2 5	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5 1/16	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref.	1 1/16	6 17 2	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	7 1 2	April
100	6%	Do. 6% Prior Lien Debs.	100½	5 19 4	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65½	6 1 8	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	11½	6 10 5	Jan, July
5	5%	Do. 5% Pref.	4⅛	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	7 15/16	7 13 8	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	3 1/16	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	1/16	7 7 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	72	5 11 1	Jan, July
5	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9⅜	6 4 8	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14½	6 15 7	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4½	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	10 1/16	9 11 9	Feb, Aug
10	5%	Do. Pref.	7 1/16	6 16 9	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	37	6 9 9	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1 1/16	4 16 4	May, Aug
1	6d.	Do. 5% Pref.	7/16	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	78½	5 0 11	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jun, Dec
St.	4%	Willans & Robinson B. Cum. Pref.	41½	9 12 9	..
St.	4%	Do. 1st Mt. Deb. St.	50½	7 18 5	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	98½†	6 1 6	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	21½	6 19 6	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69½	5 14 8	Ja.Ap,Jly,O
10	5%	Cuba Submarine Ord.	7 1/16	6 1 8	May, Nov
10	10%	Do. 10% Pref.	14	7 2 10	..
5	5/0	Direct Spanish 10% Pref.	7⅛	6 13 4	..
10	4%	Direct United States	6 1/16	6 9 4	Ja.Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	144½	4 17 1	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	63½	5 10 11	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	76	5 5 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	75½	5 6 0	Feb, Aug
10	7%	Do. Ord.	14½	4 18 3	Ja. Ap, Jly,O
10	22%	Gt. Northern Tel. Co. ex Coup. 9	36½	6 1 5	Ja. My. Jly
25	13%	Indo-European	42½†	6 14 9	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2 1/16	4 11 5	April
1	7%	Do. 7% Pref.	1 3/16	3 13 5	July
10	1%	West India & Panama Ord.	1 1/16	8 18 10	May, Nov
10	6%	Do. 1st Pref.	7 1/16	7 12 11	May, Nov
10	8%	Western Telegh. Co.	14 1/16	5 11 10	Mr, Jly, O, Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½	4 10 3	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅝†	6 12 5	Nov.
1	10%	Oriental Telephone Ord.	1 1/16	5 10 4	Apl, Oct
St.	4%	Do. Db. St.	78½	5 1 5	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6	6 13 4	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4½	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	84½	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12	5 0 0	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10 1/16	5 16 4	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	82½	6 1 9	Ja, Apl, Jly, O
..	4%	Do. $100 Pref	69½	5 14 6	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	124	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅛	6 10 8	Mar, Sept
St.	5%	Do. 5% Debs.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10½	5 19 6	..
St.	4½%	Do. 4½% Debs.	85	5 5 11	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6 1/16	7 2 7	May, Nov
5	5%	Do. 5% Pref	4¼	5 14 3	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,983. [Vol. LXXVII. No. 7.] FRIDAY, MAY 19, 1916. PRICE SIXPENCE

Abroad 9d., or 20 cents., or 1½., or 90

CONTENTS OF THE CURRENT NUMBER.

NOTES 205
Arrangements for the Week .. 208
Three-Core Cables. By M. Höchstadter. Illus. 209
The Western Electric Printing Telegraph System. Illus. 211
Third Harmonics in the Phase Pressure of Three-Phase Alternators with Cylindrical Rotors. By A. E. Clayton, B.Sc. Illustrated 216
Institution of Electrical Engineers 218
The Production of Constant High Potential with Moderate Power Capacity. By A. W. Hill. Illustrated .. 220
COMMISSIONS IN THE ENGINEERS 222
REVIEWS 223
Text Book of Practical Physics [Allen and Moore].
Structure and Properties of the More Common Materials of Construction [Upton.]
Electrical Apparatus Making for Beginners [Ballhatchet].
Illuminating Engineering Society 224
Railless Trolley Battery Vehicle at Bradford. Illustrated 225
Engineering Industry in the Economic War. By M. T. C. Elder 225
CORRESPONDENCE 226
"Speeding Up in an Engineering Factory" (Harold J. Brocklehurst).
Daylight Saving (A. P. Trotter and F. Hope-Jones, M.I.E.E.).
Technical Education (F. M. Denton).
City Guilds' Examinations (A. Dover and W. Perren Maycock).
The Institution of Electrical Engineers.
Diesel Engine Users' Association 228
The "Electrician" Commercial and Industrial Section .. 229-238

NOTES.

Coal Economy.

WE recently published a letter from the Board of Trade asking gas and electric light undertakings to inform their consumers that the consumption of coal for lighting purposes must be reduced by 10 per cent. In this letter it is stated that the question had been considered by the Central Coal and Coke Supplies Committee, and they that had recommended a general policy of economy in lighting. In issuing such a circular we think that the Board of Trade has shown a great lack of knowledge of what is practicable, at least in the case of electricity. No useful result can be expected from such an appeal. Already prices have been advanced by many undertakings, which is the surest way of securing economy, and, as a rule, it is impossible for the smaller consumers (which provide the bulk of the lighting load) to reduce their lighting below what they are already using, unless, indeed, they are able to put in smaller candle-power lamps, which would often not be feasible. The Board of Trade also seems to have forgotten that the greater part of the output of electricity works is now no longer concerned with lighting, but with the supply of power. Consequently if the whole of the lighting load were removed from some of our electricity undertakings the saving effected would not be anything like so large as would be anticipated by the layman, though it might give the 10 per cent. which the Board seem to have in mind. We fear that the only true solution of the present difficulty is to increase the output of coal, and for this purpose it is desirable to remove all such restrictions as the Eight Hours Act for the time being. Whatever steps are taken, we trust that the Government will not delay as they did last year, but will take prompt action so as to benefit by the summer months which are already upon us. The official limiting of prices, which was hailed with satisfaction last year, seems to have had but little practical effect, and we fear that unless official action goes much more to the root of the whole matter any attempt at coal economy will do little to give us the necessary reserves for next winter.

Motor Starters.

IN his recent Paper before the Yorkshire and Western Local Sections of the Institution of Electrical Engineers, Mr. H. JOSEPH expressed the opinion that many motor starters on the market are defective both as regards design and construction. We are inclined to think that this opinion will be endorsed by many users. It should be the endeavour of motor starter manufacturers to secure for their apparatus the reputation which makers of steam stop valves have earned by sound engineering. We know of works engaged upon important munition contracts at the present time in which the managers, being uncertain as to how long their motor starters will hold out, have duplicated everything ready for an immediate change over. In the case of motors of the same size, trials are being made with no less than four starters by different makers, in an endeavour to obtain a reliable starter. For this state of affairs the makers are not entirely responsible. In many instances it is found that there is a considerable market for low-priced starters, and the purchasers of such starters have only themselves to blame when burn-outs and a hundred and one other faults begin to appear. But there are many motor users who recognise the fact that the starter is to the motor what the stop valve is to the steam engine, and they are sufficiently far-seeing to pay the price for a high-grade product. Nevertheless, we are strongly of the opinion that the cheap and nasty motor starter in the long run brings discredit on its maker, and it is for the latter to educate his customers into the way of ungrudgingly paying the price for the good article. Failing this, a strong stand should be taken by the several large insurance companies handling this class of business to compel their clients to purchase apparatus of at least tolerable design and construction, as well as being mechanically robust.

Technical Societies and Research.

ALL technical societies at the present time are considering the direction in which researches of one kind and another should be prosecuted. As an instance, we may take the report of the Research Committee of the Illuminating Engineering Society, of which an abstract appears in another column. In the researches which are suggested by this committee, most of the items are of a general character, which can be handled best by a committee co-ordinating the efforts of

individuals. For example, it is difficult for a single individual to carry out effective work on the illumination of schools, hospitals and factories, although very valuable work may be done by a number of individuals in combination, more particularly if they have a certain official standing. There are, however, other researches which can be carried out quite well by the individual, provided that he can be induced to undertake the work. But here there is something of a difficulty. The man of originality does not, as a rule, care to be set a task. He likes to originate his own work, and probably in this way he carries out much better work than he would on lines suggested to him. It always seems to us, however, that a good deal might be done by societies in pointing out the direction in which research is needful. Many of our younger men, more particularly in technical colleges, are anxious to carry out investigations, but they do not always realise in what direction such a work may be useful. If lists of suggested investigations were sent to the principals of colleges, such work would probably be undertaken. It might not be of the highest class, but there is a deal of investigation work which only requires careful observation; this, in its turn, may lead to work of a more original kind, and it will in any case be useful.

The Blind Leading the Blind.

A BANK clerk in the Royal Army Medical Corps at one of the large military hospitals has been given charge of the apparatus in the radiography department. Such work, as our readers are well aware, requires a certain amount of technical skill, and the man in charge tells us that he knows nothing whatever of the subject. The authorities have sent along the operator from a neighbouring hospital to be instructed by the bank clerk, to be taught radiography by the man who is ignorant of the subject. Outside the British Army one never comes across examples of this kind, except in comic opera. Although we do not propose to make further comment on this case, which is not of our seeking, we are tempted to ask the authorities whether expert radiographers are being employed as privates in line regiments? We are now endeavouring to find an expert willing to give private lessons to the man who is expected to give lessons to the other man.

Lights on Vehicles. The recent Order of the Secretary of State prescribes the use of three lamps on vehicles, two in front (white), and one at the rear (red).

The number of accidents that have happened in the past clearly shows the necessity for this order, but the Commissioner of Police of the Metropolis has hesitated to press it unduly on account of the difficulty that has been experienced in obtaining the necessary number of lamps. He is now satisfied, however, that this difficulty exists no longer, and that suitable lamps can be easily obtained. There is no excuse, therefore, for the use after dark of vehicles unprovided with the necessary lamps, and from June 1 next the Police will be instructed to enforce the law in all cases where a contravention is observed.

Strike at American Westinghouse Works.—The "Wall Street Journal" states that the strike at the East Pittsburgh works of the Westinghouse Electric & Manufacturing Co. came as a surprise to the officials of the company, as, only so recently as the 1st ult., the employés were granted 10 per cent. rise in wages. Mr. G. E. Tripp, chairman of the Westinghouse Electric & Manufacturing Co., stated: "Between 13,000 and 14,000 men are out on strike at the main works of the Westinghouse Electric at East Pittsburgh. The Westinghouse Machine Co.'s employés are still working. The men went out without notice to the management, between 1,500 and 2,000 having gone out on Friday, picketing the works on Saturday morning, with the result of preventing practically all the rest of the force from going to work. While no formal demands have been submitted it is understood they will be for eight hours a day and an increase in wages."

Invar and Related Nickel Steels.—A recent circular of the Bureau of Standards describes in considerable detail the physical properties, microstructure and constitution of the nickel steels, with particular reference to the alloy of zero expansion known as "Invar." The circular is a compilation of data from many sources, the pioneer work of Hopkinson, Osmond, Dumas, Guillaume and Guillet being particularly emphasised, and rather full accounts being given also of the more recent investigations carried out by Hogg, Tammann, Chevenard and others. A large portion of the text deals with the thermal expansion and constancy of invar and its characteristics as a standard of length in bars, wires and tapes. The text is accompanied by numerous tables and figures illustrating the various properties not only of invar but of nickel steels in general. There are chapters on the magnetic, electrical, mechanical and thermal properties, applications and sources of supply, and brief accounts of microstructure and constitution. Those interested can obtain a copy free on applying to the Bureau.

Industrial Research.—The first meeting of the Standing Committee on Metallurgy appointed by the Advisory Council for Scientific and Industrial Research was held on Monday, the 8th inst. The committee consists as to one-half of members nominated by the professional societies concerned, the other half being appointed by the Advisory Council, and has been constituted with a view to the representation of both the scientific and the industrial sides of the industries. The committee was welcomed by Sir William M'Cormick, chairman of the Advisory Council, and Dr. H. F. Heath, administrative secretary to the Council. Sir Amherst Selby-Bigge, secretary to the Committee of Privy Council for Scientific and Industrial Research, also attended, and gave an account of the genesis of the movement, and emphasised the importance which the Government attach to the establishment of close relations between education, research and industry. Sir Gerard Muntz, Bart., is chairman of the committee and of the section on the metallurgy of non-ferrous metals, and Sir Robert Hadfield, F.R.S., is chairman of the section on the metallurgy of ferrous metals. The members appointed up to the present are as follows:

Standing Committee on Metallurgy.

Prof. J. O. Arnold.	Prof. Huntington.
Mr. Arthur Balfour.	Mr. W. Murray Morrison.
Prof. H. C. H. Carpenter.	Sir Gerard Muntz, Bart.
Dr. C. H. Desch.	Mr. George Ritchie.
Sir Robert Hadfield.	Dr. J. E. Stead.
Mr. F. W. Harbord.	Mr. H. L. Sulman.
Mr. J. Rossiter Hoyle.	Mr. F. Tomlinson.

Section on the Metallurgy of Ferrous Metals.

Sir Robert Hadfield (Chairman).	Mr. F. W. Harbord.
Prof. J. O. Arnold.	Mr. J. Rossiter Hoyle.
Mr. Arthur Balfour.	Prof. Huntington.
Prof. H. C. H. Carpenter.	Mr. George Ritchie.
Dr. C. H. Desch.	Dr. J. E. Stead.

Section on the Metallurgy of Non-ferrous Metals.

Sir Gerard Muntz, Bart. (Chairman)	Prof. Huntington.
Prof. J. O. Arnold.	Mr. W. Murray Morrison.
Prof. H. C. H. Carpenter.	Dr. J. E. Stead.
Dr. C. H. Desch.	Mr. H. L. Sulman.
Mr. F. W. Harbord.	Mr. F. Tomlinson.
Sir Robert Hadfield.	

In his opening statement as chairman of the ferrous section of the Metallurgical Committee, Sir Robert Hadfield called attention to the need in research no less than in industry for co-operation so far as may be consistent with the freedom of individual workers, and to the particular necessity for improvement and progress in the metallurgy of iron and steel.

Radiotelegraphic Transformers. A Paper on "The Theory and Design of Radiotelegraphic Transformers" was read recently by Mr. F. Cutting before the Institute of Radio Engineers, New York. Starting with the general solution of the differential equation of the circuit and a steady sparking state, expressions for input, output, currents, and condenser charge are calculated by means of the boundary conditions of the interval. The boundary conditions are continuity of currents at sparking, and a residual condenser charge experimentally determined. Calculated current and voltage of

waves for a special case are compared with an oscillogram taken for the same transformer constants. A number of curves illustrating the quantities studied (and also curves facilitating their computation) are given : and, on comparison, are found to agree closely with oscillograms taken during actual operation. On the basis of the derived theory, a complete set of transformer measurements are explained, and numerical illustrations given. The effect of harmonic components in the E.M.F., and the avoidance of their effects are explained, together with the effect of the wave-form of the E.M.F. In connection with the experimental verification of the theory, there are described the necessary measuring apparatus, including the oscillographs. The design of the transformer to meet any special requirements is then treated in detail from the theoretical and practical standpoints. The use of air-core power transformers at frequencies of 500 cycles and over is considered and found to be feasible. An interleaved set of coils of "Maxwellian" cross-section is recommended for the "sandwiched" primary and secondary. An actual satisfactory transformer of this type for 2 kw. is described.

OBITUARY.

Sir C. Woodall.—The death of Sir Corbet Woodall, Governor of the Gas Light & Coke Co., occurred on Wednesday, at the age of 75. Sir Corbet Woodall inaugurated in 1909 a system of co-partnership under which the company's employés now hold over £150,000 worth of the company's stock.

Madeline Wordingham.—We regret to record the death, on the 11th inst., of Mrs. Madeline Wordingham, widow of the late W. H. Wordingham. Many of our readers will remember Mrs. Wordingham as a familiar figure at functions of the Institution of Electrical Engineers, in company with her son Mr. C. H. Wordingham.

Lady Crookes.—Universal sympathy will be felt for Sir William Crookes, O.M., on the death of his wife, which took place on the 10th inst., at their house in Kensington Gardens, London. Lady Crookes, who was in her 81st year, was the daughter of Mr. W. Humphrey, of Darlington, and she was married to Sir William on April 10, 1856. Sir William, who is in his 84th year, was recently president of the Royal Society.

Killed in Action.—The death in action is announced of Capt. Robert J. Smith, Lancashire Fusiliers. The deceased officer was educated at the Ranelagh School, Athlone, and at the Mountjoy School, Dublin. In 1905 he won a scholarship in the Royal College of Science, Dublin, where he spent three years, and also graduated with honours in Trinity College, Dublin. Later, he became a teacher of engineering at the Newry Technical Institute, and in 1912 he took up a position with British Westinghouse Co.

The death in action of Lieut. Geo. Bewsey Dyke, R.G.A., B.Sc., A.M.I.E.E., is announced. As a collaborator with Prof. Fleming, our readers will regret the loss of yet another of our younger men.

The death is also announced of Lieut. Edward Wilson, S. African Infantry. He was educated at Sedbergh School and Clifton College, and was an exhibitioner of Pembroke College, Cambridge. After taking his degree he went out to South Africa and was placed in charge of transport with the African Transcontinental Telegraph Co., on the section from Chindi, on the Zambesi. In the rebellion in South Africa he served as sergeant in the Rand Rifles and went through the whole campaign in German S.W. Africa. Subsequently he received a commission in the South African Expeditionary Force and saw service in Egypt against the Senussi.

PERSONAL.

Mr. A. M. Parkinson, an Honours Graduate in Electrical Engineering of the University of London, was gazetted to the Royal Engineers on the 10th inst.

Royal Engineers (T.F.)—The following appointments and changes have been made :—

London Electrical Engineers.—Acting Sergt.-Major A. Kennedy to be Quartermaster and Hon. Lieutenant. The announcement of appointment of second Lieutenant T. S. Wa[illegible] is cancelled.

Tyne Electrical Engineers.—Second Lieutenant T. Henderson is granted temporary rank of Lieutenant while employed with R.F.A.

APPOINTMENTS VACANT AND FILLED.

A mains engineer is required by Eastbourne Electricity Committee. Salary £156. Applications to the Borough Electrical Engineer by 5 p.m. June 9.

A shift engineer is wanted by Grimsby Street Tramways Co., Cleethorpes, Lincs. Applications to the Manager [illegible] *ment.*

Mr. G. H. Browne, of Ilkeston, has been appointed engineer and manager of the Mexborough and Swinton Tramways.

INSTITUTIONS AND SOCIETIES.

Institution of Electrical Engineers Benevolent Fund.—A meeting of the contributors to this fund was held on Thursday, May 11. The President read an abstract of the report of the Committee of Management which stated that the capital account stood on Dec. 31 last at £4,642. 3s., all of which is invested. Receipts during 1915 were : Dividends on investments £175. 3s. 7d., interest on deposit £8. 11s. 2d., annual subscriptions £106. 19s., donations £420. 3s. 7d., legacy from the late Mr. Augustus Stroh £250. Total £960. 17s. 4d. Among the larger donations, in addition to the legacy of £250 from the late Mr. Stroh, was a donation of £105 from Mr. J. H. Rider. The Committee of Management acknowledged their indebtedness to these and the other donors and subscribers, and ventured once more to urge upon the members the pressing need for a more generous support of the fund. The Committee would be grateful for annual subscriptions, even of small amounts. Seven applications for assistance were received in 1915, and the Committee made grants in all the cases. Four grants were made of £25 each, two of £10, and one of £6, a total of £126. The capital account of the Wilde Benevolent Fund stood on Dec. 31 at £1,846. 4s. 6d., the whole of which is invested and brings in an annual revenue of £55. 17s. The balance standing to the credit of the income account at the end of 1915 was £436. 4s. 1d., of which £345. 14s. 8d. was invested, and brings in an annual income of £13. 10s. No grant from this fund was made during the year.

The President moved, and Mr. J. E. Kingsbury seconded, the adoption of the report and accounts and the motion was carried.

Mr. Sidney Sharp and Mr. J. Attfield were appointed hon. auditors, and the names of the Committee of Management were approved. These included the President (ex-officio), Mr. W. Duddell, Mr. J. S. Highfield, Mr. J. E. Kingsbury, Dr. A. Russell, Sir John Snell and W. B. Woodhouse (representing the Council), and Mr. W. B. Esson, K. Hedges and Major O'Meara (representing the contributors).

A general meeting of contributors to the Benevolent Fund was then held to alter Rule 9 so as to incorporate in the Committee of Management the Chairmen of each of the Local Sections of the Institution in the United Kingdom. The necessary resolution was passed and it will come up for confirmation at another meeting on June 15th.

Illuminating Engineering Society.—The report of the council for the session 1915–1916 states that the activities of the society have been fully maintained. The presidents of the Institutions of Gas and Electrical Engineers, Mr. John Young and Mr. Charles P. Sparks, have consented to act on the council during the present year. The council record the death of two valued vice-presidents of the society, Mr. Edward Allen and Prof. Vivian Lewes. Among the losses caused by the war we notice two of the younger members of the society, Mr. G. Maurice, who perished on the "Lusitania," and Mr. F. Harvey Gooch, who fell in action with the Cameron Highlanders in France. Five meetings, not including the annual general meeting, have been held during the past session. The society had also the privilege of hearing the views of several members of the Glass Research Committee of the Institute of Chemistry, which has been conducting researches on chemical and optical glassware. The question of factory lighting has also been receiving the attention of the American Illuminating Engineering Society, and at the last convention, held in Washington in September, 1915, a most useful "Code for the Lighting of Factories, Mills and Other Work Places," prepared by a committee of the society, was presented. An important question that has been receiving much attention, both in this country and abroad, is the desirability of arriving at a uniform

method of expressing the efficiency and illuminating value of gas, electric and other illuminants. The view is now receiving support that lamps should be rated in terms of the total output of light in all directions. Attention has also been given to the scheme for the organisation of scientific and industrial research being prepared by the Committee of the Privy Council. The Illuminating Engineering Society has intimated its willingness to take part in any movement calculated to bring about unity of effort in these matters, and to co-operate in any investigations bearing on the practical applications of light in relation to illuminating engineering. The council also consider that the moment is opportune to proceed with the work of the Committee on Research, the appointment of which was decided upon in 1914, but was delayed owing to the outbreak of war.

Royal Society.—Amongst the Papers read last Thursday we notice the following: "An Active Modification of Nitrogen," by Hon. R. J. Strutt, F.R.S.; "A Theory of Colour Vision," by R. A. Houstoun, D.Sc.

Institute of Radio Engineers.—A meeting of the Institute of Radio Engineers was held on May 3rd, when a Paper by Prof. A. E. Kennelly of Harvard University, and Mr. H. A. Affel on "Skin Effect Resistance Measurements for Conductors at Radio Frequencies up to 100,000 Cycles per Second" was presented. A number of highly valuable practical measurements have been made of solid and stranded conductors of various shapes and sizes.

University of London, University College.—Last Tuesday a private view was held of the new chemical laboratories of University College, when visitors were given an opportunity of seeing the equipment. After the view, Prof. F. G. Donnan, F.R.S., gave an interesting lecture on "The Rôle of Chemical Science in Civilisation." Prof. Donnan pointed out that, in historical sequence, chemistry might be said to have shown its importance in the extraction of metals from their ores, then in engineering and lastly in explosives. Progress in engineering now depended on progress in chemistry. Chemistry also lay behind art, in the production of colours. Undoubtedly the present century would be characterised by chemical science, and at the moment the life blood of England might be said to be sulphuric acid. This view of the matter, which is certainly true, is but little realised by the layman.

Institute of Journalists.—A further meeting was held on Tuesday last of the Technical and Trade Circle of the Institute of Journalists to continue the discussion of Prof. Garnett's Paper, which was read on March 14th, and abstracted in our issue of March 24th, p. 75.

The chair was taken by Mr. Leon Gaster, who is president of the circle during the present session. The discussion was opened by Prof. Gregory, who commented upon the fact that the curriculum in the elementary schools was too academic and the great universities were generally behindhand in matters of science. He thought favourably of the proposal of the Australian Federal Government to spend a large sum of money in the establishment of some State organisation which would forge a link between the work of scientific research and the development of industry. The most attractive feature of this proposal was that the presiding genius would be a man of business.

Mr. Hughes, the Prime Minister of Australia, was to have addressed the meeting on this subject, but unfortunately he was prevented from attending. His place was, however, taken by Mr. Gerald Lightfoot, who is one of Mr. Hughes' staff, and is directly interested in the details of this important scheme of the Commonwealth of Australia. In opening his remarks, Mr. Lightfoot emphasised the fact that co-operation was the principal motto of those who had been given the task of formulating this scheme. They were in active touch with men of science, industry and commerce in the United States and the United Kingdom. Mr. Hughes was gathering information while in this country which would be of immense value when he and his colleagues returned. Mr. Lightfoot then proceeded to outline the proposals of the Committee which had been appointed to report to the Government of Australia on the subject. [We published an abstract of the first report of this Committee in our issue of March 17, p. 829.] Mr. Lightfoot emphasised the fact that the executive and general administration of the Bureau of Science and Industry, as it would be termed, would be free from political control, and the principal officials would be appointed for seven years, in a similar manner to the High Court Judges. They would be paid salaries of about £2,000 a year, and could be removed only by resolution of both Houses of Parliament. The primary industries of the country (agriculture and metallurgy) would be first dealt with, and the directorate would provide due control and obtain first-hand evidence as to the problems which required to be taken up. The directorate would then allocate the work of investigation to the universities or State laboratories, the idea being to make use of existing institutions. Liberal grants would be made by the Federal Government for apparatus and equipment. A feature would be made of a bureau of information which would not only publish information and data, but would also collect the same. The Government was already in co-operation with the Agricultural Bureau of the United States of America. The spirit of co-operation would be extended not only to employers of labour, but also to employees. Similarly, there would be a movement to teach science in the primary and secondary schools. Mr. Lightfoot recommended that the work which was now being done in this country to establish a definite co-ordination between science and industry should be done on a national basis. The Imperial Institute, the British Science Guild and others were working to a common end. It was desirable that their efforts should not lead to waste of time and money. He thought it desirable that an Imperial Bureau should be established in this country, which would act as a clearing house of information on imperial questions. There were some problems which could be dealt with in the Dominions, and there were others which might be more advantageously handled in this country. Such a clearing house would be of value in allocating the work in the right direction, and it would also help to cement the scientific, commercial and industrial relations of the mother country and the Dominions, and establish a firm basis of co-operation upon which could be built up an unassailable imperial economic fabric.

The following resolution was put to the meeting and passed with acclamation:—

"That this meeting urges on the various Associations, Institutions and Committees engaged in the consideration of Technical Education and Industrial Research, the necessity for co-operating in order to present a National Scheme for the consideration of the Government.

"That in any measures taken for the preparation and execution of such a National Scheme the co-operation of the Scientific and Technical Press should be secured.

"That the meeting is of opinion that the Press should use its influence to secure uniformity of policy with regard to the action to be taken to encourage the Teaching of Science in Schools and Colleges of all grades, and to determine the proper position of Science in Civil Service and other examinations, especially with reference to the influence of these examinations upon Education.

"That in the meantime it is desirable that all possible support should be given by the Press and the public to the work of the Advisory Council to the Committee of the Privy Council for the Organisation and Development of Scientific and Industrial Research, and that Industrial Associations should report to the Advisory Council on the facilities required for the conduct of research in connection with their particular industries."

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 19th (to-day).

Institution of Mechanical Engineers.

6 p.m. At Institution of Civil Engineers, Great George-street, S.W. Paper on "Spur Gearing," by Mr. D. Adamson.

MONDAY, May 22nd.

Society of Arts.

4.30 p.m. At John-street, Adelphi, W.C. Lecture on "Vibrations, Waves and Resonance," by Dr. J. Erskine Murray, F.R.S.E. (Lecture IV.)

THURSDAY, May 25th.

Institution of Electrical Engineers.

5 p.m. At Victoria Embankment, W.C. Special General Meeting of Corporate Members to consider a resolution expelling enemy alien members.

FRIDAY, May 26th.

Royal Institution.

5.30 p.m. At Albemarle-street, W. Discourse by Prof. C. G. Barkla, M.A., D.Sc., F.R.S., on "X Rays."

1st LONDON ENGINEER VOLUNTEERS.

Commanding Officer, Lieut.-Col. C. B. Clay, V.D.

Orders for the Week.

Officer for the Week.—Platoon Commander J. O. Cheadle.

Next for Duty.—Platoon Commander J. R. G. Williamson.

Monday, May 22nd.—Technical for Sections 1 and 2, No. 3 Company, 46 Regency-street, S.W. Squad and Platoon Drill. Sections 3 and 4, No. 3 Company. Signalling Class and Recruits.

Tuesday, May 23rd.—School of Arms, 6 to 7. Lecture, Mr. J. Roberts, "The Geology of Otford," 7.15. Recruits, 7.15 to 8.15, Archbishop's Park.

Wednesday, May 24th.—Platoon Drill, No. 2 Platoon, No. 1 Company.

Thursday, May 25th.—Platoon Drill, No. 6 Platoon, No. 2 Company. Shooting for Sections 3 and 4, No. 3 Company, miniature range. Recruits, 5.45 to 7.45. Instructional Class, 5.45.

Friday, May 26.—Technical for Sections 3 and 4, No. 3 Company, 46, Regency-street, S.W. Squad and Platoon Drill. Sections 1 and 2, No. 3 Company.

Saturday, May 27.—Route March. Parade Golder's Green Station, 2.30. Uniform. The Corps will be accompanied by a drum and bugle band.

Sunday, May 28th. Entrenching at Otford. Parade Victoria (S.E. & C. Railway Booking Office), 8.35 a.m. Uniforms, haversacks and water bottles. Midday rations to be carried. Railway vouchers will be provided.

Musketry.—For Nos. 1 and 2 Companies, see Notice and Table A and B, at Headquarters.

Note.—Unless otherwise indicated, all drills, &c., will take place at Chester House.

THREE-CORE CABLES.*

BY M. HÖCHSTÄDTER.

Some years ago the author published some results about high-tension cables, and therein appeared the paradoxical statement that the dielectric loss in cables with single conductors varied with the square of the voltage, but with three-core cables the loss varied with a higher power of the voltage. It was not possible at that time to add any explanation of the fact, which appears strange, that the dielectric loss, which seems from the nature of the case to depend only on the material employed, should vary with the type of cable. Since then the author published in 1911, in conjunction with Birrenbach, a Paper describing the high-tension cables laid in Cologne. Tests in this case confirmed the law of squares for single-conductor cables; and on that occasion new points of view presented themselves, which may partially help to explain the paradox. The present lines are intended to give a more or less popular study of the subject.

In the course of the tests at Cologne it was always found that the quadratic law was true for single-conductor cables; and, therefore, it seemed that this must be the law for the raw material out of which the cable is made, and that the difference in three-core cables must be due to some internal processes taking place in the structure of the cable. This difference undoubtedly exists; it makes no difference whether one considers the loss to be due to leakage current through the dielectric or whether one considers the loss to be of the nature of hysteresis, and, therefore, proportional to the frequency and the square of the maximum voltage at each point in the dielectric. In both cases the calculation shows the loss in a given length of cable to be proportional to the square of the applied voltage and

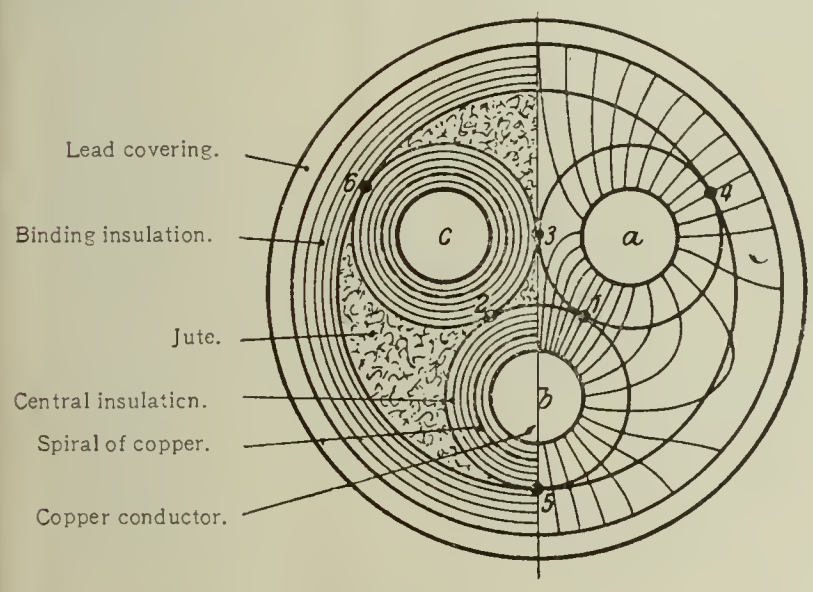


Fig. 1.—Section through a Three-core Cable of the usual construction, together with the arrangement of the Electric Field on Polyphase Current.

to the capacity of the cable; therefore, the power-factor for all unloaded cables made out of the same materials must be constant. Let us now consider what might possibly be the processes in the interior of a three-core cable, which might account for these differences.

These differences might possibly be connected with the phenomena which arise when three-core cables are exposed for lengthened periods to a high voltage. It is known that under those conditions there are signs of burning if a very high voltage is applied; in a short time, often in a few minutes, this local burning is noticeable by the smell produced and by the temperature of the cable. If such a cable is cut open, one finds the layers between the internal insulation and the jute strongly burnt, and the burning effects extend the further the longer the cable is exposed to the voltage. This burning can only be the result of a loss of electric strength inside the jute and on the outer layers of the inner insulations. It is indirectly caused by this, the direct effect being the passage of equalising currents which are caused to pass. It may be supposed that the loss of insulating power could arise at much lower voltages before the glow discharges inside the cable could be detected actually by any burning phenomena, seeing that practically it is impossible to devote lengthened periods to such tests. If this is true, then the loss of insulating power at the given spots must cause a displacement of the lines of force within the jute. The jute thus has the properties of a partially conducting layer, and has approximately the same potential throughout. Thus, the external binding

* Abstract of an article in the "Electrotechnische Zeitschrift," Heft 47, 1915.

layer of insulation, which may be called the "girdle" insulation, is partially relieved of its electric stress; the internal insulation has more or less to sustain the whole electric stress. Thus, the three-core cable becomes electrically an approximation to a mechanical combination of three single-conductor cables. Now, if this displacement of the equipotential lines actually takes place, it ought to be demonstrable by tests. With a view to this a cable was constructed exactly similar to one on which tests had already been carried out with this single difference—viz., that at a distance of about 2 mm. from the copper conductor there was inserted in the insulation a nearly closed thin spiral of copper ribbon. Tests were carried out on this cable to determine the dielectric losses and the distribution of electric stress. It was found that when all three conductors were connected to a supply of alternating current and the lead covering was earthed up to 15,000 volts the loss in

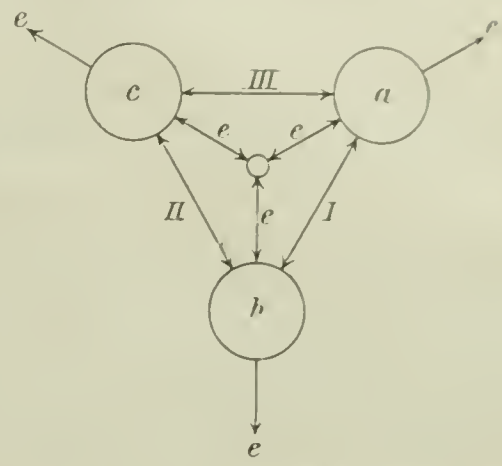


Fig. 2.—Voltages Corresponding to Fig. 1.

creased with the square of the voltage and the ratio of the voltage on the copper conductor to that on the spiral remained constant, as also the ratio of the voltages on the spiral and the lead covering. At 15,000 volts, however, both curves bend over: from this point the losses increase more rapidly and the ratios increase. This shows that the above explanation of the increased losses in a three-core cable is correct. And it seems from this that a three-core polyphase cable for 25,000 volts, with about 12 mm. of active insulation between the different conductors and between the conductors and earth undergoes some internal changes at pressures above 15,000 volts.

This fact is of considerable practical importance, and it is proposed to discuss the causes theoretically without the aid of complicated mathematics. Fig. 1 shows a section through a three-core cable of the usual construction. The directions of the lines of force are shown for a given instant, assuming polyphase power to be applied.

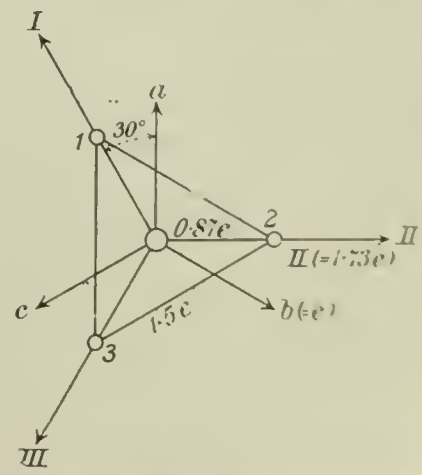


Fig. 3.—Voltage-diagram Corresponding to Fig. 1.

The voltages in a and c are equal and opposite and half the value of the phase voltage in b. The insulation round the conductors and up to the lead covering is supposed to be homogeneous. It is evident that the four wedges of jute are submitted to a considerable electric stress. Both at the outer layers and also inside the active insulation there are various points where the electric stress acts tangentially to the layers or dividing surfaces. It is well to get some idea of what these tangential stresses are. Figs. 2 and 3 show that between any two of the conductors a, b and c the voltage is 1·73 times the voltage e between the conductor and earth. In the space between the three conductors there exists an electrostatic polyphase field. The central point of the section will have a potential about equal to that of the earth. Between it and each conductor will therefore be the phase voltage e. As a result of this, and under the assumption that the bounding surfaces are good

insulators, we get the voltage diagram shown in Fig. 3, in which a, b and c are the phase voltages of the conductors a, b and c to earth, and I., II. and III. are the voltages between the different conductors in pairs. The voltages between the points 1, 2 and 3 and the neutral point are called in the diagram 1, 2, 3; they amount to $0{\cdot}87e$. The voltages between the points 1-2, 2-3, 3-1 are also shown in the diagram, and amount to $1{\cdot}5e$. Let us now find the voltage between the points 4, 5, 6 in Fig. 1 and the lead covering; and let us take the case of the above-mentioned test cable, without, however, adding the copper ribbon spiral. The dimensions of this cable are those taken for our drawing of the section. The consideration of the direction of the lines of force from the conductor b to the lead covering serves to give an approximation to the voltage of the point 5. The lines of force show that at this point we may consider the conductor b to be a part of a single-conductor cable surrounded by a double thickness of insulation. At any rate, it will be no better than this; but taking this as the actual state of affairs, we get that the voltage between the point 5 and the conductor b is about $0{\cdot}66e$. From these facts and assumptions we can get an approximation to the considerable electric stresses over the portions 1-2 and 1-5. It is seen that over the very short path 1-3, which is about equal to the thickness of the central insulation, there is a voltage of about $1{\cdot}5e$. And it is plain, that under a high voltage, the wedge 1, 2, 3 cannot withstand this stress. In consequence of these voltages equalising currents will be set up. These currents try to equalise the voltages in the wedges 1, 2, 3, so that the whole wedge tries to reach the potential of earth. Also between the points 1 and 5 there is a voltage of about $0{\cdot}44e$., as can easily be seen from the diagram. The creeping path 1-5 is about twice as long as 1-3, so that the path 1-5 is able to hold out, even if 1-3 gives in. But if the path 1-3 yields the stress on the path 1-5 automatically increases and approximates to the value $0{\cdot}66e$. At a higher voltage the path 1-5 will also be unable to resist the stress; therefore, the outer wedges and the "girdle" insulation will tend to the voltage of earth. At the same time the surfaces of the central insulation will assume the character of equipotential surfaces. The points 1, 2, 3, 4, 5, 6, 0 have, therefore, in this case no differences between them. The central insulation of all three conductors has, therefore, under normal conditions, to withstand the whole of the phase-voltage. The tangential voltages disappear except in so far as they are necessary to the residual equalising currents.

Thus we see that the processes which go on inside the cable have ultimately the effect of making the cable electrically into a mechanical combination of three single-conductor cables. But there is this difference: the outer coating is not that of metallic surfaces, but is that caused by the slow effect of the glow discharges, which tend to destroy the material: the value of the "girdle" insulation is thus almost completely lost, while the central insulation is overloaded. The voltage in a three-core cable, at which there is a displacement of the inner voltage distribution, may for our purposes be called the "limiting" voltage.

A simple calculation shows that this displacement of the voltage distribution within the cable is necessarily accompanied by an increase in the total dielectric loss. Without any great mathematical consideration, it is plain that this is simply a corollary of the quadratic law. The effective loss in each elementary portion of the dielectric depends on the square of the voltage gradient at the point. Therefore it is plain that the displacement of a certain number of the lines of force from a portion submitted to a low electric stress to another portion which has a higher electric stress must have a great effect. The change of the effective loss in both portions is proportional to the product of the original electric stress and the change of this stress. Thus the lowering of the loss in the unloaded portion will be absolutely less than the increase in the loss in the other portion: so the total loss is increased. And this takes no account of the fact that the glow discharges themselves may add to the losses at very high pressures.

In view of these facts it is only possible to regard the usual construction of three-core cables as unsuitable for voltages above the "limiting" voltage. From the operative point of view, this is also the case: above the "limiting" voltage, such a cable is exposed to an internal destructive process, but its efficiency is also lowered owing to increased dielectric loss. In order to meet possible objections, the author would like to add that he is quite conscious of the fact that the addition of the spiral of copper ribbon naturally disturbs the ordinary arrangement of the lines of force in the cable. The spiral was, therefore, placed as near as possible to the conductor, so that its influence in this direction should be kept as small as possible. In these tests, it was no question of getting quantitative results: it was merely a question of getting a better insight into first principles. In the tests above-mentioned, the limiting voltage was about 15,000 volts to earth. This means a polyphase voltage between the conductors of about 25,000 volts—*i.e.*, about that voltage for which the cable was designed. It is, however, well to notice that this is not the least voltage at which the described phenomena make their appearance. For the test has only been for the purpose of finding the effect of the phase-voltage in the outer portion 1-5. From what has been said, it is quite possible that in the middle wedge of jute, changes take place even at lower voltages.

When the foregoing facts are taken into account, they seem fairly obvious, and it is strange that the practical man should ever have thought that three-core cables were suitable for work on very high voltages. For in other branches of technical work the constant endeavour has been to try to make the insulating covering as homogeneous as possible. Ordinary three-core cables, therefore, seem unsuitable for very high-pressure work: and yet it is not difficult to see how the design of such cables could be improved. Fig. 4 shows the section of a three-core cable of the usual construction for polyphase work: it has conductors of sectional areas of 95 sq. mm., and a thickness of 12 mm. of insulation. The cable is intended for a working voltage of 25,000. In Fig. 5 a new form of construction is shown: the whole of the "girdle" or binding insulation is omitted, and the various central insulating coverings are surrounded by a metallic coating. This metallic coating has naturally the effect of keeping the outer surfaces of the central insulation at earth potential. The metal coating has only to carry extremely small equalising currents, and, therefore, their thickness can be kept as small as possible, consistent with the requisite mechanical strength. The four wedges, which are necessary to fill out the spaces between the cables, can be made out of any kind of inferior material, which does not need to be impregnated: it has no kind of electric stress to withstand. The central insulations can be impregnated before being wound on, and can be bound round with a view to making them solid and compact: this can be done during the winding-on process. As for dimensions, it seems desirable to make the central insulation about half as thick again as is shown in the old form of construction in Fig. 4. The calculated electrical data of the new cable are at least as good as those of the old one: it has the same external diameter, and is much lighter. The metallic coverings, which are added to the insulation about the different conductors, prevent the destructive processes, which have been described above, even at very high voltages. The metallic

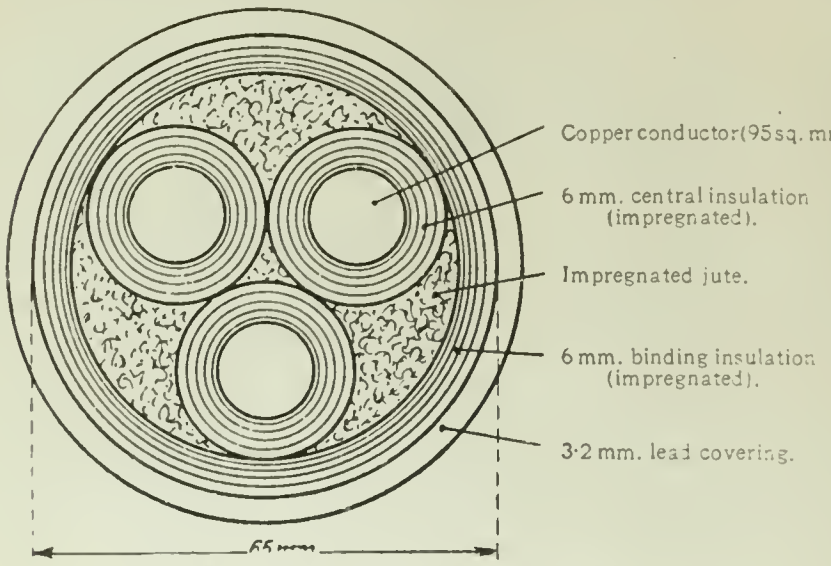


Fig. 4.—Cable of the Usual Construction.

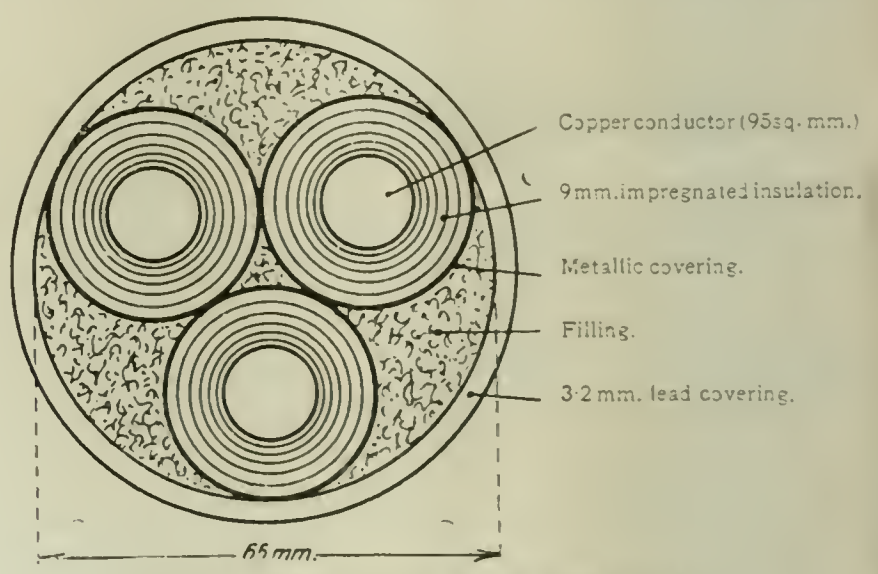


Fig. 5.—New Type of Three-core Cable.

coverings of the various cores touch the lead coating, and are in frequent metallic contact with it; so that in cases where the operation is unsymmetrical, as, for instance, if one phase is earthed, the equalising currents pass through the lead covering. Comparing the two methods of construction, it has been shown in a previous publication by the author that with a cable such as that shown in Fig. 4, the capacity of the conductor to earth is 0·10 mfd. per kilometre, and the capacity between the conductors is 0·034 mfd. per kilometre. Therefore, its working capacity as a polyphase cable is 0·2 mfd. per kilometre. It has also been shown that the dielectric constant is about 3·15. A simple calculation shows that the working capacity for polyphase current of the new cable shown in Fig. 5 is :—

$$c=\frac{3\cdot15}{18}\times\frac{1}{\log\frac{15\cdot5}{6\cdot5}}=0\cdot20\mu F/km.$$

Thus, we see that the two cables have exactly the same working capacities. Therefore, below the "limiting" voltage, the two cables will have the same dielectric loss; for higher voltages, the cable in Fig. 5 will always have lower losses than that in Fig. 4, and its efficiency will also be greater. Let us consider their breakdown voltages. We must distinguish between two different breakdown voltages. The first is the momentary one—*i.e.*, on the application for a very short period of the voltage: the other is the breakdown after a long application of the voltage. The latter is mostly very much below the former; this is supposed to be due to the fact that the breakdown process usually requires time to weaken the insulation sufficiently at its weakest spot. This sounds likely when one remembers that a certain amount of energy is needed to burn out a weak spot. The material out of which the dielectric is constructed should be such that the one breakdown voltage is as little below the other as possible, for in that case it is possible to utilise the material to the best advantage. As for the breakdown "continuous" voltage, the cable in Fig. 5 is obviously superior to that in Fig. 4. For the internal destructive processes are entirely avoided; these processes tend to lower the "continuous" breakdown voltage, and to shorten the life of the cable. Above the "limiting" voltage, the new cable is in all respects superior with regard to breakdown voltages of both kinds. For when the lines of force are displaced in the old cable, it has only two-thirds of the effective thickness of insulation of the new one. But also below the "limiting" voltage the new cable is superior with respect to the "momentary" breakdown voltage. For on normal working with polyphase current, a simple calculation shows that the mean stress per millimetre of thickness of insulation between two conductors in Fig. 5 is about three-fourths of that in Fig. 4; while the mean stress between the conductor and the lead covering per millimetre in Fig. 5 is about 33 per cent. more than in Fig. 4. The mean stress in the new cable is thus in the one part greater and in the other part much smaller than in the old one. In the new cable there are no annoying tangential stresses; the stresses in all directions round the conductor are the same. It is also very important that the uniform mean stress round the conductors in the new cable is smaller than the greatest mean stress which exists anywhere in the old one —*i.e.*, than that which existed in the insulation between the conductors. It is exactly at this point that the new construction allows stresses which are only three-quarters of the old ones. The new type of cable must, therefore, have a momentary breakdown voltage 33 per cent. higher than that of the old one on polyphase current; therefore, in respect of the "momentary" breakdown voltage the new cable is superior to the old. If we take the case of a momentary earth on one phase, the new cable seems on purely arithmetical considerations to possess about three-quarters of the strength of the old one at the threatened spot. But it is necessary to remember that such disturbances generally last only for a short time, and in such a case the insulation has much greater strength than in the case of a continuous earth. It is, therefore, neither necessary nor economically desirable to design the cable with power to resist such a continuous earth on one of its phases. The diameters of the two cables measured under the lead covering, are the same, and amount to about 65 mm. The amounts of insulating material required in the two types are set out in the preceding table.

Table I.

—	Construction as in Fig. 4.	Construction as in Fig. 5.	Differences between the new and old types.
Volume of insulation in cubic cm. for 1 metre of cable—			
Three cores	1,080	1,890	
"Girdle" insulation	1,070	0	
Total	2,150	1,890	Saving of 12 p.c.
Jute or filling for 1 metre	700	960	Increase of 37 p.c.
Volume to be impregnated per metre of cable	2,850	1,890	Saving of 33 p.c.

The amounts of copper and lead in the two cases are the same. There is a saving in paper of 12 per cent., and more than 33 per cent. in the impregnating material. This, as well as the omission of the "girdle" or binding insulation and the reduction in the time required for impregnation, makes the new cable much cheaper and lighter. There is more jute or other filling material required, but this makes little difference, especially as the filling for the new cable can be made of quite cheap materials. The cost of the metallic covering for the different insulations about the conductors is very small, and of no importance as compared with the total cost of the cable. The new type of cable seems therefore to have advantages quite apart from electrical considerations, and it is also cheaper and lighter.

THE WESTERN ELECTRIC PRINTING TELEGRAPH SYSTEM.*

Some years ago the Western Union Telegraph Co. found it necessary greatly to increase its facilities. Of the methods available, the most economical was that of utilising their present wires. The combined effort and experience of the engineers of the above company, together with those of the Western Electric Co., resulted in a development of a thoroughly practical and flexible printing telegraph system well suited to their requirements. Its main features are its scope, flexibility and operation, carrying capacity, accuracy and economy of labour and cost of maintenance. It is suitable for either overhead, underground or submarine cables through which a relay can be operated satisfactorily, and it permits of various methods of operation.

Methods of Operation.

Some of the methods are as follows: First there is the one-way method, by which the capacity of a line is about 45 words per minute in either direction. This system is intended for short-haul traffic, and is intended for underground cable not exceeding 30 miles long, or on lines free from inductive disturbances. In the two-way method of operation this system has a total of about 90 words per minute, and operates on any length of line which does not require the use of repeaters. Generally it is used on lines up to 500 miles in length. The double duplex method of operation has a total of about 180 words per minute, and simultaneous transmission in each direction is obtained by means of the duplex balance. Similarly, with the triple duplex method, a total of about 270 words per minute is obtained. In the quadruple duplex method four channels are provided in each direction, and a total of about 360 words per minute is obtained for the line. In the case of the two-way and other services mentioned the messages are prepared by using a perforator, as shown in Fig. 1. In this case, when each key is depressed, several holes are punched in the tape, and their arrangement settles the combination of positive and negative currents which will be sent to the line when working through a transmitter (Fig. 2) and distributor (Fig. 3). These impulses operate a polarised relay at the receiving station, which, by means of another distributor, passes the impulse along to a receiving printer (Fig. 4), which translates them into the form of columns, and when printed the message may be torn off and is ready printed for delivery. If desired, messages may be received in the form of a perforated tape by means of a re-perforater. This tape may be used again for re-transmission on another line operated by any of the methods referred to above. Generally, keyboard transmission is adopted for the one-way service, but when desired use may be made of tape transmission for this class of service, which possesses the advantage of affording a simple and efficient storage of signals, thus keeping the speed of transmission constant. This is of advantage in several cases.

The Alphabet Used.

The code used in this system is an equal-letter five-unit code—that is, each signal consists of five units or current impulses, and all signals require the same amount of line time for their transmission. This holds whether the signal is a letter or a figure. This type of code is known as the Baudot code, because of its employment in the Baudot system, which has been extensively used in France for upwards of 30 years. The code is shown in Fig. 5. In such a code, assuming that a pulse of positive or negative current represents each unit, there are available 31 combinations, which are sufficient for all the letters of the alphabet and the working functions. In

* Based on an article by Paul M. Rainey in the "Electrical World."

addition to these, various other movements are required in the column printer. The transmission of these extra signals over the line occupies about 10 per cent. of the working time on the average—that is to say, the code employed in this system averages 5·5 units per character so far as line transmission is concerned. An investigation of actual telegrams shows that the Continental Morse code requires 9·08 units per letter. This means that, if the maximum speed of transmission is 6,000 impulses per minute, these may form



Fig. 1.—Perforator.

660 letters in the Morse code and 1,090 letters in the five-unit code, which is an advantage for the latter of 65 per cent. Considerable advantage is to be derived from this code on long aerial lines of underground cable conductors. On shorter lines this code permits duplex operation with a greater inaccuracy in the duplex balance.

Multiplex Principle.

The code just described permits of this principle, which is employed in the quadruple duplex, triple duplex, double duplex and two-way methods of operation. The illustration gives a simple example of



Fig. 2.—Transmitter.

the multiplex idea. Two metal rings are divided into four quadrants at the stations X and Y, and rotating brushes are connected to the line as shown. It is obvious that the time of one interval would be that of a quarter of a revolution of the rotating brushes. If each signal consisted of one pulse of current it would then be possible to send one signal per quadrant per revolution. Now, with the five-unit code five segments are required instead of a solid quadrant, so that five current impulses, which constitute a given signal or letter, can be despatched and received or distributed as may be determined.

It will be seen from the figure above that if any lever is moved over to engage its battery contact during the quarter of a revolution in which the rotating brush E moves over the quadrant A, a current

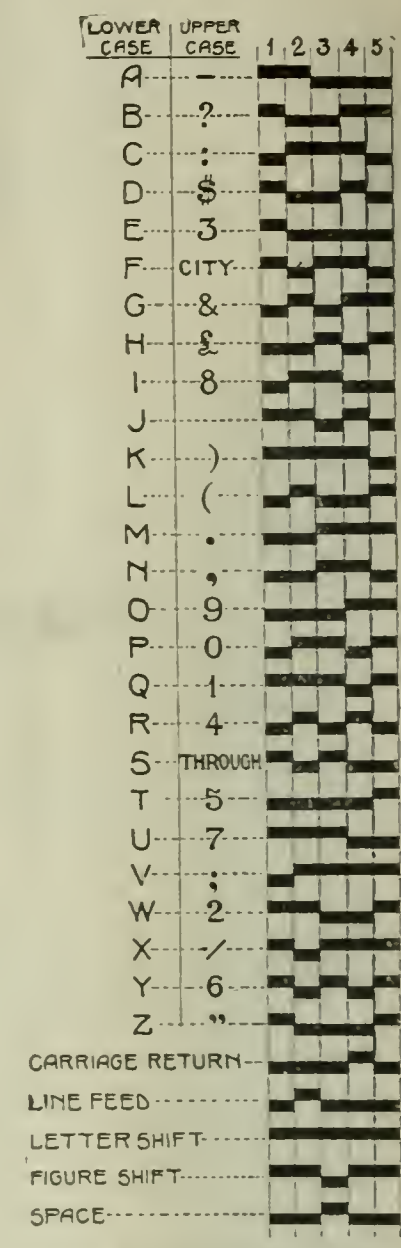


Fig. 5.—Five-Unit Code.

impulse will be transmitted to the line through the rotating brush E, and, since the rotating brush E_1 is synchronously moving over the segments at the receiver end, at the same time the corresponding relay at the receiving station will be momentarily energised. It will be noticed from the above that the multiplex principle permits us to



Fig. 3.—Distributor.

send and receive four character signals per revolution. It will be shown shortly that the functions of the levers at the sending end are performed by the transmitter, and the operation of the five relays is utilised in the printer, which selects the predetermined letter or figure. In the same way it will be understood that, by dividing

the ring into a different number of sections, it might be possible to send and receive a greater or lesser number of signals per revolution. The exact method employed will be explained later on, but the above indicates the constitution of multiplex operation. If the line is worked duplex these operations can be accomplished in both



Fig. 4.—Receiver.

directions at the same time, and we then have described a fundamental operation of a quadruple duplex, triple duplex and a double duplex.

Synchronism.

From the above description it is apparent that an essential requirement of such a system is that the rotating contact brushes at either end of the line remain in exactly the same phase relation with respect

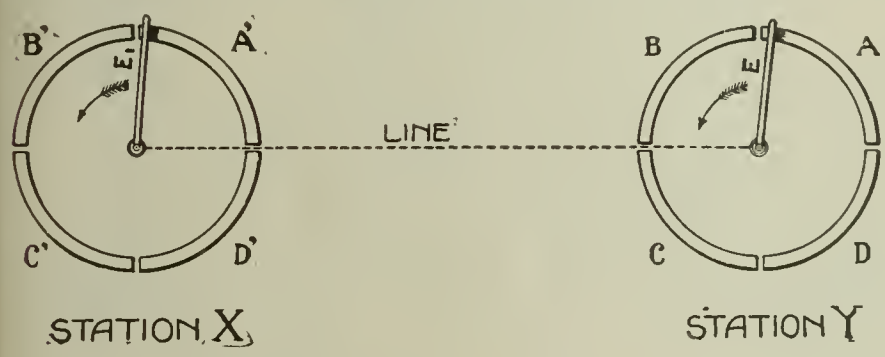


Fig. 6.—Multiplex Operation.

to each other; or, in other words, they must rotate in synchronism. It is impracticable to attempt to correct the phase relation by two motors of any type, but the apparent solution of the problem is to provide means for correcting the phase relation at frequent intervals.

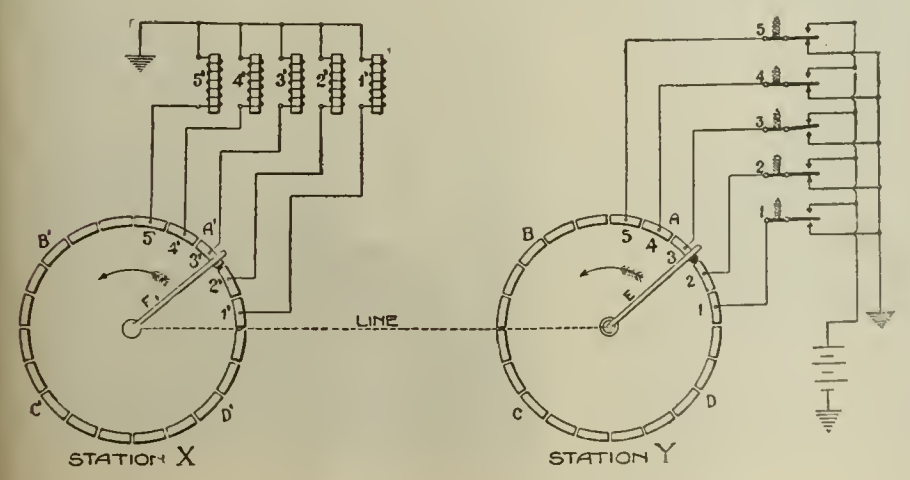


Fig. 7.—Arrangement of Five-Part Quadrant.

Baudot accomplished this result 30 years ago by using weight-driven motors with sensitive governors to maintain a nearly constant rate of rotation. In this case one motor ran slightly faster than the other, and means for correcting the phase of the brushes at the fast end once per revolution if required was provided. This correction was accomplished by mechanically stepping back the brushes whenever they had gained an appreciable amount on the brushes at the slow end of the line. Although practicable, this method was wasteful of line time, since it was necessary to transmit a special signal once per revolution, and, in addition to this, the motor used by Baudot did not permit of readily changing the speed, and was one in which the speed depended upon a number of variable factors. The methods employed to reach an ideal system, in which no extra line time is required for maintaining synchronism, and which overcomes the other objections, is as follows: Referring to Fig. 7, it will be noted that segments 1 to 5, stationed at Y, are connected to keys so arranged that they may send to the line positive or negative currents

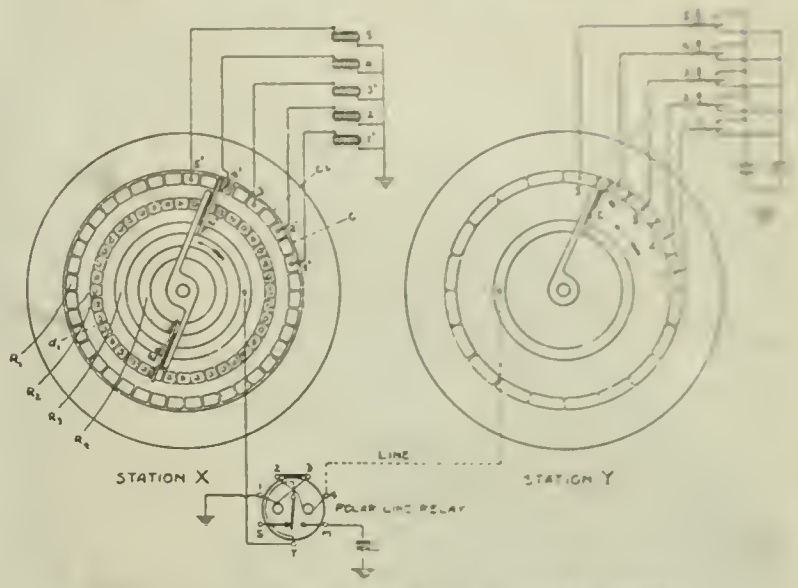


Fig. 8.—Connections to Synchronisers.

depending upon the position of the levers. The brush E contacts these segments consecutively with the solid ring which is connected to the line. At the station X the line is earthed through the windings 1, 2, 3 and 4 of a polarised relay. The tongue T of this relay is connected to the solid receiving ring R_2. The marking contact M of this relay is connected to an earth battery, and when negative current from the distant end is passing through the relay the tongue rests on the spacing contact S. As the brush E rotates it connects the



Fig. 9.—Distributor.

receiving ring R_3 with the receiving segments 1—2—, &c., of R_1 consecutively. It will be noticed that the receiving segments are made shorter than the sending segments, so that the receiving brush E_1 picks out only the centre of each current impulse or of each reversing current impulse, since the signals sent over the line are repeated by means of a polarised relay. If perfect synchronism existed between the sending brush E and the receiving brush E_1 the receiving brush should be at the point C_1, midway between segments 1— and 2—, when the sending brush passes from segment 1 to segment 2, and at

C_1, midway between receiving segments 1—2—, when the sending brush passes from segment 2 to segment 3, and so on. Thus, when a change of polarity takes place, which occurs only when the brush E passes from one segment to another, the receiving brush E_1 should be at some point in the circumference midway between two receiving segments. In other words, reversal of the line current should take place while the receiving brush is passing between receiving segments. The receiving distributor is, therefore, provided with additional rings, R_2 and R_4, called "correcting" rings. R_4 is a solid ring connected consecutively to the segments in R_2 by the brush E_2. These segments are half the length of the sending segments, and therefore double in number.

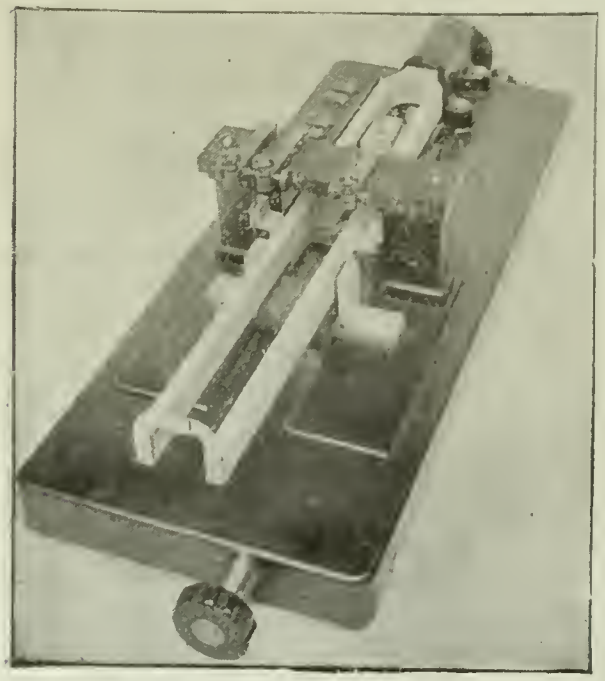


Fig. 10.—Electrically-driven Tuning Fork.

From the figure it is noticed that at each reversal of the line current the position of the correcting brush on the segmented corrected ring determines whether a correction of phase relation shall be made, and since the motor at the receiving end was

Fig. 11.—Distributor and Corrector.

running faster than the one at the sending end it will sooner or later engage a segment at the time of a current reversal. This causes the brushes to be stepped back through a small angle, so that the current reversals take place only while the correcting brush is on these segments; thus the signalling impulses provide correcting impulses which are used to maintain synchronism. The advantage that only the centre portion of the signal is utilised for signalling purposes is that the system is less subject to inductive disturbances.

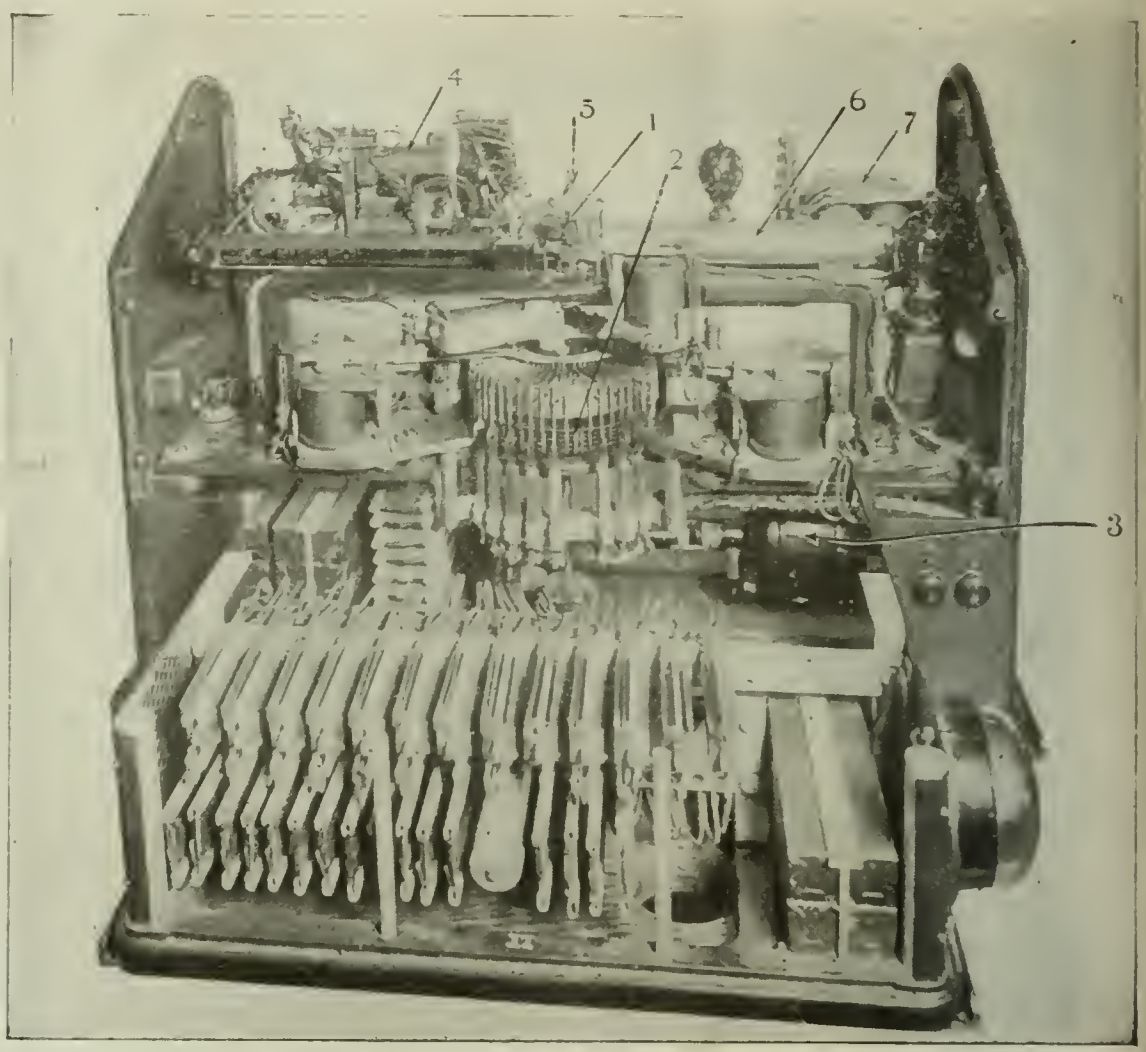


Fig. 13.—Printer and Relay.

Fig. 9 shows the face of the distributor with the brushes, and, as shown, the outside ring of this distributor is the receiving ring, only alternate segments being used for selecting purposes. The intermediate segments in each quadrant are used for specific signalling purposes, which will be described below. The second ring, No. 2, is the correcting ring, and corresponding to ring R_2 of Fig. 8. The third ring, No. 3, is the sending ring, and corresponds to the sending ring at station Y (Fig. 5). The fourth ring, No. 4, is called the local ring, and performs other important functions which will now be described. Referring to Fig. 7 above, it will be remembered that while the brush is travelling over quadrants B, C and D the combination of the levers 1 to 5 should be changed to the combination of the next letter. Likewise, while

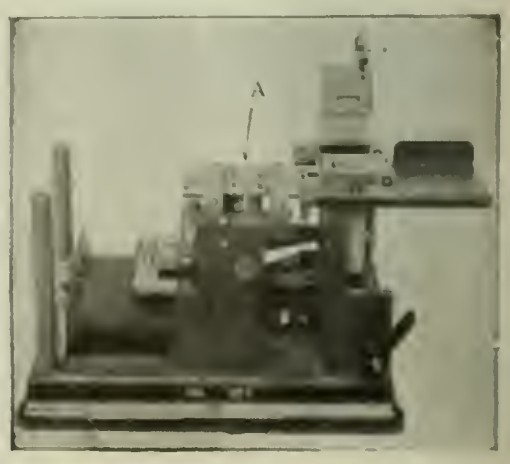


Fig. 12.—Tape Transmitter.

the brush travels over quadrants C, D and A the transmitting apparatus connected to quadrant B should change this combination to the signal of the next letter, and so on. At station X the printer connected to quadrant A′ receives a letter during one-

fourth of the revolution, while the brush E_1 is passing over the segments of quadrant A′; but while the brush is passing over the remaining quadrants B′, C′, D′ the printer has time to complete its printing operation, move the paper and clear, so as to be in readiness to receive another signal. The segments in this local ring, No. 4, are used to perform these functions—that is, certain segments are used to change the signal combinations set up in the different quadrants and start the printing mechanism after selection has been made, so that the printing operation is completed in time to receive the signal for another letter. The motors used to drive the distributors are of the well-known phonic wheel type, and are driven by impulses from an electrically-driven tuning fork. This assures a constant rate of vibration, since the frequency of a tuning fork varies only by about 1/100th per cent. per degree Centigrade, and is little affected by changes in the voltage applied to the driving mechanism. Fig 10 shows the arrangement of fork used, and Fig. 11 shows the motor distributor and mechanical corrector.

The mechanical corrector, which is shown mounted between the distributor and the motor, is a mechanism which is arranged to step back mechanically the brushes when they have advanced too far, as explained already. Large changes in the rate of vibration of the tuning fork can be made by adding weights to the two prongs, and a finer adjustment is obtained by turning the handle at the front of the fork, which by means of gears and a screw moves a small fork, F, forward and backward. The shuttles on the ends of the prongs are used for stroboscopic observation, and are not essentially part of the system.

The Perforator.

This apparatus resembles a standard typewriter, the stroke of the keys being short so that it can be operated without fatigue. The selecting mechanism consists of five horizontal bars placed beneath the keys, and so arranged that each key when depressed will engage one or more of the various bars and depress them by the movement of the key. The depression of these bars selects the punches in the punch head. After the selection of the punches is made a common contact is closed which operates the perforating magnet. The tape is perforated crosswise, so that a considerable saving is effected in the length of the tape. One tape is required for transmission, and the other is prepared by a receiving perforator, and is fitted into a printing machine, which translates it and prints it on a tape.

The above figure shows the transmitter with the cover removed. At each revolution of the distributor the tape is moved one step to the left by means of a pulse of current from a segment in the local ring of the distributor shown above.

The Printer.

In front of the printer is a box containing relays and resistances which are necessary for its operation, and a bell is provided which responds to a signal sent over the line. Alongside this box on the printer frame are two push buttons, and by operating these buttons the operator can return the carriage or cause the paper to be moved upwards. The paper is supplied to the machine from a roll mounted on the back, and so arranged that it can be readily replaced by the operator standing in front of the table. Above the window of the printer is a cutting edge which permits the message to be torn off as soon as completed. The machine is of the type in which the paper moves, and the type wheel is stationary except for its rotary movement. In order to bring the desired letter opposite the paper, this type wheel is mounted on a vertical shaft driven by a spring, which is kept under the desired torque by a small motor and dynamometer. After the letter has been selected the tape shaft is released, and it revolves until it strikes a stop, the position of the stop being determined by the letter selected, and which brings the desired letter in front of the paper. As soon as the type wheel is stopped the paper is forced against the type wheel by a printing magnet, and the letter is printed. The wheel is inked by two felt rollers saturated with ink, and which are held against the type wheel. The selection of stops is obtained mechanically by the use of five discs, each of which has its position determined by an electromagnet under the control of one of the relays connected to the receiving segments. For each combination of relays selected there is a corresponding movement of the discs, which permits the required stop to be moved into such position as to stop the type wheel in the proper position. In this printer the mechanism which moves the paper carriage and the paper across the front of the type wheel is a complete unit by itself, and in case of trouble it can be repaced in a very few minutes without disturbing any of the other adjustments.

The interior of the printer and relay is shown in the next figure.

The printing unit is shown at 5, paper carriage 6, paper lift 7. The lamps marked with numbers are signal lamps essential to its operation.

Automatic Control.

The function of this piece of apparatus is to stop the transmitter when the operator is unable to keep up with the speed set by the distributor. The tape normally forms a small loop, as shown, and

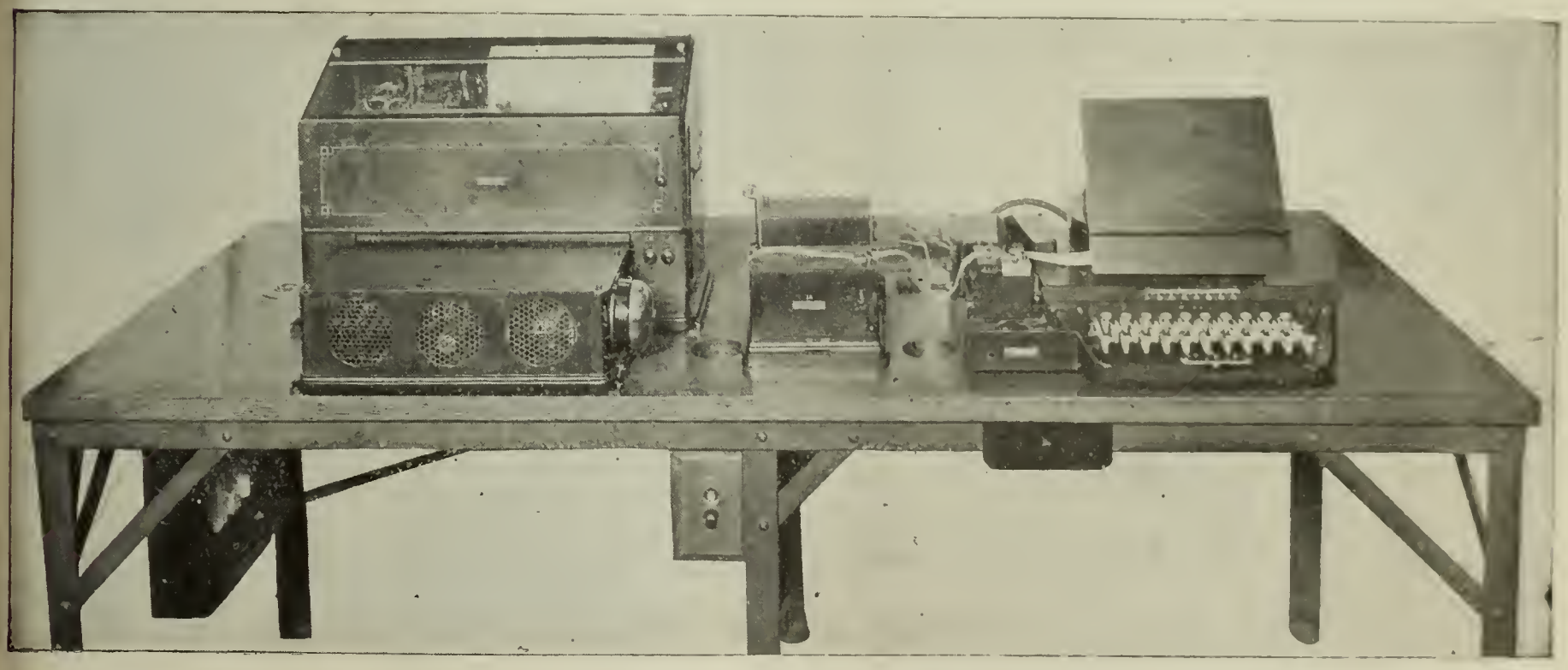


Fig. 14.—Multiplex Table Equipment.

if the perforating operator should stop, the transmitter will continue until the slack in the tape is used up and tension of the tape lifts the lever off the automatic control. This movement automatically stops the transmitter, which, however, continues to transmit only spacing current having any effect on the disc of the printer. As soon as the operator begins perforating the lever is dropped, and the transmitter continues from the point of interruption. Another important feature of the automatic control is that it enables the receiving operator to send bell signals over the line by means of an escapement mechanism which drives keys, causing certain spring combinations to be made in sequence. The next figure shows a complete multiplex table equipment. In a box below the table there are fuses and all connections between the table and the distributor. In addition to the number of table units required for each method of operation there will be required at each end an electrically-driven tuning fork, a motor, a mechanical collector and a distributor having a proper segment arrangement for the particular services required.

In figure 15 below T_1 and T_2 represent tape transmitters.

each of which is fed with tape from a keyboard perforator, and P_1, P_2, &c., represent receiving printers, or if desired re-perforators. In the top diagram of the figure is shown the system connecting four cities, A, B, C, D, which afford the following channels of communication: Between A and B four channels, two in each direction; between A and C two channels, one in each direction; between A and D two channels, one in each direction; between D and C six channels, three in each direction; between B and D six channels, three in each direction. The lower diagram shows a modification of the system for connecting six cities. Whether or not these modifications will ever be installed as described is problematical, but they are at any rate all possible. Owing to the extreme flexibility and comparative simplicity of the system, it opens up entirely new fields. The one-way method will be used to give mercantile establishments easy communication between factory and offices. Modifications of this system are well adapted for news distribution. The multiplex system of Baudot and the five-unit code used by him over 30 years ago form the foundation of the system; but it remained for Mr. Donald Murray, who had previously developed a high-speed

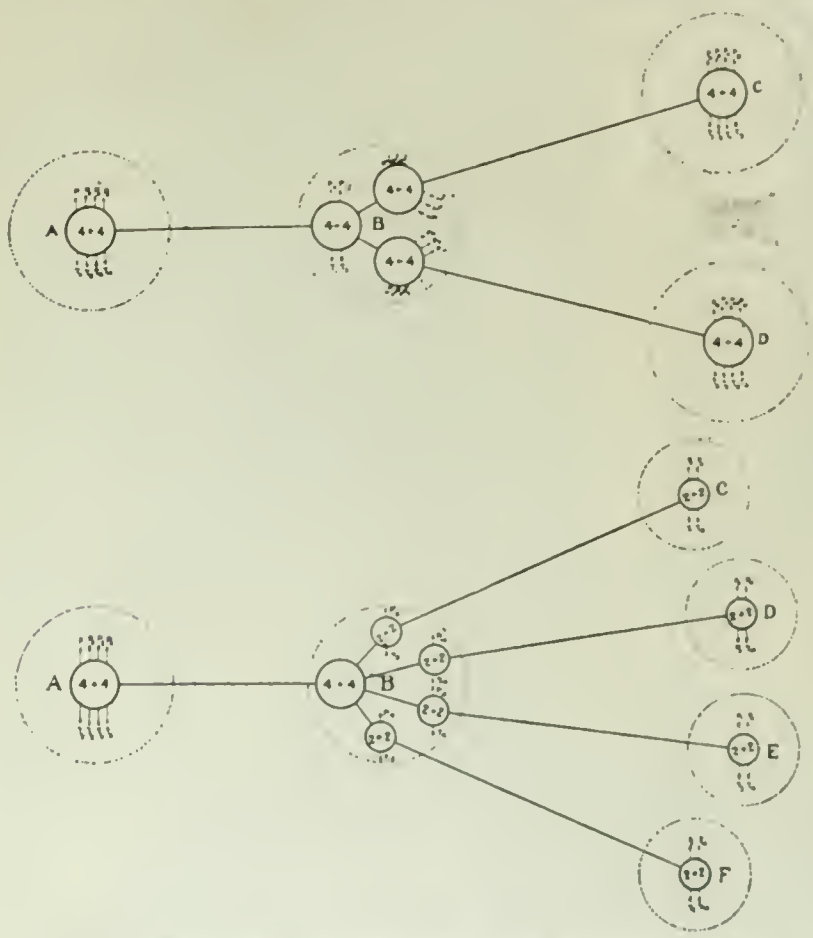


Fig. 15.—Connection between Four and Six Cities.

system using the Baudot five-unit code, to appreciate the inherent advantages of the Baudot multiplex principle. This he incorporated in the multiplex system, which is machine sending and column printing. Although the system above is novel in many respects, it is not altogether an innovation, but rather the adapting of old principles which have been tried successfully.

THIRD HARMONICS IN THE PHASE PRESSURE OF THREE-PHASE ALTERNATORS WITH CYLINDRICAL ROTORS.

BY A. E. CLAYTON, B.Sc.

Summary.—The article deals with the effect of the angle of spread of the exciting winding, and magnetic saturation, upon the magnitude of the third harmonics in the phase pressure of three-phase alternators with cylindrical rotors.

With salient pole alternators the wave shape of the flux distribution on open circuit is not influenced to any appreciable extent by the degree of magnetic saturation at which the iron parts of the machine are worked. As a result, the importance of the third harmonic in the phase pressure of three-phase salient-pole alternators does not depend to a marked extent upon the value of the exciting current.

With cylindrical field machines, on the other hand, the importance of the third harmonic in the phase pressure on open circuit, will depend to a very large extent upon the degree of saturation of the iron, since the flux distribution is largely influenced by this saturation.

The M.M.F. distribution of the exciting winding of a cylindrical field machine is of the trapezium form, shown in Fig. 1, *a*, the "steps" due to the winding being placed in slots being omitted. For convenience, attention will be confined to the case in which both stator and rotor are uniformly slotted over the whole pole pitch, although, in the case of the rotor, the central slots may or may not be wound. Under such conditions, and in the absence of magnetic saturation, the flux distribution will be of the same wave shape as the M.M.F. distribution, and may be represented by the series

$$x = \frac{4}{\pi} \cdot \frac{X}{\beta} \left\{ \sin\beta \sin\theta - \frac{1}{9} \sin 3\beta \sin 3\theta - \frac{1}{25} \sin 5\beta \sin 5\theta + \ldots \right\},$$

where β is the angle indicated in radians, and X the maximum ordinate.

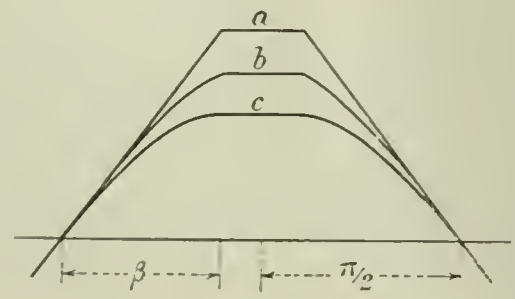


Fig. 1.—Flux Distribution Curves on Open Circuit at Various Degrees of Saturation.

The ratio of the amplitude of the third harmonic to that of the fundamental in the wave of flux distribution is thus equal to $0{\cdot}111 \sin 3\beta \sin\beta$, and is therefore entirely dependent upon the spread of the rotor winding. For values of β between 0 and $\pi/3$ the third harmonic steadily decreases, becoming zero when $\beta = \pi/3$. From $\beta = \pi/3$ to $\beta = \pi/2$ the third harmonic increases in value, but is now negative. The influence of the spread of the rotor winding upon the importance of the third harmonic is well illustrated by the curve given in Fig. 2. It is of interest to note that the third harmonic has the same percentage value for $\beta = \pi/4$, as for $\beta = \pi/2$, but that it is positive in the one case and negative in the other.

It is well known that the spread of the stator winding causes the higher harmonics to be of smaller importance in the wave of

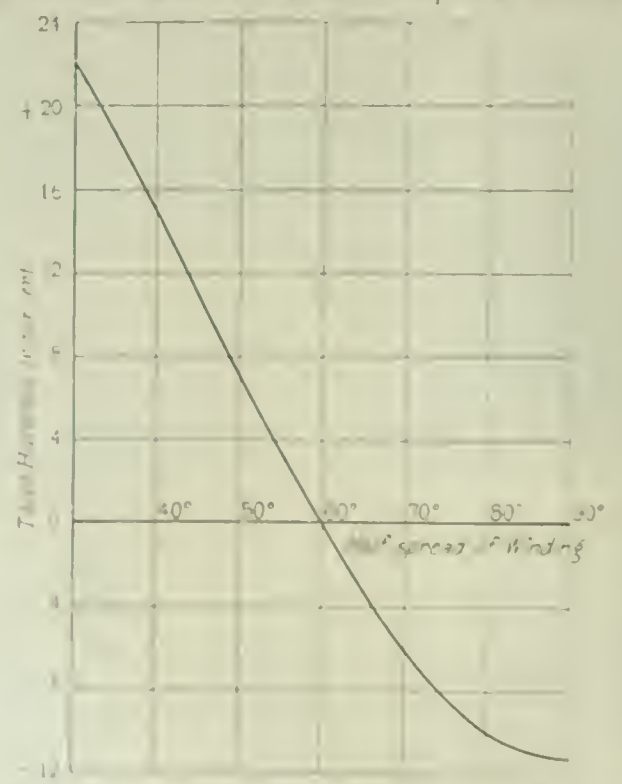


Fig. 2.—Effect of Spread of Exciting Winding upon the Value of the Third Harmonic of the M.M.F. Curve.

the phase pressure than in that of the flux distribution. This matter is very fully discussed in such text books as those by Arnold. For a stator winding spread over one-third of the pole pitch the reduction factor for the third harmonic may be taken as 0·85. As a result, for a completely unsaturated three-phase alternator with a cylindrical rotor, the value of the third harmonic in the phase pressure is $0{\cdot}85 \times 0{\cdot}111 \sin 3\beta \sin\beta$ times the value of the fundamental harmonic, *i.e.*,

$0{\cdot}075 \sin 3\beta \sin\beta$, approximately.

The effect of saturation is to cause the flux distribution to assume some such shape as indicated in Fig. 1, *b* and *c*: the shape consisting simply of portions of the magnetisation curve for an element of the magnetic circuit, joined at the top by straight lines. The flux crossing the rotor slots exercises a minor effect on the shape of the curve, which need not be enlarged upon here. The effect of saturation is thus to produce a flattening of the flux distribution curve, an effect which may largely be represented by the addition of a positive third harmonic to the wave form obtaining when the saturation is absent. So that for values of β not greater than $\pi/3$ the effect of magnetic saturation is to increase the relative importance of the third harmonic in the phase pressure. For values of β between $\pi/3$ and $\pi/2$, however, saturation at first causes a reduction in the value of the negative third harmonic, and ultimately changes it to a positive harmonic, its value then steadily increasing in importance as the excitation is increased. In his Paper* on "The Non-Salient Pole Turbo Alternator," Dr. S. P. Smith illustrates the changes which take place in the value of the third harmonic of the flux distribution for the case when $\beta=1{\cdot}21$ radians, as shown by oscillographic records.

Simple experiments to illustrate the effect of saturation upon the importance of the third harmonic have been carried out by the present author. Cylindrical field turbo-alternators are rarely available in technical colleges and universities, but a very good substitute is to be found in the slip-ring induction motor, which has the further advantage of making it possible to carry out tests with exciting windings of different spread.

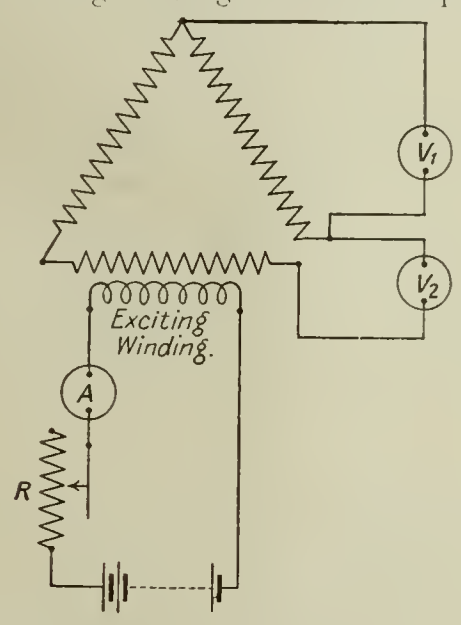


Fig. 3.—Diagram of Connections for Test.

The tests here described were performed on a three-phase motor having a two-phase slip-ring rotor. The machine was driven round at normal synchronous speed, and excited by means of continuous currents fed into the rotor winding. By using one phase only, a spread corresponding to $\beta=\pi/4$ was obtained, and by using the two phases in series the spread corresponded to $\beta=\pi/2$.

For these two cases, it will be remembered that, when the saturation is negligible, the third harmonics have the same relative value, but are of opposite signs.

The stator windings were connected mesh, and a hot-wire voltmeter (V_2) was introduced at one of the junction points as shown in the diagram of connections (Fig. 3). In addition another hot-wire voltmeter (V_1) was so connected as to record the actual phase pressure. The voltmeter V_2 thus recorded the total unbalanced pressure, and therefore gave the effective value of the harmonics of the third order for the three phases, its reading being three times as great as the value of these harmonics in the phase pressure. Readings were taken at various excitations.

Table I. gives the actual test results for the case in which the exciting winding consisted of the two phases joined in series, and Fig. 4 shows the results graphically. The manner in which the reading of the voltmeter V_2 changes is most interesting. At first the reading steadily increases, but at a diminishing rate, a maximum being reached at just below

* "Journal" I.E.E., Vol. XLVII., p. 582.

Table I. *Experimental Results with $\beta=\pi/2$*

Exciting current.	Phase pressure.	Total unbalanced pressure.	Exciting current.	Phase pressure.	Total unbalanced pressure.
Amperes.	Volts.	Volts.	Amperes.	Volts.	Volts.
1·0	11·0	..	6·0	70·0	2·4
1·5	17·0	3·1	6·5	78·5	2·6
2·0	22·5	3·8	7·0	83·0	4·4
2·5	28·5	4·4	8·0	94·0	8·5
3·0	33·5	4·8	9·0	97·0	..
3·5	38·0	5·1	10·0	99·5	14·7
4·0	42·0	5·1	11·0	72·0	..
4·5	46·0	4·8	12·0	74·0	22·0
5·0	50·0	3·9	14·0	77·0	25·2
5·5	53·0	3·1	16·0	80·0	29·0

Table II. *Experimental Results with $\beta=\pi/4$*

Exciting current.	Phase pressure.	Total unbalanced pressure.	Exciting current.	Phase pressure.	Total unbalanced pressure.
Amperes.	Volts.	Volts.	Amperes.	Volts.	Volts.
2	16·0	3·1	8	57·5	18·0
3	24·0	5·4	10	65·5	22·7
4	33·0	8·0	12	71·0	27·3
5	39·5	10·1	14	74·0	31·0
6	46·5	12·6	16	76·5	35·5
7	52·5	15·1			

4 amperes excitation. The reading of the voltmeter then falls rapidly, in spite of the increasing excitation and a minimum is reached at just above 6 amperes excitation. Beyond this point the unbalanced pressure increases very rapidly indeed

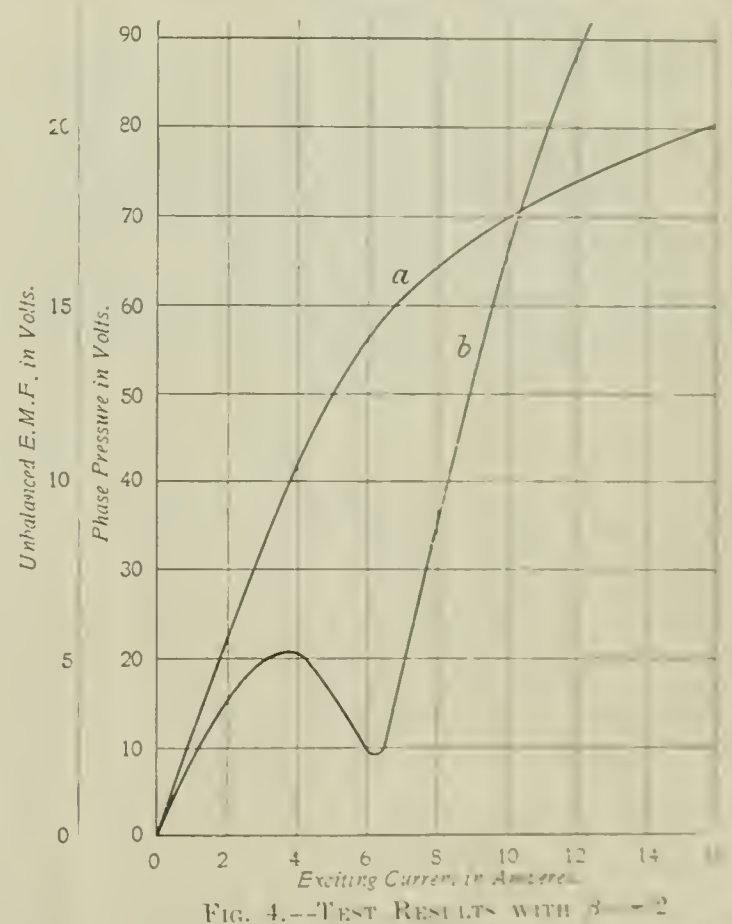


Fig. 4.—Test Results with $\beta=\pi/2$

Curve "*a*" is the phase pressure and "*b*" the total unbalanced E.M.F.

It will be noted that the unbalanced pressure does not fall to zero. This is probably due to the fact that other harmonics of the third order are present when the third itself is absent.

Table II. gives the results for the case when one phase only of the rotor was used as the exciting winding, Fig. 5 showing the results graphically. In this case it will be noted that the unbalanced pressure increases quite steadily as the excitation is increased.

The results are even more striking when the unbalanced pressure is plotted as a percentage of the total pressure per phase, as shown in Fig. 6. In obtaining these curves the total unbalanced pressure has been divided by three, to obtain the value per phase.

It will be noted that the initial value of the percentage unbalanced pressure is the same for the two cases, and that its magnitude agrees fairly well with the theoretical value. The

minimum value reached in the case of the fully distributed rotor winding is about 1·5 per cent.

Tests on a slip-ring motor with a three-phase rotor would enable the cases of $\beta=\pi/6$, and $\beta=\pi/3$ to be investigated. In the latter case the unbalanced pressure would start from zero and steadily increase as the excitation is increased.

Further experiments were carried out to determine the value of the circulating current set up in the mesh winding at various

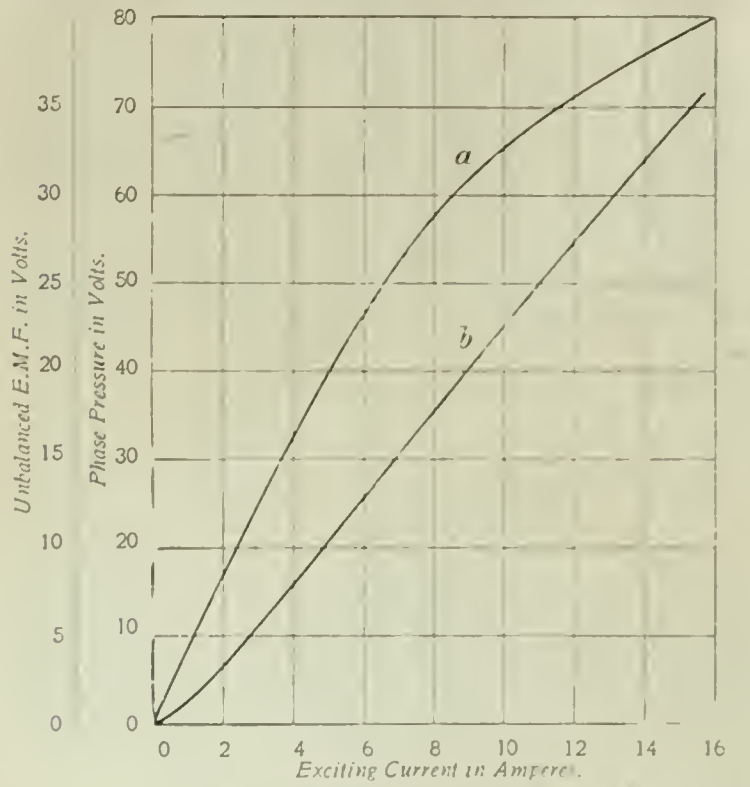


FIG. 5.—TEST RESULTS WITH $\beta=\pi/4$.
Curve "a" is the phase pressure and "b" the total unbalanced E.M.F.

excitations. For these experiments the voltmeter V_2 (Fig. 3) was replaced by a hot-wire ammeter. The current obtained followed so closely the variations measured in the unbalanced pressure that it is not necessary to reproduce the results here.

These experiments illustrate well the nature of the actual phenomena which are set up in commercial turbo-alternators with cylindrical rotors. The actual magnitude of the per-

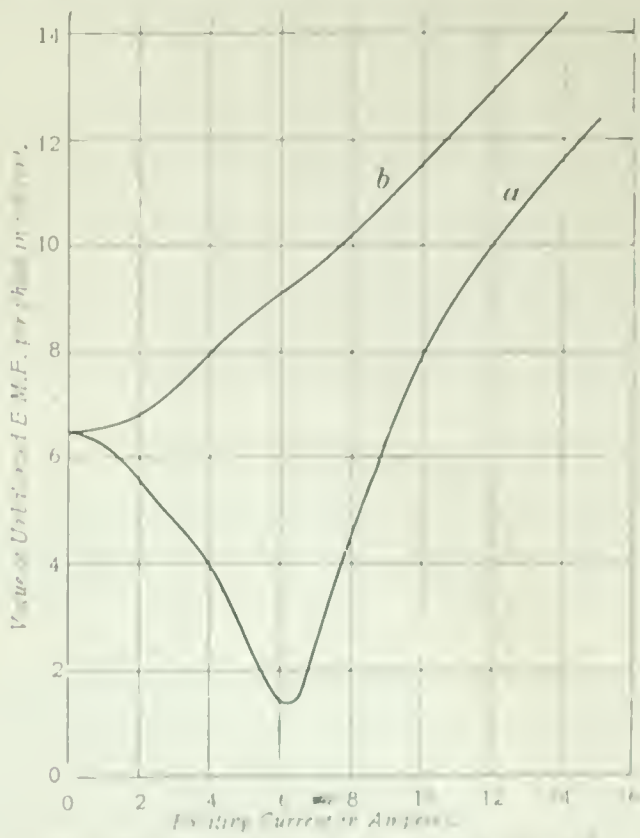


FIG. 6.—TEST RESULTS WITH $\beta=\pi/4$ AND $\pi/2$.
Curve "a" is for $\beta=\pi/2$, and "b" for $\beta=\pi/4$.

centage unbalanced E.M.F. will depend upon the length of the magnetic lines in the stator and rotor teeth, and the degree of magnetic saturation at which these teeth are worked, and also upon the value of the radial air-gap.

With cylindrical rotors in which the central portions of the poles are left unslotted the third harmonics will be considerably less than in the case considered, viz., of a uniformly slotted rotor, under normal conditions.

INSTITUTION OF ELECTRICAL ENGINEERS.

ANNUAL GENERAL MEETING.

The annual general meeting of the Institution of Electrical Engineers was held on Thursday, May 11, under the presidency of Mr. C. P. Sparks, who dealt in his opening speech with the Annual Report of the Council, an abstract of which is given below.

REPORT OF THE COUNCIL.

The membership at April 1, 1916, consisted of 7 honorary members, 1,500 members, 3,466 associate members, 520 associates, 382 graduates and 801 students, or a total of 6,676.

Thirty-four members have been reported during the year to have lost their lives in the service of their country.

Meetings.—During the past 12 months 12 ordinary meetings and 19 Council meetings have been held. The usual standing committees have met regularly, and there have also been meetings of other committees appointed by the Council for the consideration of special matters, the total number of committee meetings held during the year being 86. There have been 39 meetings of local sections—viz., Birmingham Local Section 7, Manchester Local Section 11, Newcastle Local Section 5, Scottish Local Section 6, Western Local Section 4, and Yorkshire Local Section 7. Meetings have also been held of the Local Centres at Calcutta, Cape Town, and Hong Kong.

Premiums.—The following premiums for Papers have been awarded by the Council. In accordance with precedent, in deciding upon these awards the Council have not taken into account Papers contributed wholly or in part by Members of Council: The Institution premium (value £25) to Mr. J. R. Beard, the Fahie premium (value £10) to Mr. H. H. Harrison, the John Hopkinson premium (value £10) to Prof. A. B. Field, the Paris premium (value £10) to Mr. N. W. Storer, an extra premium (value £5) to Messrs. A. Campbell and D. W. Dye, an extra premium (value £5) to Mr. A. E. Clayton, and an extra premium (value £5) to Prof. G. W. O. Howe. In view of the small number of Papers read this session at meetings of the Students' Sections, no students' premiums have been awarded, but the Papers read will be taken into consideration at the next award of students' premiums.

Scholarships.—In view of the absence of a large number of students on Naval and Military service, the Council have decided not to award the David Hughes and the Salomons scholarships this year.

Local Centres of the Institution Abroad.—During the year a local centre of the Institution has been inaugurated in Hong Kong and several meetings have been held. The formation of a Canadian local centre has also been proposed, but in view of present circumstances the Council have thought it advisable to postpone taking further action until the end of the war.

Wiring Rules.—A further revision of the wiring rules has now been completed, and the seventh edition was published in March last. 24 meetings of the Wiring Rules Committee were held during the course of the revision, and upwards of 500 amendments were considered. The new rules have been adopted by the whole of the fire insurance companies of the United Kingdom. They have also been accepted as standard practice, and their use is recommended by the Incorporated Association of Electric Power Companies, the Incorporated Municipal Electrical Association, the whole of the electricity supply companies of London, and by the principal supply companies in the provinces. 13,500 copies were issued of the sixth edition published in 1911.

Examinations.—The last examination of candidates for associate membership was held on April 30 and May 1, 1915, when entries were received from 2 students, 6 graduates and 1 other candidate who had been offered election as associate member provided that he complied with the examination regulations, the total number of candidates being 9. Papers were set in five non-technical and four technical subjects, and the examination was held in London and Manchester concurrently. One candidate did not present himself, and of the others 5 passed and 3 failed. During the year six theses were presented in lieu of the examination, of which five were accepted.

Research.—In July last an announcement was made in Parliament that the Government had included a sum of £25,000 in the annual estimates for the promotion of scientific and industrial research. On the invitation of the Committee of the Privy Council, to which the administration of this sum was entrusted, application was made for a grant in aid of the following researches now being conducted or under consideration by the Institution—viz., (*a*) the heating of buried cables, (*b*) the properties of insulating oils, (*c*) current densities in wire, (*d*) fibrous materials (treated and untreated), (*e*) porcelain, (*f*) ebonite and mica, (*g*) composite materials, (*h*) the properties of rubber.

Grants have now been received of £840 in respect of (*a*), and £250 in respect of (*b*), to cover the cost of a year's work, and the other applications are under consideration.

The Council have appointed Mr. J. S. Highfield, vice-president, to be the representative of the Institution on the Engineering Committee of the Advisory Council for Research which has been appointed by the Committee of the Privy Council to make recommendations for the allocation of the above-mentioned Government subsidy.

National Service.—From returns supplied by members it appears that the number of members serving or having served in the Navy or the Army

since the outbreak of the war is over 1,300—viz., 129 members, 585 associate members, 66 associates, 89 graduates, and 438 students.

Early in December the President at the request of the authorities nominated a limited number of young electrical engineers for commissions in the Signal Service, Royal Engineers.

The Council have had under consideration a scheme whereby the Institution may be of assistance in training and finding employment for disabled soldiers and sailors. Letters were sent to a number of electric supply undertakings to ascertain whether they can employ such men, provided that they have received some sort of preliminary training in the duties of sub-station switchboard attendants. Satisfactory replies have been received, and the manner of arranging for the training of these men, obtaining means for carrying out the same, and selecting and distributing applicants for positions is now being considered. A preliminary guarantee fund of over £300 has been established for this purpose by past and present Members of Council.

Benevolent Fund.—The committee of management of the Benevolent Fund of the Institution report that on December 31, 1915, the capital account of the fund stood at £4,642. 3s. The donations and subscriptions to the fund in 1915 amounted to £777. 2s. 7d., including a legacy of £250 from the late Mr. Augustus Stroh. In the course of the year seven grants were made amounting to a total of £126.

Excess of Income over Expenditure.—The margin to the good on the revenue account—viz., £1,847. 1s.—carried to the credit of the general fund, compares with £1,623. 10s. 8d. in 1914.

The President then announced the result of the ballot for filling vacancies on the Council. With regard to the ballot papers, 1,058 were returned, a distinct advance on the previous year when the total was just over 500. Of those returned 52 were spoilt, leaving 1,006 effective. The following were elected: *President:* C. P. Sparks. *Vice-Presidents:* R. A. Chattock, C. H. Wordingham. *Honorary Treasurer:* J. E. Kingsbury. *Ordinary Members of Council:* G. H. Nisbett, W. Llewellyn Preece (Members); F. W. Crawter, H. H. Harrison, W. R. Rawlings (Associate Members); T. O. Callender, J. Devonshire (Associates). The new Council stands as follows:—

PRESIDENT.
C. P. Sparks.

VICE-PRESIDENTS.

R. A. Chattock.	Dr. A. Russell.
C. H. Wordingham.	Roger T. Smith.

HONORARY TREASURER.
J. E. Kingsbury.

ORDINARY MEMBERS OF COUNCIL.

G. H. Nisbett.	H. Dickinson.	H. F. Proctor.
W. Ll. Preece.	Prof. T. Mather, F.R.S.	G. S. Ram.
W. A. Chamen.	G. W. Partridge.	R. J. Wallis-Jones.
J. Christie.	W. H. Patchell.	W. B. Woodhouse.

ASSOCIATE MEMBERS.

F. W. Crawter.	H. H. Harrison.	W. R. Rawlings.

ASSOCIATES.

T. O. Callender.	J. Devonshire.	J. Hunter Gray.

The President next announced that the Williams Premium had been awarded to Dr. S. Z. de Ferranti for his Presidential Address for the Session 1910-1911, and went on to say it would be seen from the Report that there were 6,676 members of all grades, a net decrease of 141. M. Maurice Leblanc, of Paris, had been elected an Honorary Member. Honours conferred upon members during the year included a Baronetcy conferred upon Sir Henry Norman, a K.C.B. upon Lord Moulton and upon Col. Holden, and Knighthoods upon Sir William Slingo and Sir George Franklin. A long list of military distinctions conferred upon members also appeared in the Report, including the Victoria Cross won by Lieut-Com. E. G. Robinson, R.N. Thirty-four members had lost their lives in the service of their country, of whom 18 were killed in action, while of the remainder 12 died of wounds. The Council deeply regretted these losses, and also the decease of Mr. C. E. Spagnoletti, Prof. Eric Gerard and Mr. Robert Hammond (honorary treasurer).

The Annual Dinner and Conversazione would not take place this year. The Kelvin Lecture was delivered by Dr. Charles Chree on Feb. 17. The premiums granted were set out in the Report (abstracted above). In view of the small number of Papers read at Students' Sections, in consequence of the war, no premiums had been awarded to students, but the Papers read would be taken into consideration at the next award.

He now proposed the adoption of the Council's Report.

Mr. F. H. NALDER seconded the motion.

Mr. E. L. JOSEPH asked if any of the resignations or lapses of members were due to the intimation that foreigners would be expelled later on. He also asked how it was that the revenue had increased while the membership had decreased. Had they anything invested in the War Loan, and if not, why not? He also suggested that an account of the investments should be given. The Council's Report was in the "Journal," and was also printed separately. He doubted whether that was in the interests of economy. It was advisable to economise in stationery all round. Several members had been entered in the Roll of Honour. Was the sympathy of the Institution expressed officially, and would a memorial tablet be made of the names later on?

The President said the resignations were 96, compared with 123 in the previous year. The lapsed members were 178 against 244. As regarded the alien question he did not think any large number of resignations had been received from that cause, although some were threatened. One member tendered his resignation because the Council were not dealing with the matter, but as soon as he saw the action they were taking by the postal vote, he expressed his desire of reconsidering, so the action taken by the Council in February had retained at least one member, whom they would have lost. The hon. treasurer would deal with the question of revenue. Only a limited number of the Reports were printed separately from the "Journal" in case members had not brought the "Journal." The extra expense was not much, the composition being the chief item of cost. He cordially agreed with Mr. Joseph's suggestion with regard to economy, and they had kept the idea in mind during the year. In every case of the death of a member on military service a letter of regret in the name of the President was sent to the nearest relative.

Mr. W. R. COOPER asked why the net cost of "Science Abstracts" shown in the accounts, was up about £100 for a smaller volume, and the President said this was due to increased cost of paper.

The motion for the adoption of the Report was then carried unanimously.

The PRESIDENT then moved the adoption of the accounts and balance-sheet.

Mr. PERCY ROSLING seconded the motion, and said the Council deserved great credit for the way they had carried on during the past strenuous year, and shown a higher margin than the previous year.

Mr. J. E. KINGSBURY (hon. treasurer) said the results were perhaps somewhat better than might have been expected. The increase in revenue was not derived from subscriptions, but from other sources such as dividends on investments, rents received. Their investments were stated, and he did not think there was any question as to their quality. There had not been any opportunity of making investments during the period that the War Loan was available, but the War Loan would be taken into account when any investments were contemplated.

Mr. W. C. P. TAPPER thought the value of some of the Council's assets was put at too high a figure in the balance-sheet, and Mr. Kingsbury explained that the assets were taken at cost, though it was clear that they would not at the moment be of that value. They dealt with them in the same way as other Institutions, including the Civils and the Chartered Accountants. There was not occasion to take into account the possible necessity of realising them, as there would be in the case of a bank's assets.

In reply to Mr. W. R. Cooper's suggestion that the previous year's figures might be printed in the accounts to facilitate comparison, the PRESIDENT said the Finance Committee's attention would be drawn to the matter.

Mr. W. B. ESSON thought investments should be written down by a certain percentage every year, while the present values were down.

The PRESIDENT said the question would be referred to the Finance Committee and the auditors.

Mr. A. A CAMPBELL SWINTON and Mr PERCY ROSLING were of the opinion that so long as they got the income on the investments and did not want to realise them they should continue at a fixed figure.

The resolution for the adoption of the accounts was then passed.

Mr. ROGER T. SMITH proposed a vote of thanks to the hon. secretaries of Local Sections and hon. secretaries and treasurers abroad.

Mr. SAM MAVOR seconded the motion and said he did so with a keen appreciation of the sacrifice of time and labour which they made for the interests of the Institution.

The motion was passed unanimously.

Mr. J. S. HIGHFIELD proposed a vote of thanks to Mr. J. E. Kingsbury, the new hon. treasurer, who took up the work after the death of Mr. Robert Hammond. Mr. Hammond's commanding personality was one which they would always carry in their hearts, and Mr. Kingsbury in taking up his work was taking up a difficult task. It was largely due to Mr. Hammond's work that the finances of the Institution were in such a good position to-day. It gave him great pleasure to propose a vote of thanks to Mr. Kingsbury, to whom they should all be grateful for producing such a good balance-sheet.

Mr. F. H. NALDER seconded, and said they all appreciated Mr. Kingsbury's work and trusted he would long live to be able to do it.

Mr. J. E. KINGSBURY acknowledged the vote of thanks and added that he wished the members clearly to understand that the finances of the Institution were not a one-man job. The Council took the most watchful care of them, and the Finance Committee, of which Mr. Highfield was chairman, went into every detail. He proposed that the best thanks of the Institution be accorded to the hon. auditor, Mr. Sidney Sharp. The Council regretted that Mr. Alabaster, who had worked with Mr. Sharp as his colleague since 1906, was prevented by ill-health from continuing this year, although Mr. Alabaster appeared now to be in better health than he had been recently. Mr. H. Faraday Proctor seconded the motion and it was carried unanimously.

On the motion of Dr. A. Russell, seconded by Mr. W. R. Cooper, a vote of thanks to the hon. solicitors, Messrs. Bristows, Cooke and Carpmael, was passed.

Mr. KINGSBURY explained that Mr. Esson who had been nominated to replace Mr. Alabaster found it impossible to go on in the office of hon. auditor, and there had not been time to give the necessary 14 days' notice for the nomination of a successor.

Mr. W. B. ESSON said he found the audit took 8 to 10 days' steady work for two men, and he did not think it right to hold the office if he could not find time to do the work. He suggested that the office of hon. auditor might be abolished.

The PRESIDENT said it would put the Council in an invidious position to suggest that an office held by gentlemen who had loyally given their work for years should be abolished.

Mr. A. A CAMPBELL SWINTON proposed that Mr. Sharp be appointed and that the Council fill the remaining position by electing the pro-

fessional auditors. Mr. F. H. Nalder seconded and the motion was carried.

Mr. Sidney Sharp said he thought Mr. Esson was mistaken as to the duties of an hon. auditor. They did not have to check the professional accountants, but to survey the ledger and accounts generally, check the bank balances and see that the Institution's property represented by title-deeds, certificates, &c., was still in being, to suggest improvements and simplifications of the system of keeping the accounts. Greater facilities for referring to title-deeds resulted from proposals made by Mr. Danvers and himself in 1906. The professional accountant was responsible for the accuracy of the accounts and the hon. auditors were responsible in a broader sense.

The President thanked Mr. Sharp on behalf of the members for his explanation and for the great help he had been to the Institution for a very long period.

The proceedings then terminated.

THE PRODUCTION OF CONSTANT HIGH POTENTIAL WITH MODERATE POWER CAPACITY.*

BY A. W. HILL.

Summary.—Unsatisfactory results have always attended any attempt to produce a high-voltage direct current of more than very small power capacity. Recently, however, a method employing the newly-developed kenotron has been utilised for producing high-voltage direct current having a moderate power capacity. The article describes in detail the method, the calculations, and the necessary apparatus, and is supplemented by oscillographic records.

Up to the present time only two methods have been available for the production of constant high potential—viz., the electrostatic induction machine and the combination of a large number of low-voltage direct-current generators in series.

The author then sketches the development of the Holtz and Toepler induction machines. Machines have been built, having 20 movable and 20 stationary discs, which can generate as much as 80 milliamperes. But a large part of this is lost at high voltages by surface leakage, which becomes so great at about 50,000 volts that it is usually impossible to get anything above this voltage unless the plates are extremely dry and clean. Some of the most recent machines have plates made of a composition that is less hygroscopic, and one of the best of these, with eight moving and four stationary plates, gives 4 milliamperes at voltages of nearly 100,000, and can deliver a little current even at 150,000 volts.

The chief limitation of machines of the electrostatic type, besides their small power, is that the voltage is not constant, but builds up indefinitely until limited by spark-over or brush discharge.

Regarding direct-current generators, the cost is generally prohibitive for small powers. The apparatus to be described was not designed to meet this general demand, but as an accessory to a definite investigation on X-ray spectra. It has, however, proved so satisfactory as to recommend itself for quite general use where constant high voltage of a few kilowatts capacity is needed.

Outline of Method. The method used was that which has been under investigation—namely, the rectification by kenotrons of high tension alternating current, and using this rectified current to feed a high-voltage condenser of such capacity that it can supply the desired current during the part of each cycle when it is receiving nothing without having its voltage drop more than a small specified amount. In the present case the capacity used was much smaller than that necessary to keep the voltage fluctuations within the desired range, and these fluctuations, which were about 25 per cent. for full-load, were damped out by the use of another small condenser of the same size and a small choking coil. The arrangement is shown in Fig. 1. Single phase alternating current of 2,000 cycles at 150 volts is stepped up to the desired voltage by a transformer, T, rectified by kenotrons K_1 and K_2, and smoothed out by the condensers C_1 and C_2 (0·001 mfd. capacity each) and inductance L_1 and L_2 (about 200 henrys each). The manner of operation of the inductance and capacity is discussed below. The voltage is measured by an ordinary voltmeter V in series with a 10 megohm resistance R.

By this means it was possible to supply 5 kw. at any voltage between 10,000 and 100,000 volts with a voltage fluctuation of less than 1 per cent. This output could, if desired, be more than quadrupled by the use of 4 kenotrons instead of 2, and still further increased by the use of three-phase alternating current as described below.

The 2,000-cycle Generator.—The generator is of the dynamotor type, that is, one in which the same magnetic field is used for motor and generator. It is designed for a 10 kw. single-phase 2,000 cycle output, and operates on a 440-volt three-phase 60-cycle line. It can be built equally well to operate on any voltage, alternating-current or direct current.

The Transformer.—The transformer is built for 75 kv. R.M.S. It has an air-gap in the magnetic circuit, and when untuned takes 75 amperes magnetising current. By the use of 50 mfd. capacity across the primary this is reduced to about 3 amperes.

This use of an open circuit transformer makes it possible to use only one-half of each wave, as in the arrangement shown in Fig. 1, without appreciably distorting the voltage wave, and it gives a very convenient means of voltage control—viz., by varying the capacity it is possible to vary the voltage over the entire range from 40,000 to 100,000 volts. This is the method of control used.

The Kenotron.—It consists of a hot filament cathode and a metal anode, generally tungster or molybdenum, which is so thoroughly freed from gas by intense heating during evacuation that no gas phenomena ever appear, even at 100,000 volts. Under these conditions the conductivity of the tube is entirely unidirectional, the current being carried only by the electrons emitted by the hot filament. An illustrated article on "The Kenotron" appeared in The Electrician, Vol. LXXV., p. 276, to which we refer the reader for further details.

The Condensers.—Since no satisfactory high voltage condensers are on the market, it was necessary to use a number of low-voltage condensers in series. This introduced a new problem. When series condensers are used on alternating current the leakage in one direction is just as great as in the other, so that there is no

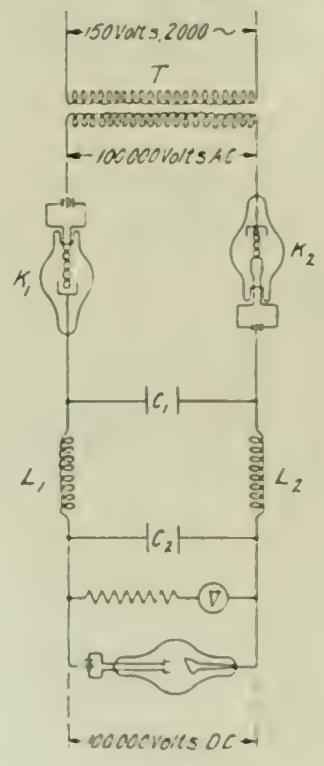


Fig. 1.

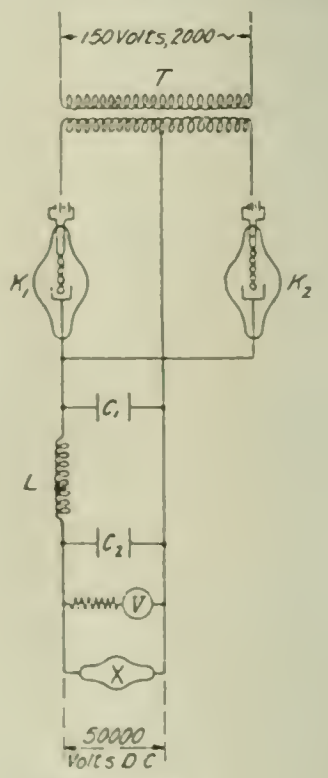


Fig. 2.

Diagrams of Connections for the Production of High-voltage Direct Current.

tendency for the voltage to become unequally divided between them. With direct current, on the other hand, unless the leakage over each condenser is exactly the same, the tendency would be for the voltage to become more and more unequally divided between the condensers, until finally one would break down. The process would then be repeated with the condensers that were left, until all had broken down. The condensers were of paraffined paper, and the gaps used to protect them were made with sewing needles with $\frac{1}{4}$ in. between the points.

The Inductance.—The high tension winding of a 6,600/110-volt 200 watt instrument transformer has proved quite satisfactory as a high impedance. The best measurements obtainable indicated that the inductance varies from 1,000 to 200 henrys. For different loads the values of voltage fluctuation calculated on this basis agree very well with the oscillograms shown in this article.

The Voltmeter Resistance.—The 10-megohm resistance consists of 1,000 voltmeter spools, 10,000 ohms each, in series. They are mounted 1 in. apart on lattices of $\frac{1}{2}$ in. by $\frac{1}{2}$ in. hard wood, 100 to each lattice, and the lattices are spaced 3 in. apart vertically above each other. The lattice allows free circulation of air, and the coils, which at maximum voltage carry only the same current as in the standard voltmeter, are in no danger of overload. In order to avoid any possible errors due to corona, the whole unit is immersed in oil, but this would not be necessary where more space is available.

* Abstract of an article in the "General Electric Review (U.S.A.)

Function of Kenotron and First Condenser.—The kenotron may be characterised as a device which has a very low resistance, of the order of 1,000 ohms, for current in one direction, and an infinite resistance for current in the other direction, and which is entirely free from the lag and "breakdown" that are necessary to the starting of gas rectifiers.

The condenser C_1 is a simple electric reservoir which absorbs energy from the transformer, through the kenotrons, during a small part of each cycle and delivers it to the circuit at a nearly constant rate during the remainder.

Writing, $$-C_1\frac{dV}{dt}=i,$$

where V is the voltage across C_1 and i the current from the circuit, then in practical cases the current i is nearly constant, so that (1) integrates into

$$-\Delta V=V_A-V_B=\frac{it}{C_1},$$

where t is the time represented by the distance AB, practically one cycle. This allows the voltage fluctuation ΔV, for any given values of i, C_1 and frequency n, to be very simply calculated. For example, with the values $i=0{\cdot}050$, $C_1=10^{-9}$ and $t=\frac{1}{n}=\frac{1}{2{,}000}$, given above, $\Delta V=25{,}000$ volts. Conversely, the capacity that would be necessary to reduce the fluctuation to any given value, say, 1 per cent., can be calculated.

Function of Inductance and Second Condenser.—The inductances L_1 and L_2 and the capacity C_2 co-operate as follows: The voltage fluctuation at the terminals of C_1 is an irregular shaped wave, which when analysed into a Fourrier's series gives a fundamental sine wave of frequency 2,000 plus a series of higher harmonics. To each of these component alternating-current frequencies, the inductance L_1+L_2 and the condenser C_2 offer definite impedances respectively. The ratio of the amplitude which any given component will have at the terminals of C_2, to its amplitude at the terminals of C_1 is the ratio of the impedance of C_2 to that of C_2 and

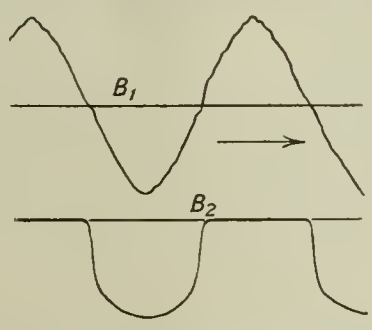


FIG. 3.

Upper curve, alternating-current voltage (base line B_1).
Lower curve, rectified current (base line B_2).

L_1+L_2 in series, that is, the amplitude of the given component will be reduced to this fraction of its value by the action of L_1+L_2 and C_2. In the case given above, where $C_2=0{\cdot}001$ mfd. and $L_1=L_2=200$, we have for the 2,000 cycle component

$$\frac{\delta VC_2}{\delta VC_1}=\frac{\text{impedance of } C_2}{\text{impedance of } C_2 \text{ and } L_1+L_2}=\frac{1/C_2\omega}{1/C_2\omega+L\omega}=\frac{1}{64}.$$

We have seen above that the maximum amplitude of the voltage fluctuation across C_1 is 25 per cent. at 100,000 volts and 50 milliamperes, and if we take this as the amplitude of the 2,000-cycle component, then the amplitude of this component at the terminals of C_2 would be 1/64 of 25 per cent., or less than $\frac{1}{2}$ per cent.

In like manner, the ratio of the amplitude of the second harmonic, the 4,000-cycle component, at the terminals of C_1 and C_2 respectively, comes out to be 1/256, of the third harmonic 1/576, of the fourth 1/1024, &c.

Regarding the effect of inductance without capacity in the position C_2. It is often carelessly assumed that inductance in a line will of itself absorb current fluctuations. It is evident from the above reasoning that this is true only when the load itself has a low impedance. For small loads this is by no means the case, and for an X-ray tube of the Coolidge type, in which the current is constant and independent of voltage, the impedance is infinite for all loads and all frequencies. Hence, in this case, the use of inductances L_1 and L_2 without capacity, or some other low impedance, in the position C_2, would be entirely ineffectual.

Proportioning of Capacity between First and Second Condensers.—The most efficient proportion of capacity between C_1 and C_2 can be calculated as follows, if we assume as seems justified by the oscillograms, that the 2,000-cycle component is the principal one and that its amplitude is approximately equal to the maximum voltage fluctuation at the terminals of C_1:

Let ΔV = amplitude of 2,000 cycle component at terminals of C_1.
Let δV = amplitude of 2,000 cycle component at terminals of C_2.
By equation above,

$$\Delta V=\frac{it}{C_1}=\frac{i}{C_1}\frac{2\pi}{\omega}=\frac{i}{C_1\omega}\text{ approximately.}$$

and
$$\delta V=\frac{1}{C_2\omega}\Delta V=\frac{1}{C_2\omega}\frac{i}{L\omega-\frac{1}{C_2\omega}}=\frac{i}{C_2L\omega^2-\frac{1}{C_2\omega}}$$

Hence,
$$\delta V=\frac{\frac{2\pi i}{C_1\omega}}{1-L\omega^2\left(C-C_1\right)}=\frac{2\pi i}{C_1\omega(1-L\omega^2(C-C_1))}$$

where $C=C_1+C_2$ is the total capacity, to be regarded as fixed in amount.

The optimum division is that which gives a minimum value of δV for a given total capacity C, and can be found by differentiating δV with respect to C_1 and placing the derivative equal to zero. This gives

$$\omega(1-L\omega^2[C-C_1])-L\omega^2C_1=0$$

Whence,
$$C_1=\frac{1}{2}\left(C-\frac{1}{L\omega^2}\right)$$
$$C_2=\frac{1}{2}\left(C-\frac{1}{L\omega^2}\right)$$

and
$$\frac{C_2}{C_1}=1\qquad\frac{2}{1+CL\omega^2}$$

Substituting in the previous equation

$$\delta V=\frac{2\pi i}{\frac{1}{2}\left(C+\frac{1}{L\omega^2}\right)\omega\left(1+\frac{L\omega^2}{2}\left[C-\frac{1}{L\omega^2}\right]\right)}\qquad\frac{8\pi i}{L\omega^3\left(C-\frac{1}{L\omega^2}\right)^2}$$

In the above example, taking $\delta V=1$ per cent. of 100,000, or 1,000 volts, $L=400$, $\omega=2\pi\times2{,}000$, C comes out to be 0·0013 mfd., and $C_1=C_2=0{\cdot}00065$. The actual capacity used was $C_1=C_2=0{\cdot}0001$.

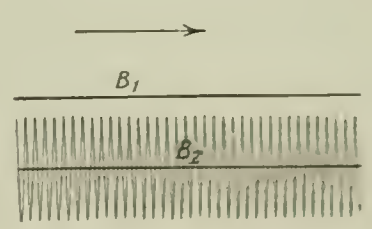


FIG. 4.

Upper curve, constant potential 50,000 volts at terminals C_2 (base line B_1).
Lower curve, 2,000 cycle primary voltage (base line B_2).

nearly twice the amount necessary to reduce the fluctuations to 1 per cent., and the oscillograms show that the fluctuations were actually about $\frac{1}{2}$ per cent.

If 60-cycle current were used instead of 2,000-cycle, the capacity necessary to keep the fluctuations to $\frac{1}{2}$ per cent. would be from equation: $C=0{\cdot}35$ mfd., $C_1=0{\cdot}19$ mfd., $C_2=0{\cdot}16$ mfd.

Results.—The constancy of the voltage obtained under different conditions is shown by the oscillograms (see Fig. 4). This was taken with a water resistance load in series with the oscillograph coil across the line, the end of the line adjacent to the oscillograph being earthed. For voltages above 50,000, where the end of the line could not be earthed, two water tubes of nearly equal resistance were used and the middle point between them grounded. Oscillograms were then taken on both sides of the ground, in order to detect any asymmetry in the form of a current to earth.

Fig. 4 shows the voltage obtained with the apparatus arranged as in Fig. 1, with a load of 50 milliamperes at 50,000 volts. The results of different arrangements of kenotrons and capacities and inductances are then illustrated by a series of oscillograms.

Attention should be called to the fact, already mentioned, that in these oscillograms the primary alternating current wave shows no trace of distortion, even at maximum load, which is a strong advantage of the open magnetic circuit type of transformer.

The apparatus described is capable of great improvement. The fact that in its present crude form it operates so well is a strong recommendation of this method of obtaining constant high potential. By the use of three-phase 2,000-cycle current and six kenotrons, it would be possible with present apparatus to furnish 100 kw. at 100 kv., with the same constancy as that of the 5 kw. installation described above, and there is every reason to believe that this can be increased to 1,000 kw. in the near future.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in "THE ELECTRICIAN," or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential circulation all over the World.** *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" commence in April and October.
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.
WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.
THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*
THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*
ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*
PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*
SECONDARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.
THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.
INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903), Full Report of Proceedings at, 8s. 6d. ; post free, 8s. 9d. ; abroad, 9s.
INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.
BRAKES FOR TRAMWAY CARS. By H. M. Sayers. Price 2s. 6d. nett.
ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.
ELECTRICITY IN HORTICULTURE. By Prof. S. Lemström. Illustrated. 3s. 6d. nett.
RADIO-ACTIVITY : AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M.A. Price 4s. nett.
MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by G. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.
PRACTICAL NOTES FOR ELECTRICAL STUDENTS. By A. E. Kennelly & H. D. Wilkinson. Price 4s. 6d.
A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Geipel and H. M. Kilgour. Price 7s. 6d. nett.
THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.
ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.
THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. G. Bond, M.I.E.E. Price 2s. 6d. nett.
CARBON MAKING FOR ALL ELECTRICAL PURPOSES. By Francis Jehl. Price 10s. 6d.
"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Down, Wh.Ex., M.I.Mech.E. Price 2s. 6d. nett.
ELECTRIC LIFTS AND HOISTS. By Gilbert Rowe, M.I.E.E., &c. *In preparation.*
THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C.E., M.I.M.E., &c. Price 5s. nett.

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM) : A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d. each, post free. Hanging Cards : 8d. each post free. Pocket Books, complete in envelope, 2s. 6d., post free.

A RELIABLE WORK OF REFERENCE.

THE LOCALIZATION OF FAULTS IN ELECTRIC LIGHT AND POWER MAINS.
By F. C. RAPHAEL.

THIRD EDITION : Price **9s. 6d.** nett, post free.

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers. Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

COMMISSIONS IN THE ENGINEERS.

In a note in our issue of the 21st ult., under the heading "Seek and Ye Shall Find," we stated that "To our knowledge . . . able engineers (for commissions) are available by the score. Men who at the present time are helping to win the war either by scrubbing barrack-room floors or by engaging upon work that could be more efficiently performed by charwomen, labourers or navvies."

We return to the subject for two reasons, namely : (*a*) It appears that there are still some vacancies in the Royal Engineers ; and (*b*) an inspection of the casualty lists reveals the melancholy fact that many of our most promising engineering students and young engineers (who should now be preparing for another day in the class-rooms and laboratories) have been maimed or killed whilst serving in infantry regiments.

The National Register either puts, or should put, the authorities in possession of the names of men suitable for commissions in the Engineers. Since no real use, other than for recruiting purposes, appears to have been made of the Register, it is reasonable to conclude that the classification was improperly carried out (as, for example, coding a man as 26 instead of 11, the one being a metal worker and the other a professional man). But there is no need to turn to the Register for names. The many engineering colleges and schools surely have such lists of names, and there is a list within easy walking distance of the War Office of colleges and schools where real engineering is taught. Furthermore, lists containing literally thousands of names are available to-day, and every day, at the several engineering institutions.

Since the outbreak of war certain of these institutions have actually prepared special lists containing the names of hundreds of men who know how to do their own particular jobs a little better than their fellow men. It may surprise the War Department to learn that the engineering institutions are professional institutions, and that certain professional qualifications are required before a man can be admitted. To our knowledge, men not having the qualifications necessary even for the lowest grade of membership in the engineering institutions can, and do, obtain commissions in the Royal Engineers. Assuming a man to be physically fit and gentlemanly in his behaviour, the principal qualifications for a commission in the Engineers should be engineering ability and the ability to control men. We submit that men holding such qualifications are more to be desired, and are more useful to the country as engineers, than are many of the "engineers" now holding commissions.

The fact that relatively few such men are so employed at the present time makes one wonder whether the professed military engineers are jealous lest the civilian engineers should share the honours with them. Since jealousy is not unknown between one Government Department and another, it is not unreasonable to assume that such jealousy can exist between a Government Department and an outside body. For all we care, they are welcome to the honours which may be showered upon them. Their jealousies and honours leave us cold, but we look for the recognition of the civilian engineer, of the man without whose engineering we should, long ere this, have been degraded or murdered. The

making of the whole of Britain into a vast arsenal in less than 12 months is an example of their work. The mere inspection of shells by some of the best-known engineers in London to-day is a further example of the willingness of the civilian engineer to sink his identity in order to help. But we deplore the fact that such good material is being put to such poor use.

It is no exaggeration to state that the cream of our engineering ability and that of our Allies is recorded on the membership rolls of the engineering institutions. That the latter have not insisted on making themselves heard, as the members of the British Medical Association made themselves heard during the passing of the Insurance Act, we regard as highly discreditable, not only from a professional standpoint, but also from a national standpoint, seeing that theirs is an unselfish and, therefore, a worthier cause. For the new armies large numbers of engineers, both of the professional and artisan classes will be required, and in a few weeks' time the staffs and Councils of the engineering institutions and colleges will be taking their holidays. Were we not convinced that there is a desire on the part of the authorities to secure efficiency we should have abandoned, long ago, the idea of mobilising the engineers. As it is "hope springs eternal," but the time is short.

REVIEWS.

Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

Text-Book of Practical Physics. By H. S. ALLEN and H. MOORE. (London: Macmillan & Co.) Pp. xv.+622. 8s. 6d. net

In the preface, the authors state that this book is intended to cover the greater part of the work necessary for a Pass Degree in Science in most universities. The authors are lecturers in Physics at the University of London, King's College. We must assume that by "most universities" is meant most universities in this country. If this be so, the reason why many of our 'varsity students find it difficult to obtain lucrative appointments in the works is apparent. From this it must not be thought we are condemning the book. To those interested in the elucidation of elementary physical principles the book will be exceedingly useful, and praise is due to the authors for producing so readable a book. But if the book does really cover the greater part of the work necessary for a Degree in most universities, then the ground covered is insufficient. After working through such a course, a student will not be in a position to command a wage as high as that of a labouring man, nor will his work be as valuable to the community as that of a labouring man.

The student is warned by the authors against a prevalent idea that an experiment is completed when the manipulations or observations are finished, and he is urged to calculate and consider the results, as well as to write out a full record of the experiment. A pleasing feature of this well got-up book is the simple nature of the apparatus described and used in most of the experiments.

To properties of matter, sound, light, heat, magnetism and electricity separate parts are allotted. The first part is subdivided into 11 chapters, and the ground covered is, for the most part, of an elementary character. In the next edition we suggest that the chapter on Periodic Motion should be amplified, and a number of experiments included on damped oscillations. Eighteen chapters are devoted to sound, light and heat. We should like to see additional matter in certain of these chapters—matter which is as important to the student of physics as to engineering students. The chapter on Thermometry will serve to make our meaning clear. If by thermometry is meant the measurement of temperature then, in our opinion, practice should be given in the methods of measuring the high temperatures frequently encountered in all branches of physical research. This is as much to be desired as the ability to calibrate the form of a thermometer tube, which properly belongs to the measurement of fundamental quantities.

The remaining 11 chapters deal with magnetism and electricity, and the experiments described cover the ground fairly well. In connection with apparatus for the measurement of current, it would give us satisfaction to hear that the use of the tangent galvanometer was prohibited in every student's laboratory in the country. The more so since we are told that to understand the action of the moving-coil ammeter requires a greater knowledge of the subject than the student . . . is supposed to possess. In recommending the book we urge the authors to include a section on the making of simple apparatus, as skill in this direction is as much to be desired as in the making of experiments. To be of the most service in the works our young physicists will find it necessary to possess a certain amount of skill in the handling of tools and in the making of apparatus.

Structure and Properties of the More Common Materials of Construction. By G. B. UPTON. (London: Chapman & Hall.) Pp. v.+327. 10s. 6d. net.

Those who desire to become acquainted with the facts of metallurgy will find this book useful. These facts are of importance to all users of the raw materials of engineering.

The book contains 20 chapters and is divided into two parts. The 11 chapters forming the first part deal with the determination of the properties of the materials by means of engineering testing. Under each method of loading there is a discussion of what goes on inside the material throughout the progress of the loading. The ordinary formula for the calculation of stresses and deformations are examined, and the assumptions on which such calculations are based are critically examined. The factors changing the results of tests are discussed, bringing out the need of standard specifications, and an attempt is made to teach a student how to interpret and criticise test results.

The second part of the book deals at some length with the nature of the internal structure of materials, and with the control of physical properties through the control of the internal structure. This takes the form of a short study of theoretical and applied metallography. The author has taken care to present in simple language the principles of physical chemistry, and to make the relations clear he has made use of a large number of diagrams. A considerable amount of matter is given on carbon steels, heat treatment, cast-irons, alloy steels, and on non-ferrous metals and alloys. After reading this excellent book, the student will be sufficiently well grounded to be able to turn with profit to the larger works on modern metallurgy.

Electrical Apparatus Making for Beginners. By A. V. BALLHATCHET. (London: Percival Marshall & Co.) Pp. 164. 2s. net.

The author states in the preface that "if a boy at school could be induced to proceed in a definite path" more time could be saved. Consequently this small book of some 162 pages, containing eight chapters dealing with the making of simple cells, galvanometers, electromagnets, induction, and electrolytic apparatus, voltmeters and ammeters has been written. Although exception might be taken to some of the very crude looking electric motors illustrated, and especially to the fact that the ring in the tangent galvanometer is of brass or copper strip "about an inch" wide, yet we are of opinion such a book has much to recommend it. The Kelvin graded galvanometer shown is very easily constructed, and a boy can learn a great deal from it. It is far better for a youth (of the type the author has in view) to *make* such things, rather than waste his time listening to lectures on "electricity" given perhaps by a teacher whose only qualification is a Board of Education pass in a second-grade examination. There is a distinct need for such a book, and we wish it every success.

ILLUMINATING ENGINEERING SOCIETY.*

The appointment of the Research Committee was announced at the end of the session in 1914, but owing to the war it was not found practicable at that time for the Committee to take up the tasks before it. The following have been nominated to serve on the Research Committee of the Illuminating Engineering Society: Mr. A. Blok, Mr. J. G. Clark, Mr. W. C. Clinton, Mr. J. F. Crowley, Mr. F. W. Goodenough, Lieut. Haydn T. Harrison, R.N., Dr. James Kerr, Prof. T. Mather, Prof. J. T. Morris, Mr. S. R. Mullard, Mr. C. C. Paterson, Prof. Silvanus P. Thompson (chairman), Mr. A. P. Trotter, Mr. F. W. Wilcox; *ex officio*: Mr. L. Gaster (hon. secretary) and Mr. J. S. Dow (assistant hon. secretary).

The immediate object of the Committee was to prepare a list of subjects specially deserving of research at the hands of the society, and the suggestions so far received, together with others arising out of past discussions of the society, have been assembled in the list at the end of this report. While not intended to be exhaustive, the list already contains many more subjects for investigation than could be at present undertaken by the society. It will, however, serve to show how past discussions have developed prospects of further useful work and the many opportunities for research now before us. In dealing with these suggestions the Committee may nominate from among its members sub-committees to organise or undertake specific researches or may take advantage of the services of other members of the society or gentlemen outside the society who have special knowledge of the proposed researches.

In connection with subjects of importance from the industrial standpoint, the Committee suggest that priority should be given to investigations relating to the development of lamps and lighting appliances, and researches having for their object the elucidation of general problems on which the development of the lighting industry depends. As an instance, the investigation of the properties of illuminating glassware is a matter which, in the opinion of the Committee, should receive immediate attention at the hands of a special sub-committee appointed for the purpose.

Another subject which merits early attention in view of its relation to the dyeing and colouring industries is the preparation of a standard series of colours, and in particular of a standard white surface, suitable for acceptance in all researches in which the accurate definition of colour is involved. Conjointly with this subject, the design of suitable apparatus for analysing and specifying colour and for measuring the reflecting power of various materials should receive attention. There is also the further problem of providing a fixed standard for the permanence of coloured materials.

Among other matters which, in view of their important bearing on the future development of lighting, deserve special attention, may be mentioned the study of glare and the limits of permissible intrinsic brilliancy; the investigation of the comparative effect on vision and the physiological influence in inducing fatigue of natural and artificial illumination, and of various systems of artificial lighting; and the conditions, as regards the intensity of illumination and arrangement of lights, desirable for various industrial operations. The latter question is of interest as being supplementary to the report of the Home Office Departmental Committee on Lighting in Factories and Workshops, and it is suggested that the preparation of an illustrated bulletin forming a guide to the best present practice in various sections of industrial lighting, might be undertaken.

In the list of researches the various suggestions have been roughly classified under the following headings: (*a*) Photometry, standards of light and researches on colour; (*b*) electric, gas and other illuminants; (*c*) lighting appliances; (*d*) general.

(*a*) Photometry Standards of Light and Researches on Colour.

1. *The production of a satisfactory standard of light.*

2. The development of a *standard laboratory photometric equipment* to take the place of those designed abroad.

3. The specification of a *series of standard colours* and of methods of determining the amount of light reflected from them, and the general problem of a method of determining the total reflection from all kinds of surfaces, should be considered.

4. The standardisation of *methods of analysing and specifying colour*, and design of simpler and more convenient instruments for testing the same.

5. The standardisation of the so-called "*artificial daylight*" (i.e., the various forms of artificial light used in conjunction with special devices in order to imitate the colour of natural light). In investigating this question an attempt should be made to arrange the chief artificial illuminants in the order of their resemblance to daylight.

7. The subject of *colour photometry.*

8. The question of *direct-reading physical photometers* was discussed at a recent meeting of the society, and a number of fruitful investigations were suggested.

9. The design of better and simpler *illumination photometers.* Instruments of the simpler class are probably best left to individual workers; but it would be useful to make an inquiry into the probable accuracy of the various kinds available, and to institute a series of comparative tests with various instruments by different observers in streets and interiors.

(*b*) Electric, Gas and Other Illuminants.

10. Experiments on *the improvement of lamps* are naturally undertaken mainly by manufacturers, but questions of scientific interest arise, the elucidation of which would be of value in establishing the principles governing the efficiency of illuminants.

(*c*) Lighting Appliances (Globes, Shades, Reflectors, &c.).

The remarks made under the last heading also apply here. The supply of *optical glass* and the investigation of its properties are at present of great national importance.

11. The best means of promoting the scientific study of *lighting glassware* and of encouraging the manufacture of kinds of glass which have not hitherto been developed satisfactorily in the British Isles.

12. Appropriate methods of *testing and prescribing the requisite qualities of glassware* of the above kinds.

13. *Uniformity of method in testing and specifying the distribution of light absorption* and other qualities of globes and reflectors of importance from the illuminating engineering standpoint.

14. The best means of promoting agreement as to *uniform sizes and shapes of glass articles in common use in the lighting industry.*

(*d*) General.

15. Research work on an instrument for the *automatic control of artificial light in factories, schools, &c.*, the light being automatically turned on when the illumination has fallen to a certain value.

16. As a development of the Home Office Report on Factory Lighting, it would be helpful to make further unofficial investigations on the *conditions desirable for various classes of work*, and subsequently to issue these as a brief series of recommendations for the guidance of managers and others interested in factory lighting.

17. A good deal remains to be done in further prosecution of the work of the *daylight illumination in schools.*

18. *Street Lighting*, after the war, will be a good field for effort particularly as regards the development of more decorative forms of design as well as more scientific treatment as regards the shading of lamps and the distribution of light.

19. *Searchlights.*—There are many questions of interest, such as possible improvements in efficiency like those involved in the new searchlight evolved by O. Lummer, of Breslau. Investigations into the various points suggested by Mrs. Ayrton in connection with the choice of carbons, best electrical conditions, &c.; also into the type of electrical generator best adapted for searchlights. Preparation of simple instructions for working searchlights. Attempt to define more precisely the "range" and the "candle-power" with a view to these quantities being specified in the future. Inquiry into the best colour of light, as regards its effect on penetrating power and on the apparent sharpness of object illuminated by the searchlight beam.

20. *Visibility.*—A series of queries was put forward in connection with the Paper on this subject by Messrs. Paterson and Dudding ("Illum. Eng.," May, 1915, p. 208).

21. *Lighting of Rifle Ranges.*—The series of queries prepared in this connection has not been completely answered. (*See* "Illum. Eng.," June, 1915, p. 250.)

22. An inquiry is suggested into the *physiological difference between natural and artificial light—e.g.*, the intensities considered necessary for vision.

23. Investigation of the conditions determining *permissible limits of intrinsic brilliancy* ("glare"). A suggestive report on this subject has been issued by a committee in the United States which merits discussion.

24. The problem of devising some means of judging *the comparative effect on the eyes of various methods of lighting as regards fatigue, comfort of vision, &c.*

25. *Library Lighting.*

26. *Lighting of Museums and Picture Galleries.*—It was proposed to form a committee to study this subject previous to the war.

27. *Lighting of Hospitals.*—The lighting of hospital wards is admittedly often unsatisfactory. There is also room for investiga-

* Abstract of Interim Report of the Committee on Research presented at the annual meeting on 9th inst.

tion in the lighting of operating tables. The subject might also be studied in connection with field hospitals using portable illuminants, &c.

28. *Testing the Gloss of Paper* and the determination of a *standard of matness.*

29. *Nomenclature of Illuminating Engineering.*

30. Tests of the effect of varying *the reflecting power of walls, ceilings and floors in rooms*, with a view to preparing data by the aid of which the increased illumination due to reflected light may be more precisely estimated.

RAILLESS TROLLEY BATTERY VEHICLE AT BRADFORD.

A new motor wagon has recently been designed by Mr. C. J. Spencer, general manager of the Bradford City tramways, for the conveyance of goods in connection with the ordinary passenger tramway service, and was given a trial on the 8th inst., when it was found to give very satisfactory results. The new vehicle is quite simple in design, but very adaptive to the purposes to which it is to be put. Mr. Spencer has built upon the chassis of an old trackless trolley car a long, broad lorry, similar in shape and dimensions to the motor lorries which are now so common. There is the marked difference, however, that, instead of using petrol, the wagon is run by means of the tramway overhead trolley lines; but, as the wagon is also equipped with accumulators, it can also be run independently of the tramway system.



Railless Trolley-Battery Vehicle at Bradford.

The chairman of the Bradford Tramways Committee (Mr. Enoch Priestley), and several other interested persons, witnessed the test of the vehicle on the 8th inst. A load of 2 tons was put on the wagon at Thornbury, and with this it made a satisfactory journey to Wibsey.

The equipment of the chassis of the railless trolley battery vehicle is identical with the ordinary railless trolley chassis as used on the Bradford tramways—that is to say, two 20 h.p. motors with ordinary series-parallel control—and will, therefore, operate on a 500-volt circuit. The earthing device is an extension of the steering arm of the vehicle bearing on the track by the medium of a cast-iron block, and at the same time automatically steering the vehicle. This device, which has been used with considerable success for some time in connection with the ordinary trackless trolley cars when taking them over the tramway routes to the depot at Bradford, was designed by the general manager of the Rotherham tramways, Mr. E. Cross.

The accumulators employed are of the Edison type (120 cells), giving a normal voltage of 150. As shown by the illustration, they are carried under the floor of the wagon. They supply current to the ordinary 500-volt motors, the only difference being that the motor with battery supply runs correspondingly slower—that is, *pro rata* to the voltage. As the torque of a series motor is proportional to some power of the current passing through the windings, the vehicle is capable of climbing steep gradients, but at a speed corresponding to the low voltage. Whilst the vehicle is running on the 500-volt circuit, the batteries may be in series with the motors, thus charging them whilst the car is in trolley service. The battery is capable of running the vehicle about 10 miles.

The change-over from battery to overhead wire is merely a question of throwing over a switch, the putting of the trolley on the wire and the earth connector on to the steering gear.

ENGINEERING INDUSTRY IN THE ECONOMIC WAR.*

BY M. T. C. ELDER.

It cannot be too often repeated that the struggle is not between whole nations; that is to say, it is not simply a trial of strength on the battlefield between comparatively small trained armies. All the material resources, all the accumulated capital, all the mental and physical qualities of the inhabitants are called into play, and as soon as so much is stated, it will surely appear that such a competition cannot be brought to a dramatic close just because a number of statesmen and soldiers sit round a large table some months hence and agree upon military and political terms of peace. The chain of historical causation is continuous and endless, and although it has often been announced quite properly that our immediate aim is to smash German militarism, we are more convinced as every month passes that in the best interests of the nation and the Empire it will be necessary to get beyond that objective and endeavour to establish safeguards against the recrudescence of Germany's former economic policy. It is otherwise quite possible that we may achieve our military triumph and afterwards be fighting a losing economic warfare for many years following. Unless it is understood that Germany's military power, which has exerted such amazing resistance in the face of such a powerful combination of adversaries, has been based on her industrial system, and particularly on her engineering trade—that, in fact, modern militarism is helpless without engineering—we shall be led into error in our calculations concerning the future.

Her military and her industrial system have both been designed for the same purpose. Germany has for 20 or 30 years been out for plunder—for rapidly achieving power and prosperity at the expense of her neighbours, and especially at the expense of the British Empire, and has been restrained by no scruples of any description. The craze for getting rich quickly has inspired Germany's Government to attempt the creation of a world empire in a single generation, with no other motive than the entirely selfish one of concentrating economic power in Germany, the country least fitted for its humane administration.

Now we have become more and more familiar with the abominable methods adopted by the German people, not only in their conduct of military warfare, but in their machinations for destroying the commercial power of this country and for breaking up our Empire. Our enemies counted upon dissension and disorganisation within the Empire either to keep the Empire out of the war or to weaken its value as an ally. They believed that we should have civil war; that we should have desperate labour disputes; that there would be an overwhelming opposition to military service; that we should be hopelessly involved in general political folly and confusion; and that, in fact, we were suffering from universal public and private neurasthenia and debility!

We have proved the contrary in the presence of imminent danger. But shall we continue to be a united nation and a nation reorganised and re-inspired when peace is declared and we enter upon the next stage of the struggle which will finally decide industrial leadership as between this generation of British and this generation of Germans, beyond which period we need not attempt to penetrate? The speaker then suggests that the Allies must find some way of preventing Germany resuming business as usual after the war, so that manufacturing of a military nature will be stopped.

After referring to fiscal policy and the old Free Trade and Protection, it is pointed out that the war indicates discrimination in our trading.

The idea of industrial preference suggests first consideration for three groups—the agricultural, the textile and the engineering, which includes shipbuilding. The case for jealous safeguarding of at least certain departments of agriculture and of the textile employment which has earned enormous revenues for this country does not need to be argued here. What we are concerned with is the engineering group, and we base our claims on three propositions:—

1. National and Imperial safety depends on the maintenance of a progressive and prosperous engineering industry. The decisive influence of machinery in warfare becomes more and more marked, and we cannot again take the risk of allowing Germany to attain

* Abstract of address at the Royal Technical College, Glasgow, on the 16th inst.

mechanical military superiority on land or sea, or under the sea, or in the air.

2. Engineering is in peace also the key industry. Machinery is universally employed, and in agriculture, in manufacturing and in transport efficiency and prosperity depend on the prompt adoption of modern equipment. The existence of a great engineering industry in Britain is an obvious advantage to general productive occupation. If we keep Great Britain a well-engineered country we are going far to ensure that it will be a well-populated, a well-capitalised and a well-employed country.

3. The national earning power of this group of industries can be greatly increased by taking intelligent advantage of its extension and improved equipment due to the demand for munitions, and by collective exploitation of foreign markets by associated manufacturers and financiers.

Here, then, is surely an industry which is entitled to preferential consideration. Whether engineering should have special State encouragement has no dependence on a general change of British fiscal policy. Free Trade in some other descriptions of manufactures may still be left as a debatable question. Free Trade in engineering must go for ever. To go on employing Germany to make machinery for us; to allow her syndicates to corner our metal supplies; to give her equal opportunities of developing her engineering and ship-building as though these were purely peaceful industries would be a political crime. It would be an insane gamble with the primary interests of our country and our Empire. It would be an infamous betrayal of those who have shed their blood in our defence. It would be an abject surrender of all that they are fighting for, because we cannot guarantee to guard our own liberties and to fulfil our duty of maintaining the independence of the smaller nations if we again allow this enormous mechanical power to be wielded by those who have proved themselves the world's leading exponents of scientific savagery.

Are we in danger of such an exhibition of political folly? We have every reason to believe that the intention of our people is sound on this question; but we all have seen frequently as a curious phenomenon of British politics how much is achieved to our detriment by busy minorities as against the inertia or the inarticulateness of the genuine majority. The author then refers to the importation of German plant and machinery for all purposes.

Fortunately, one man has done much to foil their plots in advance. Australia has lent us Mr. Hughes. Where he appears the poisonous gases of cosmopolitan conspiracy are swept away by a breeze of hearty patriotic common sense.

We wish that our home political leaders would be equally direct and downright in their expressions of opinion concerning future trade with Germany. When they seek to quieten us by reminding us of the need to concentrate all our attention on the war, we might retort by hinting that they, too, might patriotically forget that there will ever be another general election. The committees appointed by the Board of Trade to report on the future of engineering industries are not received with much enthusiasm. The question is one of how we are to live after the war, and not exclusively the concern of managing directors. The author considers that the 1,500,000 men engaged in munitions together with the men returning from the front after the war, will understand the necessity for engineering work in this country.

We cannot suppose that our men will come back from the North Sea and the Mediterranean, from the trenches in France, from the rocky shores of Gallipoli, from the sandy plains of Mesopotamia, indifferent to the question whether Britain or Germany shall in the future be the most powerfully engineered nation in Europe. So that, if the rest of the population should miss the point—which we have no reason to assume—there will exist in this country an electorate of about five millions capable of understanding what engineering means to the Empire's safety and prosperity.

That is why it seems to me a gross blunder to refer the future prospects and conduct of this salvation industry to a small group of company directors. Here was a magnificent opportunity for bringing together representatives of the board room and the workshop to discuss their common interest in industrial progress.

While trade unionists are naturally interested in wages and manufacturers in profits, they stand on common ground when national policy is under discussion touching the right method of maintaining the flow of revenue out of which alone these demands of capital and labour can be met.

In another direction the manufacturers must show more breadth of mind. They must be readier to discuss common interests with their competitors, and they must associate and organise so that German and American business leagues may be met and withstood in the great markets of the world.

While the chambers of commerce have their great value for certain purposes, and the sectional associations may discuss with advantage their particular interests, it has become obvious that some concentration of manufacturing interests is imperatively required to act in the general behalf of productive industry, and to act promptly and powerfully. The solitary British manufacturer seeking business abroad, in the face of competition supported and subsidised by the diplomacy and the finances of the German Empire, has often been sorely in need of an organisation of this kind.

Such an association is now in course of construction, on the most solid foundations, and if as an executive machine it can be used to further the national business purposes so frequently enumerated by the chamber of commerce and other industrial bodies, the effect should be to remove many obstacles to the advancement of our imperial economic interests. The author's conclusions are:—

(1) That it is necessary for the world's peace that Germany shall be restrained as far as possible from retaining her past and present proportion of military power. (2) That to accomplish this it is necessary to cripple her engineering industry and force her populace into peaceful pursuits. (3) That this end can be attained by an international convention of the Allies and the British Empire. (4) But that it will also need a reconstruction of British trade policy, with special regard to the engineering and allied industries. (5) And such a reform will need to be accompanied by a practical conception of the common interests of all engaged in British engineering trade and by the exertion of collective power on the part of manufacturers for the development of business abroad.

CORRESPONDENCE.

"SPEEDING UP IN AN ENGINEERING FACTORY."

TO THE EDITORS OF THE ELECTRICIAN.

If you will allow me to make an observation upon Mr. Rankin's reply to the correspondence arising from his Paper, I should like to point out that such reply, taken in conjunction with certain parts of his original Paper, completely illustrates the point which I endeavoured to make in my letter to you last week.

Mr. Rankin says that at the introduction of the bonus system nothing was hidden from the men, and emphatically enforces this fact by concluding with the following words: "The system in no way relies on withholding anything from the men." At the same time we find it stated in the original Paper that "the system of payment amounts to paying a certain figure for a fixed number per hour, and so much per piece when the fixed number is exceeded. This aspect of the system was not enlarged upon to the workman. . . . The writer believes that the system was far more successful in operation than any system would have been which they could have understood thoroughly."

Surely a man having access to the inner working of a system that he cannot understand, and which, moreover, it is intended that he should not understand, is in reality no different from a man from whom all facts are withheld. So Mr. Rankin, in conceding the former condition, must necessarily accept the results of practice under the latter condition. This latter condition in such a vital matter as the calculation of the worker's wages, leads, as I showed in my last letter, to disaffection among the men. As it is generally agreed that harmony between employer and employed must first be obtained before increased output can be expected, so a system of wage-payment whereby the men can determine their week's wages for themselves appears to be the first essential of a work's "speeding-up" programme.

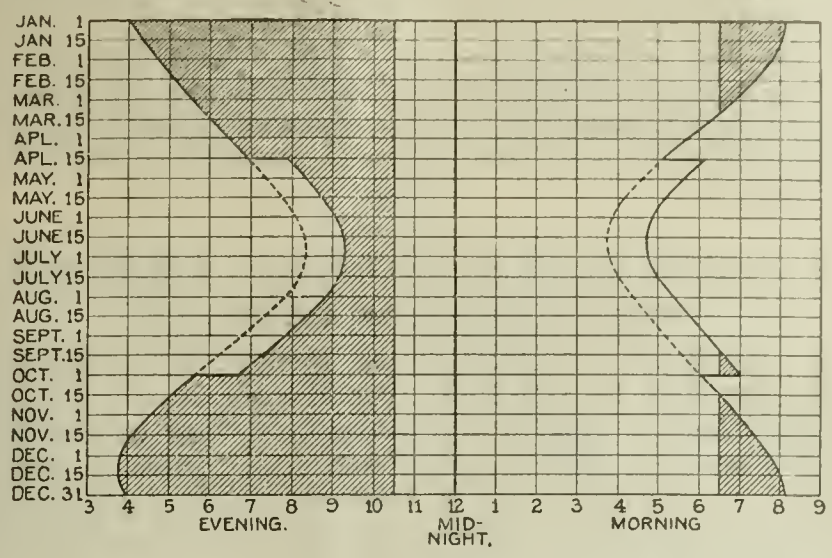
Liverpool, May 16. HAROLD J. BROCKLEHURST.

DAYLIGHT SAVING.

TO THE EDITORS OF THE ELECTRICIAN.

Thirty two years ago I contributed to THE ELECTRICIAN, Vol. XIII., p. 38, a diagram to facilitate calculation of the hours of lighting. A revised version of this, based on information supplied by electric supply undertakings, was published in Vol. XXXII., p. 290, and it has appeared in many editions of "The Electrical Trades' Directory." A solid figure having

the ordinates of a load diagram as a third dimension would give kilowatt-hours.



The shaded portion shows the hours of lighting when the light is turned off at 10.30 p.m., and turned on if required at 6.30 a.m. Each rectangle is half an hour-month, or 15·2 hours.

This diagram may be used to show the effect of the daylight-saving delusion.

London, May 13. A. P. Trotter.

TO THE EDITORS OF THE ELECTRICIAN.

"What is a Philistine? The definition which pleases me best is: The Philistine says to every new and sensible proposal 'idiotic nonsense.' He amuses himself over everything and anything that he has not been accustomed to see, hear, &c.; opposes any alteration in his common-place way of life; finds everything absurd that anyone else does, because it is different from what he does himself; is the mortal enemy of all progress, but enjoys it when it has been carried through."

For eight years as a hobby I have spent my spare time on and off in answering the Philistines' silly questions about daylight saving. Though the battle has now been won there still remain many thoughtless objectors who look upon the alteration of our clocks as a childish deception reflecting upon our moral courage and who worship Greenwich mean time as a fetish, as if it was an unchangeable law of the universe, forgetting that the position of the hour hand is already varied for the convenience of man in a succession of 24 hourly zones, and that, with the same object in view, it can just as legitimately be varied in the seasons in countries whose latitudes demand such correction.

Greenwich mean time standardises the minutes and seconds only. Greenwich has imposed that standard upon the world, and daylight saving takes nothing from its permanence and universality nor from the prestige of our National Observatory.

Willett's scheme was born and nurtured in peace, and its strongest claim was to give our young men more time for outdoor recreation when their work was done; yet it was matured in war for reasons of economy, and is, in effect, the gift of our enemies. For the quotation at the head of this letter is from a pamphlet of a German professor whose championship of daylight saving secured the prompt action of his more practical Government. It is certain that our Ministry would never have taken it up unless Germany had adopted it first. Just as Germany's much vaunted superiority in several branches of science has been due rather to systematic investigation along lines suggested by others rather than to original research and invention, so in this simple and common-place matter of daily life they quickly put to practical use an idea which is essentially British in its origin.

As to how the alteration is to be accomplished, I think we may rely upon the Press to remind us all in eye-compelling type in their issues of Saturday next to set forward our clocks and watches one hour before going to bed. The bill says 2 o'clock on Sunday morning, but much of the work will be done on the Saturday afternoon in City offices and factories, leaving turret clocks to be altered any time after dusk. The present absence of illumination will permit this to be done.

Those whose premises are equipped with systems of electric clocks will find their task a comparatively easy one, as all their dials can be set from one master clock. In London alone the Synchronome Company will be able to alter 5,000 clocks in public buildings for whose time they are responsible by dealing with about 100 master clocks, merely moving a lever from N. (Normal) to A. (Accelerate).

But it is the clock-winder who will want our help and sympathy. He has a week to cover his rounds in normal times. On Saturday, the 20th, he must cram all his visits into the afternoon, the evening and the night. If we make the change for him in our houses, it should be done with ceremonial cost, turning the clock hands from 11 p.m. to midnight, and giving them time to strike. And let us combine with the act a little gratitude for the light of heaven and a tribute to the memory of William Willett, the originator of the idea of daylight saving who did not live to see his dream realised.

London, May 16. F. Hope-Jones, M.I.E.E.

TECHNICAL EDUCATION.

TO THE EDITORS OF THE ELECTRICIAN.

I heartily second Dr. Ashton in thanking you for your recent leading article on technical education. The position ought, I think, to be put even more strongly and definitely than Dr. Ashton puts it.

The idea which, in our odd way, we seem to delight in fostering, that the Germans are scientifically and technically a better equipped nation than ourselves, is, in my opinion, false. Mentally, physically and morally we are better built for the great search after truth than the Germans: the past history of science has amply proved this, and I am confident that the future will still more amply emphasise it.

But in organisation—that soulless framework upon which the wheels of progress in the application of science are mounted—we have, as yet, done ourselves less than justice. Organisation is a dry and dreary thing, but it is an important duty and we are neglecting it.

In the organisation of high-class technical day schools Germany is far ahead of us; her annual output of qualified engineering students greatly exceeded ours before the war, and the demand for the graduates of German schools was growing.

We profess to have come to realise that Germany's remarkable progress in science and commerce was due to her organisation of technical education, and that to overtake Germany we must put new energy into our own educational systems. Yet when this war came and forced upon us an opportunity to leap ahead we were blind to the opportunity.

In the early months of the war students and teachers showed an admirable impatience to join His Majesty's Forces, and the sacrifice they thus nobly made has been accepted. I believe the acceptance of this sacrifice was an ill service to our Empire.

In July, 1914, the engineering schools of the country had their normal numbers of first, second, third and final four-year students (the men who would have completed their courses in 1917, 1916, 1915 and 1914 respectively). These students, almost without exception, were allowed to obey their instincts of patriotism in the only clear way before them—by joining the forces or undertaking some other form of national service.

Some say that when the war ends the majority of those students will return to us, but we who have talked to numbers of them know that this is not so. They have tasted a life of stern and strenuous activity and will not come back to mix with untried boys.

The position, therefore, is this: we have already sacrificed our normal output of qualified students for the years 1914, 1915, 1916 and 1917, and if the war were to end at once four years more would have to pass before we should again have a graduating class. *The country has already sacrificed eight years' supply of qualified engineering students.* And though the gain resulting from this sacrifice, when reckoned in terms of the nobility and unselfishness of those who have been allowed to make it, has been a great and noble one, yet when

reckoned in terms of numbers added to our army of five millions the gain is invisible.

For the sake of adding a few thousands to an army of millions we are willing to obliterate all our engineering schools for eight years, and that at a time when these schools are needed more than ever they have been. With a little foresight these eight years would have provided just that start that we so badly want.

I write this letter in order to support the effort which at this late day, is being made to save the situation. Numbers of the present first-year students in our engineering colleges are turned 18, and the majority will be 18 before they can complete their second year. The essential thing at the moment is that the Government should make all men studying in our leading engineering colleges exempt from military service, and should instruct them that it is their duty to continue their studies.

London, May 16. F. M. DENTON.

[The suggestion in the last paragraph of our correspondent's letter is insufficient to meet the case. The endeavour must be made at once to get some of our senior technical students out of the Army. As to the lateness of the date, we have been insisting on the importance of the subject for 12 months and more, but it is only recently that we have received any encouragement.—EDS. *E.*]

CITY GUILDS' EXAMINATIONS.

TO THE EDITORS OF THE ELECTRICIAN.

I was pleased to see that the above subject was commented upon in your Notes of last week. I agree with your criticism that the range of questions is too narrow. There is, however, another fault—namely, that a complete lack of balance exists among the questions. For instance, in the alternating-current Paper a question was set on the power-factor of a three-phase motor, the volt, amperes and watts being given. The solution involves only simple arithmetic, thus

$$\text{Power-factor} = \frac{2{,}000+3{,}700}{200\times\sqrt{(3\times 18{\cdot}5)}} = 0{\cdot}89.$$

A student giving these figures would, obviously, be entitled to full marks, since no proof or other information was asked for.

In the same Paper there are questions involving a knowledge of single-phase commutator motors, motor converters, rotary converters, polyphase wattmeters, &c. Moreover, in one question an important item of the data was omitted, while one question also appeared in the Grade III., Part I. paper!

In Grade I. there is a similar want of balance; in fact, two questions were entirely beyond the syllabus and involved Grade II. work.

It would seem desirable, therefore, that short solutions should accompany the questions when the latter are submitted to the Board of Examiners. The merits of each question would then be apparent and the omission of important data would be impossible. Moreover, the terminology should agree with modern practice.

London, May 15. A. DOVER.

TO THE EDITORS OF THE ELECTRICIAN.

In your Editorial Note last week commenting on the recent examination papers in the above, I was sorry to see that no allusion was made to "*electric-wiremen's work*."

This is a subject that suffers from an inadequate title, and if it were called, say, *electric installation work*, it might be less ignored.

A few years hence perhaps it will be recognised that all electrical engineering students could with great advantage start with this subject. Then we should not have the present absurd state of things which gives us advanced students who are in many cases unfamiliar with the practical details relating to the fitting of electric light, heaters, bells, telephones, &c., &c.

The chief reason for not ignoring the subject in your columns is that it cries out for all the encouragement possible from those managerially responsible for the practical and theoretical classes in which the subject is taught. To adopt a military metaphor, we train our officers well, but treat the rank and file of the electrical army as if they were of little account. Q.E.A.

Will not this army be expected to do great things in the future?

West Norwood, May 14. W. PERREN MAYCOCK.

[We agree that wiremen's work suffers from an inadequate title. It was impossible for us to comment on the subject as the examination paper was not in our possession at the time.—EDS. *E.*]

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITORS OF THE ELECTRICIAN.

At the general meeting of the Institution of Electrical Engineers, held last Thursday, considerable stress was very properly laid on effecting economies. In view of the high rate of taxation and the great rise in the prices of necessities, I would suggest that the best way of enforcing economy on the "powers that be" would be by allowing a reduction of (say) 25 per cent. on all our fees during the war.

London, May 15. A.M.I.E.E.

[Although this course might be very acceptable to the members, we fear that it would be out of proportion to the possible economies.—EDS. *E.*]

DIESEL ENGINE USERS' ASSOCIATION.

At the last meeting it was stated that the list of membership was now representative of upwards of 30,000 B.H.P. of Diesel engine plant. Several further engineers having control of such plant were elected members. The president was thanked for the trouble he had taken in compiling notes on the subject of air compressor troubles and the risk of oil vapour explosions from various sources.

Further discussion took place regarding the Smithfield explosion.

Mr. R. L. QUERTIER, B.Sc., of Reavell & Co. (Ltd.), said his firm thought they had a theory which seemed to fit the case and which, if correct, showed that quite a simple precaution should prevent further accidents of a like nature. The abnormal conditions shown by the examination of the compressor after the accident were, so far as they knew, confined to the high-pressure suction and delivery valves, which were exceedingly badly carbonised, and to the relief valve on the intermediate purge-pot, which when tested after repair only blew off freely at about 380 lb. per square inch. This relief valve was set by the makers to blow off at about 275 lb. per square inch, so that it must have been re-adjusted by screwing up the spring to the limit. The accident occurred almost immediately on starting up, and, therefore, the temperature of the compressor was very much lower than normal, and it would seem that the conditions were not at all favourable for an explosion to take place. There seemed no doubt, however, that an explosion did occur, as, in the first place, a calculation of the strength of the purge-pot showed that the bursting pressure would be in the neighbourhood of 2,500 lb. per square inch, and, secondly, the fact that it was broken into fragments indicated a heavy and instantaneous shock. Assuming, therefore, that an explosion occurred, and that this was caused by the ignition of lubricating oil, it has been suggested that such explosions are caused by the ignition of oil in the form of mist or fog. One, therefore, had to account for the oil fog and for the means by which the temperature was raised to ignition point. His firm's theory was as follows: The high-pressure valves were not functioning, with the result that there was more or less open passage connection between the final delivery pipe to the blast bottle and the intermediate purge pot. The valve between the blast bottle and the compressor was opened just before the accident, and this would allow the dense air in the blast bottle to rush back along the pipes to the intermediate purge pot by way of the high-pressure cylinder. They suggested that the velocity at which the rush took place and the density of air caused it to lick up and carry away any oil deposited on the pipes and to churn this into a fog. The intermediate relief valve, as tests recently made proved, is capable of dealing with all the air aspired by the compressor with a rise in pressure of not more than 30 lb. per square inch, but it was obviously incapable of dealing with an almost instantaneous rush of air from the blast bottle, and consequently the pressure rose till a balance was obtained. All the while, of course, the intermediate cylinder was delivering air, and had now to compress against the greatly increased pressure, so that the temperature of the delivered air rapidly increased till it was sufficiently hot to ignite the oil mist in the purge pot and cooling pipes. It was not necessary for this rush back of air to take place immediately the blast bottle valve was opened, because the compressor was at work and the conditions necessary, that is, a more or less free passage into the I.P. purge-pot and coils, may not have been immediately present. Again, the same conditions would be obtained with a slower leak back if for any reason the I.P. relief valve were not in proper working order.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

COMMERCIAL TOPICS	229	Horn Type Switch-Fuses. Illustrated	44
Imports and Exports of Electrical Manufactures	230	The Panda Pump. Illustrated	46
LEGAL INTELLIGENCE	230	Large Ironworks in Sweden	46
Educational	231	"Zenex" and "Negrex" Finish for Conduits. Illustrated	47
Business Notices	231	"Verilux." Illustrated	48
Bankruptcies, Liquidations, &c.	231	Turbo-Electric Propulsion	48
Electricity Supply	231	Tenders Invited	234
Traction Notes	232	Tenders Received & Accepted	235
Empire Notes	232	Companies' Meetings and Reports	235
Miscellaneous Notes	233	New Companies, &c.	237
The Round Table	41	City Notes	238
Electric Hand and Bench Drills. Illustrated	42	Electrical Companies' Share List	238
New X-Ray Reflectors for Half-Watt Lamps. Illus.	43		

COMMERCIAL TOPICS.

Organisation of Manufacturing Interests. An effort is being made for the purpose of establishing a central organisation of manufacturing interests in the United Kingdom.

The movement has hardly taken definite shape at present, but the idea of the organisers seems to be to form one strong representative and influential body, which will include all the individual effort which is at present being made by separate organisations. It has been decided to form an association, and a circular has been issued setting forth its main objects. It is proposed that 100 preliminary members (with an entrance fee of £1,000) shall form the basis of the Grand Council. Until this number of subscribers is guaranteed no further steps towards the establishment of the association or the arrangement of its detailed working conditions will be taken, but it is stated that nearly half the number of subscribers has been already secured. Among the interests which are to be amalgamated in the scheme are the iron, steel and coal industries, shipping and shipbuilding, electrical undertakings, railway and wagon construction works, motor and rubber industries, chemical product manufacturers, engineering and munitions. The association will (it is claimed) be a representative gathering of British manufacturers, and one of its first objects will possibly be to press for a Ministry of Commerce, but no details of policy will be decided upon before the meeting of the first grand council when the 100 subscribers have been secured. The new organisation will endeavour to maintain a friendly attitude towards all labour organisations, with whom it is hoped to work in harmony with the desire to establish a true partnership of interests between capital and labour. The circular bears the names of Mr. F. J. Nettlefold (chairman of the Institute of Industry), Mr. W. Peter Rylands (on behalf of the conveners of the "Central Association"), and Mr. F. Dudley Docker, C.B. Mr. A. W. Tait, Basildon House, Moorgate-street, E.C., is the hon. secretary (pro tem.), to whom correspondence should be addressed.

* * * *

Callender's Annual Report. From the annual report of Callender's Cable & Construction Co., which we give in another column, it will be seen that this important British Company has had an exceptionally good year. A dividend of 10 per cent. per annum is proposed, together with bonuses amounting to 10s. per share, or 20 per cent. for the past year, compared with 15 per cent. for 1915. As might have been anticipated, the report states that the year's operations have been carried on under exceptional difficulties as to men, materials and transport. The company was declared a controlled establishment under the Munitions of War Act on Aug. 18, 1915, and its output has been and is largely for warlike materials required by the Government. The shareholders are assured that no firm in the electrical industry has rendered more effective service to the nation than has the company. The ordinary home trade has consequently been much interfered with, but it has been possible to carry out some municipal and other contracts in connection with munition work, and also to satisfy to some extent the demands of the old and valued customers of the firm. The shortage of shipping has seriously interfered with the delivery of orders for overseas customers, but in spite of this, good work has been done in several of the colonies. Altogether, the record is excellent, and one of which the directors of the company might very well feel proud.

The Metal Trade and the War. A good idea of the effect of the war upon the metal trade may be gained from the result of the past year's working of Messrs. Richard Johnson, Clapham & Morris (Ltd.). At the meeting last week, Mr. Edward Stone, managing director, who presided in the absence of the chairman (Capt. W. Morton Johnson), congratulated the shareholders on the successful results of the year's trading.

He said the results were due to a combination of circumstances. In the first place they had had a largely increased demand for their goods, the total value of the sales being £1,234,795. In addition, they kept very large stocks, the value of which had been gradually increasing, and the demand for their goods for munitions of war had been very great. Although they had successfully carried through a considerable amount of that work, yet by far the larger portion of their business with the Government had been indirect, through their many customers. So far the company had been successful in considerably increasing their turnover, but the outlook was not clear. Even at present the turnover of their export trade was seriously shrinking, and that was entirely owing to difficulties in getting supplies.

* * * *

After-the-War Problems. At the recent annual meeting of the Association of Trade Protection Societies several subjects dealing with problems which are likely to arise after the war were discussed.

Mr. G. M. Chamberlain, in the course of his presidential address, declared that the establishment of a Ministry of Commerce was long overdue, and if concerted measures were to be taken to organise and put the nation into a position of preparedness to meet a fresh onslaught on our trade by Germany after the war, now was the time for the Government to give a lead. No stronger and more effective lead could be given than to establish a Ministry of Commerce. Resolutions were adopted urging that a complete scheme for the extension after the war of British trade with the Colonies and foreign countries should be furnished now by the Government; that the Consular service should be staffed by men with trained business experience, instructed to promote British trade within their jurisdiction; and that power should be given to regulate the dumping into the country of foreign goods at unreasonable prices. It was also urged that our education system should be directed to the teaching of business methods, habits and duties, to training in science as applicable to industry, and to greater attention to the languages of countries where British trade relations could be extended.

* * * *

Increase of Coal Output. An important conference on the very serious question of increasing the output of coal took place in London on Tuesday between the Executive Committees of the Mining Association and the Miners' Federation of Great Britain. The conference, which was convened at the suggestion of the Home Office, had before it proposals emanating from the Coal Mines Organisation Committee for improving supplies.

In a letter, Sir Richard Redmayne, chairman of the Organisation Committee, remarked that the deficiency of coal supplies was very serious, and the Committee were unanimous that it was of vital importance that every effort should be made to increase output. The decrease in output for the first 12 months of the war was about 30 million tons, and the monthly rate of decrease had shown no improvement. The demand for coal for home consumption was growing, largely owing to the requirements of works engaged in the manufacture of munitions. The demands of the Allies were also increasing. To meet home demands export had been greatly reduced, and yet it was necessary to maintain exports to various countries in exchange for essential articles from them. Coal was our largest and most important export, and its export had an important bearing on paying for the war and maintaining the rate of exchange. Five points, he mentioned, had been discussed by his Committee for increasing supplies, and he asked for their favourable consideration. The suggestions were as follows: (1) Suspension of the Eight Hours Act; (2) Further utilisation of the facilities for working an additional hour on 60 days of the year at collieries; (3) reduction in age of boys entering mines from 14 to 13, and permission to use the services of boys on the surface; (4) Further employment of women on the surface; (5) reduction of wilful absenteeism. The proposals were considered by the Miners' Federation last week, and the Executive Committee were given powers to act within certain limits. They were strongly opposed to the suspension of the Eight Hours Act unless a complete case was made out for its temporary withdrawal. The conference was adjourned until June 22, but the following resolution was unanimously adopted:—

In regard to absenteeism, this meeting agrees to the matter being referred to the districts on the distinct understanding that committees will at once be set up in each district to devise, and to put into operation, effective machinery to secure the attendance of all the workmen employed to the fullest possible extent and to inquire into the circumstances

of workmen employed in the mines not being provided with work whenever they present themselves, the intention being to secure as far as possible the output of coal necessary for the country's needs.

At the adjourned meeting on June 22nd reports from the districts as to the suspension of the Eight Hours Act and the working of one hour extra on 60 days of the year will be considered. It was also recommended to the several districts that holidays be curtailed as far as possible in the national interests in order to obtain an increased output.

* * * *

Alien Control of Australian Ores.

It is announced that the Government has now cancelled the German contracts of the British Broken Hill Companies.

Under the terms of the Trading with the Enemy Amendment Act, 1916, the Board of Trade has made an order determining all contracts made by the British Broken Hill Proprietary Co. and the Zinc Corporation with the German smelters. The only other British company operating at Broken Hill (the Sulphide Corporation) has also made an application for release, and when this has been effected the British companies will be in the same position as the Australian concerns, who were released by the Enemy Contracts Annulment Act (passed by the Commonwealth Parliament last year) and will now be free to dispose of their lead and zinc concentrates. "The Times" reports that negotiations were recently in progress between the British Broken Hill Co. and Japanese buyers for a further sale of concentrates on a scale that might have enabled the company to resume milling, but they were stopped owing to the action of the Commonwealth Government in prohibiting the further export of lead concentrates from Australia for the present. The Commonwealth Government is believed to favour the idea of all Australian metals being smelted locally, but as no facilities exist for smelting the whole of the Broken Hill lead output this prohibition seems much too premature. The company is considering the question of erecting modern works in this country, where both lead and zinc concentrates could be treated at a lower cost, owing to cheaper labour and materials, than in Australia. The principal Broken Hill companies have agreed to join the Zinc Producers' Association Proprietary (Ltd.), formed under the Commonwealth Government's auspices with the object of securing that the future output of these concentrates in Australia shall be realised through one channel. Metallurgical experts contend that the cost of production in Australia would be prohibitive to users in this country. But whatever the companies decide to do they feel that the only sure plan for the Government to adopt as regards the security of its own requirements is the erection of State smelters.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From May 8, 1916, *to* May 13, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

GREECE.—*Sweden:* Elec. machinery, 19 pkgs.

HOLLAND.—*Sweden:* Electric machinery, 66 pkgs.

LIVERPOOL.—*U.S.A.:* Unenumerated, 66 pkgs.

LONDON.—*U.S.A.:* Elec. machinery, £1,879; elec. lamps, £578; carbon candles, £134; telephone material, £102; wire and cable, £12,150; unenumerated, £2,978 —505 pkgs. *Holland:* Elec. lamps, £6,575 145 pkgs.; incandescent elec. lamps, 9 pkgs.; elec. lamps and caps, 125 pkgs.; elec. machinery, £169; elec. bulbs, 110 pkgs.; elec. lamps and parts, 10 pkgs. unenumerated, £16. *France:* Elec. machinery, £1,061; carbon candles, £4 0; unenumerated, 10 pkgs. *Switzerland:* Elec. machinery, £180; unenumerated, £2 04. *Denmark:* Unenumerated, £71. *Italy:* Elec. machinery, £90; wire and cable, £60. *Japan:* Elec. machinery, £40; unenumerated, £60. *Sweden:* Elec. machinery, £40.

MANCHESTER.—[illegible]; Unenumerated, 114 pkgs. *Holland:* Elec. lamps, 25 pkgs.

SOUTHAMPTON.—*France:* Unenumerated, 8 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Unenumerated, £24. *Melbourne:* Elec. machinery, £396; wire and cable, £10; unenumerated, £61. *Invercargill:* Unenumerated, £1,9[illegible]. *Sydney:* Elec. machinery, £117; [illegible]; unenumerated, £1,[illegible]. *Wellington:* Elec. machinery, £20; lamps, £50; unenumerated, £1,761. *Brisbane:* Elec. machinery, £20; wire and cable, £125; elec. [illegible], £11[illegible]. *Perth:* Elec. machinery, £51; unenumerated, £70. *Christchurch:* Wire and cable, £30; unenumerated, £60. *Lyttelton:* Elec. machinery, £160. *Invercargill:* Elec. machinery, £40; wire and cable, £312; unenumerated, £7[illegible]. *Dunedin:* Telegraph material, £50; [illegible]. *Adelaide:* Elec. machinery, £35. *Adelaide:* Elec. machinery, £[illegible].

AFRICA.—*Durban:* Wire and cable, £[illegible]; unenumerated, £1,115. *Port Elizabeth:* Wire and cable, £[illegible]. *East London:* Unenumerated, £1[illegible].

EGYPT.—*Alexandria:* Wire and cable, £100; [illegible].

MADAGASCAR.—*Majunga:* Elec. machinery, £120.

GIBRALTAR.—Telegraph material, £[illegible].

MALTA.—Wire and cable, £[illegible]; unenumerated, £11; [illegible] £12.

SUMATRA.—*Medan:* Unenumerated, £[illegible].

INDIA, CEYLON, STRAITS SETTLEMENTS AND STRAITS SETTLEMENTS.—Wire and cable, £8,752; elec. machinery, £430; [illegible]; unenumerated, £430. *Madras:* Elec. machinery, £50; Cable, Wire and cable, £147. *Singapore:* Elec. machinery, £1; [illegible]; unenumerated, £323. *Penang:* Unenumerated, £[illegible]; Wire and cable, £160; unenumerated, £8[illegible].

JAVA.—*Samarang:* Unenumerated, £[illegible].

JAPAN.—*Yokohama:* Unenumerated, £[illegible].

CHINA.—*Hong Kong:* Wire and cable, £141; [illegible]; Elec. machinery, £80; telegraph material, £[illegible]; [illegible]; Elec. machinery, £75.

U.S.A.—*New York:* Unenumerated, £[illegible].

SOUTH AND CENTRAL AMERICA.—*Buenos Aires:* Wire and cable, £[illegible]; unenumerated, £1,635. *Colon:* Unenumerated, £10; [illegible]; [illegible]. *Santander:* Unenumerated, £114.

HOLLAND.—*Amsterdam:* Wire and cable, £2[illegible]; [illegible]. *Rotterdam:* Wire and cable, £530; elec. machinery, £12[illegible]; [illegible]. Wire and cable, £19[illegible].

FRANCE.—*Paris:* Wire and cable, £137; unenumerated, £189. *Dieppe:* Elec. machinery, £269; unenumertaed, £161. *Bordeaux:* Elec. lamps, 3,500 no. wire and cable, £3,829; unenumerated, £329. *Calais:* Unenumerated, £24. *Dunkirk:* Unenumerated, £660.

PORTUGAL.—*Lisbon:* Wire and cable, £1,614; unenumerated, £86.

SPAIN.—*Huelva:* Elec. machinery, £116.

CANADA.—*Montreal:* Unenumerated, £40. *Toronto:* Unenumerated, £26. *Halifax:* Telegraph material, £60; wire and cable, £1,220; unenumerated, £55.

JAVA.—*Batavia:* Wire and cable, £603; unenumerated, £45.

NORTH ATLANTIC.—Telegraph cable, £25,560.

TANGJONG.—Elec. machinery, £360.

HENDEL.—Wire and cable, £136.

TJILATJAP.—Unenumerated, £32.

FOREIGN GOODS (duty paid and free).

Adelaide: Unenumerated, £1,498. *Bombay:* Unenumerated, £153. *Ceylon:* Unenumerated, £265. *Dieppe:* Unenumerated, £195. *Perth:* Unenumerated, £30. *Sydney:* Unenumerated, £15. *Wellington:* Unenumerated, £14. *Kobe:* Unenumerated, £32. *Melbourne:* Elec. meters, £105.

IN TRANSIT.

Auckland: Elec. lamps, £200. *Shanghai:* Elec. glow lamps, £365.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

LEGAL INTELLIGENCE.

Alien Enemy Patents.

In the Patents Court on the 10th inst. an application was made by Messrs. Watson & Sons (Electro-Medical), Ltd., for a licence to use patents 9,499 of 1912 and 13,903 of 1913, granted to Siemens & Halske (A.-G.). It was said that the patents covered an improved means of varying the primary current in order to obtain a better electrical discharge in the Röntgen-ray tube. A rectifier ensured that the direction of discharge in the X-ray tube was always the same. The excitation of a Röntgen-ray tube, under the 1912 patent, was produced by suddenly commuting the continuous current flowing in the primary windings of a transformer or induction coil, and rapid successive discharges were obtained by means of an interrupter or rectifier for the secondary current, in conjunction with a rotating commutator to the transformer or induction coil. That gave a high-tension discharge in the X-ray tube. The improvement in the second patent aimed at reducing the time constant in the apparatus, and consisted in varying the primary circuit at the moment of commutation. Prior to commutation the patentees had the whole primary winding in circuit, and the commutator automatically cut out half the primary, so that at the moment of commutation there was only half the primary coil in circuit. Or the patentees might effect the same result by having two primary windings possessing different time factors.

Mr. GEOFFREY PEARCE, managing director of applicants, made an affidavit setting out the facts of the case, and that he was familiar with the subject matter of patents 9,499 and 13,903, and would find no difficulty in building up the apparatus. His company possessed every facility for the manufacture at their own works by their own British workpeople of apparatus constructed in accordance with the specifications, and they desired to manufacture the apparatus to fulfil an urgent Government order which they had obtained. They had also other orders and inquiries for the apparatus, and it was highly desirable in the interest of British industry and British workpeople that the apparatus should be manufactured to an adequate extent in this country to meet the demand.

For the opponents, Mr. IMRAY stated that Messrs. Siemens Bros. & Co., of London, were beneficially interested in the patents, and were doing a great amount of Government work. They were prepared to carry out the manufacture of that type of apparatus, but as the Government had approached Watson & Sons they would not object to the licence being granted to them. The only question was the amount of royalty.

Thereupon Mr. MARKS offered a royalty of 2½ or 3 per cent. on the patented part of the apparatus, roughly half of the entire apparatus, which would cost about £100. Finally, the applicants agreed to pay 4 per cent. on the selling price of the entire machine.

"Unsealed Patents" to be Licensed.

The Patents Court on the 11th inst. heard the first application under the Trading with the Enemy Amendment Act, 1916, for a licence under an unsealed alien patent. The present application was made on behalf of two Sheffield firms, and the invention, which was made by two German engineers, named Timmer and Dinger, of Solingen, related to a grinding machine for making blades. Mr. Walter Tyzack (managing director of Messrs. Needham, Veall & Tyzack) and Mr. Albert Hobson (of Thomas Turner & Co.) applied in order to fulfil War Office contracts of so extensive a nature that they could not ordinarily be complied with.

The Controller (Mr. THEODORE FRANKS) explained the procedure. He said the Public Trustee was likely to be made custodian of the "unsealed patents." Hitherto the licence had been issued by the Board of Trade. The new type of licence would be executed by the Public Trustee and granted in his own name. The Public Trustee would hold the royalties, but somebody would have to pay the sealing fee for the unsealed patents. He would recommend the grant of a licence to Mr. Tyzack and Mr. Hobson, at 5 per cent. royalty on the selling price, and they could decide among them who was to pay the sealing fee. The patents would have to be sealed to somebody. There would be a variation of procedure in the case of licences in these new cases. No time would be lost, and the applicants might count on hearing from the Public Trustee at any early date.

Unofficially it is estimated that there are 2,000 "unsealed patents" whose specifications have been filed.

EDUCATIONAL.

Sheffield University.—Under the will of the late Mr. W. Edgar Allen, founder of the Medico-Mechanical Institute in Sheffield, the sum of £32,000 has just been paid to the University of Sheffield as part of the residue of the estate.

Of this sum £5,000 is intended for the applied science department and the balance is to go to University scholarships, half of these to be reserved for the sons of working men. Sir Joseph Jonas, chairman of the applied science department, has added £5,000, and the total of £10,000 will be applied to the provision of a material-testing laboratory, to be known as the Allen and Jonas Laboratory. Any further amount which may be received from Mr. Allen's estate will be set aside for scholarships.

School of Technology, Manchester.—The syllabus of the summer evening classes in mechanical engineering contains courses on hydraulics, experimental mechanics, inking in, colouring and tracing, locomotive management, graphics, oxy-acetylene welding, stationary steam boilers and smoke abatement, experiments on the value of ductibility of material in machine construction, steam applied to road transport, problems in the design of aero-engines. The electrical engineering courses are as follows: The curing of defects in electrical machinery, measurement of power and energy in single-phase and polyphase circuits, wave forms, examination of the magnetic properties of iron, insulation and insulation testing, electrical railway practice in America.

BUSINESS NOTICES.

The Board of Trade announce that the Labour Exchanges and Unemployment Insurance Department will, in future, be known as the Employment Department of the Board of Trade.

The firm of H. Hartjen & Co., Noble House, 35-37, Noble-street, London, E.C., has been turned into a private limited company, under the title of "Holder-Harriden (Ltd.)," Mr. F. W. Lang being the sole director.

The registered office of the Lyme Regis Electric Light & Power Co. (Ltd.) has been altered from Coombe-street, Lyme Regis, to Moorgate-court, Moorgate-place, London, E.C.

Plant for Sale.—The Metropolitan Railway Co. advertise for sale the electric generating plant until recently employed by the Great Northern & City Railway, including four 800 kw. d.c. generators, with Corliss engines, 10 boilers, four condensing plant, auxiliary engine and generator, coal handling plant, feed pumps, &c.

Leeds Corporation electricity department advertise for sale a 1,000 B.H.P. triple-expansion three-cylinder vertical Belliss engine, two sets horizontal surface condensing plant with air pumping and circulating engines, six 700 kw. two-phase alternators and exciters and one additional circulating engine. Offers to the manager, Mr. C. Nelson Hefford, 1, Whitehall-road, Leeds.

Copper for Sale.—Belfast Harbour Board advertise for sale a quantity of electrolytic copper strip and wire. Tenders to the Secretary, Harbour Offices, Belfast, by 31st inst.

LIQUIDATIONS, BANKRUPTCIES, &c.

Russell E. Connold, member of R.N. Air Service, formerly electrician, of 6A, The Parade, Canterbury, has been adjudicated bankrupt.

An order has been made that the application for the discharge of Arthur Faraday Hawdon, electrical engineer, Yetholm, Elmfield-gardens, Gosforth, be withdrawn.

The Riddle Automatic Signal Co. (Ltd.) is being wound up voluntarily, and Mr. W. Braby, 25, Victoria-street, London, S.W., has been appointed liquidator.

Winding-up Petition.—A petition by Haslam & Stretton (Ltd.) for the winding up of the Colston Electrical Works (Ltd.) will be heard at the Guildhall, Bristol, on May 31.

ELECTRICITY SUPPLY.

EXTENSIONS.

Carlisle.—The Electricity Committee have decided to borrow £240 for main extension to supply current to a proposed electric coaling plant at the L. & N.W. locomotive sheds.

London County Council.—On Tuesday sanction was given to the following loans for electricity purposes: Hammersmith Borough Council, £3,000; Hampstead Borough Council, £3,000.

Repayment of Capital Expenditure.—The Finance Committee reported that the Treasury, after consultation, had agreed to the following periods for the repayment of the capital expenditure (which will probably exceed the original estimate of £22,000) involved in the substitution of turbines and reciprocating engines at the Greenwich generating station:—

(i.) Expenditure on river works, foundations for new machinery, and alterations to building (for conversion of engines to permanent character, £23,640), 60 years; (ii.) other alterations to existing buildings (£1,310), 25 years; (iii.) expenditure on new plant and machinery (other than additional steam, exhaust, feed condenser, &c., pipes), 25 years; on the understanding that, in the event of payments into the renewals fund on the agreed basis being resumed at any future date, the question of the period for repayment shall be reviewed; (iv.) expenditure on additional steam, exhaust, feed condenser, &c., pipes, 25 years; (v.) cost of re-bladin, turbines and re-winding generators to be charged to renewals account or renewals fund; (vi.) outstanding debt in respect of each of the old machines, to be provided for in two years, from the end of the financial year during which the old machine in question is replaced.

Shoreditch (London).—The L.C.C. has advised the Borough Council that they are prepared to advance the £2,000 required by the electricity department for house services and meters.

GENERAL.

Barnes.—As the net profit (£769) on the electricity undertaking for the past 12 months is not, having regard to the present state of the markets, a sufficient margin to meet all eventualities, the electrical engineer (Mr. C. S. Davidson) suggests that as from the June quarter 10 per cent. should be added to all accounts.

This increase would produce about £1,250, and, provided the cost of materials remains the same, would ensure a net profit of about £2,000 for the year 1916-17.

Coal Supplies.—Shoreditch Lighting Committee agrees with Stepney Borough Council that proper facilities should be afforded by the Government for obtaining adequate supplies of coal for electricity supply undertakings which are engaged in the supply of power and light to a large number of local factories, and it is making representations to the Board of Trade, the Railway Executive Committee and the Admiralty Coasting Trade Office on the matter. In order to counteract the present difficulty of obtaining supplies, the Committee has applied for a certificate of recognition of the works as "munition works."

Dublin.—We are informed by the city electrical engineer (Mr. M. Ruddle) that on the whole the electric supply department coped very well during the recent disturbance.

The general supply of electrical energy to the public was maintained throughout without intermission, the only exceptions being when the burning buildings in O'Connell-street area blew so many fuses that one of the sub-stations had to be temporarily shut down. The gas supply was shut down from the first, so that only the consumers of the department had lighting supplies. The street lighting was maintained as usual for the first couple of nights until the military authorities ordered its discontinuance until last week, when it was resumed in most districts. In the street fighting the lamps suffered much damage, some 80 lamps being destroyed by rifle fire, about 150 globes being broken and several poles being smashed by falling buildings; altogether about £700 damage has accrued to date. The staff stuck to their work well throughout, some members in the zone of fire being on continuous duty for seven days and nights without relief. The generating station at Pigeon House and the chief distribution station at Fleet-street were under military guard from the first day of the outbreak, but no attack was made on the property of the electricity department, other than the damage mentioned to the street lighting. Still (says Mr. Ruddle) it was a strenuous and anxious time for all concerned, and the work of disconnecting the supplies to the fallen buildings entailed serious risk on the staff engaged on that work. The destruction of property in the principal business area of the city will mean a serious loss to the department in the immediate future as regards income, as the work of rebuilding at the present time must be slow for want of material and labour.

Ealing.—The electrical engineer (Mr. J. D. Knight) reports that the amount paid in wages to employés of his department serving with H.M. Forces between Aug. 4, 1914, and April 29 last was £784. 11s. 1d.

Hove.—On the recommendation of the Lighting Committee the Council propose to grant an additional war bonus of 3s. weekly to the men in the electrical department.

Knottingley.—The Board of Trade have extended for one year from July 31, 1916, the periods of two years and 18 months respectively mentioned in sec. 21 of the schedule to the Electric Lighting Clauses Act, 1899, as incorporated in the Knottingley Electric Lighting Order, 1914.

Nelson.—The Council have increased the price of electricity by ½d. per unit for lighting and ¼d. for power.

Plymouth.—The Corporation have approved a proposal of the Electricity and Street Lighting Committee to purchase an electric lorry for £1,055.

At the recent meeting of the Corporation the Tramways Committee proposed a revision of existing fares and the adoption of penny fares on

certain routes as soon as through running of cars to Devonport is effected. As members of the Council had not seen the report of the manager upon which the Committee based their recommendation, the matter was postponed until next month.

Swansea.—The Electricity Committee has approved the proposal to substitute metal filaments for the existing enclosed arc lamps.

Westminster.—The Charing Cross, West End & City Electricity Supply Co. and the St. James' & Pall Mall Electric Light Co. have terminated their contracts for the supply of energy to the Council buildings, and after June 24 the charges will be as follows :—

Charing Cross Co. 20 per cent. increase on existing prices, viz., 3d. per unit for lighting and 10s. per kilowatt of connected demand plus 1d. per unit for power. St. James' Co. 4d. per unit instead of 3d. per unit for lighting and 1d. plus 7s. 6d. per rated horse-power per quarter (no change) for power. The Council has been recommended to accept the amended offers of the companies.

Whitehaven.—The receipts of the electric supply department for year ended March 31 were £5,766, against an estimate of £6,475.

The expenses were £5,726, leaving a credit balance of £40. This year's revenue is put at £5,836 and the expenditure at £5,593, or a profit of £233.

TRACTION NOTES.

Birmingham.—In February last the Corporation authorised an experiment being made with trailer cars, and the Handsworth route was selected for this purpose by the Tramways Committee.

In order to carry out the experiment, special brakes and couplings were required for the tractor car and the trailer in order to meet the requirements of the Board of Trade, and as the department were so short of skilled men, all of the available staff being engaged in the maintenance of the existing lines, the special work had been delayed. It has, however, been now completed, and the experiment with trailer cars will be begun this week. The experiment is being undertaken to show whether trailer cars are feasible, having regard to the peculiar conditions of the city, what the effect will be on the general traffic in the thoroughfares, and, finally, whether trailers are advisable from the point of view of economy.

The Tramways Committee has reported increased traffic receipts during the past year of £125,000. Passengers carried were 163 millions, an increase of 14 millions.

Blackpool.—Over 100 women have been employed as conductors on the local tramways and it is now proposed to employ women as drivers also.

East London Railway.—This company whose line is worked by a joint committee of six companies has successfully appealed to the London Quarter Sessions on four previous occasions, and has obtained a reduction on rateable value from £5,092, recently fixed by the assessment committee, to a nominal figure of £100.

Keighley.—The Council have agreed to give merit badges (carrying 1s. a week extra pay) to permanent employés of the tramways department on completion of three years' continuous and satisfactory service as conductor, motor-man or inspector.

Leeds.—There are now more than 400 women conductors on the Corporation tramcars, and it is stated that in a few weeks all the car conductors will be women.

Southampton.—The tramways manager recommends the levying of a charge for excess luggage on the cars—*i.e.*, parcels other than personal luggage not exceeding 28 lb. in weight.

Southend-on-Sea.—The Light Railways Committee has instructed the electrical engineer (Mr. R. Birkett) not to proceed with the proposal for testing suitable women and girls with a view to using them as temporary drivers on the cars, but to apply to the Tribunal to postpone the calling up or to exempt provisionally the 17 motor men employed on the cars, who have enlisted under the Derby Scheme, and, in addition, to appoint temporarily such other suitable men for the season traffic as the necessity arises.

Swansea.—The Tramways Committee proposes to apply for an extension of time for constructing the Carmarthen road and Port Tennant-road tramways.

EMPIRE NOTES.

Australasia.—At a recent meeting of Sydney (N.S.W.) City Council the Electric Lighting Committee recommended, with regard to a reference from Council as to preference to British goods and goods of Allied nations during the war, that the same be rescinded and that each tender received be dealt with on its merits.

The committee also recommended that in connection with works proposed to be established by the Australian Electric Steel Co. for making steel by an electrical process, three-phase current at 5,000 volts be offered at 0·5d. per unit between 9 p.m. and 7.30 a.m. on condition that no supply be given between 3.30 a.m. and 6.30 p.m., that the minimum demand is 500,000 units per year for five years, and that the company provide accommodation for switchgear. At a later date if the company require a much increased quantity of current the Council will consider the advisability of a reduction in the price.

Other recommendations by the Committee were that in view of the contractor for 4 in. fibre conduit being unable to give delivery, 15,000 yds. of earthenware pipes be purchased locally under the existing contract, at a cost of £1,030; that in view of the City Electrical Engineer's advice that, owing to war conditions, contracts for the supply of great additions to the generating plant, boilers, &c., at the power house should not be completed at present, the Castlereagh sub-station be proceeded with, and that tenders be invited for the following equipment for the sub-station : (*a*) A large storage battery, (*b*) converting and battery charging plant, (*c*) switchgear. It is also recommended that tenders be invited at a later date for cables for connecting the power house to this sub-station, and for the supply of direct current from the sub-station to the street mains. The estimate of total cost of building and equipment and mains is £115,000. The Committee further recommended that authority be given for an expenditure of £1,050 for 13 steam flow meters on the 13 newest boilers at the power house, and that the General Electric Co. of America be asked to quote for the same ; and that the action of the City Electrical Engineer in directing the contractors for the supply of fibre conduit (Haes & Eggers) to postpone the importing of material ordered in view of the great increase in freight (from 70s. per ton measurement to £8. 10s. per ton) be approved.

The "Australian Mining Standard" says a technical school was opened at Footscray (Victoria) recently by the Minister for Education, Mr. Lawson. The Mayor (Coun. Pearce) said that the main building cost £5,050, and provided accommodation for 200 students. Already this number of students has been enrolled. Workshops are being erected at a cost of £2,000. Manufacturers are being asked to assist in installing machinery. Mr. Warde said the time had arrived when the Government should enforce technical education on boys over 14 years of age.

The New South Wales works department has offered to supply the Councils of Bowral, Moss Vale, and Mittagong, on the table land back of Illawarra, with electric current from the coal jetty power-house at Port Kembla. The Minister for Works says it had been arranged to supply Wollongong from this source, and current could be supplied more economically if the output were increased by the supply of these municipalities. Current would be transmitted at high pressure, transmitted to the boundaries of the municipalities and transformed down. The price to be charged to Wollongong was £7 per kilowatt per annum, plus 1d. per unit. On account of the greater cost of the transmission line, the charge to the other municipalities would be £8 per kilowatt. The districts of these municipalities are over 2,000 ft. higher than Port Kembla and 40 to 50 miles distant.

The Alexandra (Victoria) Shire Council has decided to establish an electric supply undertaking.

The Amalgamated Zinc Co. are having a trial parcel of material put through the electrolytic plant of the Anaconda Copper Co. in America to provide data to guide them in their decision as to starting zinc treatment works in Tasmania. It is proposed to negotiate with the Tasmanian Government for power from the hydro-electric works at Great Lake. 10,000 H.P. would be required at the outset, and probably 40,000 or 50,000 H.P. later. The Premier states that another investor is negotiating for 50,000 H.P.

A report has been prepared by Mr. R. H. Garvie, engineer for the Launceston (Tas.) marine board, in regard to the proposed works at Bell Bay, which had been decided on for the deep-water port for the Tamar. Amongst the works which will form the first section are wharf equipment, consisting of electric cranes and capstans, and a power station for generating electricity required to operate cranes, capstans, lighting and any other electrical appliances.

At a recent meeting of the ratepayers of Port Adelaide it was decided to approve of the Council borrowing £12,000 for electric tramways.

The "Commonwealth Engineer" says: Gympie (Queensland) Council has authorised Mr. C. S. Dent to establish electricty works in the town.

The N.S.W. Minister for Works, Mr. Cann, stated recently that he intended to inquire into the question of erecting a bridge at the Spit, over Sydney Middle Harbour, to carry electric railway cars and vehicular traffic. It is estimated that the bridge would cost £43,000.

It is proposed to construct a tramway at Eastern Northcote (Victoria), at a cost of £20,300.

The Fitzroy, Northcote & Preston (Victoria) Tramway Trust is sending representatives to India to obtain information regarding motor-propelled tramcars.

Provided the treasurer of Queensland, Mr. Theodore, agrees to allow 12 months' grace to the company which it is proposed to form for the purpose of supplying Ipswich (Queensland) with electric light and power, there is every likelihood that the scheme will be carried out. This concession is asked for on account of the difficulty there will be in securing from England the necessary plant and machinery so long as the war lasts. The conditions on which the Minister has consented to issue an Order-in-Council are that the company's tenure shall not exceed 25 years ; the local authorities (and probably the State Government) to be given the right to purchase the undertaking at the end of 15 years of the order or 25 years. The price for current to be charged to the local authorities for tramway purposes is ½d. per unit plus £5 per kilowatt of maximum demand per annum. The municipal authorities have agreed not to

exercise their right of purchase before 25 years and support the promoters' request for 12 months' grace.

New South Wales Government has received three proposals for the generation of electricity by water power in different parts of the State. It is proposed that the undertakings shall be State-owned and controlled. One, the Burrinjuck scheme, is estimated to cost £100,000 and the others, on the Clarence and in the Kiama district, are smaller schemes.

New South Wales Public Works Department Tender Board has received two tenders for the installation of an electric passenger lift at Accommodation House, Jenolan Caves, and six tenders for the supply and erection of electric hoists and motors, for new beef houses, for N.S.W. abattoirs and meat works, Homebush. The tenders are to be reported upon.

The installation of the hydro-electric plant by the Town Board of Kaponga, Hawera County (N.Z.), is now completed. A concrete dam was built across the Kaupokonui to supply the necessary power. The plant consists of a Boving turbine developing 70 B.H.P. under a working head of 33 ft., coupled to a 45 kw. G.E. dynamo, giving direct current at 230-5 volts. A battery of about 128 cells with a capacity of 90 amperes has been installed. Supply is given on the two-wire system. The National Elec. Engineering Co. were the contractors for the plant and Mr. H. Priestley is the engineer-in-charge.

Messrs. Goodlet & Smith (Ltd.), cement manufacturers, Granville (N.S.W.), are changing over their works from steam to electric drive. Current will be purchased in bulk from Sydney Council. The electrical equipment is being supplied by the Australian Gen. Elec. Co.

H.M. Trade Commissioner for Australia reports that Sydney Council has rescinded its decision to give a 10 per cent. preference on the price ex works of British-made goods. It is stated, however, that there is no intention on the part of the Council to depart from its rule of accepting British tenders whenever possible.

The New Zealand Government has granted licences for the erection of electric lines for lighting, power and heating purposes in (1) Thames County, (2) the Borough of Spreydon, (3) the Kidnapper Survey District, and (4) Inangahua County.

A correspondent of the "Mining Journal" says the Electrolytic Refining & Smelting Co. is increasing its plant at Port Kembla (N.S.W.) by one-third. Its present production of refined copper is from 20,000 to 24,000 tons annually.

The Shire Council has decided to purchase the undertaking of the Kilmore (Victoria) Electric Supply Co. for £2,500 if the money can be borrowed at a sufficiently low rate of interest. The Council pays the company £160 per annum for street lighting, and the charge to private consumers for lighting purposes is 7d. per unit.

The "Financier" says Mr. H. Teesdale Smith recently visited Perth (W. Australia) on behalf of a company which proposes to establish an electric furnace in the city for making cast steel out of scrap iron. Australia at present imports 8,000 or 10,000 tons of the best steel per annum, and the steel which the company hopes to make (it is claimed) will be worth from £40 to £50 per ton.

Electric Smelting & Refining in Canada.—H.M. Trade Commissioner for Canada (Mr. C. Hamilton Wickes) states that a zinc smelting plant has been established at Trail (B.C.), which is a new departure from those hitherto in use.

The metal is treated electrically and the method is stated to be successful. After the outbreak of war the British Government offered to take 5,000 tons of zinc at 8 cents (4d.) per lb. This offer was handed over to mining interests at Trail, and they decided to start the plant, judging from experiments that they could produce zinc from their own ores at about 4½ cents per lb. The plant for the electrical treatment of the ore has at present a capacity of only 5 tons a day, but the capacity is to be increased by using a better grade of ore.

A syndicate, with a capital of $100,000, has been recently formed at St. John's, Newfoundland, for the purpose of carrying on electric smelting. The "Electrical News" of Canada states that the syndicate (the Hydro-Electric Smelting Co., Ltd.) has taken over property, the Little Bay Mines, at Little Bay, and has installed a Wile electric smelter with a capacity of 10 tons per day. This smelter is situated on the property of the Reid Newfoundland Co. near tidewater, electric current being purchased from that company. It is proposed with this plant to treat galenas, coppers and other valuable ores from different parts of the island, with a view to encouraging individual claim holders to work their properties until such a time as a permanent supply of about 200 tons per day will be available, when the company will erect a concentrating plant and smelter to handle this quantity at some convenient point in Green Bay, where there are numerous deposits of ores at tidewater. The Little Bay property has been idle for the past two decades, but in 1881 an English company shipped 22,000 tons of ore, averaging 10 per cent. copper. At that time the company did not find it remunerative to ship any ores under the above percentage, consequently there are dumps, estimated to contain 500,000 tons, on the property, running from 2 to 7 per cent. copper. There is also a lake on the property with an estimated capacity of 26 million gallons which is rich in copper, being leached from the mines and dumps. Tin scrap deposited in this lake precipitates copper very rapidly, as, in three to four weeks, when taken from the water it assays from 32 to 35 per cent. copper. The syndicate has also acquired a water power from the Government, and contemplates erecting hydro-electric plant for the concentration of these dumps, and for electric smelting on the spot. Mr. P. L. Simpson is consulting engineer and chemist of the company.

India.—The "Review of the Trade of India," by the Director of Statistics to the Indian Government, contains information regarding trade openings in British India. The following are extracts :—

Electrical machinery for use in connection with water-power plant has great capabilities of expansion. The number of electrical installations in India is large and increasing. All the larger towns and chief ports have electric light and electric tramways, or are about to use power for these purposes. A gradually increasing market for electrical machinery is anticipated. In recent years the collieries of India have largely adopted electrical equipment, and here German goods have found an opening. Calcutta has been flooded with cheap German materials for electric wiring, such as cables, switches, ceiling roses and fittings. Since the outbreak of hostilities this source of supply has ceased.

The imports of earthenware and porcelain into India came chiefly from the United Kingdom, although an appreciable quantity was also imported from Germany and Austria-Hungary. German goods under this heading included insulators.

In his recent presidential address to the Mining and Geological Institute of India Mr. H. H. Hayden said, prior to the war half the world's supply of tungsten ore was absorbed by Germany, who produced the metal, and Great Britain was dependent on that country for her supply of tungsten for the manufacture of high-speed tool-steel. The industry had now been taken out of Germany's hands, and none of the ore produced in the British Empire is sold to producers of tungsten other than British. As Burma was a large producer, special steps were taken and a staff was appointed to supervise the mining industry of Tavoy. The measures taken had resulted in a remarkable increase of production, and the amount won during the last three months of the year 1915 was approximately double the normal amount. If the final result was the increase of Burma's share of the world's production to 4,000 or 5,000 tons of wolfram per annum the question arose as to the extent to which the industry would be able to survive the drop in prices after the war, when the present excessive demand ceased to exist. The present high price of the ore offered a favourable opportunity for development to be carried out in the most efficient manner. India's chief rival in the European market would be Portugal, while in the United States she would have to compete with Argentina, Bolivia, Chile and Peru. Under the prices now ruling the manufacture of ferro-tungsten would seem to be a proposition worth serious consideration, especially if it could be carried out in the neighbourhood of Tavoy itself; this would involve the adoption of the electrical method, whereas if reverberatory furnaces were to be employed it would probably be preferable to carry the raw material to the fuel and manufacture it in the neighbourhood of the coalfields of Bengal. The manufacture of metallic tungsten was more complicated, but even that might prove to be worth considering.

The chief municipal engineer of Rangoon, while on leave in the United Kingdom, will inquire into the various systems of street lighting.

Transvaal.—Johannesburg Town Council recently rejected an offer of a bulk supply of electrical energy from the Victoria Falls & Transvaal Power Co.

The company offered to give a minimum supply of 4,000,000 units per annum, for a period of five years, at ¾d. per unit, the time of supply to be restricted to the hours between 4 p.m. and 8 a.m.

The general manager of the municipal electricity undertaking (Mr. J. H. Dobson), who reported on the offer, was of opinion that the Council would save several thousands of pounds per annum by generating its own electricity. He urged the Council to improve the position of their undertaking by arranging for a cheaper supply of water.

MISCELLANEOUS NOTES.

Contracts with Enemy Firms.—At the last meeting of West Hartlepool Corporation a resolution was moved that the undermentioned resolution be added to the standing orders of the Council :—

No contract shall be entered into with any person of German or Austrian nationality. No contract shall be entered into with any firm or company whose subscribed capital (whether by way of shares or otherwise) is held or controlled to the extent of one-third or upwards by persons of German or Austrian nationality.

An animated discussion arose on the resolution and ultimately the following amendment was put and carried unanimously: That no contract be entered into with any firm or company any part of whose capital was subscribed or controlled by Germans or Austrians.

Enemy Firms to be Wound Up.—The Board of Trade have now ordered the winding up of 142 businesses controlled by alien enemies.

Amongst the latest are Bleichert's Aerial Transporters (Ltd.), Egypt House, 36, New Broad-street, London, E.C., constructors of aerial wire railways. (Controller, W. Hancock, 90-91, Queen-street, Cheapside, E.C.) The Flender Co., Broad-street House, New Broad-street, London, E.C., wooden pulley manufacturers. (Controller, J. Baker, Elden-street House, Eldon-street, E.C.) Hammer Bayreuther & Co., 21, Mincing lane, London, E.C., rubber merchants. (Controller, R. J. Knight, 3, Raymond-buildings, Gray's Inn, W.C.) Jahresuhren, Fabrik (A. Schatz), 65A, Aldersgate-street, London, E.C., importers of clocks and watches. (Controller, A. H. Knight, Devonshire-chambers, 146, Bishopsgate, E.C.) L. Auerbach & Co., 2, Aldermanbury-buildings, Aldermanbury, London, E.C., metal leaf and bronze powder manufacturers (Controller: H. S. Ortmans, 7, St. Mildred-court, E.C.); Paul Metz, 215, Newhall-street, Birmingham, importer of hardware, &c. (Controller: J. W. G. Hill, Sun-chambers, 9, Bennetts-hill, Birmingham).

Claims against the Alphons Custodis Chimney Construction Co. (Ltd.) are to be sent by May 31 to the controller, D. H. Allan, 20, Copthall-avenue, London, E.C.

Inquest.—At Bradford last week an inquest was held on Alfred Dickinson, switchboard attendant, who was killed at one of the electricity sub-stations.

Mr. THOMAS ROLES, City electrical engineer, explained that the switch-gear and connections which carried the extra high-tension current were connected with cubicles with iron doors, which were locked and keys kept in the charge of an attendant. Deceased had been told that a rod which worked up and down in the cubicle was running against some concrete. Whether on the day of his death he had been to remove a portion of the concrete witness did not know. He had certainly not been ordered to do the work. It was necessary when work of that nature was done that a man with technical knowledge and experience should be present.

ARTHUR MORETON said that on the night before the accident he went into the room underneath the cubicle to investigate the rod. On the following morning he went with deceased into the cubicle, and the latter told him he was going to chip off some concrete. He went in to do so, and a moment later there was a flash, and as the deceased fell he exclaimed "It is alive."

The jury returned a verdict of "Accidental death."

Radiotelegraphists in Australia.—Application has been made under the Commonwealth Conciliation and Arbitration Act for the registration of an association called the Radiotelegraphists (Marine) Institute of Australasia, as an organisation of employés.

Tribunal Cases.—At Southwark Tribunal Messrs. Alex. Hawkins & Sons, electrical engineers, applied for exemption of the manager of their despatch department, who was responsible for repair of electric motors in works where Government contracts were being carried out.

He was granted exemption as being in a certified occupation, the stipulation being that he should join the Volunteer Training Corps for home defence, if required. Frank John Hawkins, a member of the firm (and a fully trained electrical fitter who superintended the erection of motors in munition factories) was granted a similar exemption.

At Clayton-le-Moors Tribunal recently an electrician (32 years and married) claimed exemption on business grounds. He had contracts to complete and he could not get anyone to take his business. He was the only electrician in Clayton-le-Moors. He would have been quite willing to go were it not that he was in business. Exemption granted until July 10th.

Imports. The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during April, 1916, and (*b*) the aggregate figures from Jan. 1 to April 30, with increase or decrease compared with corresponding periods of 1915:—

Electrical machinery, (*a*) £107,521 (decrease £40,785), (*b*) £371,727 (decrease £217,737); including generators and motors other than for aeroplanes, motor cars and cycles, (*a*) £12,207 (decrease £10,179), (*b*) £57,347 (decrease £29,708); and electrical machinery unenumerated, (*a*) £95,217 (decrease £30,606), (*b*) £314,380 (decrease £188,029); telegraph and telephone cables other than submarine, (*a*) £9,048 (increase £5,246), (*b*) £21,737 (increase £22,738), telegraph and telephone apparatus, (*a*) £44,572 (increase £37,308), (*b*) £91,561 (increase £73,200); other electrical wires and cables, rubber insulated, (*a*) £4,512 (decrease £8,850), (*b*) £34,457 (increase £4,765); with other insulations, (*a*) £1,600 (decrease £2,729), (*b*) £3,004 (decrease £7,361); carbons, (*a*) £6,742 (decrease £8,099), (*b*) £33,303 (decrease £2,267); glow lamps, (*a*) £37,152 (increase £27,977), (*b*) £86,413 (increase £42,581); arc lamps and electric searchlights, (*a*) nil (decrease £290), (*b*) nil (decrease £1,153); parts of arc lamps and searchlights (other than carbons), (*a*) £5,488 (decrease £2,616), (*b*) £25,087 (decrease £1,843); primary and secondary batteries, (*a*) £17,147 (increase £9,289), (*b*) £70,291 (increase £27,222); meters and measuring instruments, (*a*) £3,386 (increase £1,453), (*b*) £12,326 (increase £4,322); switchboards, (*a*) £5 (decrease £4), (*b*) £253 (decrease £2,710); electrical goods and apparatus unenumerated, (*a*) £18,923 (decrease £253), (*b*) £90,948 (increase £36,184). Total of electrical goods and apparatus other than machinery and uninsulated wire, (*a*) £148,575 (increase £58,432), (*b*) £479,380 (increase £195,668).

Exports.—The exports of electrical machinery, material, &c., (*a*) during April, 1916, and (*b*) from Jan. 1 to April 30, with increase or decrease compared with corresponding periods of 1915, were as follows:—

Electrical machinery, (*a*) £81,476 (decrease £61,956), (*b*) £389,733 (decrease £52,619); including railway and tramway motors, (*a*) £1,330 (decrease £35,000), (*b*) £13,217 (decrease £42,259); other generators and motors except for aeroplanes, motor cars and cycles, (*a*) £39,238 (decrease £12,482), (*b*) £207,465 (increase £25,909); and electrical machinery unenumerated, (*a*) £40,908 (decrease £13,874), (*b*) £169,021 (decrease £35,769); telegraph and telephone cables, submarine, (*a*) £16,732 (increase £932), (*b*) £85,402 (decrease £60,873); other than submarine, (*a*) £42,760 (decrease £8,026), (*b*) £201,916 (increase £63,182); telegraph and telephone apparatus, (*a*) £22,935 (decrease £4,244), (*b*) £92,857 (increase £23,476); other electrical wires and cables, rubber insulated, (*a*) £30,605 (increase £6,317), (*b*) £142,126 (increase £53,148); with other insulation, (*a*) £58,733 (increase £29,677), (*b*) £234, 20 (increase £113,755); carbons, (*a*) £1,268 (increase £1,051), (*b*) £3,539 (increase £1,794); glow lamps, (*a*) £10,938 (decrease £2,990), (*b*) £50,313 (increase £6,463); arc lamps and searchlights, (*a*) £710 (decrease £9), (*b*) £4,851 (increase £3,509); parts of arc lamps and searchlights (other than carbons), (*a*) £1,652 (increase £5), (*b*) £4,697 (increase £649); primary and secondary batteries, (*a*) £21,097 (increase £8,183), (*b*) £79,079 (increase £10,588); meters and measuring implements, (*a*) £14,903 (increase £5,681), (*b*) £59,246 (increase £9,716); transformers, (*a*) £1,077 (decrease £5,497), (*b*) £17,903 (decrease £1,629); switchboards, (*a*) £6,346 (increase £3,918), (*b*) £21,571 (increase £5,131); electrical goods and apparatus unenumerated, (*a*) £40,818 (decrease £653), (*b*) £182,197 (decrease £8,511). Total of electrical goods and apparatus, other than machinery and uninsulated wire, (*a*) £273,274 (increase £34,375), (*b*) £1,180,018 (increase £220,386).

TENDERS INVITED.

Telegraph and Telephone Material.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, Perth (W. Australia) requires tenders by 3 p.m. June 7, for the supply of 15 tons of Galvanised Iron Wire (Schedule 308, W. A.), for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specifications from office of Deputy Postmaster-General, Perth, W. A.

The Deputy Postmaster-General, Perth (W. Australia), requires tenders by 3 p.m. July 12 for the supply of 3,000 Dry Cells for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

Wiring.

KEIGHLEY AND BINGLEY Joint Hospital Board require tenders by May 22 for the wiring of the Fever Hospital and Sanatorium at Morton Banks. Specifications, &c., from the Borough Electrical Engineer.

Electrical and General Stores.

LIVERPOOL OVERHEAD RAILWAY CO. require tenders by 10 a.m. May 31, for 12 months' supply of Electrical Fittings, India Rubber, Iron and Steel, Oil, Packing, Waste, &c. Forms of tender, &c., from the General Manager.

Mechanical Stokers.

The Tramways and Electricity Committee of BELFAST Corporation invite tenders for the supply of Chain-grate Mechanical Stokers. Specifications from the city electrical engineer (Mr. T. W. Bloxham), East Bridge-street, Belfast. Tenders must be lodged at the Town Clerk's office, City Hall, Belfast, by 10 a.m. May 21.

Electric Lorry.

SYDNEY (N.S.W.) Council require tenders by 3 p.m. June 20 for the supply of a 2-ton Electric Lorry. Specification, &c., from the City Surveyor.

Street Lighting, Generating Plant, &c.

PAHIATUA (N.Z.) Borough Council requires tenders by noon July 10 for (contract No. 1) Overhead Wires, Poles and Street Lamps; (No. 2) Gas engines, Producers, Dynamos and Auxiliary Apparatus; (No. 3) Accumulators. Specifications and plans from the Town Clerk, Pahiatua.

Transformers, Mains, Water Wheels, Alternators, &c.

The VICTORIAN RAILWAY COMMISSIONERS require tenders by 11 a.m. May 31 for supply of Transformers, with Terminal and Fuse Boxes during five years. The first order will be for 220 transformers to be delivered in six months. Specifications, &c., from the Commissioners' Offices, Spencer-street, Melbourne.

OAMARU (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1, 1s. for each contract.

Electric Lamps, Lamp-Holders, &c.

Tenders will be received until 11 a.m. June 14 by the Victorian Railway Commissioners, Spencer-street, Melbourne, for the supply of 5,000 6-volt, and 1,000 110-volt Electric Lamps for signal system (Contract 29,912); and 4,000 Lamp-holders (Contract 29,913). Specifications from the offices of the Commissioners.

TENDERS RECEIVED AND ACCEPTED.

London County Council.—The Highways Committee has accepted the following tenders for the year 1916-17, except where otherwise stated, for the tramways departn ent :—

Motor and Generator Spares.—Alfd. Clare & Co.(six months), £507. 8s. 3d. British Westinghouse Elec. & Mfg. Co. (amount not stated ; indefinite quantities involved).

Controller, Circuit Breaker and other Switch, &c., Details and Magnetic Brake Spares.—British Westinghouse Elec. & Mfg. Co. (amount not stated ; indefinite quantities involved).

Contact Fingers and Parts, Segments, &c.—British Westinghouse Elec. & Mfg. Co., £224. 5s. ; Dyer & Young, £121. 1s. 6d. ; E. Showell & Sons, £212. 14s. 7d. ; Tramway Supplies (Ltd.), £1,156. 10s. 6d.

Electric Cable, Fuse Wire and Cotton Covered Copper Wire.—Liverpool Elec. Cable Co., £910. 4s. ; Callender's Cable & Construction Co., £554. 4s. 2d. ; British Insulated & Helsby Cables, £3,619 ; London Elec. Wire Co. & Smiths (six months), £648. 9s. 2d.

Copper Bonds.—Watlington & Co., £1,606. 6s. 3d.

Rubber Details.—J. G. Ingram & Son, £1,710. 18s. 6d. ; Irwell & Eastern Rubber Co., £46. 8s. 10d.

Moulded Insulators, other than Rubber.—British Westinghouse Elec. & Mfg. Co., £111. 16s. ; Crystalate Mfg. Co., £16. 16s. ; Ebonestos Mfg. Co., £116. 3s. ; Litholite (Ltd.) (amount not stated ; indefinite quantities involved).

Fibre Articles.—Micanite & Insulators Co. (six months), £13. 1s. 5d. ; L. Andrew & Co., £23. 1s.

Track Insulators and Porcelains for Electric Trackwork.—Bullers (Ltd.). £3,000 ; Taylor, Tunnicliff & Co., £67. 1s. 4d.

Machined Bronze Bearings.—Anti-Attrition Metal Co., £4,555. 8s. 4d.

Machine Finished Articles (Brass, Gunmetal, &c.).—E. Showell & Sons, £232. 11s. 4d. ; Player & Mitchell, £4. 1s. ; Anti-Attrition Metal Co., £45. 17s. 4d.

Machine Finished Articles (Wrought Iron and Mild Steel).—W. J. Ritchie & Co., £146. 4s. ; British Westinghouse Elec. & Mfg. Co., £28. 14s. 6d. ; J. Holroyd & Co. (six months), £21. 1s. 6d.

Gear and Pinion Wheels, Ratchets, Worms, &c.—F. W. Rowlands & Co., £1,824. 5s.

Iron and Steel Forgings.—Male & Jordan (six months), £16. 4s. ; W. J. Ritchie & Co., £227. 9s. 6d. ; Warren & Sons, £13. ; Hurst, Nelson & Co. (six months), £15. 16s. 8d.

Springs.—Crown Spring Co. (six months), £101. 6s. ; West Bromwich Spring Co., £980. 10s.

Machined Iron Castings.—J. Holroyd & Co. (six months), £212. 10s. ; J. Crowley & Co., £237. 15s. ; Peter Hooker (Ltd.), £900 ; Carron Co. (six months), £106. 7s. 6d.

Iron Castings.—Sheepbridge Coal & Iron Co. (amount not stated, indefinite quantities involved) ; J. Williamson & Co. (ditto).

Brake Shoes.—Pease & Partners, £3,843. 15s.

Machined Malleable Iron Castings.—Bullers (Ltd.), £427. 10s. 11d. ; Ley's Malleable Castings Co., £170. 10s. ; J. Crowley & Co. (six months), £9. 6s.

Malleable Iron Castings.—[illegible] & Co. (amount not stated, indefinite quantities involved).

Steel Castings.—Hadfields (Ltd.) (one member), £2. 6s. 7d. ; Pease & Sons (six months), (amount not stated, indefinite quantities involved) ; Edgar Allen & Co. (six months), £62. 4s.

Foundry Crucibles, &c.—Morgan Crucible Co. (six months), £230. 6s. 10d.

The Highways Committee has also accepted the following tenders :—Willans & Robinson, new blades for turbine, £80 ; Dronsfield Bros., cast steel propeller and pair cast steel wheel plates, £42 and £41, &c., respectively ; W. J. Jenkins & Co., [illegible], £196 ; British Electric Transformer Co., [illegible], £198. 15s.

The Stores and Contracts Committee has decided to continue from Jan. 1, 1916, to Dec. 31, 1918, the contract with the Synchronome Co. for hire and maintenance of 11 electrical [illegible] clocks at the Board of Arts and Crafts, at the existing contract price, and to vary the contract with L. Andrew & Co. (dated Dec. 14 last) for electric [illegible] materials (item 11, schedule 15) by allowing a [illegible] as from Jan. 1, 1916.

Southend-on-Sea.—The Light Railways Committee has accepted the following tenders for the supply of material required for [illegible] the new overhead equipment on the Leigh route :—

D. B. Rose, 18 in., 24 in. and 36 in. cars, approximate cost £80 ; P. W. Blackwell & Co., strainers, wire bolts and mechanical fogs, £25.

Fulham (London).—The Borough Council is recommended by the Electricity Committee to accept the tender of J. Cochrane & Sons for extension of condensing pipes at the electricity works at £1,500.

Kirkcaldy.—Messrs. Chamberlain & Hookham have obtained the contract for the supply of electricity meters to Kirkcaldy for the following 12 months.

Glasgow.—The following tenders have been accepted by the Corporation for 12 months' supply of cables and meters :—

Craigpark Cable Co., rubber-covered cables ; Callender's Cable & Construction Co., l.t. and e.h.t. cables ; W. T. Glover & Co., h.t. cables ; and Chamberlain & Hookham and Ferranti (Ltd.), meters.

Battery Maintenance.—Hants County Council has entered into an agreement with the Chloride Electrical Storage Co. for the maintenance of the storage battery at the Park Prewett Asylum for 10 years, at £61 a year.

Sydney (N.S.W.).—The Council is recommended by the Electric Lighting Committee to accept the tender of New & Sons for coal-trimming chutes, at £228.

The committee recommends the Council to grant 10 per cent. increase in prices for motors to be supplied by the Australian General Electric Co. under its contract (specification 382) of Jan. 12, 1916. The committee also recommends that, in view of the entire exhaustion of stocks of rubber-insulated cable, the purchase of cable as follows be authorised : (a) Noyes Bros., 3½ miles 7/20—660 volts at £37. 17s. 3d. per mile, ½ mile 7/18—6,000 megohms, £44. 11s. per mile, 1 mile 7/18—600 volts £54. 11s. 9d. per mile, 1 mile 7/16—600 volts £81. 7s. 7d. per mile, 4½ miles 7/14—600 megohms £100. 15s. 7d. per mile, 1½ miles 7/14—600 volts £111. 0s. 5d. per mile ; F. S. Lee, double-braided weatherproof cable, 5½ miles 7/20 £21 per mile, plus 10 per cent., 2½ miles 7/18 £32. 10s. per mile, plus 10 per cent. The committee further recommends that an order be placed with the Australian General Electric Co. for extensions to the existing switchgear in Town Hall sub-station, including one 5,000-volt three-phase motor panel 2,000 kw., £405 ; two 5,000-volt three-phase 200-ampere feeder panels, £47[illegible] ; one 600-volt d.c. generator panel, 2,000 kw., £520 ; four 600-volt d.c. feeder panels 1,000-ampere, £963.

FINANCIAL MATTERS.

COMPANIES' MEETINGS AND REPORTS.

West India & Panama Telegraph Co. (Ltd.)

The ordinary general meeting was held on Wednesday Sir Alexander Freeman King, K.C.B., in the chair.

The SECRETARY (Mr. J. Winser) having read the notice convening the meeting and the auditors' report,

The CHAIRMAN, after making a feeling reference to the death of the late Chairman (Mr. W. B. Kingsford), and to election of Sir Timothy Augustine Coghlan to fill the vacancy on the Board, said : In our report for the half-year to June 30, 1915, we foreshadowed that the second half of that year, with which we are dealing to-day, would probably show a great falling-off in our traffic receipts, concurrently with increased expenses, due, to a large extent, to the hurricane which visited the West Indies in August last ; and I am sorry that our prognostications have proved to be correct, as indicated by the accounts now in your hands. Several circumstances have combined to militate against our putting before you a more satisfactory record, but we must recognise that apart from these we cannot at the very best of times hope to emulate the prosperity of the larger telegraph companies, owing mainly, if not entirely, to the narrow field in which we carry on our operations. I have it stated recently that the population of the whole of the British West Indies was only about 2,000,000—less than one-third of the population of London. Further, the productive area of these colonies is very limited, and, as there is little sympathy of trade between the several islands it follows that our traffic receipts must be comparatively small. You are aware, from previous reports, and from speeches from the chair, that under arrangements with the Government we reduced our rates of charges on and from the 1st of October, 1914. The loss from so doing was estimated at £26,000 a year, but, as a set-off the Imperial and the Canadian Governments granted subsidies amounting to £16,000 a year for 10 years—leaving £10,000 a year to be made up by the increased traffics which we were told would result from the concessions the Government would induce. Certainly the volume of words has increased, but some part of this is certainly due to circumstances not connected with the question of rates. For instance, war conditions, the difficulty and uncertainty of steamer communications, the favourable crops and the higher prices obtained for them are factors to which much of the increase in our work can be attributed

Under conditions which have ruled for very many years, our staff has had to be kept down to a minimum strength; and, owing to the Government requirements that our offices shall at times be kept open day and night, the working costs have been higher than in previous years. We have, however, formulated a claim for what we know to be a modest proportion of the extra cost entailed upon us by the special services we were called upon to render, and our claim is at present under consideration of the departments concerned.

I have already mentioned the hurricane which passed over the West Indies in August last. In speaking of the damage done I think I may use the expression that it was enormous, and that the Island of Jamaica suffered most severely. The deficit in the Jamaica Budget for last financial year was £62,000, and the estimated deficit for this financial year is no less than £115,000—both largely due to the hurricane and to war conditions. But while giving you details of the past we are not without some hope for the future. Our Canadian friends seem to feel that there is something better in store for our West Indian colonies. Banking interests are being pressed forward by the establishment of branches of a Canadian bank, and the Dominion is apparently alive to the fact that, given transport facilities, it can offer a market for all the sugar our colonies can produce. Reciprocity of trade relations between Canada and the West Indies ought in the natural order of things to bring about better results for our Company. Indeed, our traffic receipts to the end of March show an appreciable increase over the corresponding period of 1915, but at the same time it is only right that I should point out that at present at any rate our expenses are not likely to decrease. It is common knowledge that the cost of labour and the cost of materials have both increased considerably. Some of the articles we have had to supply to our repairing ship have increased in cost from 100 to 200 per cent. However, gentlemen, the Directors' interests and yours are identical, and you may rest assured that we will continue to do our best for all; and I think I may add that we hope that circumstances will enable us to present a more satisfactory account for the current half-year. He concluded by moving that the Directors' report and accounts be adopted, and that the dividends as recommended be declared.

Mr. T. WALDEMAN GOULDING seconded the motion, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. H. W. BIRKS, Mr. George von Chauvin was re-elected a Director of the Company; and the Auditors, Messrs. Deloitte, Plender, Griffiths & Co., were also reappointed, a vote of thanks to the Chairman, the Directors and the staff terminated the proceedings.

ANGLO-PORTUGUESE TELEPHONE CO. (LTD.)—The chairman (Mr. H. Allen) stated at the meeting on Tuesday that six months ago they paid an interim dividend of 3 per cent., and the board now recommended a final dividend of 5 per cent., making 8 per cent. for the year. The number of subscribers increased during the year by 10½ per cent., and the gross revenue by 14 per cent. Unfortunately, however, the net profit showed little advance on that of the previous year, owing partly to increased cost of labour and material and in greater measure to the loss on exchange. The company's business was expanding at an unprecedented rate, and scarcely had they got their new exchange at Lisbon into working order than they were confronted with the possible necessity of further extensions. How much longer they could defer the opening of a new exchange at Oporto he did not know. For the time being their policy was to restrict new work as far as possible to the actual bringing in of subscribers, but the present rate of progress could not be maintained without an adequate increase in the capacity of the exchange and of the cable routes.

BIRMINGHAM DISTRICT POWER & TRACTION CO. (LTD.)—The revenue for 1915 was £101,909, compared with £87,767 for 1914, and the surplus (after setting aside £9,000 for renewals) is £58,738. The directors propose to place £5,000 to reserve, to pay a dividend on the preferred ordinary shares at the rate of 4½ per cent. for the year (against 3½ per cent.), and carry forward £2,551 (against £960).

BRISBANE ELECTRIC TRAMWAYS INVESTMENT CO. (LTD.)—The revenue account for 1915, consisting of the dividend received from the Brisbane Tramways Co. (£94,936), together with sundry receipts and amount brought forward (£5,782), less charges in London and Brisbane (£5,052) shows an available balance of £95,667. After paying debenture stock interest (£17,550), preference dividend (£16,250), interim dividend on ordinary shares (£24,000), and allocating to depreciation of investments fund, £3,500, the directors recommend a balance dividend of 4s. per share (tax free) on the ordinary shares (making a total for the year of 8 per cent.), and that £10,367 be carried forward.

BRITISH EVER READY CO. (LTD.)—The directors recommend a final dividend on the preference shares at rate of 10 per cent. per annum for the half-year to March 31, making the maximum of 10 per cent. for the year, and a final dividend on the ordinary shares at rate of 10 per cent. per annum for the half-year to March 31, making 10 per cent. for the year. They also recommend a bonus of 10 per cent. on the ordinary shares. For the year ended March 31 the profit, including amount brought forward and after writing off depreciation and transferring £7,500 to general reserve, amount to £59,218. A sum of £27,718 is to be carried forward.

CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)—The report of the directors for the year ending Dec. 31, 1915, states that the balance at credit of profit and loss is £113,266. 14s. 10d., to which has to be added the amount brought in from 1914 of £163,169. 6s. 7d., making together £276,436. 1s. 5d. From this must be deducted interest on debenture stock (£13,500), dividend on preference shares (£10,000), appropriation for depreciation of buildings, plant and machinery (£10,334. 11s. 7d.), and appropriation for depreciation of office furniture (£254. 8s. 10d.), leaving an available balance of £242,347. 1s. 0d. It is proposed to pay a dividend on the ordinary shares at the rate of 10 per cent. per annum (less tax), being 10s. per share, whereof 5s. (less tax) was paid on Nov. 1, 1915, and 5s. (less tax) will be paid on 31st inst. (£17,500), a bonus of 5s. per share (less tax) (£8,750), and also a special bonus of 5s. per share, less tax (£8,750), both to be paid on the 31st inst., and to carry forward £207,347. 1s. The year's operations have been carried on under exceptional difficulties as to men, materials and transport, and the directors are, therefore, pleased to submit a report which shows such satisfactory results. The company was declared a controlled establishment under the Munitions of War Act on Aug. 18, 1915, and as the directors considered that it was the company's duty to place its resources unreservedly at the disposal of the country, its output has been and is largely for warlike materials required by the Government. The shareholders are assured that no firm in the electrical industry has rendered more effective service to the nation than has the company. The ordinary home trade has consequently been much interfered with, but it has been possible to carry out some municipal and other contracts in connection with munition work, and also to satisfy to some extent the demands of the old and valued customers of the firm. The shortage of shipping has seriously interfered with the delivery of orders for overseas customers, but in spite of this, good work has been done in several of our colonies, and in some of the neutral countries, which will, it is hoped, be of considerable service after the war. It has been necessary to rearrange many of the departments of the factory, so as to adjust them to the new conditions. There have been difficulties in doing this, but the arrangements have now been made in a satisfactory manner, and the works at Erith and at Leigh are fully and most usefully employed. Substantial additions to the plant and machinery at Erith and at Leigh have been necessary to meet the special requirements of the various Government departments, and further additions are being made. As usual, all the plant and appliances belonging to the company have been thoroughly maintained, the expenses consequent thereon being charged against the year's accounts. The Anchor Cable Co. (also a controlled establishment), whose operations are so closely interwoven with those of the company, has also been able to show satisfactory accounts of its year's working. The Leigh factory has been running for many months continuously day and night on work on behalf of the company. Both at Erith and at Leigh great difficulty has been experienced in regard to labour, owing to the drain on the available supply for the direct manufacture of munitions, and the large number of workmen and of the staff who have joined the colours. At the Anchor works women have to a large extent taken the place of men, and arrangements are now being made at Erith for the employment of female labour upon an effective basis. These arrangements include hostel and canteen accommodation as approved by the Government.

CHISWICK ELECTRICITY SUPPLY CORPN. (LTD.)—The profit for 1915, after writing off £1,431 for depreciation and paying sinking fund premium and trustees' fees, was £7,175. Interest on first mortgage debenture stock (£3,600) has been paid, leaving £3,575, out of which it is proposed to pay a dividend at rate of 5 per cent. for the year, and to carry the balance of £435 to depreciation reserve fund.

EASTERN TELEGRAPH CO. (LTD.)—The directors' report for the year ended Dec. 31, 1915, states that the revenue amounted to £2,104,431. 10s. 4d., from which are deducted £655,888. 10s. 9d. for the ordinary expenses, and £202,609. 4s. 9d. for expenditure relating to maintenance of cables, sundry differences in exchange, income tax payable abroad, interest on temporary loans and special war payments to staff and other expenses in connection with the war, leaving a balance of £1,245,933. 14s. 10d., to which is added £32,741. 11s. 6d. brought from the preceding account, making a total available balance of £1,278,675. 6s. 4d. After providing for income tax payable in England and excess profits duty, interest on mortgage debenture stock and dividends on the preference stock, which in all absorb £457,037. 11s. 3d., there remains £821,637. 15s. 1d., out of which the directors have placed £460,000 to general reserve fund, £10,000 to insurance of war risk at stations fund, and £5,000 to insurance of goods in transit fund, and have paid three interim dividends of 1¼ per cent. each on the ordinary stock aggregating £150,000. The directors now recommend the declaration of a final dividend on the ordinary stock of 2½ per cent., and a bonus of 2 per cent. amounting together to £170,000, both payable on May 24, and making, with the three previous payments on account, a total distribution of 8 per cent. (tax free) for the year 1915. It is proposed to carry forward the balance of £26,637. 15s. 1d. to the next account. The stockholders will be asked at the forthcoming general meeting to approve the payment of the directors' remuneration tax free. The general reserve fund has been charged with £204,879. 12s. 3d. in respect of the new Aden-Colombo cable and other special expenditure and with £125,000 as a further provision on account of investment fluctuations. After crediting the £460,000, referred to above, the net addition to the fund for the year is £130,120. 7s. 9d.

The annual meeting will be held on 24th inst., and the register of transfers of the ordinary stock are closed from 17th to 24th inst.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)—The report of the directors for the year ended Dec. 31, 1915, states that the gross receipts amounted to £950,029. 19s. 7d., against £819,583. 0s. 7d. for the previous year. The working expenses, including £51,311. 16s. 4d. for maintenance of cables, absorb £386,671. 15s. 5d. against £364,978. 14s. 11d., leaving a balance of £563,358. 4s. 2d., to which is added £31,370. 17s. 7d. brought forward, making a total available balance of £594,729. 1s. 9d. After providing £30,096 for interest on mortgage debenture stock and £85,816. 15s. 8d. for income tax payable in England and excess profits duty, there remains £478,816. 6s. 1d., out

of which three interim dividends of 1¼ per cent. each, amounting to £112,500, have been paid, and £200,000 credited to general reserve fund. The directors now recommend the declaration of a final dividend of 2½ per cent., with a bonus of 2 per cent., amounting together to £127,500, and making with the three previous payments on account a total distribution of 8 per cent., tax free, for the year 1915. It is proposed to carry forward the balance of £38,816. 6s. 1d. The shareholders will be asked at the forthcoming general meeting to approve the payment of the directors' remuneration free of income tax. In addition to the £200,000 above referred to, the general reserve fund has been credited with £40,912. 5s. 7d. in connection with the closing and disposal of the Banjoewangie–Roebuck Bay cable owing to the establishment of improved means of communication with Australia making it unnecessary to continue the maintenance of this cable. On the other hand, the fund has been debited with £74,685. 14s. 8d. for partial cable renewals carried out during the year, £11,382. 10s. 11d. representing the loss incurred on the sale of investments, and £25,000 as a further provision on account of investment fluctuations, bringing the total provision against depreciation up to £225,000. An agreement has been concluded with the Australian Commonwealth Government enabling the company to deal direct with the public in Melbourne, as at Sydney, Adelaide and Perth, and an office has been opened by the company for the reception and delivery of telegrams in Melbourne. The annual meeting will be held on 23rd inst. The register of transfers is closed from 16th to 23rd inst., inclusive.

KIDDERMINSTER & DISTRICT ELECTRIC LIGHTING & TRACTION CO. (LTD.)—At the meeting last week it was reported that the capital expended during 1915 was £309, and £1,753 was written off in respect of plant sold, leaving the net capital expenditure on buildings, plant, &c., for electric supply, £56,279. The net receipts of the lighting undertaking were £4,561, and with £3,471 for dividends on investments, and £219 brought forward, the total was £8,251. After deducting expenses, interest on temporary loans and debenture stock, and providing £500 for renewals, there remains £3,708, of which it is proposed to appropriate to reserve £750, to dividend on cumulative preference shares for year 1915 (already paid) £1,500, and to carry forward £1,458. The profit on the year's working of the tramways company, after providing for renewals, is £2,439, which, added to £163 brought forward, leaves £2,602. There has been applied to reserve £500, to payment of a dividend at rate of 3½ per cent. £2,002, carrying forward £100.

LONDON & LANCASHIRE FIRE INSURANCE CO. (LTD.)—The annual report again shows a successful year's working. The net realised profit in the fire department was £166,090, in the accident department £64,698, and in the marine department £44,450—an aggregate of £275,238. The sum of £241,886 is placed to reserve, which has now reached the handsome total of £3,708,229. The total security to policy-holders now amounts to no less than £6,349,479.

PUEBLA TRAMWAY, LIGHT & POWER CO. (LTD.)—The net profit in Mexico for 1914 amounted to $692,499 (Mexican), against $736,952 for 1913 and $753,635 for 1912. Reckoning the earnings at the parity of exchange, the debit balance (after charging all expenses, bond interest, &c.) is £17,153, but, owing to the heavy loss on exchange, which amounted to £42,996, the final result is a debit balance of £60,150. The transmission line to Vera Cruz was completed and power delivered to that city at the end of the year and commencing with January, 1915, a regular supply of power has been given to the Vera Cruz Electric Light, Power & Traction (Ltd.) under contract. The directors are able to report that, except for a small amount of damage done by bandits from time to time, and considerable thefts of copper, the company's properties remain intact. Owing, however, to the difficulty of operating the plants at Portezuelo and San Agustin in face of continued interferences, these were closed in August, 1914, and the Tuxpango plant has since borne the entire load of the company's output. The business suffered during the year on account of a large number of factories having been destroyed or closed down.

RICHARD JOHNSON, CLAPHAM & MORRIS (LTD.)—The net profit for the past year, after making provision for excess profits duty, was £32,215, and with £9,308 brought forward the total was £41,523. A dividend on the ordinary shares for the half-year of 10 per cent. per annum is recommended, making 10 per cent. for the year, placing to reserve £20,000 and carrying forward £8,081.

SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)—The profit for 1915 was £31,084, compared with £33,602 for 1914. Including £4,703 brought forward, the balance was £35,787. There has been transferred to reserve for renewals £10,000 and applied in reduction of preliminary expenses account £2,000, and a dividend of 7 per cent. for the year (less tax) is recommended, carrying forward £1,387.

SOUTH WALES TRANSPORT CO. (LTD.)—The net receipts for the past year were £9,015, and after deducting administration and general expenses and £360 for mortgage and other interest, and providing £3,500 for renewals, the balance is £1,661, which, with £1,400 brought forward, makes £3,061. A dividend at rate of 7 per cent. per annum on the ordinary shares is proposed, carrying forward £1,319.

SUBMARINE CABLES' TRUST.—The revenue for the year to April 15 amounted to £25,489. 3s. 7d. and the expenses to £1,509. 18s. 4d., leaving a balance of £23,979. 5s. 3d., to which is added £50. 5s. 11d., brought forward, making an available balance of £24,029. 11s. 2d. After providing £15,843 to meet payment of the coupons, £8,109. 4s. has been transferred to redemption fund, leaving £77. 7s. 2d. to be carried forward. Since the last report, 68 certificates have been redeemed (exclusive of the coupons of reversion), 25 by purchase, 7 by tender, and 36 were drawn by lot on May 1st inst., absorbing £8,109. 4s.

WEST COAST OF AMERICA TELEGRAPH CO. (LTD.)—The gross receipts for the year ended Dec. 31 last amounted to £65,475. 11s. 3d., against £61,129. 5s. 8d. in 1914. The working expenses were £46,215. 13s. 6d., compared with £43,054. 9s. After deducting £477 for excess profits duty, the revenue account shows a balance of £18,782. 17s. 11d., to which is added £1,994. 16s. 4d., brought forward, making a total of £20,777. 14s. 3d. Out of this amount £6,000 has been paid for interest on the 4 per cent. debentures, £800 provided for the interest on the 4 per cent. income bonds, £5,000 transferred to general reserve fund, and £2,000 to provision on account of investment fluctuations, leaving a balance of £6,977. 14s. 3d. to be carried forward.

WEST LONDON & PROVINCIAL ELECTRIC SUPPLY CO. (LTD.)—The revenue of the company is provided by the dividend on the shares of the Chiswick Electricity Supply Corpn. and from the fees charged for managing the business of the corporation. The balance at credit of profit and loss is £3,038. A dividend on the cumulative preference shares at rate of 6 per cent. per annum for the year is proposed, carrying the balance forward.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ANCHOR ELECTRIC CO. (LTD.) (143,676.)—Reg. April 20, capital £4,100 in £1 shares (1,700 10 per cent. cumulative preference), to take over the business of electrical engineers, manufacturers of electrical apparatus, fittings and batteries, being a portion of the business carried on by A. Richmond and T. T. Rankin, together with the benefit of the experiments made and secret processes used by the proprietors. Private company. First directors are A. Richmond and T. T. Rankin (both permanent). Reg. office, 81, Cannon-street, E.C.

GENERAL INSTRUMENT & ENGINEERING CO. (LTD.) (143,690.)—Reg. April 26, capital £5,000 in £1 shares, to take over the business of an engineer carried on by R. O. C. Hurst, and to carry on same and the business of scientific instrument makers, electricians, machinists, &c. Private company. First directors are R. O. C. Hurst (permanent managing director and chairman) and E. Troughton. Reg. office: 49A, Adam-street, New Kent-road, S.E.

HARLESDEN LAMP CO. (LTD.) (143,701.)—Reg. April 26, capital £10,000 in 9,000 preference shares of £1 each and 4,000 ordinary shares of 1s. each, to acquire and turn to account any invention relating to electric and other lamps, or any lenses, reflectors or other component parts or accessories for use in connection therewith, to carry on the business of manufacturers and repairers of and dealers in electric lamps, electricians, glass blowers, &c., and to adopt an agreement with C. B. Leake. Private company. First directors are C. B. Leake and J. M. Lange.

JUNGO MFG. CO. (LTD.) (143,735).—Reg. April 28, capital £2,000 in £1 shares, to carry on the business of metal stampers, pressers and workers, mechanical, electrical and general engineers, electricians, &c. Private company. First directors are H. M. Lush (managing), C. Martin (secretary) and J. R. Claypole. Reg. office: 84-86, Chancery-lane, W.C.

K. E. SYNDICATE (LTD.) (143,777)—Reg. May 5, capital £1,000 in £1 shares, to acquire certain options and rights in respect of two inventions relating respectively to electric arc lamps and to improvements in direction indicators, to carry on the business of electricians, manufacturers of and dealers in electrical, chemical and scientific apparatus and materials, &c., and to adopt an agreement with G. A. Knapton and H. Justus Eek. Private company. First directors are G. A. Knapton, H. Justus Eek, F. Rutherford Harris (chairman) and R. O. Graham.

NATIONAL WOLFRAM CORPN. (LTD.) (143,568.)—Reg. April 11, capital £1,000 in £1 shares, to carry on the business of smelters, refiners, dressers, and preparers for market of wolfram, slates, quartz, ore, &c. First directors are E. Holwill and F. Naylor. Reg. office, 30 and 32, Ludgate-hill, E.C.

MORTGAGES AND CHARGES.

BRILLIANT ARC LAMP & ENGINEERING CO. (LTD.)—Memorandum of deposit on April 25, 1916, charged on certain contracts, to secure all moneys due or to become due to London & South Western Bank.

LLANDRINDOD WELLS ELECTRIC LIGHT & POWER CO. (LTD.)—Particulars of £2,200 debentures, created Dec. 11, 1915, have been filed, whole amount being now issued. Property charged: Company's undertaking and property, present and future. No trustees.

G. H. TURNER & CO. (LTD.)—Memorandum of satisfaction in full on April 14, 1916, of second debentures, dated April 21 and July 12, 1915, securing £100, has been filed.

G. H. TURNER & CO. (LTD.)—Issue on April 14, 1916, of £200 second debentures, part of a series of which particulars have already been filed.

RECORD ELECTRICAL CO. (LTD.)—Particulars of £7,000 debentures, created April 6, 1916, have been filed, amount of present issue being £6,000. Property charged, company's undertaking and property, present and future. No trustees.

WAKELIN'S (LTD.)—Memorandum of satisfaction to extent of £120 on April 15, 1916, of debentures dated May 7, 1914, securing £720, has been filed.

CITY NOTES.

MEMORANDA (May 17).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 57⅜. Consols Pay Day, June 1. Stocks and Shares Ticket Days, May 30 and June 14. Pay Days, May 31 and June 15. Price of silver, 36¼d.

BRITISH ELECTRIC TRACTION CO. (LTD.)—The directors recommend a dividend of 3 per cent. on the new ordinary stock for the year ended March 31.

CENTRAL ELECTRIC SUPPLY CO. (LTD.)—The 4 per cent. guaranteed debenture stock transfer books of this company will be closed from 18th to 31st inst., inclusive, preparatory to payment of interest due June 1.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—A dividend of 8s. per share has been declared on the ordinary shares, making 7 per cent. for the year.

GWYNNES (LTD.) The company intimates that it is impossible to complete the accounts at the usual time, and to prevent inconvenience the directors have decided to pay a dividend of 10 per cent. (tax free) on the ordinary shares. No further distribution will be recommended for the year ended Jan. 31, 1916.

MELBOURNE ELECTRIC SUPPLY CO. (LTD.)—The directors announce an interim dividend of 5 per cent. (tax free) on the ordinary stock for the half-year to Feb. 29.

SOUTH METROPOLITAN ELECTRIC LIGHT & POWER CO. (LTD.)—The company is offering to its share and debenture holders £30,000 4½ per cent. first mortgage debenture stock at 85.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—A final dividend of 5 per cent. on the ordinary share capital, making 8 per cent. for 1915, tax free, has been declared, the same as for 1914. The amount carried forward is £6,234, against £6,563.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date May 16, the following as the present basis prices of

New Metal.	per lb.		per ton.
Solid Drawn Brass Tubes	18½d.	English Lead	£34 10 0
Solid Drawn Copper Tubes	21d.	Antimony	Nominal.
Brazed Copper Tubes	21d.		
Brazed Brass Tubes	20½d.	**Old Metals.**	**per ton.**
Brass Wire	17¾d.	Clean Copper Scrap	£120 0 0
Copper Wire	20d.	Clean Brass Scrap	£70 0 0
Rolled Brass	17¾d.	Brazier's Copper Scrap	£105 0 0
Brass Sheets	18½d.	Old Lead	£28 0 0
		Old Zinc	£60 0 0
	per ton.	Hollow Pewter	£120 0 0
Copper Sheets	£174 0 0	Black Pewter	£85 0 0
Spelter	£95 0 0	Gun Metal	£85 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date May 16, the following approximate prices of Scrap Metals:—

	per ton.		per ton.
Aluminium Cuttings	£100 0 0	Old Lead	£29 0 0
Clean Mixed Brass	£74 0 0	Tea Lead	£27 0 0
Clean Copper	£116 0 0	Old Zinc	£70 0 0
Braziery Copper	£102 0 0	Hollow Pewter	£135 0 0
Gun Metal	£86 0 0	Shaped Black Pewter	£95 0 0

Mr. Joseph can supply Solder at the following prices per ton: Plumber's Solder (in bar or strip), £90; Commercial Tinman's Solder, £115; Blowpipe Solder, £125.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, May 16. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., May 16.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	9⅛	5 3 5	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	9¼	6 3 1	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅛	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St.	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	80	5 0 0	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	7 4 0	..
5	5%	Do. Ord.	3¼	7 9 2	Aug, Feb
5	4½%	Do. City Pref.	2⅝	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅞	6 5 6	Mar, Sept
St.	4½%	Do. do Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12½	6 2 3	Feb, Aug
10	6/0	Do. 6% Pref.	10⅝	5 16 4	Mar, July
St.	5%	Do. 5% Deb. St.	93	5 7 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10⅜	6 16 2	Mar, Sept
10	6%	Do. 6% Pref.	8⅝	5 16 4	Feb, Aug
St.	4½%	Do. 1st Deb.	89½	5 1 .	Jan, July
St.	4½%	Do. 2nd Deb.	97	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	7[illegible]	[illegible]	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 .	Jan, July
5	6/	London Elec. Supp. 6% Pref.	4⅞	7 4 .	..
St.	4%	Do. 4% Mort. Debs.	87[illegible]	4 12 .	Jan, July
5	3%	Metropolitan E. Supp. Ord.	3[illegible]	6 1 .	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs.	9[illegible]	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	9[illegible]	5 8 9	Mar, Sept
[illegible]	6%	North Metropolitan E. P. Supp. 6% Pref.	[illegible]	6 0 0	Apl, Oct
4	5%	South London E.S. Ord.	3⅛	6 10 7	Mar, Sept

† Ex dividend or Interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., May 16.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply—cont.		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5⅛	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅛	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Do. St.	83	5 8 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅜	7 6 4	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅜	6 7 3	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4⅛	5 10 9	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	73	6 8 2	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	71½	8 7 10	Feb, Aug
St.	4%	Central London Gtee. Assented Ord.	66½	6 0 4	..
St.	4%	Do. do. Assented Def. Ord.	64½	6 4 0	..
St.	4½%	Do. 4½% Pref.	78	5 15 5	Jan, July
St.	4%	Do. 4% Deb. St.	93½	4 5 9	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	70½	7 1 4	Feb, Aug
10	11½%	London Electric Ry. Ord.	2⅛	5 17 9	Jan, July
St.	4%	Do. 4% Pref.	64½	6 4 3	Mar, Sept.
St.	4%	Do. 4% Debs.	85	4 14 4	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25⅝	3 13 9	Feb, Aug
St.	3½%	Do. 3½% Pref.	63	5 11 1	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	74½	4 13 9	Feb, Aug
St.	3½%	Do. 3½% A Debs.	65½	5 7 6	Jan, July
St.	3½%	Do. 3½% Debs.	83½	4 4 1	Jan, July
St.	..	Metropolitan Dist Ry. Ord.	18⅞	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	92	4 7 0	May, Nov
St.	4½%	Do. 4½% First Pref.	71	6 6 9	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	103½	5 10 7	Jan, July
St.	4%	Do. 4% Debs.	71	5 12 8	Jan, July
St.	4%	Do. 4% Debs. 1903-5)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	66½	6 1 0	Mar, Sept
		Electric Manufacturing, &c.			
1	14%	Babcock & Wilcox Ord.	2⅛	5 7 11	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅛	6 1 1	Mar
100	5%	Do. Prior Lien Debs.	89½	5 13 0	Jan, July
1	6%	Do. 6% Pref.	[illegible]	6 17 2	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10[illegible]	7 2 5	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Co. 6% Pref.	[illegible]	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2[illegible]	6 19 1	April
100	6%	Do. 6% Prior Lien Debs.	100	6 0 0	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65½	6 1 8	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	11[illegible]	6 7 6	Jan, July
5	5%	Do. 5% Pref.	4[illegible]	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Deb.	93	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	1[illegible]	7 13 8	Sept
5	..	Edison & Swan U. Elec. Ltd. A. £3 pd.	[illegible]	..	Feb, Aug
St.	4%	Do. 4% Deb.	5[illegible]	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	[illegible]	7 7 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	72	5 11 1	Jan, July
10	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9[illegible]	6 3 6	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14[illegible]	6 19 2	Feb, Aug
5	2/3	Do. 4½% Cum Pref.	4[illegible]	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	10[illegible]	9 [illegible] 11	Feb, Aug
10	5%	Do. Pref.	7½	6 13 4	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	3[illegible]	6 10 5	Mar, July
100	4%	Do. 4% Debs.	95[illegible]	4 6 0	Jun, July
1	7½%	Vickers Ord.	1[illegible]	4 16 4	May, Aug
1	6%	Do. 5% Pref.	[illegible]	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	7[illegible] †	5 0 11	Jun, Dec
[illegible]	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jun, Dec
St.	4½%	Willans & Robinson B. Cm. Pref. x d. & [illegible]	41½	9 18 10	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	3/0	Anglo American 6% Pref. Ord.	100	6 0 0	Feb, May, Aug, N
St.	1½%	Do. Def. Ord.	21½	6 18 4	Feb, May, Aug, N
St.	4%	Commercial Cable 4% Debs.	69[illegible]	5 14 8	Ja. Ap Jly. O
10	5%	Cuba Submarine Ord.	7⅛ †	6 1 3	May, Nov
10	10%	Do. 10% Pref.	14[illegible]	7 2 10	..
5	5/0	Direct Spanish 15% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅛	6 12 0	Ja, Ap, Jly, O
St.	7%	Eastern Tel. Co. Ord.	14[illegible]	4 16 11	Ja, My, Jly, O
St.	17/6	Do. 3½% Pref.	63[illegible]	5 10 11	Ja, My, Jly, O
St.	4%	Do. 4% Debs.	76	5 5 3	May, Nov
St.	4%	Eastern Extension Tel. Co. 4% Debs.	76½	5 4 7	Feb, Aug
10	7%	Do. Ord.	14½	4 18 3	Ja. Ap. Jly. O
10	22½%	Gt. Northern Tel. Co. ex Coupon	3[illegible]	6 1 5	Ja, My, Jly
25	10%	Indo-European	4[illegible]	6 14 9	May, Nov
1	10%	Marconi's Wireless Tel. Co.	[illegible]	4 10 2	April
1	7%	Do. 7% Pref.	1[illegible]	3 14 8	July
10	10%	West India & Panama Ord.	1[illegible]	8 18 10	May Nov
10	6%	Do. 1st Pref.	7[illegible]	7 12 11	May, Nov
10	8%	Western Telegh. Co.	14[illegible]	5 12 0	Mr, Jly, O, Dec
St.	4%	Do. 4% Deb. St.	7[illegible]	5 3 7	Jun, Dec
..	4½%	Western Union Extr. Bds.	9[illegible]	4 10 3	May, Nov.
		Telephones.			
1	7½	Monte Video Telephn. Ord.	[illegible]	6 12 5	Nov.
1	10%	Oriental Telephone Ord.	1[illegible]	5 8 6	Apl, Oct
St.	4%	Do. Db. St.	7[illegible]	5 1 5	Jan, July
St.	4½%	Telephn. Co. of Egypt Do. St.	83	5 8 5	Jan, July
5	6%	United River Plate Ord.	6[illegible]	5 12 8	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4[illegible]	5 3	Jan, July
St.	4½	Do. Deb. Stk.	81[illegible]	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust.	1[illegible]	4 17 6	Sp, De, Mr, Jn
10	6%	Do. 6% Pf.	1[illegible]	5 18 6	Sp, De, Mr, Jn
100	5%	Mackay Companies' Common	[illegible]	6 1 9	Ja, Apl, Jly, O
..	4%	Do. $100 Pref.	[illegible]	5 14 6	Ja, Apl, Jly, O
100	6%	Submarine Cable Trust Certs.	12[illegible]	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, &c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4[illegible]	6 10 8	Mar, Sept
St.	5%	Do. 5% Debs.	9[illegible]	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	1[illegible]	[illegible] 12 6	..
St.	4½%	Do. 4½% Debs.	8[illegible]	5 5 11	Jan, July
5	9%	Calcutta E. S. Corp. Ord.	6[illegible] †	7 2 7	May, Nov
5	5%	Do. 5% Pref.	4[illegible]	5 14 3	Mar, Sept

† Ex dividend or Interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,984. [Vol. LXXVII. No. 8.] **FRIDAY, MAY 26, 1916.** PRICE SIXPENCE

CONTENTS OF THE CURRENT NUMBER.

NOTES 239
Arrangements for the Week .. 242
Service Requirements of the Electric Arc Furnace. By H. Hollis 243
Telephonometry. By B. S. Cohen. Illustrated 244
Exhaust from Liquid Fuel Engines 245
The Shildon-Newport Railway Electrification. Illustrated 246
The Electricity Supply of Great Britain 249
Photometry of the Gas-Filled Lamp. By G. W. Middlekauff and J. F. Skogland. Illustrated 252
Arcs in Gases Between Non-Vapourising Electrodes. By G. M. J. Mackay and C. V. Ferguson. Illustrated 254
A Method of Exhibiting the Velocity of Iodine Ions in Solution. By S. W. J. Smith, M.A., D.Sc., F.R.S. Illus. 255
THE ARCHITECT IN RELATION TO ELECTRIC LIGHTING 256
The Determination of the Dimensions of Commutators. By Thomas Carter. Illustrated 257
CORRESPONDENCE 261
"Speeding Up" in Engineering Factories (H. Ambrose Carney).
Engineering Industry after the War.—*Discussion* 262
LEGAL INTELLIGENCE 262
The "Electrician" Commercial and Industrial Section .. 263-272

NOTES.

Linking-up.

THE increasing difficulty in providing for the supply of coal to important consumers makes it imperative that rigid economy in consumption should be exercised lest there be a serious shortage in the near future. During the week a circular has been sent out by the Railway Department of the Board of Trade, in which attention is called to the very considerable saving that can be effected by the linking-up and joint working of electric generating stations. The present difficulties in regard to labour and materials are recognised by the Board, but we are in doubt as to whether the Board are fully aware of the many engineering difficulties that will have to be considered. In the past the Board have not exercised wise judgment in allowing supply authorities to supply currents at a dozen or more different voltages, and, in the case of alternating currents, at many different frequencies. An examination of the chaotic state as regards system, voltage and frequency that prevails in the London area alone will serve to show how great are the difficulties in the way of interconnecting on a large scale. We agree that rigid economy should be practised in coal consumption, in times of peace as well as in times of war; but we would not have our engineers, by linking up, prolong a state of affairs for which there has been no excuse for 10 or 15 years. Rather would we have them lay the foundation for a scheme that could be developed year by year on sound engineering lines. The London area would lend itself well for the purpose of the experiment. The Board announces that they are prepared to arrange the terms and conditions under which an interconnecting scheme shall be carried out. Should it be decided to link-up the generating stations in Greater London we hope that one of the conditions imposed by the Board will be that nine-tenths of the generating stations shall be closed down, and that the remaining stations be compelled to supply on a uniform plan. In no other way can real and lasting economy be obtained. It were better to build locomotives and rolling stock than to waste copper and improperly use dynamo machinery in order to secure transient economy.

The Shildon-Newport Electrification.

IN our present issue we give some description of the electrification of the Shildon-Newport branch of the North Eastern Railway. This work is of more than usual interest, because the line is concerned entirely with mineral traffic. Engineers are liable to consider that there are only two classes of railway electrification—namely, for suburban lines and for the main-line working of passenger trains. The position of suburban lines from the electrical point of view is now assured, for the advantages of electrical working are thoroughly appreciated. In the case of main-line working, however, the position is very different. The range of speed required for the locomotive in the running of main-line passenger trains varies between wide limits, and so far as it has been found more easy to obtain this range satisfactorily in a steam locomotive than in an electric locomotive, except at considerable cost. The case is very different, however, when we are concerned with goods and mineral traffic. In this class of service a large torque at high speed is no longer necessary; we are concerned with large tractive effort at comparatively low speeds, and there is no difficulty in obtaining these conditions very economically by means of electric locomotives. On the Shildon-Newport line continuous current has been adopted at a pressure of 1,500 volts, and this is supplied by means of a double overhead wire from which it is collected by means of two double-bow pantograph collectors per locomotive, so that eight contacts are provided. By this means the collection of current is made without difficulty. The locomotives are 74 tons in weight, and are designed to give an average pull of 28,000 lb. on the tread of the wheels when starting under normal conditions. Tests showed a maximum drawbar pull of 16 tons. The average speed in running from Newport to Shildon, which is on an up gradient, was 18·3 miles per hour, the maximum speed being 26 miles per hour. On the level, a 1,400-ton train was hauled at the rate of 26 miles per hour. The tests appear to have been quite satisfactory, and we hope that the present electrification will be an inducement to other railways to consider the desirability of electric traction for the handling of goods and mineral traffic.

Submarine Telegraph Companies in 1915.

NOTWITHSTANDING the difficulties created by the War, the principal submarine cable companies appear to have had a good year, for the receipts of nearly all of them show a very substantial increase compared with those of 1914. There is no more reliable and accurate means of communication than the submarine telegraph, and it is, therefore, fortunate for the Empire in this great crisis that nearly every portion of it is

connected by a submarine cable with the Mother country. Of course, like other commercial undertakings, the telegraph companies have lost some of their staff by enlistment in H.M. Service; the restrictions upon the use of codes and the great increase in the number of Government messages to which priority has been given, have all added to the difficulties of the situation, and increased the operating expenses. In addition, the generous terms granted to British and Colonial soldiers and sailors and to their relatives for communicating with one another brought a greatly increased traffic of an unremunerative character. Yet, in spite of these disadvantages, substantial progress was made, as will be seen from the reports of the proceedings at the annual meetings of the Eastern and Eastern Extension Telegraph Companies, which appear in another column. The gross receipts of the Eastern Company increased from £1,570,000 to £2,021,200, and after meeting all ordinary expenses, including maintenance of cables, special payments to staff and other expenses due to the war, income tax and excess profits duty, interest on mortgage debenture stock and the dividends on the preference stock, &c., the balance was £821,638. A sum of £460,000 was placed to general reserve fund, a final dividend of 2¼ per cent., and a bonus of 2 per cent. were declared, making a total distribution of 8 per cent. (tax free) for the year, against 7 per cent. for the previous year. The gross receipts of the Eastern Extension Company were £959,030, and after paying expenses, interest on debenture stock, &c., and placing £200,000 to general reserve fund, a final dividend of 2¼ per cent., together with a bonus of 2 per cent., were declared, making 8 per cent. for the year, against 7 per cent. in 1914. The record of the other telegraph companies is also a good one, and in most cases the financial position is even sounder than it was at the end of 1914. The radio-telegraph developments do not seem to have affected them in the least, and this is not surprising for in *secrecy*, speed and accuracy—conditions which are of prime importance in warfare—submarine telegraphy has at present no rival. Of course, radio-telegraphy has a field of its own—an expanding field it is true—but where there is any considerable commercial or other traffic, recourse must be had to submarine telegraphy.

Engineering Institutions and Courteous Receptions.

UNDER the heading "Scheme for the Organisation and Development of Scientific and Industrial Research," the following note appeared in the March "Journal" of the Institution of Mechanical Engineers:—

> The Council, on behalf of the Institution, have joined with the four other leading British Engineering Institutions in presenting to H.M. Privy Council a petition that a suitable number of persons representing the great departments of engineering industries and operations should be added to the Advisory Council of the Committee of the Privy Council, constituted to carry into effect the above scheme.

In the current issue of the "Journal" of the same Institution, under a similar heading, appears the following paragraph:—

> Referring to the paragraph ..... of the March "Journal," a reply was received from the Privy Council expressing the view that it would be premature at present to increase the Advisory Council for Research. On April 13th a deputation appointed by the Conference of the Engineering Societies was courteously received by Lord CREWE. The deputation put forward some considerations as to the representation of engineering on the Advisory Council.

We have pleasure in giving publicity to the fact that the leading British Engineering Institutions presented to H.M. Privy Council a petition, and our regret is that the petition was presented a considerable time after the Advisory Council of the Research Committee was formed. But we urge the Engineering Institutions not to be discouraged by courteous and futile receptions. The remedy is in their own hands. If they regard research as an important factor in ensuring engineering development, and if the general feeling of the members is that they are not properly represented on the Advisory Council, it is surely within their power to request those of their members at present serving on the Council either to withdraw from the Council or from the Institutions. We ask, "Of what use are the Institutions if the discipline be lax?" Seeing that the Institutions alone possess the men for the carrying out of the work, and remembering that, potentially, they have command of the necessary funds, it is easy for them to carry out their own scheme of research. Judging by the records of the researches that have already been made by the Institutions, we are certain that *their* scheme would at least yield results of value to the profession. The work of the Alloys Research Committee, which was carried out under every conceivable disadvantage, is sufficient testimony to the ability of the Engineering Institutions to carry out research. Such immediate action on the part of the Engineering Institutions would, we venture to think, lead wisdom to prevail in the deliberations of the Committee of the Privy Council. Even without such wisdom, the future of engineering research is safe in the keeping of the Engineering Institutions. Ably supported, as they would be, by the engineering colleges, we doubt not that the work which lies at their hands would be properly carried out. With the unspeakable examples of the past 22 months before us, and with the knowledge that the position is not now hopeless solely as the result of the work of the members of those Institutions which the State affects to ignore, our readers will agree that we have good grounds for believing that should the State put "its deadening hand" on engineering research the results of such research would be to the detriment of engineering in this country.

Photometry of the Gas-Filled Lamp.

A COMMON method of obtaining the mean horizontal candle-power of a lamp is to rotate the lamp at a convenient speed in the photometer, so that a mean result is at once obtained. It is interesting to note that in the case of gas-filled lamps this simple method is no longer available. In an interesting investigation by Messrs. G. W. MIDDLEKAUFF and J. F. SKOGLAND, which we give in abstract in another column, it is shown that the rotation of a gas-filled lamp in this way materially affects the candle-power. Even when the lamp is stationary, both the current and candle-power have higher values when the lamp is mounted tip up than when it is mounted tip down. The explanation of the rotation effect appears to be that the normal convection currents are disturbed by the rotation, and consequently the efficiency of the lamp is altered. The effect is also complicated by the voltage at which the lamp is run, and by the speed of rotation. These effects will form another argument in favour of photometry on the lines of the Ulbricht sphere.

Fire Extinguishers.

MOST people are aware that a number of what are termed "dry fire-extinguishers" have been placed on the market since there has been a risk of fire from aerial attacks. Such fire extinguishers are sold at a lower price than those which depend upon water or chemicals, and are, of course, assumed to have corresponding advantages. Some light is thrown on the subject by the report of a Committee appointed by the Home Office which has just been issued. From this it appears that the ingredients of these dry fire extinguishers are chiefly sodium bi-carbonate and calcium carbonate. The cost of the bi-carbonate would not exceed 1½d., and, therefore, it will be realised that the price at which these extinguishers are placed on the market is little less than extortionate, to use the word applied by the Committee. It is interesting to note that the general conclusion reached by the Committee is that the best

extinguishing agent is a plentiful supply of water and that the use of dry fire-extinguishers should be deprecated, as giving a false idea of security. The Committee do not appear to have considered fully the question of chemical extinguishers. From the point of view of electricity works, it is desirable that this inquiry should be carried a little further. In such works a fire introduces special problems. So far as we are aware the Pyrene form of extinguisher has chiefly found favour in such cases, as it introduces no bad effect upon the electrical machinery. There may possibly be others of the same class which would be worth studying, both from the point of view of doing harm to electrical plant and the effect upon any persons who have to be near the fire in attempting to extinguish it.

Peace, Prosperity, Preparedness *and* Probity.

In offering to the American Society of Mechanical Engineers one of the Boulton and Watt relics, Mr. George Tangye, at Birmingham in 1910, said he had an intense admiration for Americans. America, said Mr. Tangye, comprised 48 separate and sovereign commonwealths, literally covering the country, and had a population of nearly 90 millions, harmoniously working together without the need of Dreadnoughts to keep them in order. From this unity the nations on this side of the Atlantic, whether English, French or German, might, he thought, with advantage take a lesson. At the present time many prominent Americans think differently. For reasons best known to herself, the United States is preparing for war, and with feverish haste a fighting navy is being equipped. The cry in the United States is "Peace, Prosperity and Preparedness." We seem to remember that Germany had such ideals for many years. To-day all the world knows their significance. If it be prosperity that accounts for war—and it is only prosperous nations that are in a position to indulge in such extravagance—we would have the whole of mankind bankrupt, and dependent upon excessive toil for the means of a bare livelihood. Even prosperous peoples are not able indefinitely to draw upon their manhood in pursuit of an ideal assuredly born in Hell. On the pedestal which the Americans are erecting, in addition to "Peace, Prosperity and Preparedness," we would have them carve "Probity." In common with ourselves and the rest of Europe, they have a lesson to learn. Without probity at the bottom of every transaction in every sphere of life to talk of peace and prosperity is to talk trash.

"City Guilds Examination."—Erratum.—With reference to Mr. A. Dover's letter in last week's issue, p. 228, the denominator should read $200 \times \sqrt{3} \times 18{\cdot}5$.

Trade After the War.—The President of the Board of Trade has appointed Mr. Henry Summers to be an additional member of the Committee recently appointed to consider the position after the war of the iron, steel and engineering trades.

Tapping Blast Furnaces Electrically.—The "Iron and Coal Trades' Review" refers to an electrical method of tapping An electric arc is struck between an electrode and the chilled metal in the taphole. The metal is burned through until the fluid contents are reached. A current of 800 to 1,000 amperes at 250 volts is used, the apparatus consisting of a special electrode holder, cable, resistance and a protective head shield for the operator.

Technical Education.—Prof. J. Wertheimer, principal of the Merchant Venturers' Technical College, recently gave an address on "Scientific and Technical Instruction in Relation to the Welfare of the State and the Worker." After referring to the mistakes that had been committed, and the fact that Germany spends seven millions annually on original scientific research against our £500,000, the relative importance of science versus Latin and Greek was dealt with. He did not consider it right that a professor of mediæval poetry was the most suitable person to be at the head of the Technical Department of the Board of Education, one instance amongst many others. A discussion followed, in which the comparative failure of the continuation schools was referred to, and the impossibility of getting boys to attend school after a full day's work. It was agreed that these schools could never be a success until employers allowed boys off in the mornings or afternoons, so that boys could attend.

Interconnection of Electric Supply Undertakings.—We have received the following communication from the Board of Trade (Railway Department):—

The Central Coal and Coke Supplies Committee have had under consideration the increasing difficulty in providing for the supply of coal to important consumers, and have advised the Board of Trade that in view of the possibility of a serious shortage in the near future every practicable economy in consumption should be adopted without delay. In this connection the Board desire to call attention to the very considerable saving that can be effected by the adoption of arrangements for interconnection and joint working of electric supply undertakings, including interconnection with stations supplying tramways and railways. The Board are aware of the difficulties involved at the present time, particularly in regard to labour and materials, but they are advised that in many cases the necessary arrangements could be made at once, and they wish, therefore, to urge upon electric supply undertakers the necessity in the national interest of taking immediate steps to avail themselves to the fullest possible extent of the powers which exist for the purpose. Any application which may be made to the Board of Trade for their approval of such arrangements under the powers conferred on them by the Electric Lighting Act, 1909 (Sec. 4, sub. sec. 3), and the London Electric Supply Acts, 1908 and 1910 will receive their immediate attention. The Board are prepared to assist as far as possible in cases where difficulty is experienced in securing the agreements of all the parties interested in any proposed scheme or in arranging the terms and conditions under which it shall be carried out.

Heat Transmission Through Boiler Tubes.—An account of a research on this subject by Messrs. H. Kreisinger and J. F. Barkley is given in Technical Paper 114 recently issued by the Bureau of Mines. The report is one of a series of publications of the Bureau on the general subject of the transmission of heat in boiler plants. The first of these publications, entitled "The Flow of Heat through Furnace Walls," treats of the heat losses through furnace walls of different materials and construction. The second publication, entitled "The Transmission of Heat into Steam Boilers," treats chiefly of the impartation of heat from the hot products of combustion to the heating plates of a boiler. This report, the third of the series, presents the results of a study of the transmission of heat through the metal of the heating plate, the temperatures of the surfaces of the plate being measured while the boiler is in operation. A large number of temperature determinations were made of both surfaces of a tube of a Heine boiler, and while these temperatures were being determined, the average rate of evaporation was obtained by measuring the water fed to the boiler. The relations between the temperatures were studied by means of charts. The deductions from these studies can be briefly stated as follows: The temperature drop from the hot products of combustion to the tube of the boiler is high, whereas that through the metal of the tube itself and from the metal to the boiler water is low. In other words, the metal of the boiler tube is nearly at the same temperature as the boiler water. The temperatures also indicate that as long as the water side of the heating plate is free from scale, oil, or other deposit the metal of the boiler tubes can not be overheated, even though the boiler is worked at several times its rated capacity.

APPOINTMENTS VACANT AND FILLED.

An advertiser wants a submarine cable electrician, one with works and office experience preferred.

A mains engineer is required by Eastbourne Electricity Committee. Salary £156. Applications to the Borough Electrical Engineer by 5 p.m. June 9.

The curators of Edinburgh University have appointed Sir J. Alfred Ewing, K.C.B. (Director of Naval Education), principal of the university, in succession to the late Sir William Turner.

Mr. A. V. Barraclough, of Messrs. Aldridge & Ranken, has been appointed chief assistant to the general manager of the Aldershot and District Gas, Water and Lighting Co.

Mr. S. Y. Maling, of Melbourne, has been appointed deputy manager of the Sydney (N.S.W.) electric supply undertaking.

Mr. G. H. Browne, A.M.I.E.E., of Ilkeston, has been appointed engineer and manager of the Mexborough & Swinton Tramways Co.

INSTITUTIONS AND SOCIETIES.

Belfast Association of Engineers.—The annual meeting was held on the 27th ult. at the Municipal Technical Institute. The following were elected office bearers for the ensuing year: *President*, Mr. Stanley Johnston; *Vice-Presidents*, Messrs. A. M'I. M'Cleland and Edward Wilding; *Hon. Treasurer*, Mr. Grant; *Committee*, Prof. J. H. Smith, Messrs. J. Bracegirdle, T. A. Gibson, J. W. Kempster, Bowman Malcolm and W. Pleasance.

The Chairman reviewed the work of the year, and referred to organisation. The following resolution was passed: "That this meeting of the Belfast Association of Engineers approves of the prompt organisation of the engineering industries within the British Empire, in co-operation with other industries, under State auspices, with the object of stimulating internal progress and of exerting collective influence and common action in the severely intense competition for trade in the markets of the world that, it is anticipated, will arise immediately upon the termination of the present war. That a copy of this resolution be sent to Mr. Edward L. Hill, the honorary secretary of the Engineers' Club, Manchester, asking him to lay it before the Council for the Organisation of British Engineering Industries, assuring him of the co-operation of our Belfast Association of Engineers in the effort to organise the British engineering industry, and expressing the hope that the organisation may extend to all industries throughout the Empire, including those of Ireland."

The Royal Society.—At last Thursday's meeting the Bakerian Lecture was delivered by Prof. G. C. Barkla, F.R.S., on "X-rays and the Theory of Radiation."

Institute of Metals.—The May Lecture, delivered by Prof. W. H. Bragg, D.Sc., F.R.S., dealt with "X-rays of Crystal Structure," and had particular reference to certain metals. When a regular train of waves falls on a surface separating two media, part is reflected, and part transmitted. If it again meets a second surface a portion is again reflected and transmitted. In general it happens that the two reflected beams are out of phase and partially destroy one another, in the same way as is shown by the colours of soap films, oil on a liquid, or tempering colours of steel. When the reflecting surfaces are great in number the effect is much more intense, as in the colours of potash crystals as shown by Lord Rayleigh. One essential is that the wave-length and the spacing of the layers should not greatly differ in magnitude. Since the wave-length of X-rays are about 10,000 times smaller than light waves the reflecting surfaces must be much closer than those referred to above. These surfaces exist in the layers of atoms in the materials examined. It is not necessary that they should be continuous, since an iron railing can reflect sound, and they might act in a similar way. Consequently, when a pencil of X-rays of definite wave-length is allowed to fall on a crystal, the reflection of the beam is non existent, except when the incident angle is about 90 deg. The instrument used is an X-ray spectrometer. It has no lenses because X-rays cannot be refracted, and the rays are invisible, so that in place of the usual telescope, there is a chamber containing a gas which can be ionised, and the electrical effect can be observed on an electrometer. By using the same X-rays we can compare the spacing between the layers parallel to one another of the crystal faces, and finally arrive at the crystal structure. Silver and copper, and, by inference, gold, have been shown to possess a very simple structure, in which the atoms are arranged as in the piling of shot. Other cases are more complex.

British Science Guild.—The tenth annual report of this Guild will be read with somewhat mixed feelings by scientific men.

In an extract from Prof. E. R. Poulton's Romanes lecture at Oxford, in which he referred to Sir William Ramsay's efforts to stop the importation of cotton into Germany, it is stated that Sir W. Ramsay began the press campaign "only after exhausting every other effort," and again that it "was not until December 3rd that the importation of linseed oil was prohibited."

The Technical Optics Committee state, after referring to the terrible shortage of binoculars for army use, that "It is with serious regret . . . the necessary funds for this imperial and urgently important object are not yet forthcoming."

Regarding Science Committees and war problems, Dr. Addison, replying to a question in the House of Commons, stated that the Director-General of Munitions Design had a salary of £2,000 per annum. He referred to "a number of most eminent chemists and other men of science . . . who had rendered 'invaluable services' to the country 'without payment.'" Science in education and industry are dealt with, and in an appendix is given a report by Prof. R. A. Gregory on "The Promotion of Higher Education and Research," in which it is stated that up to the present the work of the Council has been mainly preparatory. There is also included the recent lecture by Mr. A. P. M. Fleming and some information on the way in which the Government grants are made in this and other countries.

With reference to the memorandum published in "The Times" and other journals on "The Neglect of Science," which was signed by 36 distinguished scientific men, pointing out the urgent necessity to have more scientific men at the head of our educational affairs, it is mentioned that the professors at the Imperial College also supported this manifesto in a memorandum sent to Lord Crewe. A Reorganisation Committee was formed with the object of bringing home to all classes "the necessity of applying scientific treatment to affairs of all kinds."

At the meeting at which this report was presented Dr. R. M. Walmsley, principal of the Northampton Polytechnic Institute, referred to the way in which optics had been neglected in this country, and had led to the loss of the position which we ought to have held, due to the work of our scientific men. At the outbreak of war we found ourselves in a very difficult position through lack of optical glass, but the situation was saved by Messrs. Chance Bros. The scheme of the Northampton Institute for a School of Optics had been before the authorities for 13 years, but without avail. If we were not still to be too late, it was necessary to start work at once and obtain the required £40,000. The Minister of Munitions agreed that such a school was most important for the training of men.

Royal Meteorological Society.—A letter has been issued by the President stating that in accordance with the provisions of the Summer Time Act Greenwich Mean Time will continue to be used for all meteorological observations and publications, so that no discontinuity will be caused during the period when summer time is in force. But besides the observations which are made by regular observers many meteorological phenomena of various kinds are from time to time recorded or reported, and it is hughly desirable that there should be no ambiguity in these reports which are often of much interest and importance. The Council of this Society desire to draw attention to the necessity of stating precisely the time of occurrence in all such cases and whether the times quoted refer to Greenwich mean time or to summer time, since the omission of this information may render the record of the phenomenon useless for meteorological purposes.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 26th (to-day).

PHYSICAL SOCIETY.

5 p.m. At the Imperial College of Science, Exhibition-road. The following Papers will be read: "The Correction of Chromatic Aberrations when the External Media are Dispersive," by Mr. T. Smith, B.A.; "Note on the Use of the Auto-Collimating Telescope in the Measurement of Angles," by Mr. J. Guild, A.R.C.S., F.R.A.S.; "The Viscosity of Colloidal Solutions," by Mr. Emil Hatschek.

ROYAL INSTITUTION.

5.30 p.m. At Albemarle-street, W. Discourse on "X-Rays," by Prof. C. G. Barkla, M.A., D.Sc., F.R.S.

TUESDAY, May 16th.

ROYAL INSTITUTION.

3 p.m. At Albemarle-street, W. Lecture on "Optical Research and Chemical Progress," by Dr. T. M. Lowry, F.R.S.

ASSOCIATION OF SUPERVISING ELECTRICIANS.

7.15 p.m. At St. Bride Institute, Bride-lane, E.C. Paper on "Internal Combustion Driven Electrical Sets," by Mr. W. A. Tookey.

1st LONDON ENGINEER VOLUNTEERS.

Commanding Officer, Lieut.-Col. C. B. CLAY, V.D.

Orders for the Week.

Monday, May 29th.—Technical for Sections 1 and 2, No. 3 Company, 46, Regency-street, S.W. Squad and Platoon Drill, Sections 3 and 4, No. 3 Company. Signalling Class and Recruits.

Tuesday, May 30th.—School of Arms, 6 to 7 p.m., lecture, Mr. J. Roberts, "Water Supply." 7.15 p.m. Recruits, 7.15 to 8.15 p.m., Archbishop's Park.

Wednesday, May 31st.—Platoon Drill, No. 3 Platoon, No. 1 Company.

Thursday, June 1st.—Platoon Drill, No. 7 Platoon, No. 2 Company. Shooting for Sections 1 and 2, No. 3 Company, Miniature Range. Recruits, 5.45 to 7.45 p.m. Instructional Class, 5.45 p.m.

Friday, June 2nd.—Technical for Sections 3 and 4, No. 3 Company, 46, Regency-street, S.W. Squad and Platoon Drill, Sections 1 and 2, No. 3 Company.

Saturday, June 3rd.—Company Commander Fleming's Instructional Class, 2.30 p.m.

Sunday, June 4th.—Entrenching at Otford. Parade Victoria (S.E. & C.R. Booking Office) 8.35 a.m. Uniform, haversacks and water bottles. Midday rations to be carried. Railway vouchers will be provided.

Musketry.—For Nos. 1 and 2 Companies. See Notice and Tables A and B at Headquarters.

NOTE.—Unless otherwise indicated, all drills, &c., will take place at Chester House.

SERVICE REQUIREMENTS OF THE ELECTRIC ARC FURNACE.*

BY H. HOLLIS.

Summary.—The author gives a detailed description of the arrangements made by a comparatively small generating station to handle the load imposed by a 1-ton, three-phase electric furnace. The characteristics of a furnace load are dealt with and particulars are given of the artificial reactances that are used for limiting the short-circuit current. In conclusion, it is pointed out that such loads are commercial propositions for small generating stations.

One of the modern developments in the steel business is the manufacture of so-called "electric steel" by means of the electric furnace The adoption of this process by steel mills has opened up a comparatively undeveloped field of new business for the central station. The Edison Company, of Lebanon, in November, 1914, secured a contract to supply energy to a three-phase, 60-cycle, Héroult 1-ton furnace, which has been in successful operation for the past 12 months. The furnace was installed by the manufacturers at the Lebanon (Pa.) Steel Foundry.

The mechanical operation of this furnace is taken care of by a small motor-generator set supplying direct current to three motors controlling electrode feed and a small motor driving the "Thury" regulator. A three-phase motor of the slip-ring type is used to tilt the furnace in pouring a heat. The motor-generator set and all transformers are located in a fireproof compartment so that the furnace operators do not come in contact with any high potential. The transformer room is kept locked and a suitable danger sign is located on the door of this room.

The energy is generated by the central station at a pressure of 2,400 volts, three-phase, 60 cycles, and the furnace load is taken from the same 'bus-bars that supply a mixed load used for lighting, industrial power and street railway. The railway load is carried by a 500 kw. rotary converter. The generating units include one 1,250 kw. and one 500 kw. turbo-generator. The average demand during the winter months, between the hours of 7 a.m. and 11 p.m., is about 1,000 kw. at 80 per cent. power factor, the 1,250 kw. set carrying the load except over the lighting peak, when the 500 kw. unit is operated.

Primary Feeder and Transformers.—The 2,400-volt feeder consists of three No. 0000 wires mounted on a wooden cross-arm with a mean distance between wires of 24 in. The length of line is 1·08 miles. The feeder panel at the generating plant is equipped with an oil-switch with an overload trip, operated through an inverse-time-limit relay set for 200 amperes (800 k.v.a. at normal potential), and trips in eight seconds at this setting.

The receiver panel at the foundry end is located in the transformer room, and is equipped with three single-pole, disconnecting switches. The instruments consist of a power-factor indicator and a recording watt-hour meter. The energy is measured and sold as primary power. From the receiver panel the primary wires pass through an oil-switch operated from the furnace-control panel. The switch has an overload trip operated through an inverse-time-limit relay set to operate with 91 amperes in six seconds; that is, with 362 kw. at normal potential, the furnace being rated at 225 k.v.a. at 92 per cent. power-factor. The three single-phase transformers are rated at 75 k.v.a. each, with primary wound for 1,330 Δ—2,300 Y volts and the secondary for 90—110 volts. The primaries are Y-connected to the primary mains. The secondaries are connected delta and, as operated, give 110 volts. The three electrodes of the furnace are connected to the 110-volt secondaries by means of two 500,000 circ. mil cables in parallel.

Characteristics of Furnace Load.—The character of the furnace load is that of a three-phase electric arc without a steadying resistance or reactance in series with the same. The furnace when starting a heat starts the arc without making a short-circuit by having coke placed on the scrap metal directly under each electrode. After the three arcs are started the first 30 to 40 minutes are generally free from short-circuits. At the end of that time the electrodes have melted holes in the scrap metal a little larger than themselves, and into these the electrodes feed. The iron, therefore, begins to fall in along the sides of the holes into which the electrode extends, causing short-circuits which operate an automatic oil-switch on the control panel. If the operator immediately raises the three electrodes and places coke into these holes the furnace can be started again, but if this is not done the breaker is liable to trip out as often as the operator puts it in. Other short-circuits are caused after the greater part of the charge is in a molten state by the operator pushing into the bath solid pieces of the unmelted metal lying along the sides of the furnace. After the charge is all melted, the slag formed on the molten metal by lime tends to prevent short-circuit. The load varies continually during the heat, due to change of resistance of the arc, these variations averaging 30 per cent. above and below normal load. Short-circuits sufficient to operate the breaker five or six times each heat of 3½ hours occur, and must be considered as characteristic of the electric arc furnace melting cold scrap. These must be limited to the capacity of the generating system.

The effect of a short-circuit on the regulation, both as to frequency and voltage, of an electric generating system depends on the magnitude and time element of short-circuits and the regulating characteristics of prime movers. The speed regulation of the prime movers is of considerable importance, and especially so when equipped with direct-connected exciters, as any sudden change of speed, due to heavy loads being thrown on and off, gives the automatic voltage regulator double duty.

Limiting Short-circuit Currents to Capacity of Generating System.—A practical method to limit the short-circuit current to a value that will not cause disturbances in the generating system is secured by means of reactors. The practice of the writer's company in one case where it was found necessary to add additional reactance can be taken as an example of the requirements in this regard.

With a full load value of 75 amperes per phase at 2,300 volts in the case mentioned, the resistance drop is 2·58 per cent., and reactive drop 6·6 per cent., including line and transformers. The power factor of the short-circuit current depends on the ratio of the reactive drop to resistance drop:—

$$\tan\varphi = 0{\cdot}066 / 0{\cdot}0258 = 2{\cdot}55$$

and

$$\cos\varphi = 0{\cdot}364.$$

A measure of the impedance which limits the short-circuit current expressed in per cent. of operating voltage is then

$$= \sqrt{(0{\cdot}0258^2 - 0{\cdot}066^2)} = 0{\cdot}0708.$$

The short-circuit current, therefore, is

$$1/0{\cdot}0708 = 14{\cdot}1 \text{ times full-load current.}$$

With a normal load of 300 kw. the kilowatt-value of the short-circuit current is

$$\{0{\cdot}364 \times (14{\cdot}1 \times 300)\} = 1{,}539 \text{ kw.}$$

Thus with a load on the generator of 1,000 kw., a momentary load of 2,539 kw. may exist when the furnace is shorted. Because of this possible fluctuation, voltage regulation such as is demanded by the motor and lighting load, can hardly be expected.

Addition of Artificial Reactance.—It was then decided to increase the reactance of the line by the addition of artificial reactance. These reactors consist of three coils of 70 turns each of No. 0 seven-strand copper wire, with a mean diameter of coil of 30 in. The wire supports are resin-filled maple mounted by means of brass studs on cores made of a seasoned chestnut pole. The complete installation on the steel foundry premises cost about £62.

The addition of these reactance coils in the primary leads of the transformers brought the resistance drop of the circuit to 2·9 per cent. and the reactive drop to 11·68 per cent. The power-factor then becomes

$$\tan\varphi = 0{\cdot}1168 / 0{\cdot}0294 = 3{\cdot}96.$$

and

$$\cos\varphi = 0{\cdot}2453.$$

The impedance in this case is

$$= (0{\cdot}0294^2 + 0{\cdot}1168^2)$$
$$= 0{\cdot}1204.$$

The short-circuit current is

$$1/0{\cdot}1204 = 8{\cdot}3 \text{ times full-load value.}$$

The kilowatt-value of the short-circuit current is

$$0{\cdot}2453 \times (8{\cdot}3 \times 300) = 610{\cdot}8 \text{ kw.}$$

and the load on the generator during short-circuit is then

$$1{,}000 + 610{\cdot}79 = 1{,}610{\cdot}79 \text{ kw.}$$

The automatic switch on the control panel was reset to trip out with a current value twice the normal operating demand and the inverse-time-limit set to operate as near instantaneously as possible. The quick action of the automatic overload tripping device is desirable to prevent the automatic voltage regulator on the generator building up an excessive field due to the load of the short-circuited feeder with a power-factor of 0·2453, combining with normal load resulting in a load of 1,610 kw. at a power factor of 0·47. With this high saturation of generator field when the automatic overload switch opens, the generator voltage overshoots normal voltage due to the regulation of the generator. Therefore, the overload trip should be set to trip out, if possible, before the automatic voltage regulator has time to operate in building up an excessive field.

Desirability of Electric-Furnace Load.—The general conclusions are that the electric arc furnace is a desirable business, giving a balanced three-phase load of high power-factor and load-factor, and can be successfully operated from a central station of moderate capacity. That the service has been satisfactory is attested by the

* From the "Electrical World," slightly abbreviated.

fact that the Edison Electric Illuminating Co. has recently closed a contract to supply current to an additional furnace of 2-ton capacity at the foundry which has operated the 1-ton furnace for the past 12 months.

In any case the short-circuit current of the furnace feeder should be limited to a definite value by means of reactance. On the new 2-ton installation, transformers having a reactance drop of 10 per cent. are specified by the company.

It is of great importance to the steel mill, as well as to the central station supplying energy to operate furnaces, that all electrical equipment of the furnace be inspected at definite intervals by a competent electrician-mechanic. The steel plant already referred to employs a capable engineer, who calls at the foundry every Saturday and spends about three or four hours going over the equipment. This is all the expert attention required during the 12 months' operation.

Illustrations of the furnace and of the reactance coils are given in the original article, together with recording ammeter and voltmeter charts.

TELEPHONOMETRY.*

BY B. S. COHEN.

Summary.—After a brief introduction, the author deals with standard cable measurement and transmission testing. A new device termed a telephonometer is then described, and the results of tests given in the form of tables are compared.

The author in the introduction refers to the methods of measuring transmission efficiency, first by using sinusoidal currents to measure accurately the constants of lines and apparatus, and then to obtain the attenuation constant. Secondly, by making what are called standard cable measurements where the lines and instruments are compared under working conditions, using speech and the ear, and where the human element enters largely.

Standard Cable Measurement.

The first essentials for telephonic measurement are standards for the sending, receiving and the attenuating of speech. The department's standards for both the sending and the receiving of speech are embodied in what is termed the standard transmission circuit,



Fig. 1.—Electromagnetic Standard Transmitter.

and consist of the essential part of a B coil circuit No. 1 C.B., using a toroidal repeater and including a solid back transmitter and 60-ohm receiver, each of which has been selected as truly representative of their class as regards efficiency. This standard transmission circuit is probably too well known to necessitate any more detailed description.

With regard to the standard transmitter and receiver, these were originally selected some years ago, and by calibrating a number of examples in terms of the original standards and re-calibrating and cross-checking at frequent intervals the original value of these standards has been carried down fairly accurately to the present day. A great deal of importance attaches to these standards, and at the present time a considerable number of reference standards have been calibrated in terms of the primary standards, and these reference standards are only employed to calibrate further working standards used in everyday testing, both in the research section and test section, and by contractors to the department. These working standards are re-checked at frequent intervals against the reference standards.

Recently some electromagnetic transmitter standards have been constructed. These, having less variation than a carbon transmitter, enable a calibration to be carried out in less time. For example, when testing, say, a dozen samples of a new type of transmitter, it is advisable to compare each of those transmitters (a) with two carbon standards, b and c, in order that the triangular test should indicate whether any change in a, b, or c has taken place, or takes place during the period of testing. With the electromagnetic transmitter this can be dispensed with. Fig. 1 illustrates the construction.

In one pattern the aluminium diaphragm is 60 mils thick, and carries an armature weighing 4 grammes at its centre. The natural period of the combination when damped is about 1,000 ~, corresponding approximately with the natural period of the solid back transmitter. The field coil is supplied with 300 milliamperes, direct current, through a high impedance coil to prevent transformer action between the field and armature coils. The gap between the armature

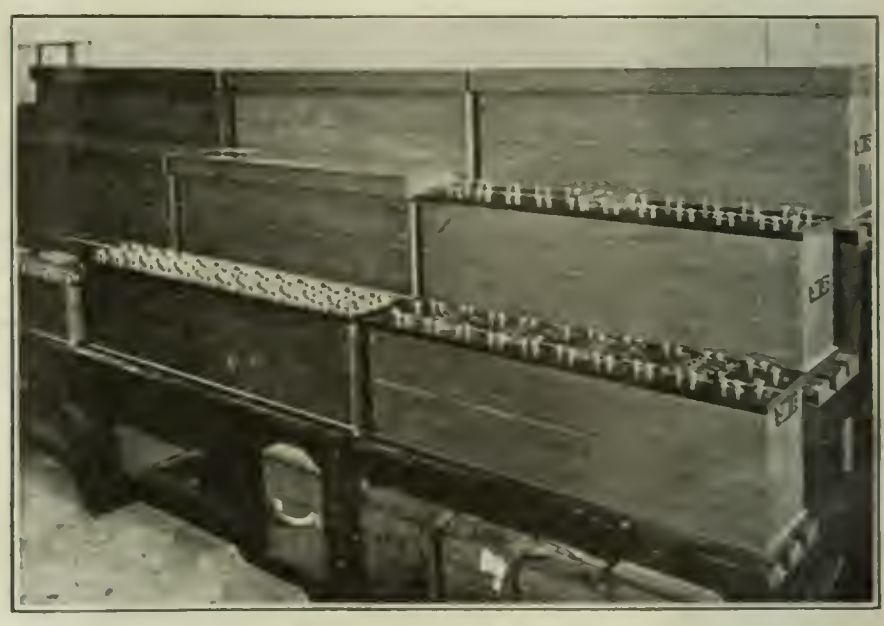


Fig. 2.—800-mile Artificial Aerial Line.

and pole faces is maintained constant at varying temperatures by supporting the front aluminium ring on iron pillars. The volume efficiency is 42 M.S.C. worse than the department's standard. It is essential that the behaviour of these electromagnetic transmitters should be identical with carbon standards under varying conditions of use for both relative tone and volume, and this behaviour is still under investigation. The possibility of using electromagnetic receivers or thermal receivers, such as the De Lange thermophone, as new standards of reception, to supplement the permanent magnet receiver standard, is also under investigation. The standard of attenuation is a mile of standard cable, which has the following values:—

Factor	Constants per loop mile
Resistance	88 ohms.
Capacity	0·054 mfd.
Inductance	1·0 millihenry.
Leakance	5·0 micromhos.
Simple attenuation constant	·107 at 800 ~
Characteristic impedance	$571\angle 42\ 50$

The following lengths of various types of main line equal 1 mile of standard cable:—

14·7 miles of 200 lb. aerial copper
26·0 ,, 400 lb. ,, ,,
45·75 ,, 800 lb. ,, ,,
25·8 ,, loaded 300 lb. London–Birmingham trunk cable.

A 20 lb. cable with an equivalent of 1·05 or 5 per cent. variation from standard cable has been installed at King Edward Building. This cable consists of 20½ mile drums of eight pair multiple twin, and

* Abstract of a Paper read before the Institution of Post Office Electrical engineers.

is arranged to give 80 miles as the maximum length and any part of the 80 miles down to 1 mile. When investigating the losses due to bridging and terminal apparatus, it is advisable to conduct such tests with the apparatus connected in lines similar to those used in practice. For example, the ordinary local battery induction coil 1—25 ohm, compared with the 1—150 ohm coil, is of the order of 5 M.S.C. better when the comparison is carried out on 20 lb. cable, but is only about 3 M.S.C. better when compared on a line made up of cable and open wire. In order to conveniently investigate such terminal reflection effects, and also other effects in the laboratory, an artificial aerial line totalling 800 miles is now being brought into use. This artificial line is made up in 100 mile boxes. The line represents both 200 lb. and 400 lb. aerial copper.

Artificial Aerial Line Data, Values per Loop Mile.

	200 lb. ...	400 lb.
R.....	9 ohms ...	4·5 ohms.
K	0·01 mfds.	
L.....	3·7 millihenries.	

The insulation resistance can be varied in the case of two of the boxes from the natural insulation of the ebonite top to 1, 0·5 and 0·1 megohm per loop-mile. The line inductance is reproduced by toroidal wood-core inductance coils. The capacity by condensers with mica dielectric and the leakance by hurdle wound coils of very fine wire. The electrical constants are lumped in 8 mile lengths—*i.e.*, 0·62 M.S.C.—for the 200 lb. condition, which gives a lumping factor considerably less than that commonly adopted for artificial 20 lb. cable boxes—viz., 2 M.S.C.

Only two boxes are fitted with variable leakance ; the remainder are unprovided with leakances. The attenuation constants, as

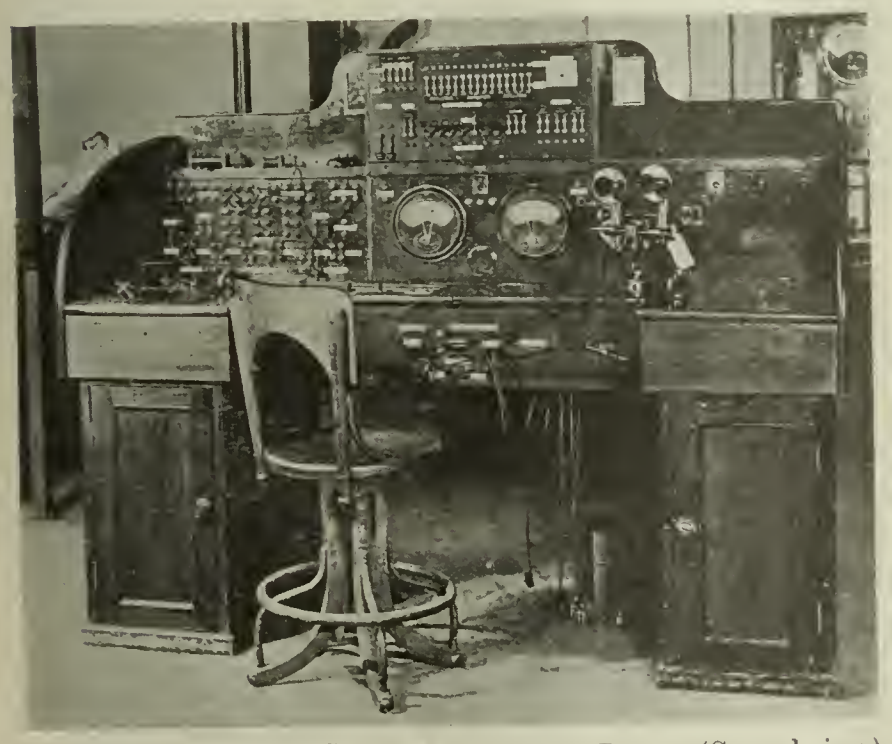


Fig. 3.—Standard Cable Measurement Desk. (General view.)

measured by the Francke machine, are for the 200 lb. 0·00717 and for the 400 lb. 0·00371. These results are very close to the calculated values—namely, 0·00717 for the 200 lb. and 0·00365 for the 400 lb. Having dealt with the sending, receiving and attenuating standards and apparatus, I will conclude the first part of this Paper with a short description of how these standards are employed in carrying out a standard cable measurement.

Transmission Testing Desk.

A special S.C. testing desk has been designed and installed in the department's laboratories. Fig. 3 is a general view of the front of this desk. The upper central panel contains a series of knife switches, so connected that any standard circuit can be quickly set up for testing C.B. or L.B. transmitters, receivers, induction coils, &c. The lower central panel contains ammeter and voltmeter for measuring transmitter resistance and for other purposes.

Between the two meters is a row of three lamps marked B, =, W respectively—*i.e.*, better, balance, worse. Below these lamps is a signal buzzer. The left-hand panel contains terminals for connecting up various test apparatus, and the right-hand panel contains strips of relays used in changing over from one condition to another. Half the relays are single make and the remainder single break, and the operating coils, which are 500 ohms in resistance, are all connected in parallel to be operated by 30 volts. An artificial standard cable box, used as a fixed length, in circuit with the apparatus under test, is shown on the right of the desk. On the right is a handle which rotates a contact drum used to operate the relays for changing over from the standard to the apparatus under test. An adjustable swing arm on the right carries supports for a pair of carbon transmitters.

In the silence cabinet, which is used in conjunction with the testing desk, is fitted a row of mechanically retaining keys out of which, when depressed, remain so until another is operated. There is one of these keys to operate each of the three lamps marked B, =, W on the testing desk. The observer in the cabinet has also before him a pair of lamps marked 1 and 2, which indicate by their alternate lighting whether he is connected to the standard apparatus or the apparatus under test.

We are now in a position to consider the general method of operation. The actual standard cable measurements are mainly carried out by youths, termed transmission assistants, under the supervision of an engineer.

Assuming that transmitters are being tested, one transmission assistant sits at the desk and counts 1, 2, 3, 4, 5 alternately on a test transmitter and a standard changing over the circuit after each count. There is a fixed length of about 35 M.S.C. in circuit with both transmitters, and, in addition, a variable length in circuit with the better of the two transmitters. As the change-over switch is operated the lamps marked (1) and (2) light in the silence cabinet and the observer in the cabinet depresses one of the three keys (B, =, W), which indicates by lighting the corresponding lamp on the front of the testing desk the relationship of condition (2) to condition (1). The key at the same time operates the buzzer on the desk momentarily. The balancing cable is then varied until cable lengths definitely indicating better and worse are determined. The mean of these is taken as the correct value. A reversing key is provided so that the test apparatus can be connected on either circuit (1) or circuit (2). It may be mentioned here that two separate 22-volt batteries are employed for feeding the standard transmission circuits at either end in order to eliminate the error due to cross-talks. The lamp signals enable the observers to concentrate on the volume balancing, and avoids the necessity for the speaker to state after each count which condition he has just spoken on. The last lamp signal, whether better, =, or worse, remains glowing until the next signal is sent, thus preventing error.

(To be concluded.)

EXHAUST FROM LIQUID FUEL ENGINES.

In a Paper read before the Institution of Mechanical Engineers by Second-Lieut. R. W. Fenning, R.E., B.Sc., on "The Composition of the Exhaust from Liquid Fuel Engines," this question is very thoroughly investigated by means of "exhaust gas charts."

These are obtained by plotting on a "strength of mixture" base, the percentages of carbon dioxide, carbon monoxide and oxygen in the exhaust gases, the strength of mixture being expressed as the ratio of air to fuel by weight. A mixture flask was used to prepare mixtures of air and fuel in known ratios, a matter of some difficulty, the required volume of the mixture being carefully measured in a burette of the Ma farlane & Caldwell gas analysis apparatus. In this way various mixtures were obtained, and tested. Generally the mixture was exploded in an explosion chamber by means of an electric spark, and the products of combustion absorbed by suitable absorbents, such as caustic potash for carbon dioxide, pyrogallol for oxygen, fuming sulphuric for heavy hydrocarbons and palladium sponge for hydrogen. From the product an analysis was made and tabulated. The exhaust from a petrol engine of the sleeve-valve pattern running at 800 revs. per min., the single cylinder being 10·2 cm. dia. by 12·9 cm. was tested. From the experiments in the Paper it can be concluded : (*a*) With volatile fuels there is but little difference in the composition of the products of combustion resulting from air-fuel mixtures in a small explosion-vessel to an engine cylinder, in spite of the conditions being so dissimilar. In fact, the agreement between the CO_2, O_2 and CO values in engine and explosion vessel tests is so close that an exhaust-gas chart prepared from explosion vessel tests can be used to estimate the strength of mixture supplied to an engine. (*b*) A very small quantity, if any, of unsaturated or saturated hydrocarbons is present in engine exhaust gases. Taking a petrol for instance, methane is almost entirely absent. (*c*) The hydrogen constituent in exhausts from strong mixtures is an important item, and increases in value rapidly with increase in mixture strength. [illegible] of air to fuel in the original mixture can be obtained with a considerable degree of accuracy from the composition of the exhaust gases. The author urges that since mixture strength has been demonstrated to have a great effect on the thermal efficiency, then given an exhaust chart for the fuel, the strength of mixture can readily be found from an analysis of exhaust gases, consequently the method should be adopted in setting carburettors. In this way fuel would be economised, carbonisation reduced, and less poisonous gases such as carbon monoxide set free to pollute the atmosphere.

THE SHILDON-NEWPORT RAILWAY ELECTRIFICATION.

The North Eastern Railway Company was one of the first main line British Railway Companies to adopt electric traction, having as far back as 1904, when Sir George Gibb was General Manager, successfully applied electrical operation to their Newcastle and Tyneside suburban traffic. Once more this Company has acted as a pioneer of electric traction in applying it to heavy freight haulage.

In 1911 the General Manager, Sir A. Kaye Butterworth, instructed their consulting electrical engineers, Messrs. Merz & McLellan, to report generally on the question of electrification with reference to the special conditions of the North Eastern system, and following the visit of their chief mechanical engineer, Mr. Vincent Raven, with Mr. Merz to the United States in 1911, the Directors decided to proceed at once with a preliminary scheme.

Some historical interest attaches to this selection, since the track runs over a portion of the original Stockton to Darlington Railway, the first public railway on which steam locomotives were used for conveying passengers and goods.* The fact that the first trial of heavy freight haulage on a large scale in England should be carried out on this particular route is noteworthy.

Beyond the usual considerations affecting the decision to apply electric traction to such a line, there was a special factor which differentiated the North Eastern Railway lines from others in the United Kingdom. As is well known, the production and distribution of electric power has been developed upon a larger scale on the north-east coast than in any other part of this country, and a large proportion of the power is derived from electric generating stations

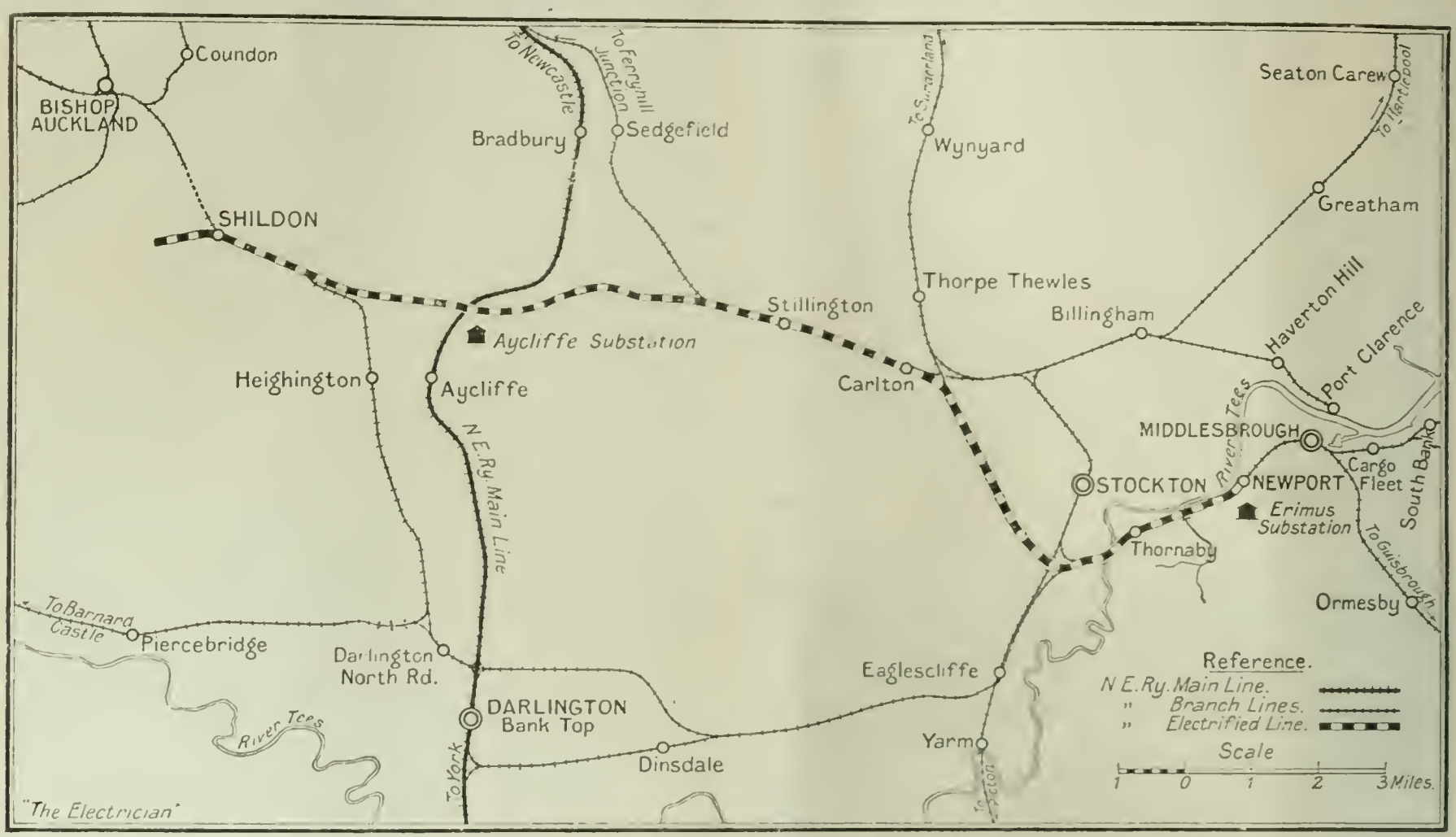


Fig. 1.—Sketch Map showing Route Plan of Line.

Electric working was started on July 1, 1915, on the Shildon-Newport line, a night service being run at present, as work on the overhead equipment is still being carried on in the day time.

The Shildon-Newport route was selected for trial, this being an important freight line dealing almost exclusively with heavy mineral traffic.

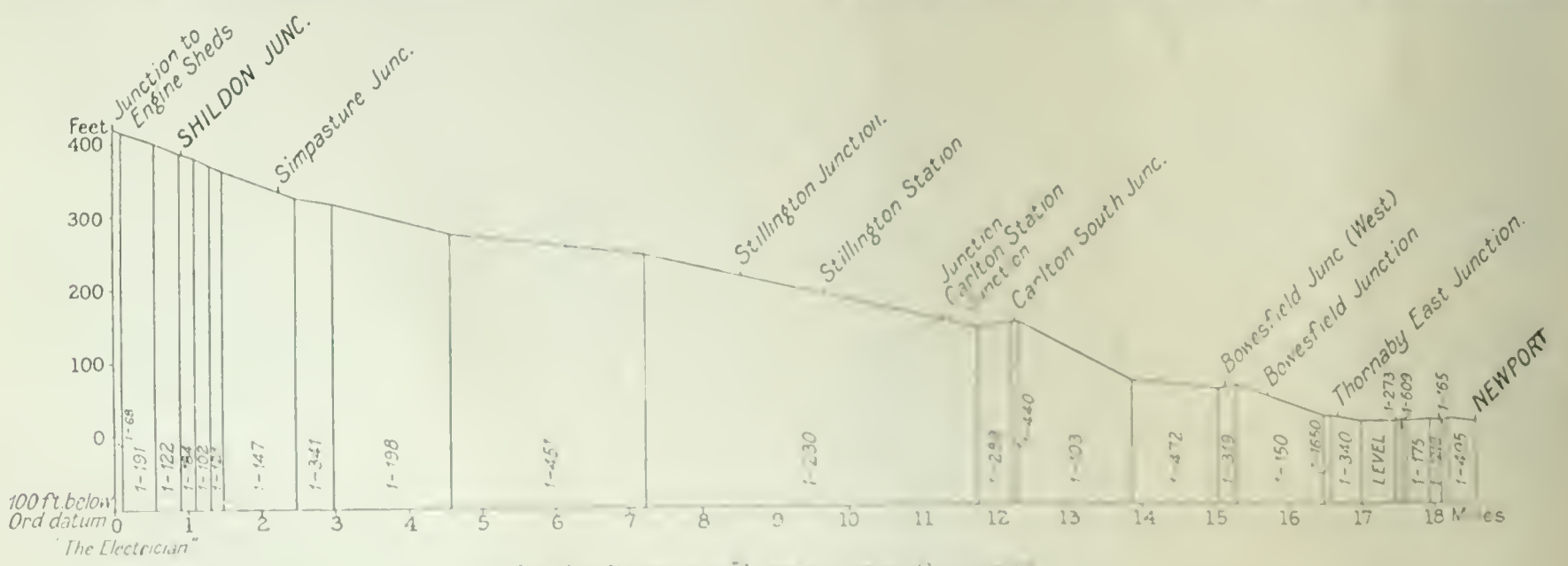


Fig. 2.—Profile of Line showing Gradients.

The Shildon-Newport route was selected for trial, this being an important freight line dealing almost exclusively with heavy mineral traffic. Once more this Company has acted as a pioneer of electric traction in applying it to heavy freight haulage.

In 1911 the General Manager, Sir A. Kaye Butterworth, instructed their consulting electrical engineers, Messrs. Merz & McLellan, to report generally on the question of electrification with reference to the special conditions of the North Eastern system, and following the visit of their chief mechanical engineer, Mr. Vincent Raven, with Mr. Merz to the United States in 1911, the Directors decided to proceed at once with a preliminary scheme.

Beyond the usual considerations affecting the decision to apply electric traction to such a line, there was a special factor which differentiated the North Eastern Railway lines from others in the United Kingdom. As is well known, the production and distribution of electric power has been developed upon a larger scale on the north-east coast than in any other part of this country, and a large proportion of the power is derived from electric generating stations using as fuel the waste heat and gases derived from coke ovens and blast furnaces in the Durham and the Cleveland districts. An ample supply of cheap electrical energy was therefore available from the systems of the existing power companies, and this fact, obviating

* This line was opened in 1825, and two of the original locomotives designed by George Stephenson are to this day preserved in the Darlington Station of the N.E.R.

as it does the necessity for a large capital expenditure by the railway company on power station plant, had an important bearing on the whole scheme.

The electrified line described hereafter has a route length of between 18 and 19 miles, and connects the mineral sidings at Shildon, which form one of the largest marshalling yards in Great Britain, with the Erimus sidings at Newport, near Middlesbrough. A considerable portion of the sidings at both ends is also electrified, so that, including the sidings, about 50 miles of single track are equipped for electric working.

Fig. 1 shows the general route electrified, and Fig. 2 the gradients. The general gradient is in favour of the laden traffic, the steepest gradient being 1 in 103. The line carries the heavy mineral traffic from the south-west Durham coalfields to the Middlesbrough district, supplying the large number of blast furnaces and iron works concentrated there. On the return journey, the load consists mainly of empty wagons returned to Shildon sidings.

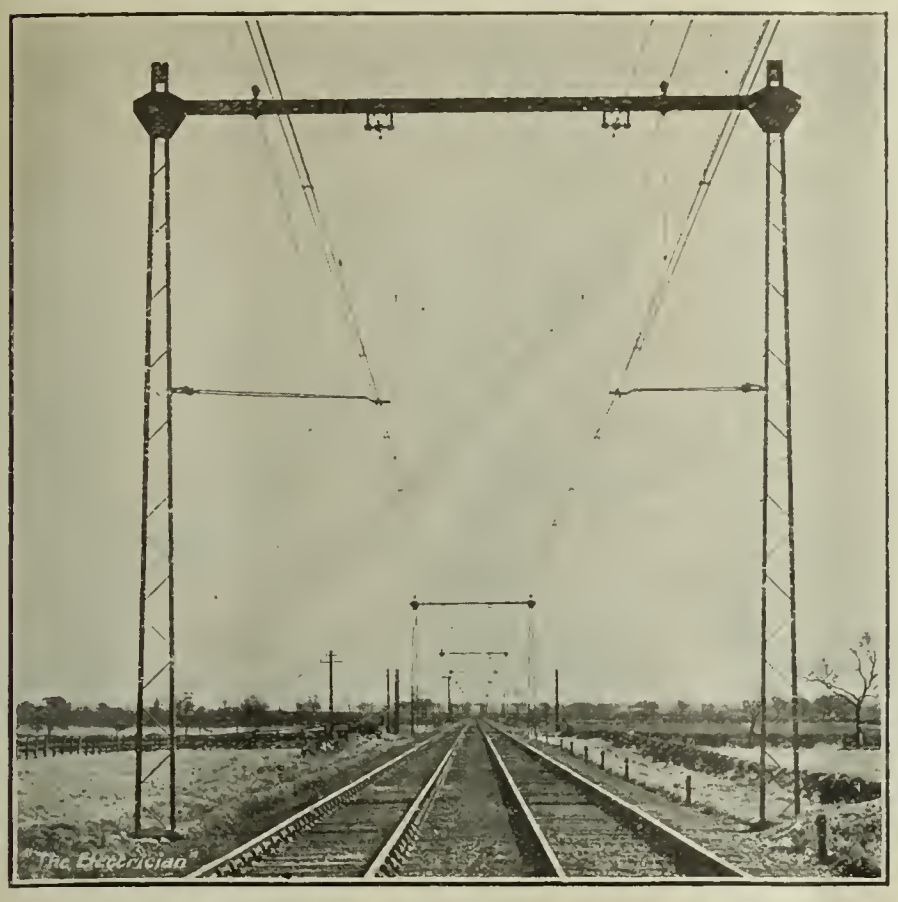


Fig. 3.—End View of Overhead Equipment.



Fig. 5.—Cantilever Construction.

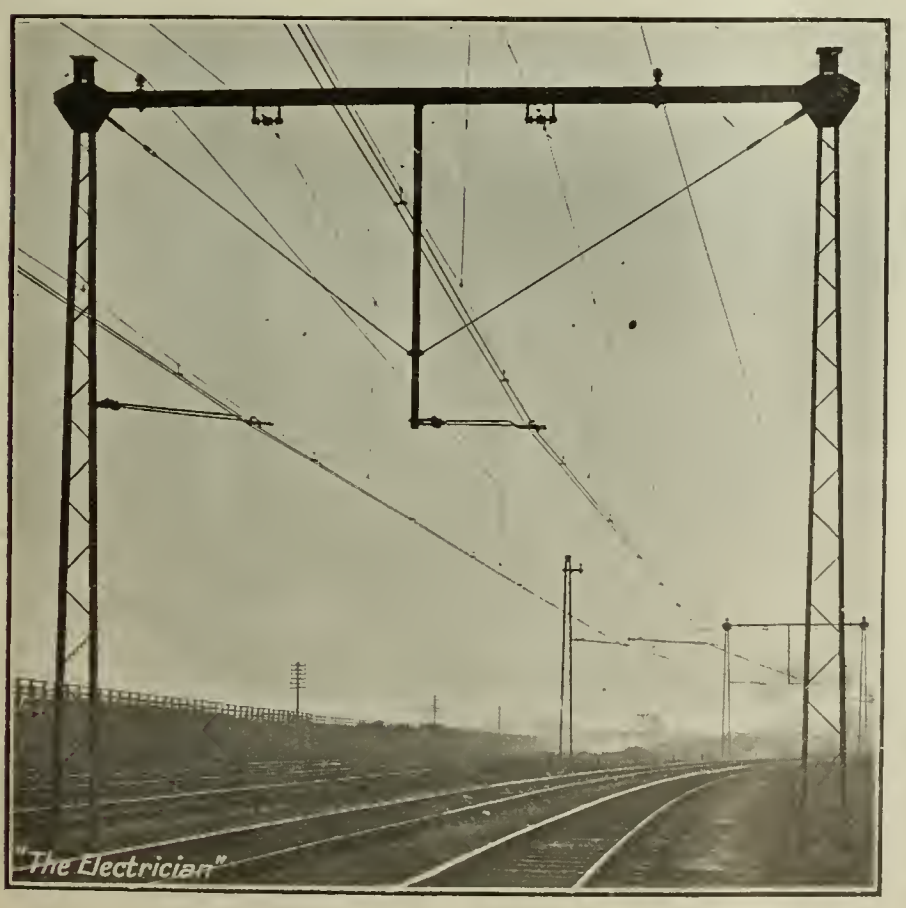


Fig. 4.—View of Curve at Bowesfield Junction.

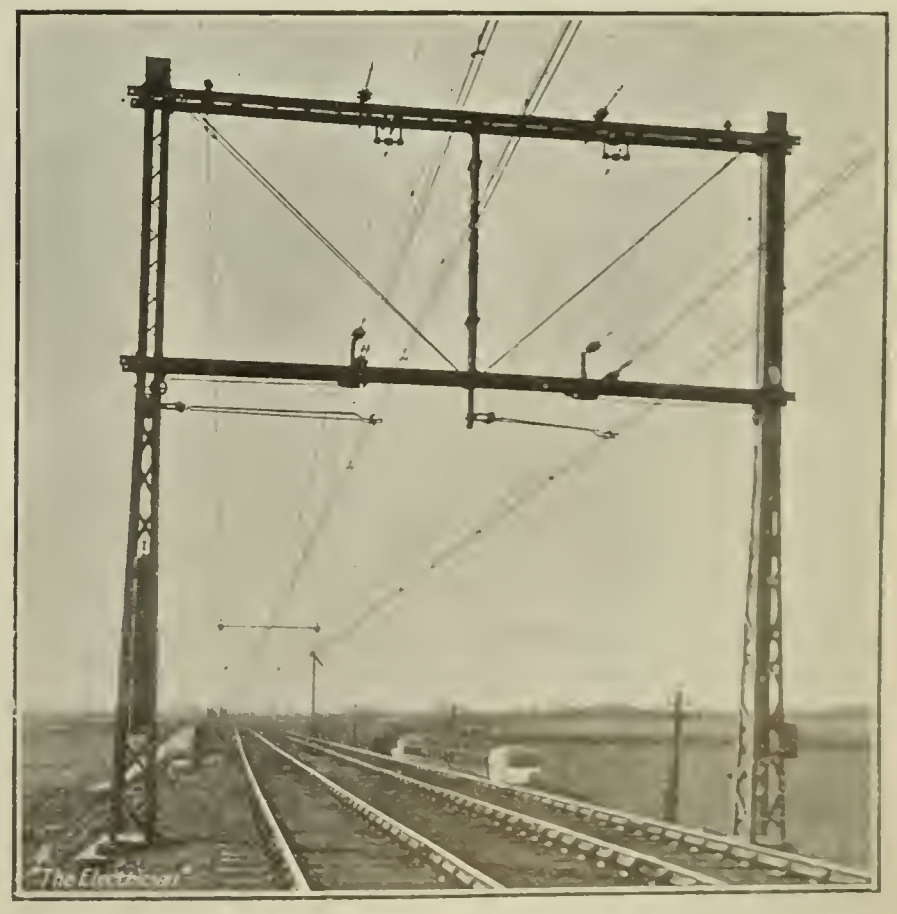


Fig. 6.—Tensioning Structure.

Overhead Track Equipment and Electrical Equipment of Locomotives.

System Adopted.—It was decided to adopt the high tension direct-current system, current being supplied to the locomotives through overhead contact wires at a pressure of 1,500 volts from the two rotary-converter sub-stations described later.

The overhead track equipment was carried out under the supervision of the railway company's then chief engineer, Mr. C. A. Harrison.

Suspension of Wires.—Fig. 3 shows the general type of catenary construction adopted. The overhead contact wires on the main portions of the track consist of two hard-drawn copper conductors.

each 0·155 sq. in. section, but on certain portions of the sidings, where the loads are not so heavy, a single contact wire only is used.

The wires are supported by a solid steel auxiliary catenary wire. to which they are attached by sliding clips. This auxiliary catenary is in turn suspended from the main stranded steel catenary by means of steel wire droppers. The main steel catenary wire is supported from the steel structures, shown in several of the accompanying tures referred to, and are connected in parallel with the main contact wires at frequent intervals. The purpose of these feeder wires is to increase the conductivity of the overhead equipment.

Each steel structure carries a pair of insulated steadying arms (*see* illustration). These steadying arms are pivoted in all directions, and



Fig. 7.—Terminal Arrangement.

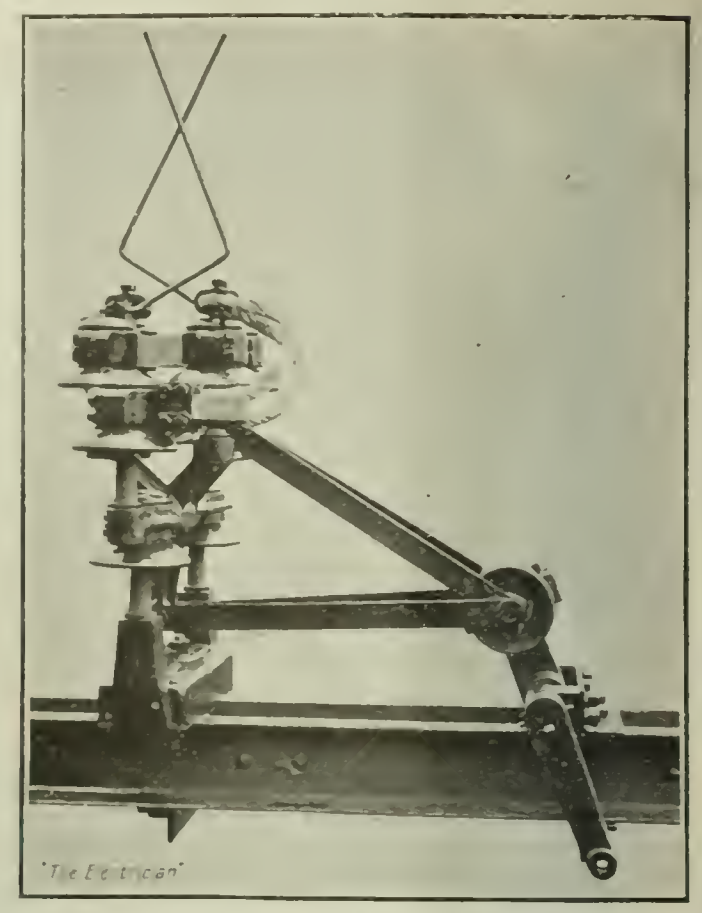


Fig. 8.—Detail of Section Switch.

photographs, by means of special insulators, double insulation being used throughout.

The normal span between the steel structures is 110 yds., but on curves and sidings they are placed at smaller intervals depending on the conditions existing.

The normal height of the contact wire from rail level is 16 ft. 6 in., but at level crossings this is increased to 18 ft. 6 in., and under some of the low bridges, of which there are a large number on this route, the height from the rail level is reduced, the minimum height being about 13 ft. 8 in.

Two auxiliary stranded copper feeder wires, one for each track, of 0·194 sq. in. section, each are carried on the top of the steel structures referred to, and are connected in parallel with the main contact wires at frequent intervals. The purpose of these feeder wires is to increase the conductivity of the overhead equipment.

Each steel structure carries a pair of insulated steadying arms (*see* illustration). These steadying arms are pivoted in all directions, and are attached to the contact wires by means of clips, their purpose being to fix the position of the contact wire relatively to the track. The contact wires are staggered in the usual way to prevent undue wearing of the bow collectors.

Structures.—The general type of steel structure carrying the wires over straight parts of the track can be seen in Figs. 3 and 4. It consists of two steel masts and a cross girder, each of these being made up of two channels with flat steel bracing. On curves, a centre strut, steadied by steel tie rods, is added (*see* Fig. 4), the steadying arm on the mast on the inside of the curve being removed and fixed to the centre strut mentioned so as to ensure the steadying arm being always in tension.

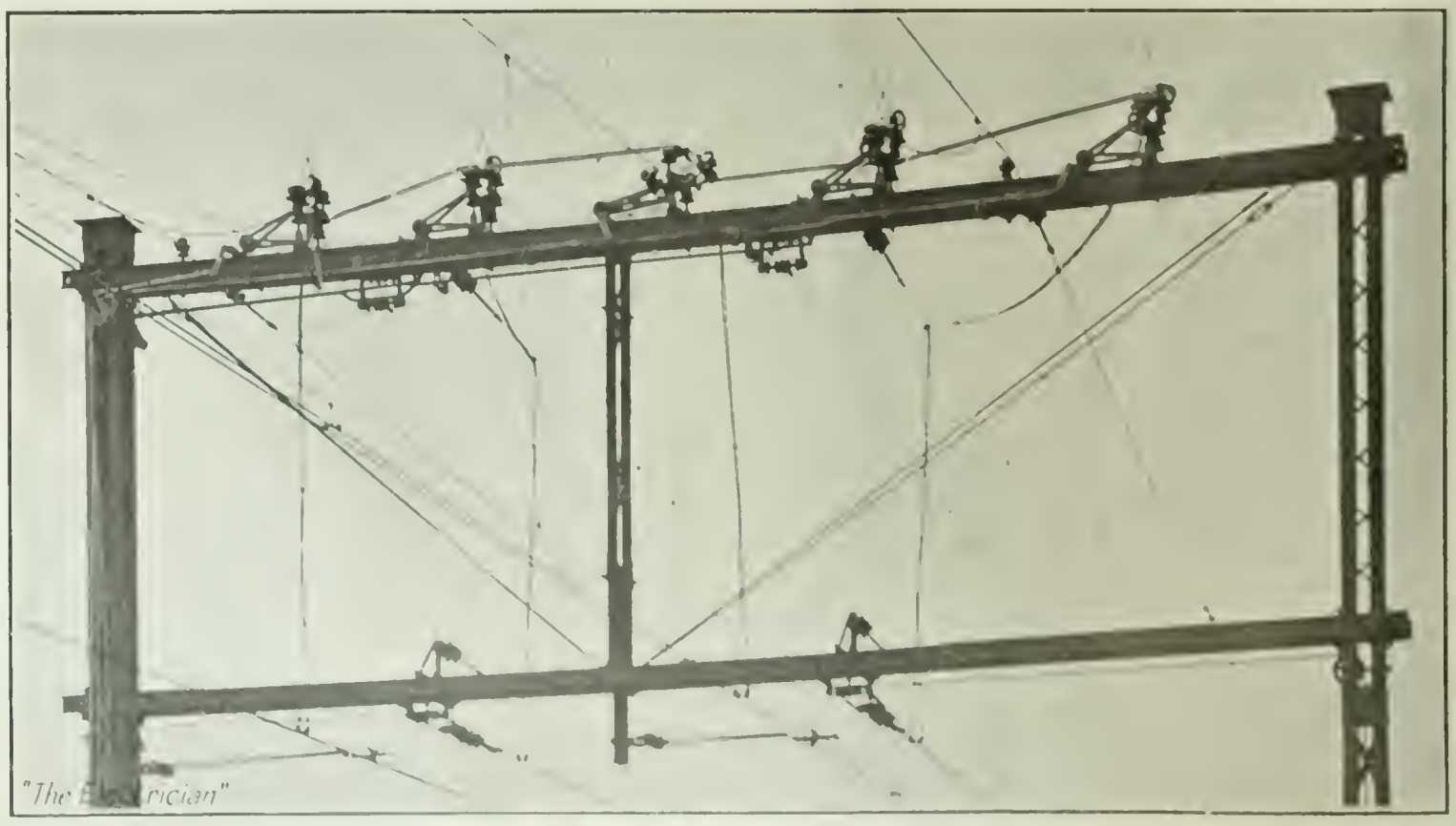


Fig. 9.—General View of Section Switches, &c.

Fig. 4 shows an independent pull off mast. Such an arrangement is fitted on sharp curves where necessary.

In Fig. 5 an arrangement is shown of a two-track structure where it was impossible to erect two masts. Cantilever construction is here adopted, the general features of which can be seen from the figure. A similar cantilever construction has been used over single track, but in this case wood poles were used, a short length of single track being equipped in this way for experimental purposes.

All steel structures carrying the overhead track equipment are bonded to the running rails by means of a hard copper bond of 0·08 sq. in. section. Any steel structures carrying signals, which are in proximity to the electrical equipment, are also similarly bonded to the running rails.

Contact Wire Tensioning.—In order to limit as far as possible the sag of the contact wires due to temperature variation, automatic tensioning was adopted. The tensioning points are approximately 1,100 yds. apart. Fig. 6 shows a typical tensioning structure. Two of these structures are placed 65 yds. apart at the end of each tension length, the wires from the opposite lengths over-lapping by this amount. The end of each contact wire is raised at the tensioning structure to which it is fixed to a height of about 18 in. clear of the normal level at that point so that the locomotive bows ride gently and without shock from one tensioning length on to the next.

The contact wires are anchored to the auxiliary catenary wire at a point two-thirds of the distance along each tensioning length in the running direction.

The tensioning structures consist of strong steel masts made up of four angle irons with angle iron bracing, and it will be seen from the figure that the structures are fitted with two cross girders with a centre strut. The tensioning weights are slung in the centres of the

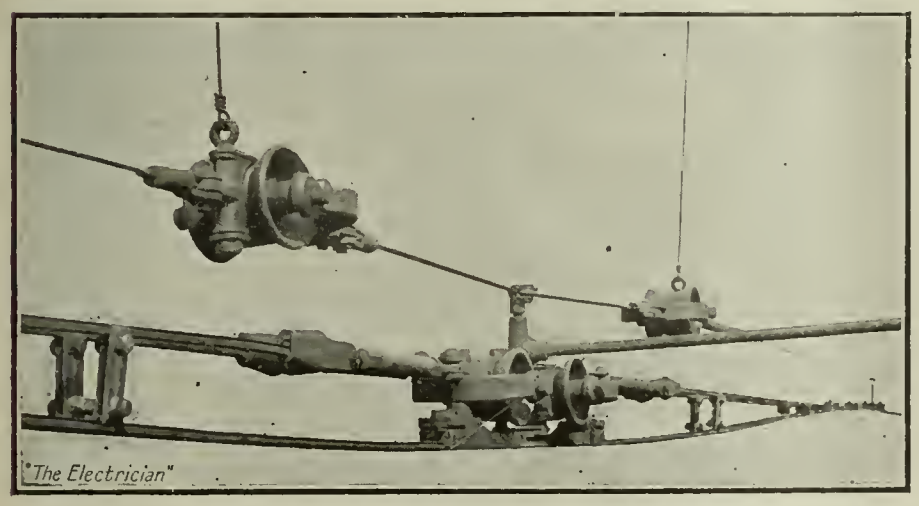


Fig. 10.—Detail of Section Insulator.

mast structures by chains passing over pulleys attached to the contact wires. A normal tension of about 1 ton is maintained by this means in the double contact wire. The auxiliary catenary wire is in all cases anchored off to the lower girder of the tensioning structure, but the main catenary is continuous except at tensioning points, at which section switches are fitted. At the latter points, the main catenary is also anchored off, but to the top girder.

On some of the sidings where only shunting work is done, and the loads on the locomotives are not heavy, a single contact wire is used over each track with ordinary tramway span wire construction. On some of the marshalling and reception sidings, which are not equipped throughout, and on which it is only necessary for the overhead construction to permit of the locomotives entering to pick up their load, the wires are terminated as shown in Fig. 7.

Danger boards are fitted beyond which electric locomotives should not pass, but if by any chance they should over-run these, the terminal construction is such that no damage would be done to the bow collectors or to the overhead track.

There are a large number of low stone bridges on this route. At some of these bridges it is possible to carry the main catenary wire through the bridge, but at most of them it is necessary to anchor it off to the bridge. In these cases, in order to obtain the necessary clearance, the contact wires, together with the auxiliary catenary, are brought towards the centre of the bridge so that contact is made towards the extreme edge of the bow collector. In order to prevent the other edge of the bow collector from striking the bridge a guard wire is fitted. This guard wire is anchored off to the structures on either side of the bridge, and is only alive while a locomotive is passing underneath.

Section Switches.—The track is sectioned on the normal length at intervals of about 2½ miles, and considerably more frequently on sidings. Section points are arranged to occur in most cases at tensioning points so as to avoid the use of section insulators.

Fig. 8 shows the type of section switch adopted. These switches are fitted in the open, so that it is permissible to use the horn break arrangement which can be seen in the figure. They are erected on the uppermost cross girder of the section structures, and operated by levers in the signal cabin to which they are connected by the usual arrangement of railway point rods.

Fig. 9 shows a view of five section switches fitted on a girder. Normally the tracks are coupled in parallel, but by means of the section switches the up and down tracks can be operated separately if desired.

As the train control system of working is in use on this route, the signal cabins are connected by telephone with a central controlling office situated at Newport, and the handling of these switches is directed from the same point.

In certain positions, such as at cross overs and some of the sidings, where it was impossible to avoid their use, section insulators are fitted. The type of insulator is shown in Fig. 10. In all cases, however, these are fitted at points where the locomotives are travelling at low speed.

The overhead equipment was carried out by Siemens Brothers Dynamo Works, Ltd.

(To be continued.)

THE ELECTRICITY SUPPLY OF GREAT BRITAIN.*

The following is the reply, somewhat abbreviated, of Mr. Williams to the discussions in London and Manchester recently on the above Paper.

LONDON DISCUSSION.

Mr. Merz asks us to consider why have we not made greater progress towards the ideal in electricity supply? Long consideration of the subject leads me to believe that the chief reasons are because we have not, as a profession, trained ourselves to consider the electricity supply problem from the sandpoint of the country as a whole, because we have been lacking in a central organisation to translate theory into practice and co-ordinate effort, and because, generally speaking, proposed schemes have failed to embrace various interests. Mr. Merz considered the reason why the electricity supply of Great Britain has not been dealt with more comprehensively and made greater advance is that the profession as a whole is not agreed that centralisation of plant in large interconnected power stations is the ideal. I think those who have studied the problem in recent years have generally come to the conclusion that not only is it the ideal arrangement, but also the only one which can give the highest results, and the one which must come sooner or later if we are to see the general adoption of electricity for lighting, heating, power and transport in this country. If the profession is still in doubt as to what our aim should be, then undoubtedly the sooner all its agencies get to work to clear up the doubts and thrash out the issues the better. We are indebted to Mr. Merz for his splendid achievements on the north-east coast and for showing something of the possibilities of public electricity supply. Can there be any question in the minds of engineers of the essential soundness of interconnected power stations with large units after studying Figs. 1 and 2, supported by Mr. Merz's statement that a saving in fuel of 30 to 60 per cent. by this means is possible. I had not thought the profession was still so much in doubt on this subject as Mr. Merz believes, and this is borne out in both the London and Manchester discussions; but I heartily agree that if such is the case its settlement must be one of the first considerations in our plan of campaign.

Might we not ask, however, how far Mr. Merz's suggestion—that the profession has still to make up its mind of what is the ideal—is due to doubt of where the acceptance of that ideal would lead to? This is fully borne out by Mr. Rolls' remarks, which I will refer to later. For this reason I have come to the conclusion that it is the basis of organisation which requires solution if we are to solve the technical and financial problems connected with electricity supply, and present a united front to Parliament and the people. I would like to make it quite clear at this stage that my proposals were addressed to electrical engineers, and the intention is *not* that we shall seek the establishment of an electricity board first, and then proceed to educate engineers to its advantages. The presentation of our proposals to Parliament must be subsequent to and following upon the support of the profession in general, and of the electricity supply industries in particular. Without this I believe our scheme would hardly secure success, but with it I think our cause is so strong as to command attention and compel achievement.

The Paper does not state that the technical and financial aspects of the subject are simple—they are far from that: but that "the basis of organisation," which may be taken to include the human factor and the co-ordination of various interests, is the most difficult. Difficult though this may be, I am convinced that if electrical engineers will only come together and without prejudice seek a common cause for the benefit of all without hurting the interests of any, the obstacles will soon be overcome.

* *See* The Electrician, April 14, 1916.

Mr. Merz calls attention to the difference between the geography of Great Britain and that of other lands—for example, Germany and the United States. This is very greatly in our favour, for an interconnected scheme, for with the densely populated manufacturing districts, each requiring a large power station, the distance between such stations will be comparatively short, and thus their interconnection made easier and less costly. The remarkable load factor Mr. Merz has attained at the north-east coast is due to the interconnection of the stations there, which interconnection has been made possible at reasonable cost due to the comparatively small area covered. It has been the study of the geography and industrial conditions of Great Britain that has led me to the conclusion that perhaps no district in the world if taken as a whole offers so favourable a field for a cheap and efficient electricity supply. I regret I have not had the pleasure of reading Mr. Chattock's address referred to by him, but I am happy to learn that on many of the main principles we are in agreement. The indebtedness of the profession to Dr. Ferranti, Mr. Chattock and others is very great. I do not agree with the nationalisation of our electricity supply, as that is generally understood. For various reasons I think it would be impossible of achievement in the early future, nor, if achieved, do I consider it is the best solution. This opinion is formed after some years' inner knowledge of the disabilities under which Government departments work.

Mr. Chattock would that I had laid more emphasis on the justification for such a scheme as advocated in the Paper. I am afraid the cutting down of the original Paper to its present dimensions in order to form a basis for a general discussion is responsible for this and for other points raised by various members in the discussion. To illustrate one point only out of a large number which could have been used to support the proposals advanced in the Paper: The fallacious argument is often used that because a manufacturer's costs for power are only, say, 1 per cent. of the total costs it is of no importance to reduce the price of current by 10 per cent., as this only represents 0·1 per cent. reduction on the total costs. Assume this argument to be used for all items making up the costs, then no reduction follows; but if each section of costs is reduced by 10 per cent. then the total costs will show a corresponding reduction, enabling the manufacturer to sell at lower rates in the home market and compete successfully abroad. It is surprising how general is this argument of small economies not being important. They often mean the difference between success and failure, between profit and loss. Now, if a cheap and reliable electricity supply is generally available, it follows that advantage will be taken of it by all sections of the community, not only for reasons of economy, but for convenience and as relieving capital for use in their businesses, in which they are experts, and can, therefore, more profitably employ it, and enabling greater concentration to be given to the chief business issues by having one department less to require attention. Mr. Chattock raises a very large issue in his proposal that no return shall be expected during the early years on the money spent in carrying out the scheme. I take it Mr. Chattock refers to the money spent by the proposed board, and *not* to that which might be expended by municipalities or companies. This proposal goes down to the fundamental principles of political economy. The Continental school largely accept such proposals as being sound for benefiting the trade of the country as a whole, and Germany in particular has followed this line of argument with success. The British policy, however, has been different, and, with the exception of a subsidy to certain steamship lines, the principle followed generally has been that each development must make its own progress without State support.

It is not desirable to enter into a discussion of the merits or demerits of these opposite policies here, but because the British policy is what it is, and because we wish to remove all obstacles to the early carrying out of our scheme, I would advocate the non-dependence on State finance for the scheme. We would be perfectly justified in asking, and the Government to grant, an annual sum to cover the cost of the salaries, office expenses, &c., of the electricity board, because it would be relieving Parliament and Government offices of work and acting somewhat in controlling capacity as the representative of the public. For any other expenditure the board might incur, either for power stations, bulk network or distributing systems, the board should be responsible. Thus, if the board find it desirable to erect any power stations, provide bulk networks, &c., they will raise the money on the security of these items and for the payment of interest and sinking funds they would have to obtain a credit balance between expenditure and revenue. This would put the board on a commercial footing so far as the operating part of their powers are concerned, and would necessitate such operations being carried out on sound financial lines. It would also mean that any operations of the board would have to be made with due caution, a step by step policy being followed as against a wholesale plunging into heavy expenditure. If Government grants are given at any time they should be for specified objects, such as carrying mains into a sparsely populated agricultural district, and the main financing of our scheme (apart from the annual grant for the board's salaries and expenses) should be independent of State assistance. On the other hand, the fact that the board would not operate for profit—as a company paying dividends or a municipality looking for relief for the rates—and would be able to raise funds at favourable rates of interest, it is considered sound finance, and broad minded development would be readily achieved. The chief objection to Mr. Chattock's proposal to replace small generating stations by a bulk supply at once is that it would raise powerful opponents against our scheme, and thus prevent its fruition or defer it indefinitely. It would also make our scheme more difficult to establish from a financial standpoint; and without wishing to remark on this proposal considered alone, I do strongly feel that we would be following the safer, wiser and more diplomatic course by letting an intervening or transition stage pass between existing conditions and those we propose to bring about. If the success of the scheme is as great as we may anticipate, I believe the period of transition will be much shorter than we might expect. Wayleaves are of great importance. To seek Parliamentary authority for such wayleaves is too cumbersome and slow an operation, nor would Parliament give the drastic powers for authorising and enforcing the right for wayleaves to any but a quasi-government body such as the proposed board. With its powers the right of granting wayleaves to electrical undertakers would have to be handled wisely, as it would be answerable to Parliament for the judicious use of such powers. Mr. J. W. Mears remarks as to the practice in India in granting wayleaves are of great importance, and might be used as a precedent.

I suggest that the question of whether Parliament would be able to deal with a scheme of this kind at present mainly depends on how it is presented and whether it has the unanimous backing of a united profession. It is only a few years ago that a "daylight saving proposal" was met with derision, and yet in the height of a great war it has now secured recognition, and a Bill has been put through Parliament. I believe that if we could go to Parliament as a united profession, with a strong backing of municipalities and electricity supply companies, with a sound, straightforward proposal it would be welcomed and would soon become law. For this reason I would earnestly advocate confining our proposals strictly to electricity supply, and of eliminating from any scheme factors which might cause serious division between us. "Half a loaf is better than no bread." I would like to correct an impression held by Mr. Highfield and other speakers that because I have brought out the thought of trading for the public good I propose to do it at a sacrifice to vested interests, whether of capitalists or of engineers. This is not my intention. The crux of the whole position lies in the fact that by working together we can cheapen the cost of electricity and so create a high demand. The result will be that not only will the public benefit, but the capitalist and the engineer will also participate in the advantages that will follow. It is our duty to the interests we represent and to ourselves that we should ensure this being the case in any scheme we may advocate. I think the Paper makes it clear that there is no tendency to belittle our past and present achievements in electricity supply. With the legislative difficulties to overcome, what has been attained is truly remarkable. But apart from the few exceptions, of which the north-east coast is only one example, can we say that the position of the industry is satisfactory considered from the standpoint of what it might be? Does not the very success of the north-east coast heighten the contrast with other areas, and yet auger well for the supply of Great Britain if we can organise our resources and treat the country as a whole without unduly interfering with the separate enterprises? Can we say the position is satisfactory while vast areas have no supply of electricity at all, and in other areas the undertakings are small and the price of electricity very high? Mr. Highfield raises the very important and difficult subject of the same board having controlling as well as operating powers. This has been and is one of the real difficulties to be considered. If we could be assured that the requirements of the country could be met without the board having operating powers I would readily agree that it should only be a controlling board. Again, if this question of dual powers became a stumbling block in the profession reaching an agreement, I would suggest that, rather than have no board, or co-ordinated control at all, it would be better to give way on the operating question and carry through as a united profession the proposal for an electricity board with controlling powers only. That would be a very great advance on our present position. Before we do this, however, let us consider whether the interests of present undertakers cannot be properly safeguarded in the Act of Parliament by which the board would be created, and which would form its charter. I believe this can be done without great difficulty, and the board prevented from operating in competition with any existing undertaking in that undertaking's area. If any existing or future undertaking is operating satisfactorily in its specified area, then the board would have no power to compete nor would there be anything gained by its so doing. If, however, any undertaking was misusing or abusing its powers it would be the Board's duty to represent the matter to Parliament with a view to having the powers transferred to another undertaker or to the Board itself. If the Board had no operating powers would it not be a very serious loss to the present undertakers? For example, the interconnecting network between power stations, or the provision and maintenance of certain bulk supply mains might readily and economically be dealt with by the Board. Then the question of a supply in agricultural districts, are they to be left without a supply if no undertaker can be found to work them? Again, the important national question of the conservation of fuel, if present undertakers are not prepared to lead the way with experiments on gas-fired boilers and the production of by-products on a large scale, is the Board's power to be restricted to prevent its acting as a pioneer? Then it is readily conceivable that in some cases the Board might act as co-operators (with companies or municipalities) to the advantage of all parties, for with their powers of raising money at low rates of interest, they could bring important financial support to play in assisting development. I would, therefore, urge that before we summarily dismiss the question of the Board's having operating as well as controlling powers we should carefully investigate and consider whether the difficulty cannot be overcome by fully safeguarding the interests of present or future undertakers without depriving the Board of powers which would be very valuable to the industry, but which powers it might be exceedingly difficult to obtain once the Board is established. We are all agreed that the electricity supply industry has suffered from legislation. One object of this scheme is to remove some of the difficulties and make the path of development easier. There is no doubt that an electricity Board properly constituted would be a

great advantage. Co-ordination of control would make for progress, and it is most desirable in the public interests that there should be a body responsible for the control of this great public service. The Board would be responsible to Parliament. If any additional link to Parliament than the Parliamentary member of the Board is desired there could also be an additional member, say, a Government official representing the various Government Departments. It should be remembered that the Parliamentary member of the Board will have to answer questions put to him by any member of Parliament respecting the operations of the Board. Thus any person, Corporation or public body can, through the member of Parliament representing their district, make their voices heard. The asking of questions in Parliament is a more important factor in Parliamentary control than is generally realised. I think the inclusion of a Member of Parliament on the Electricity Board supplies the need Mr. Highfield has in mind in raising the question of who the Board will be responsible to. Though I have indicated the possible addition of a Government official I do not think this is necessary and would prefer to see the Board without. We want the powers and authority of a quasi-Government Department with great freedom of action within certain clearly defined limits.

Mr. Faraday Proctor's support of the scheme and his energetic demand to "get a move on" and to get the proposed Board formed has the backing of a large number of electrical engineers. Things move quickly in these days and it is no time for discussing academic trifles while the main chance is slipping away. There is a call for action, for achievement and the sooner we, as a united profession, make our demands known and felt the sooner we shall commence a new era in electricity supply. Mr. Faraday Proctor referred to our problems also as those of the chemist and others, and that we must all get together to work for the common good. I would suggest that if we are to make an early advance we shall be wise not to widen the scope of our inquiry. Once the Board is established there are limitless possibilities open to it, but they are for the future rather than the present. I would suggest that we keep out of our thoughts any proposal with the word "Ministry" in it, for that involves political questions and Government Department methods which we desire to avoid. Also it would at once create difficulties as additional Ministries are rightly not welcomed by the powers that be. The points raised by Mr. W. B. Woodhouse and Mr. C. H. Wordingham have been mainly dealt with in the replies to other speakers. The more we can raise the interest of our colleagues and the public in this very important subject the more we shall advance our cause. I beg to thank Mr. Wordingham for calling attention to my independent point of view because I know however willing or desirous one may be of taking a detached view of this problem, this is exceedingly difficult if one is attached to either a municipality or company undertaking. I am in full agreement with Mr. Wordingham that it is important to avoid Government operation in electricity supply. It is for this reason I propose a non-Government Board with only a Parliamentary member to link the Board up with Parliament. But while deprecating Government operation I submit that Parliament would never put extensive powers into the hands of any other organisation than a Government Department or a Public Board. For this reason and after much consideration I propose the Board with controlling powers and preferably also with limited operating powers. I am glad Mr. W. L. Madgen has criticised the operations of the Ontario Hydro-Electric Commission, and it would be well if our Canadian colleagues can throw some light on this subject. Any mistakes made by others in dealing with similar problems we must avoid in our proposals. THE ELECTRICIAN recently contained an abstract of Paper read by Mr. C. H. Mitchell before the International Engineering Congress, San Francisco, in which he states "The entire success (of the Ontario Hydro-Electric Power Commission) as a commercial system, as an engineering work and as a popular undertaking has entirely vindicated the situation. The municipalities originally included in the power agreements numbered 15 in 1910; on February 28, 1915, this number had increased to 82." May I emphasise here that I am absolutely and unreservedly opposed to anything which would deal unfairly with existing concerns or crush enterprise. I consider Mr. Rolls' contribution to the discussion is of great value. Speaking of a large and important section of the profession who will be a controlling factor in the success or failure of the scheme, he admits that there is little doubt in the minds of most electrical engineers as to what ought to be done. Can we expect them to advance these schemes he asks when it is not clear to them that it will not be against their self-interests. I have very great sympathy with and respect for the interests to which Mr. Rolls refers and for his candid statement of the facts. In evolving the scheme proposed I not only kept the interests of these gentlemen in view, but also those of all sections of the profession. I knew it was useless to bring forward a scheme which could not be supported by electrical engineers while remaining loyal to their own interests and those they represent. In order to ensure that engineers of smaller undertakings shall not suffer we could include a clause in the proposed Act of Parliament to protect them. Not that I consider this to be necessary, for instead of decreasing the value of their positions I am satisfied that with extended areas for distribution and an increased demand due to lower costs, the importance of their undertakings would be much greater than at present. With the transition period proposed the change from the old to the new conditions would be brought about without any disorganisation or questions being raised of engineers losing their appointments. It must be remembered that engineers of the undertakings whose generating stations would ultimately be replaced by transforming stations would have powerful and sympathetic support in the Electricity Board, and it is reasonably to be expected that their positions would be strengthened and improved under the scheme. I welcome Mr. Rolls' suggestion of endeavouring to bring into the scheme those smaller stations, which would not form part of the ultimate scheme, in order to avoid the opposition of the electrical engineers and municipal committees or supply companies controlling these. I propose this might be done in the following manner. Assuming a number of small towns in any district will be supplied by one large station in the final scheme, there is no reason why the necessary capital should not be subscribed by these Town Councils or companies, and the large stations built and worked jointly by the electrical engineer of the towns concerned. Thus, during the transition period as the small stations were gradually changing from generating stations to transforming and distributing centres the large station would be growing rapidly and the borough or company's electrical engineers would be transferring their generating interests from one small station to one large joint station. I would very much like to see the power companies brought into such joint action, and this is where I consider the electrical engineer managers of the Electricity Board would be very valuable in acting as an intermediary or independent centre for co-ordinating the common interests of any district and enabling such joint schemes to be brought about. The new Electricity supply era would create such a large demand and extension of electrical operation that consulting and supply engineers, manufacturers and all connected with the electrical profession and industry would find more openings and engineers' status would improve and their services would be at a premium. This home demand would react favourably on exports, and there is more to be gained for the profession and electrical industries in the solution of this cheap supply problem at home than in any other way. But let us consider the alternative and presume for a moment that we are not going to work together to solve the supply problem. What will the position probably be? In the trade depression which it is generally agreed will sooner or later follow the war, accompanied by a dearth of capital for all but the most promising and reliable investments, we shall experience a considerable setback in the electrical industries because the inducements we shall have to offer will not be sufficiently great to attract the necessary capital for extending electric operation and for carrying out improvements in many directions. Thus when the slump comes we may expect the electrical industries to be badly affected. If we have taken advantage of the period of the war and that which will follow when a boom in trade may be expected before the slump comes, to organise and give electricity at low cost then we may hope that the inducements to electric operation will be so great that the very need for economy will draw capital to electrical work to the advantage of the industry and the country in general, for the more efficiently and economically we can organise the sooner the period of trade depression will be over. I desire to thank the members and those who took part in the discussion for their sympathetic consideration of the Paper. The strong line of argument in favour of a scheme was agreed to be: (*a*) Interconnection of power stations necessary for security of supply; (*b*) the necessity for reducing costs; (*c*) the conservation of fuel; (*d*) the co-ordination of control to assist in and encourage development.

MANCHESTER DISCUSSION.

Mr. Robertson states "the bulk supply undertaking would be owned and operated by the State through a central board." The Paper states in the summary: "It should be clearly understood that our proposed scheme is not for the nationalisation of our electric supply, nor is it for the municipalisation of that supply. Its true function is the co-ordination into one body of the control of the electricity supply, assisting existing undertakings whether municipal or company owned, and taking upon itself only those functions of generation and distribution which are essential to the furtherance of wise development and a supply at the lowest cost . . . guiding future policy and co-operating with the present authorities for the well-being of the whole." Again, the Paper does not suggest that the country is to be divided into six districts for supply purposes, but for the purposes of *control* under the central board, which is an entirely different matter. I cannot agree that the "stages to be passed and the difficulties to be overcome" have been "overlooked in the Paper." Such stages and difficulties have been most carefully considered and the proposals in the Paper are the outcome though the lengthy route by which the conclusions were reached has not been given. There is no suggestion in the Paper to set aside the technical difficulties. The chief reason for the presence of six expert highly-paid electrical engineers on the central board is to assist in solving those difficulties. It is certainly not proposed in the Paper to place the control of any one of the six districts in the hands of one engineer manager. The control of the electricity supply of any district would come under the board as a whole. The true functions of each engineer manager would be: (i.) To be a technical member of the central board: (ii.) to represent the central board in one district; (iii.) to represent the electrical interests of that district on the board; (iv.) to manager in his district such parts of the electricity supply as are the property of the board. Thus, as an individual, he would manage only board property in that district, and not the property of municipalities, companies or subsidiary boards. On the operative side he would be responsible to the board for managing the board's own property. On the control side he would be responsible for seeing that the board's decisions were made effective in his district, and conversely for representing to the board for their consideration problems arising in his district. There would be nothing to prevent any person, company or body in that district presenting its case direct to the board if so desired. The electrical engineer manager could also act as an intermediary for any joint efforts in his district, and as an independent co-ordinating centre for such efforts.

Mr. Robertson mentions the failure of power companies to offer such terms as will cover, amongst other items, the standing charges on *super-*

seded generating plant. One aim in my proposed scheme is to avoid such charges by not replacing or superseding the smaller generating plant until it has fulfilled its economic purpose. That is to say, such plant would not be superseded by a bulk supply until the cost of such supply would be less than running the plant plus meeting any then remaining standing charges. This is important. Mr. Robertson states "the central board would have no power to compel a local authority to shut down its generating station or to fix the price which the existing authorities are to charge for current." This was purposely omitted. We do not wish to impose restrictions where they can be avoided. The board can withhold its approval for extensions or the replacement of obsolete plant unless it is satisfied it is in the interest of that town or district that this shall be given. This surely will have all the necessary effect. The price of current within the limits laid down in any district is mainly a local question. The board could bring pressure to bear on any undertaking that was unreasonably using its powers either by running stations which could be more economically replaced by a bulk supply, charging higher rates than necessary, or by paying an undue percentage to the relief of the town rates. Our object would not be defeated by leaving municipalities the liberty I propose; on the other hand, I consider that if we suggest giving the central board power over municipalities on these points we shall raise opposition to our scheme where we hope to gain strong support. This view is supported by Mr. Mackenzie and other speakers. I have dealt with the foregoing points in some detail, as it is essential in our discussion to keep all proposals and the general issues very definite and clear. I cordially disagree with Mr. Robertson that "the present is not an opportune time for central station engineers to discuss questions of this magnitude." If ever there was a time in the affairs of electricity supply which taken at the flood would lead on to success, it is the present. Nay, I would even go further, and say that I fear there will be a time, sooner or later, after the war, when conditions are less plastic than they are now, and when there may not be that atmosphere of compromise and co-operation, when the realisation of some such scheme as that proposed will be infinitely more difficult than at present. I submit the early solution of the problem lies with the profession itself, and that the early solution of the problem lies with the profession once we can make up our minds and bring forward a concise rational scheme on which we are all agreed we shall have overcome the greatest obstacles, and be well on the road to success. Electrical engineers' contribution to the alleviation of after-war distress and to the rebuilding of the social and industrial fabric would surely be a noble one if it went no further than placing the electricity supply for the country as a whole on a satisfactory basis.

It is with great pleasure I turn to a section of Mr. Robertson's remarks with which generally I am in hearty agreement—viz., his proposal for local or subsidiary boards. I consider such local boards would be an outcome of the larger scheme which would be an important factor in enabling the local boards to be formed. The services of the electrical engineer managers in their different districts would be valuable in this respect. From my knowledge of the "official mind" I believe the formation of the central board, and with it the larger scheme, would be attained far more readily in the first place than that of a number of local boards. The Paper refers to Mr. Bonar Law's remark in this respect: "I hope (they) will realise that the war has made a great difference, that it has made everything plastic, that things which were impossible before are easy now, and that *above all* it may be found that a *big step* is not more difficult than a small one." The penultimate paragraph under "VII. Summary" of the Paper foreshadows a method of development on the lines proposed by Mr. Robertson. I believe the establishment of the central board would be the beginning of many developments and would earnestly deprecate any proposal for postponing the consideration of the problem for the country as a whole, so far as the central organisation is concerned. Without the central board large districts would be left uncared for and unconsidered, and the interconnection of one large industrial area with another, which will be so advantageous, will hardly be possible. How, without this central board could we ensure the carrying out, as advocated by Mr. Robertson, of that "taking care only to make extensions or adopt methods which can be worked into the larger scheme when the time is ripe for it?" Under the scheme as proposed in the Paper there is nothing which will prevent the London County Council, any municipality or any power or supply company, from energetically prosecuting its developments, and it is probable the formation of the central board will enable that combination of public and private ownership, advocated by many engineers as a solution to the problem, to be brought about. I, for one, should not be satisfied with the scheme if it discouraged private and municipal enterprise, and I am sure that electrical engineers would be glad to see the success of those large power companies which have been working to advance electricity supply. I hope the Paper does not convey the idea that I propose to disregard the past history of electricity supply, for I agree with Mr. Highfield that to do this would be a mistake. The intention was to call attention to the new needs of our country, and that because many engineers had publicly advocated certain lines of policy in the past the new conditions called us to consider the subject from present needs rather than for defending our past proposals. To take only one outside illustration of the change I refer to many pre-war determined free-traders are now advocates of a limited tariff, and consider it unnecessary to defend their change of opinion. Mr. Highfield calls attention to an important matter—viz., that in many cases the periods of operation of supply companies after which they can be bought out by municipalities will soon be drawing to a close. I think it is desirable that at no distant date it should be made necessary for such municipalities to settle their policies, so that there will not be a period of uncertainty of further tenure which has undoubtedly hampered electrical development. I believe the proposed electricity board would be very helpful in this connection, also that there would be greater probability of the companies getting considerably extended periods under the board. In other words, the board being mainly a technical and financial board, would appreciate the problems to be met by companies and would probably discourage the taking over of companies' powers by municipalities so long as the interest of the municipality for a cheap supply of electricity were safeguarded. I think there would not be great difficulty in arranging for the control of any local boards by the central board, and this gives an added value to the central board. The central board itself would be responsible to Parliament as explained in the reply to the discussion in London, which also deals with the remaining points raised by Mr. Highfield at Manchester. Ald. Walker considers the cost of a site for a power station is "quite immaterial." I venture to suggest that no item of cost is immaterial. Other things being equal, the cost of a site is important, not only because very large sites will be required for the high-power stations of the future, particularly if the recovery of the by-products of coal is part of their operations, but also because we hope that industries requiring enormous supplies of electrical energy will grow up round the power stations. With this exception I am glad to see Ald. Walker approves of the scheme.

Mr. Scott asks if the members of the central board are to be paid, and strongly advocates professional as against amateur boards. In introducing the Paper in London I stated that the members of the board should be in receipt of salaries of not less than £2,500 per annum. All the members of the board, with the exception of the president, would be expected to devote the whole of their time to the work of the board. The vice-president of the board would be one of the electrical engineer managers, and, as kindly suggested to me by Mr. Sparks, the centralisation would be in the president and not the secretary, as shown in the proof of the Paper. In Mr. Scott's argument that we should realise the importance of electricity in electro-chemistry and metallurgy, and adopt a wide outlook and bold policy I find much support for the proposals made in the Paper. It has been stated that these proposals are too far-reaching; I think not. The expansion of electricity supply and operation during the next two or three decades will largely depend on the capacity of electrical engineers for cultivating clearness and breadth of vision and right and prompt decision. Success should be assured if our financial arrangements are made with wisdom and discretion, and our dealings with the interests of others governed by a sympathetic understanding. I thank Mr. Rolls for his remarks on the Paper and proposed scheme. If opposition is raised by the Home Office, Board of Trade and Local Government Board it will have to be met, though it does not follow that officials now engaged on electrical questions would not be equally well treated and, perhaps, find greater scope if working under the board to which they presumably would be transferred. However, if such opposition became insuperable I would suggest proceeding with the board with whatever powers we succeeded in obtaining for it. The first and most important point is to get the board established—the expansion of its powers would follow later. Where the remarks of any gentleman have not been replied to it will be generally found that the replies to other speakers cover the points raised.

In the discussion in both London and Manchester I have noted a tendency to get away from the central theme and embrace a large number of what may be called subsidiary (though important) subjects. It may interest members to know that during the years I have had this subject under consideration and the many times parts of it have been written and rewritten these subsidiary matters have been introduced and again deleted or modified for this reason—that their inclusion would create controversy, delay achievement, and attract attention from the essentials. Valuable and important as many of these side issues are, my opinion is confirmed as stated in the Paper, that "whilst the whole subject requires to be handled in a complete and comprehensive manner, yet it is most desirable to keep in mind the main issues and not to introduce various questions and complications with which it will be the business of the electricity board to deal with . . . by keeping the subject on concise and clear lines, and dealing with it in a businesslike manner we shall more readily attain our end."

In conclusion, and referring to the discussions in both London and Manchester, the agreement that something should be done somewhat on the lines suggested, is more general than anticipated. This augurs well for the future. The time is ripe for re-organisation and advancement. The influences which make for compromise and definite achievement are in our favour. This being so the profession will heartily welcome any energetic and progressive action the Council of the Institution of Electrical Engineers may decide to take.

PHOTOMETRY OF THE GAS-FILLED LAMP.*

BY G. W. MIDDLEKAUFF AND J. F. SKOGLAND.

Summary.—The new high efficiency gas-filled lamps introduce variables not hitherto encountered in photometry. These difficulties are referred to in the Paper, and the results of tests are shown in the curves.

The authors refer to previous experimental work which led to the discovery of unexpected variables.

New Variables and Photometric Difficulties.

In the gas-filled lamp the filament is coiled into the form of a closely-wound spiral or helix, the diameter of which, though small, is large in comparison with the filament itself. Hence, as viewed

* Abstracted from the Scientific Papers of the Bureau of Standards.

from certain directions perpendicular to the axis of the lamp, one section of this helical filament may, more or less completely, cut off the light from another section. In addition to this cause of irregularity in the light distribution, there is usually a lack of symmetry in the arrangement of the filament as a whole about the vertical axis of the lamp. Consequently the light on the photometer screen flickers excessively when the lamp is rotated at ordinary speeds. Fortunately, this difficulty is readily overcome by placing at the back of the lamp two mirrors inclined to each other so that the photometer screen is illuminated simultaneously by the direct light from the lamp and the reflected light from the mirrors. With this arrangement very low speeds of rotation may be used.

Although this expedient obviates the flicker difficulty, it does not eliminate the most serious trouble caused by rotation. It was found that at constant voltage both current and candle-power have

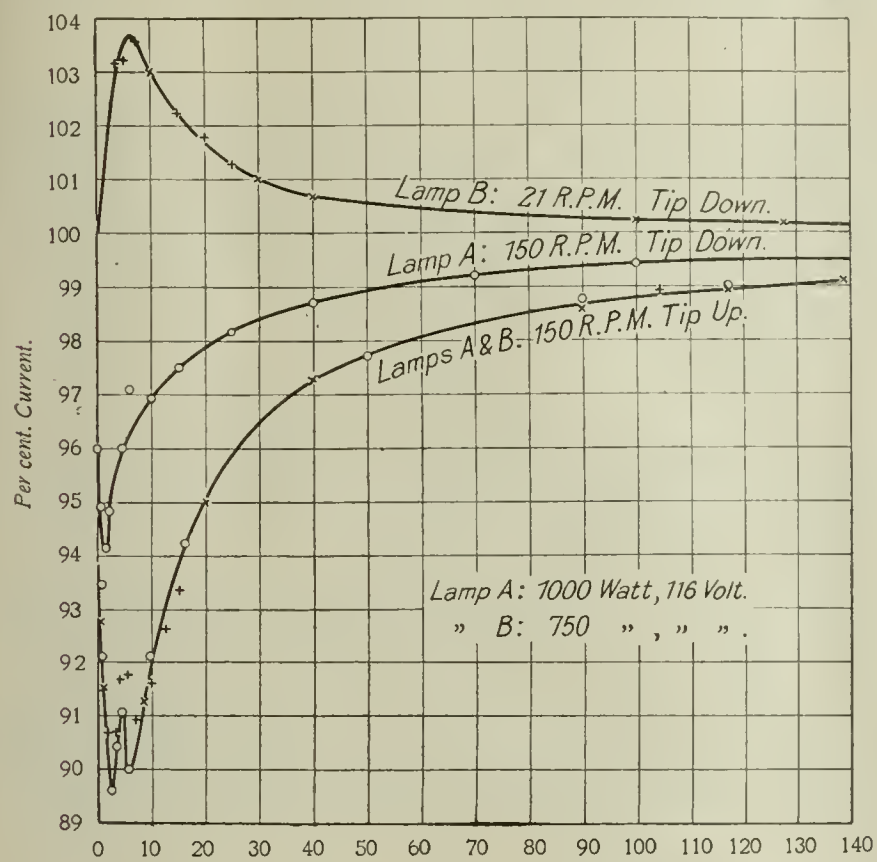


Fig. 1.—Ratio of Current with Lamp Rotating at Constant Speed to Current with Lamp Stationary.

different values when the lamp is rotating than when it is stationary, the current changing in one direction and the candle-power always in the opposite direction. In other words, there is a change in the operating efficiency of the lamp, although the voltage remains the same. It was found, further, that the values of current and candle-power may be either increased or decreased by rotation, depending upon the speed, and by amounts sufficiently great to affect seriously the result of candle-power and efficiency determinations.

Experimental Investigation of the Variables.

The lamps used in the principal experiments described below were of the nitrogen-filled 450-watt series and 750-watt and 1,000-watt multiple types, all having round bulbs with the filaments centrally mounted.

Measurements of voltage and current were made simultaneously by means of two potentiometers. The rotator was supplied with mercury-cup connections and two sockets, so that the lamp could be mounted either tip up or tip down. The rotating mechanism was under perfect control at every speed, which was determined by a specially designed indicator, and the current to the lamp was supplied from a storage battery, thus ensuring perfectly steady working conditions. In the candle-power measurements use was made of the two-mirror arrangement described above.

A few rough preliminary tests indicated that for any change in speed the percentage change in candle-power was at least several times the percentage change in current, but always in the opposite direction. As current can be measured with considerably higher accuracy than candle-power, such measurements furnish a convenient method of determining approximately the variation of the candle-power. It was, therefore, decided that before making careful determinations of candle-power it would be advisable to make a series of measurements of voltage, current and speed, varying only one of these quantities at a time.

Current Variation at Constant Speed with Different Voltages.

The next step taken was to determine with great care the changes in current due to rotation at a specified speed at different values of voltage through a wide range. This test was applied to two lamps, the 750-watt lamp mentioned above and a 1,000-watt lamp, both rated at 116 volts. Readings of current corresponding to a chosen voltage were first made with the lamp stationary, then with it rotating at a speed of 150 revs. per min. In this way the changes in current for each lamp at different voltages over a range from 0·5 volt to 100 volts were obtained.

The results for both lamps rotated tip up are shown by the lowest curve of Fig. 1, values obtained for the 750-watt lamp being represented by crosses and those for the 1,000-watt lamp by circles. The behaviour of the current in these two lamps is thus shown to be practically identical at every value of voltage except from 3 volts to 8 volts, which is a critical region. It is probable that, even within this region, these curves would be found to coincide also were measurements made at a sufficiently large number of neighbouring points. The upward indentation in the curve at this point is as real and reproducible as any other part of the curve.

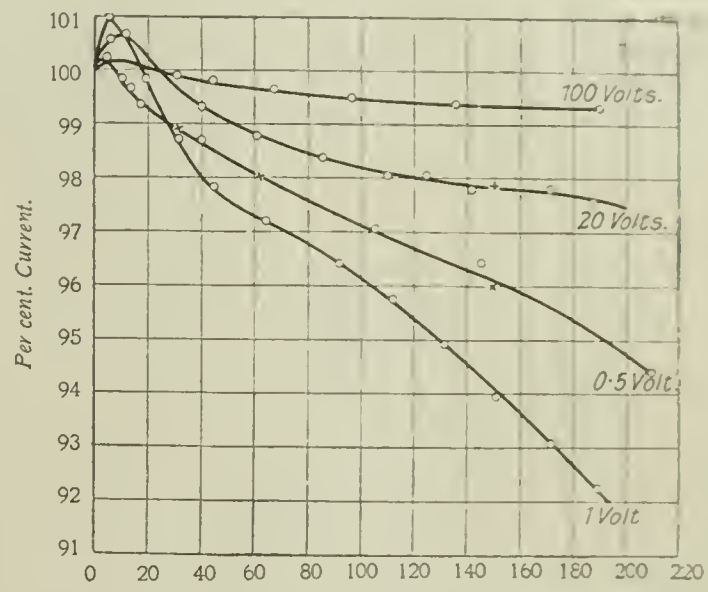


Fig. 2.—Ratio of Current with Lamp Rotating Tip Down at Different Speeds to Current with Lamp Stationary: Voltage Constant at Different Values.

Upon rotating these lamps tip down, it was found that for the same speed the percentage change in current for all voltages was only about half as great as when the lamps were rotating tip up. The values for the 1,000-watt lamp tip down are given by the middle curve of Fig. 1.

Current Variations at Constant Voltage with Different Speeds.

In order to investigate further the behaviour of the current in the critical region above mentioned, as well as at other points, measurements of current at constant voltage, with variable speed, in succession at different values of voltage were made on the 1,000-watt lamp through a considerable range extending as low as 0·5 volt. The speed was varied from 5 to 200 revs. per min., the lamp being rotated tip down. The results of this test are shown in Fig. 2. The important fact indicated by these curves is that, as the speed is increased from zero, the current, at constant voltage, first increases to a maximum and then decreases to the stationary value, and continues decreasing below the stationary value as the speed is further increased. (By stationary value is meant the value obtained with the lamp stationary.)

Upon carefully testing all available 450-watt to 1,000-watt lamps, including both series and multiple types in round bulbs, and one 750-watt lamp in a straight-side bulb, it was found that in every lamp while rotating with the tip down the current at constant voltage returned to the stationary value at a speed between 33 and 40 revs. per min. This held true through a considerable range of voltage, extending above and below the normal or rated value.

Although there was a considerable difference in the speeds required for lamps having different numbers of loops in the filament, it was possible to find for every lamp tested a particular speed at which the current returned to the stationary value, the speed being in every case such as can be used in practice.

Voltage Variation at Constant Current with Different Speeds.

The effect of rotation on voltage was determined by testing a few of the 450-watt lamps tip down with the current held constant at 6·6 amperes and the speed varied over a wide range, beginning at 5 revs. per min. as the lower limit. For every lamp it was found that, as the speed was increased from zero, the voltage first decreased to a minimum and then increased to the stationary value, and continued increasing above the stationary value as the speed was further increased. In other words, the effect of rotation upon the voltage at constant current was opposite in sign to the effect upon the current in the same lamps at constant voltage.

Candle-power Variation at Constant Voltage with Different Speeds.

The effect of rotation on candle-power was very strikingly shown by the following experiment: The voltage was so adjusted that the filament when stationary was just visible in a darkened room. Upon rotating the lamp at a speed of about 180 revs. per min. it was found that, although the current decreased in value, the intensity of the light largely increased, the effect being greater with the tip up than with the tip down, thus corroborating the preliminary measurements of current and candle-power at higher voltages. With the lamp in either position and either rotating or stationary, the upper loops of the filament glowed more brightly than the lower ones, thereby indicating a considerable difference in temperature between closely neighbouring regions of the gas.

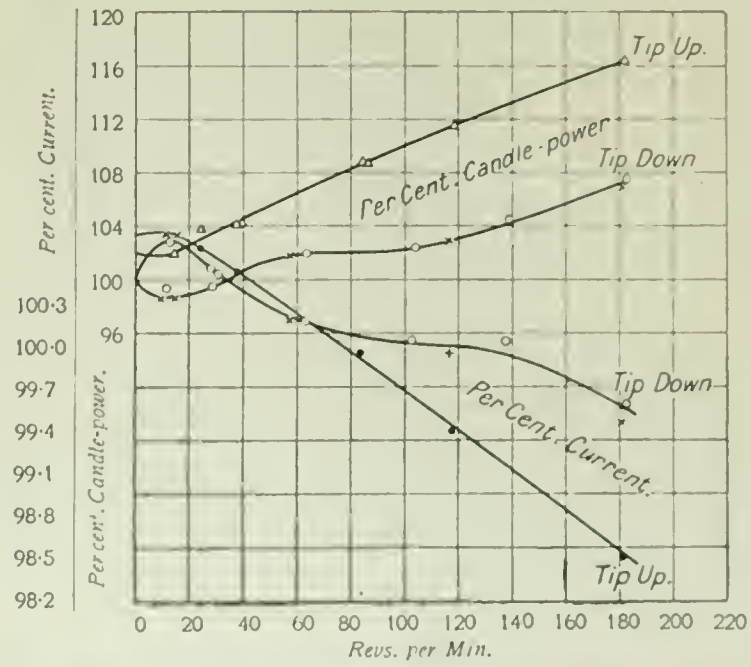


Fig. 3.—Ratio of Current and Candle-power with Lamp Rotating Tip Up, and also Tip Down, to Current and Candle-power respectively, with Lamp Stationary Tip Down.

Since there was a speed at which the power consumption was the same as when the lamp was stationary, it was considered probable that at this same speed the candle-power also would return to the stationary value. This led to a series of simultaneous measurements of current and relative values of the candle-power with voltage constant and speed varied over a wide range.

Results obtained in this way with the 750-watt lamp operated at 90 volts are shown by the curves of Fig. 3. All values of current and candle-power respectively are expressed in percentages of the value of each obtained with the lamp stationary and the tip down. In determining the candle-power with the lamp stationary, readings were taken at intervals of 7·5 deg. about the vertical axis, there being a total of 48 determinations.

Law of the Variations.

The results of these experiments may be summarised as follows, in which the voltage is to be regarded as constant:—

1. With the lamp stationary, both current and candle-power have higher values when the lamp is mounted tip up than when it is mounted tip down.

2. Rotation of the lamp causes both current and candle-power to change in value but in opposite directions, the change in both being about twice as great when the tip is up as when it is down.

3. As the speed is increased from zero the current first increases to a maximum and then returns to the value it has when the lamp is stationary, and continues decreasing below this value as the speed is further increased. The candle-power varies in the opposite direction.

4. For each position of the lamp there is a particular speed at which both current and candle-power have each the same value as when the lamp is stationary, the speed at which this occurs being practically the same for all lamps having the same number of loops in the filament. For lamps having different forms of filament mounting the speed for the above condition varies from lamp to lamp, being highest for those having the smallest number of loops.

Two Photometric Methods.

For groups of lamps having the same form of mounting, and therefore the same reduction factor, the method of rotation is perfectly satisfactory in determining relative candle-power and efficiency ratings, and practically the same speed may be used for all lamps of the group. However, this method pre-supposes a knowledge of the reduction factor, which for gas-filled lamps in general, as now made in the present more or less experimental stage of manufacture, varies considerably from lamp to lamp, principally on account of the great variety of methods of mounting the filament.

Total Flux Method.

For the determination of the voltage-current-candle-power characteristics the sphere has no particular advantage over the method of rotation, and has the possible disadvantage in that, if the coating of the sphere is not perfectly non-selective, the ratio of the candle-power at different voltages may be more or less affected by a change in the absorption of the light at the different colours.

Then follows a discussion of the possible errors and a subsidiary investigation of the causes of the phenomena.

A Probable Explanation of the Cause of the Variations Observed.

The results of the above tests show quite conclusively that practically the whole of the effect observed in the change in current, candle-power and specific consumption arises from a change in the convection currents of the gas within the bulb.

When the lamp is stationary there is a considerable difference in temperature between the gas at the top and bottom of the bulb. Very low speeds of rotation disturb the steady current of hot gas which is rising in the centre and flowing down at a distance from the axis. The result is an increase in heat convection by the gas, and consequently a lowering of the temperature of the filament. As the filament has a positive temperature-resistance coefficient, the resistance decreases, and consequently the current increases at constant voltage. At high values of voltage the mean temperature of the gas is higher than at low voltage, consequently the temperature of the filament is reduced in a lesser degree by rotation, and the change in current, though positive, is less at high than at low voltage.

On the other hand, when the lamp is rotated at high speeds the cooler gas at the bottom of the bulb is thrown out by centrifugal force, which varies as the square of the speed, and the hot gas tends to remain near the centre, thus considerably retarding the convection currents which cool the filament. The result is an increase in the resistance of the filament as a whole and a decrease in the value of the current. At high voltages the mean temperature of the gas is higher than at low voltage, and the retarding effect due to centrifugal force is decreased; hence the change in current due to rotation is less than at low voltages.

ARCS IN GASES BETWEEN NON-VAPOURISING ELECTRODES.*

BY G. M. J. MACKAY AND C. V. FERGUSON.

By using tungsten electrodes it has been found possible to construct arcs carrying 10 to 20 amperes which will act as rectifiers of alternating current, besides having a life of many hundreds of hours. In the nitrogen-filled lamp, which operates at about 2,800°K. and the vapour pressure is 3×10^{-5} mm. approximately, the loss of tungsten seems extremely small, and is accounted for by its evaporation at the high temperature. It appears also that tungsten is carried in the arc stream from anode to cathode.

In Fig. 1 there is shown the volt-ampere characteristic for an arc in hydrogen, and it will be noticed there is an unstable portion at A, where the discharge changes from an almost invisible glow to a very concentrated arc discharge. Other gases, such as nitrogen and argon, do not show such well-defined points of instability. Although thin the arc is clearly defined and its power consumption very high, an arc 1 mm. long and 0·5 mm. diameter taking 700 watts and operating at 25 amperes and 28 volts. This power consumption is probably due to the dissociation of the material into atoms.

Rapid evaporation of the substance does not appear to affect the characteristics of the arc in any way, and spectroscopic examination

* Abstract of an article in the "Journal" of the Franklin Institute.

of various arcs show that in many cases it forms none of the conducting mechanism. Heating the cathode reduces the voltage necessary to start an arc; an arc in hydrogen 1 mm. long will start

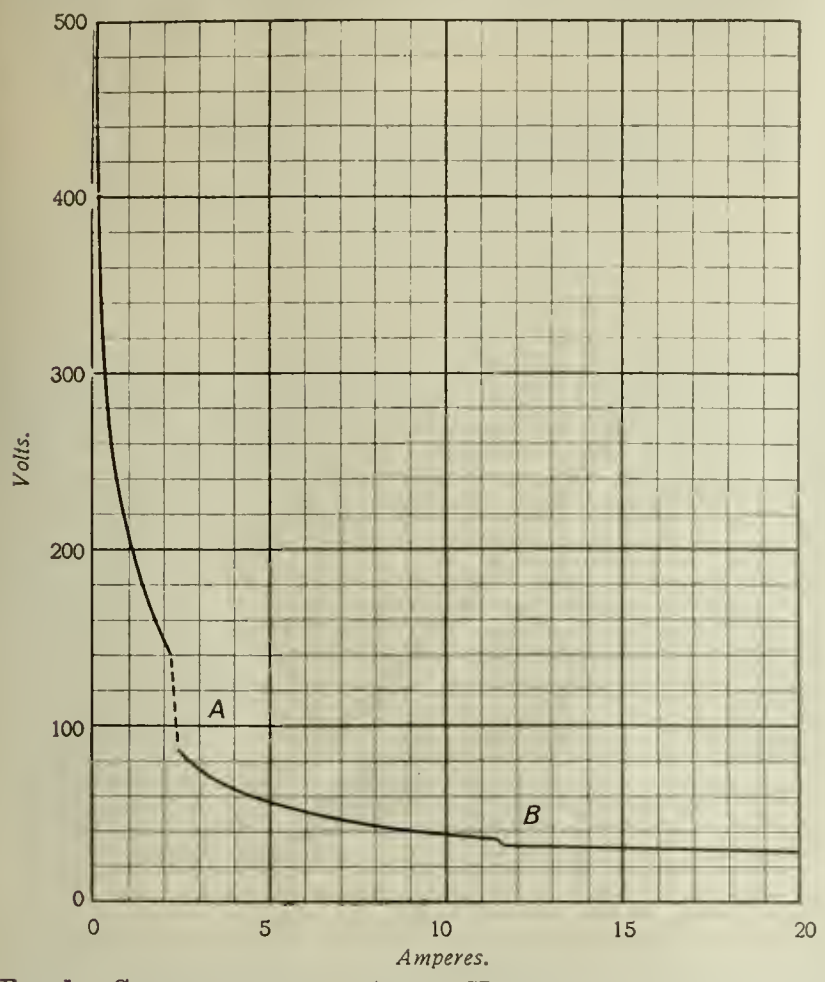


Fig. 1.—Characteristic of Arc in Hydrogen at 400 mm. Pressure between Tungsten Electrodes 1 mm. apart.

with a heated cathode in 400 volts, whereas, if cold, it requires something like 4,000 volts.

The wave shapes in the figure show that the voltage necessary to start the arc from the hot cathode is no greater than the fall of

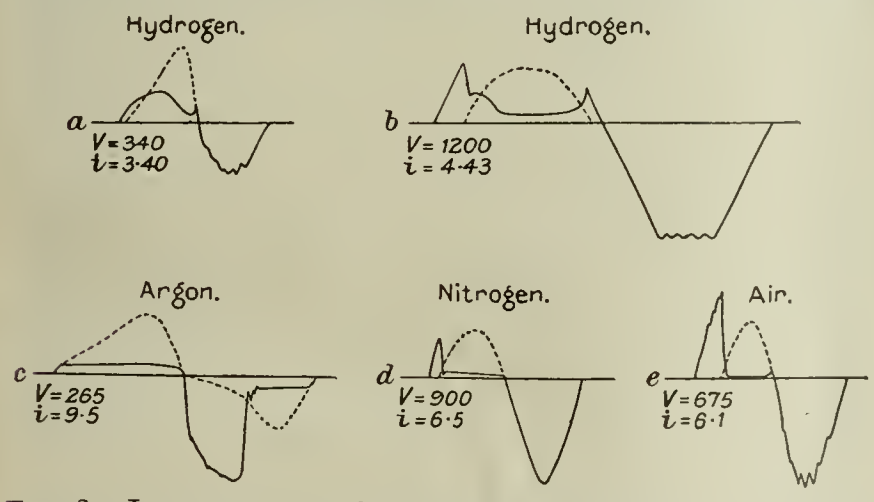


Fig. 2.—Instantaneous (60 cycle) Characteristics of Arcs in Different Gases. Effective Values of Volts and Amperes.

Volt ————. Ampere - - - - - -.

potential on the arc itself. Under suitable conditions all these arcs give complete rectification; but gases such as hydrogen rectifies well at high and low pressures, whereas argon works better at pressures less than 10 centimetres.

A METHOD OF EXHIBITING THE VELOCITY OF IODINE IONS IN SOLUTION.*

BY S. W. J. SMITH, M.A., D.Sc., F.R.S.

The apparatus is represented in the diagram. The containing vessel is a U-tube with widened ends as shown. The diameter of the tube may be about 0·5 cm. or less. The cross-section of the tube should be fairly uniform. Either 25 cm. or 50 cm. is a convenient (total) length for the tube if it is desired to use it in connection with an ordinary lighting circuit voltage of 100, or thereabouts, and to obtain a rapid estimate of the velocity of the ions. The electrodes (at A and B) are, preferably, of platinum foil. The liquids used are

* Abstract of Paper read before the Physical Society of London.

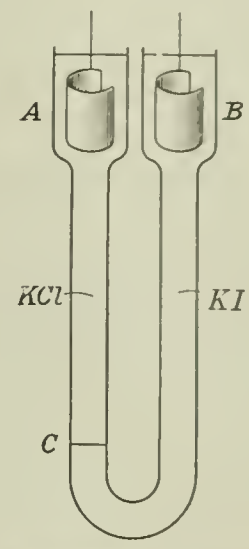
equally concentrated solutions, containing—*e.g.*, either 0·2 gm. or 0·1 gm. mol. per litre, of potassium chloride and potassium iodide respectively. The novelty of the experiment lies in the method of exhibiting the line of separation between the solutions. For this purpose a small quantity of mercuric chloride (corrosive sublimate) is dissolved along with the KCl. In the endeavour to maintain symmetry an equal quantity of the same salt may be added to the KI.

In this case a thin yellow disc of mercuric iodide, precipitated by the action of the KI upon the $HgCl_2$ contained by the KCl, will appear at the junction between the electrolytes.

When the line of separation has become well defined, the electrodes at A and B are connected to the source of supply, that at A being made the anode. The boundary at C immediately begins to move upwards. It travels as an extremely thin horizontal disc, which can be located very accurately and projected with ease. And the disc will move at speeds of the order of 1 mm. per minute, so that its motion can be followed without difficulty by a large audience, and an approximate estimate of its velocity can be obtained in a few minutes.

A table giving the results of an experiment then follows, and it is remarked that the possibility of observing the reverse motion of the ions is due to the yellow coloration produced by chlorine ions which decompose a fraction of KI.

The solutions (as in the previous case) contained 0·2 gm. mol. per litre. The following are the results of an experiment made to obtain an estimate of velocity under the potential gradient of 1 volt per centimetre at a definite temperature. The distance traversed by the line of separation during the first half hour of the experiment (measured by means of a small cathetometer) was 4·13 cm. The distance traversed in the second half hour was 4·53 cm. The difference was



Arrangement of Apparatus.

probably due mainly to a higher mean temperature in the second half of the experiment. On this occasion an ammeter was included in the circuit. The reading rose slowly during the observations. Its mean value during the hour was 0·03 ampere. The specific resistances of the electrolytes were measured at 10°C. (the temperature of the room) just before the tube was filled. The mean value was approximately 55 cm. ohms. The value of the current immediately after the circuit was completed was 0·023 ampere. The area of cross-section of the tube was about 0·31 sq. cm. Hence the initial potential gradient in the tube was approximately 4·1 volts per centimetre, and the velocity of the anions, iodine and chlorine, as determined in this way, is about 0·00059 at 25°C. in cm. per sec. per volt per cm. If accurate and not rapid determinations were required much smaller potential gradients could be employed.

The author concludes by referring to the solutions used, and their conductivities and concentrations. It is also mentioned that a small quantity of $AgNO_3$ might be added to the KCl solution, and redissolving the precipitate by NH_4OH. The AgI formed during the experiment being insoluble in NH_4OH then acts as an indicator, and the progress of the ions may be watched as before. It is found, however, that this method is not so satisfactory as the one mentioned above.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from The Electrician Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Gli Strumenti per Misure Elettriche Industriali." By Ing. Dino Nobili. (Milano: Rivista Tecnica di Ellettricita.) Pp. 501.

"Elementary Applied Mechanics." By T. Alexander, C. E. and A. W. Thomson, D.Sc. (London: Macmillan & Co.) Pp. xx. + 512. 15s. net.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City 4698 & 4699. *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed* "*Coutts & Co.*"
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm. D.Sc. *Nearly Ready.*

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 8d. nett.

INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.

ELECTRICITY METERS : THEIR CONSTRUCTION AND MANAGEMENT. By C. H. W. Gerhardt. Profusely Illustrated. Price 9s. nett. [Price 10s. 6d.

MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.

SIGNALLING ACROSS SPACE WITHOUT WIRES : THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.

BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By C. M. Baines. Price 7s. 6d. nett.

THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol. I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.

THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. *New Edition.* Bound cloth, 2s. 6d. nett, post free 2s. 9d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone 9s. nett, post free 9s. 4d.

STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett

ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S Heather, M.I.E.E. 9s. nett.

AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.

WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.

ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.

LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s 10d.

ELECTRIC BLASTING APPARATUS AND EXPLOSIVES : With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.

THE SHOT-FIRER'S GUIDE : A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.

ENTIRELY NEW BOOK.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s** nett, post free.

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

THE ARCHITECT IN RELATION TO ELECTRIC LIGHTING.

It has been a common complaint that the architect has usually constructed his buildings, quite irrespective of the requirements of the electrical contractor. Perhaps it is only natural that this should be the case. The architect is largely concerned with art, even though this may be of the kind that has been debased by utilitarian needs, so that very little art in many cases remains, and, therefore, he is liable to put aside the requirements of special trades. It is true that in the larger buildings special provision is usually made for the running of pipes for the supply of water, for steam heating and possibly for ventilation. But as a rule the electric conduits are left to take their chance.

It might be thought that these reflections were only applicable some years ago. This, however, is by no means the case. In fact it may be said that the requirements of electric wiring are even more neglected at the present day than they were some 20 years ago, though it must be admitted that the neglect now is more in matters of detail. Perhaps this is because electricity is carried in less obvious fashion than gas or water, and the wiring contractor is supposed not to require any special facilities. Be that as it may, the fact remains that methods now used in building construction make the work of the wireman much more difficult than formerly. As an example, we may take the cellular form of floor construction which is frequently used in fireproof buildings. In such cases the thickness of material is not sufficient to permit the cutting of chases. And yet it may be that the floor is finished off in such a way that a chase would be the only reasonable method if circumstances would permit. Similarly, the plaster on such a ceiling gives but slight facility for the concealment of work.

Again, in the case of partitions, the older lath and plaster has given way to artificial slabs made of slag and similar materials. The thickness without the surface plaster is not much over 2 in., so that the cutting of chases becomes a somewhat delicate matter. There are also other cases in which the space available is insufficient for the concealment of conduit and where wood casing, as an alternative, is scarcely permissible. The only systems of wiring which lend themselves easily to such work are Henley's or Stannos. Of course, standard practice demands the use of screwed conduit, but where the difficulties we have mentioned above are encountered, steel conduit may necessitate the adoption of devices that are preferably avoided. What it amounts to is that surface work, on the one hand, is inadmissible for æsthetic reasons, and on the other hand it alone is permissible if standard practice is to be adopted.

The problems of illumination are also among those which the architect has generally omitted to consider to the extent they merit. Daylight illumination is essentially in the hands of the architect, but the efficiency of artificial illumination also often depends upon the architectural features.

It would be well, therefore, if the architect in his designs would bear in mind rather more the problems that he may unwittingly force upon the consultant, the wiring contractor or the illuminating engineer. A general knowledge of the principles underlying electric wiring and illumination should prevent some of these difficulties. We say a "general knowledge" because we do not think it necessary, or ex-

pedient, that the architect should attempt to know all the ins and outs of electrical work. Any such attempt might lead him into a false position. There is enough in architecture alone for one professional man to master, and he will find it best to leave the carrying out of electrical work to the electrical profession.

THE DETERMINATION OF THE DIMENSIONS OF COMMUTATORS.

BY THOMAS CARTER.

Summary.—The article shows how to develop an expression, simple in form, which denotes the watts lost in friction and brush contact drop on a commutator. After a short introduction (I.) and a discussion of relations between the physical constants concerned (II., III.), an elementary form of the expression is given (III.); then a more developed form is arrived at, applicable to slip-rings as well as to commutators (IV.). This is further discussed for commutators only (V.), and two final forms are given which show how the dimensions of a given type of commutator can be determined for a given output from the known characteristics of the brushes used, the permissible rise of temperature, and other specified quantities; and when the commutator dimensions are settled the brush dimensions can be settled also (V.). The effect on the length of a commutator of using various types of brushes is shown both in symbols and in curves, three widely-separated classes of brushes being considered (VI., VII.), and the results are illustrated by numerical examples (VIII.). After showing how to calculate from simple expressions the weight of copper and the weight of mica in any commutator (IX.), the article closes (X.) with a statement as to its scope.

I.

As a labour-saving device in a design office, a simple formula for determining the dimensions which a commutator must have in order to dissipate, without overheating, the losses inseparable from the collection of current is of great use, more especially for the purpose of estimating the cost of large machines. Small standardised machines generally have fixed commutator dimensions, sometimes ample, sometimes barely sufficient, according to the current to be carried; but in special cases, even in small machines, as when a very low voltage and high current generator is required for electrotyping or electrochemical work, the commutator size will have to be carefully considered. In getting out large and less rigidly standardised machines, however, it is worth while, owing to the weight of copper involved, to investigate separately each case for itself, and fix the dimensions to suit the circumstances of the output.

The formula about to be developed is merely a symbolic statement of the losses which occur as a consequence (*a*) of the motion of the revolving surface under the brush contact surface, and (*b*) of the passage of current from the revolving surface into the brush, or vice versa, through the contact surface. The loss in the brush itself is usually negligible in comparison with the contact loss. It is assumed that the current density in the brush contact surface is uniform, which is not always even approximately the case: the nature of the consequences of want of uniformity is indicated later. The cause of variable contact density, which occurs in a circumferential direction, is that commutation is not ideal, and the designer must allow for this according to his experience. In other words, a formula covering all variables cannot be put down; which is, perhaps, a blessing in disguise, as otherwise the art of designing would be reduced to the mechanical grinding out of results from fixed and unalterable premises, with no room for nice judgment, although it may be said, on the other side, also with no room for unpleasant surprises.

II.

The symbols used are as follows, the formula being made applicable to commutators or to slip-rings in its general form:—

A=Total area of all brushes used in any given case.
S=Peripheral speed in feet per minute of the revolving surface.
P=Pressure of brush on revolving surface in pounds per square inch.
μ=Coefficient of friction between brush and revolving surface.
C=Current per complete set of brushes on each electrical pole—*i.e.*, armature current, in a continuous-current machine; or, if the formula be used for slip-rings, current dealt with on each ring.
V=Drop in volts required to send C through each brush contact across which it passes.
Δ=Current density in amperes per square inch in brush contact surface, assumed uniform.
D=Diameter of revolving surface in inches.
L=Axial length of revolving surfaces in inches.
N=Revs. per min. of revolving surface.
q=Number of separate brush contacts across which C has to pass.
m=Ratio of axial length of revolving surface to axial length actually occupied by brushes.
p=Number of pairs of poles on a continuous-current machine, it being assumed that there is one row of brushes per magnetic pole, so that there are p rows in parallel per electrical pole, carrying C.
W=Width of each brush used, measured axially.
T=Thickness of each brush used, measured circumferentially.
B=Number of brushes in a row in a continuous-current machine.
K=A heating constant, being the rise in degrees Fahrenheit of the revolving surface above the temperature of the surrounding air for 1 watt loss per "equivalent square inch" of revolving surface.
R=Temperature rise in degrees Fahrenheit of the revolving surface above the temperature of the surrounding air, due to the total losses dissipated.

There are certain obvious relations between some of these symbols. C/Δ is the area required to carry the current at the density suitable for the selected type of brush. This area may be made up of a number of small areas in parallel, such as those of a row of brushes, or of p rows of brushes on a continuous-current armature. As the current C has to pass q times between the revolving surface and the brushes in any collecting arrangement, $A=qC/\Delta$.

q=2 for a continuous-current commutator.
=2 for single-phase slip-rings.
=2 for slip-rings of the revolving field of an alternator.
=3 for three-phase slip-rings.
=4 for four-wire two-phase slip-rings.
=6 for six-phase slip-rings.

For a three-wire two-phase system one ring carries $\sqrt{2}$ times as much current as each of the other two rings, and due allowance must be made for this in estimating q for such a case. If Δ be constant for the brushes on each ring, A will be correspondingly greater for the ring carrying the larger current than for each of the other two, so that q would be $2+\sqrt{2}$, or 3·414. This may involve a wider ring for the larger current, unless each ring is made capable of carrying the maximum, or unless the arrangement is such that heat transference between the rings is possible, owing to their radiating the losses as a whole, and not individually.

$S=\pi DN/12$; m depends on the type of brush holder used, being about 1·10 for clamped carbons, which can be set almost touching each other sideways, 1·16 for carbons in a box holding several side by side without a division, and 1·22 for carbons each in its own box type holder; that is to say, for a given available commutator length, the length of brush contact surface that can be employed is always less than L, and is $L/1{\cdot}10$, $L/1{\cdot}16$, and $L/1{\cdot}22$ respectively for the three types of brush holders mentioned, which comprise the principal broadly classified varieties.

III.

The dissipating surface is taken as merely the cylindrical surface of the revolving part, namely, πDL. In the case of a commutator, L is the free length between the arms, if any, and the outer end of the copper. In the case of slip-rings, L may be something quite different from the mere total axial

length of rings employed. Air-insulated rings, for instance, may have a dissipating surface much greater than would be indicated by axial length only; and partly because of the great variety of types of slip-ring mountings, and partly because alternating-current motors in a standard line generally have fixed sizes of slip-rings, as the rotor currents are more or less fixed for the various frame sizes, the general formula will be got out for both slip-rings and commutators, but will be left there as far as slip-rings are concerned, and developed further for commutators only.

It will be noted that in defining K, the expression, "equivalent square inch" of revolving surface, is used. This means that πDL is not used alone in the formula, but a ventilation factor also comes in, which is unity at standstill, and increases as the value of S increases. Many varieties of formulæ for this factor have been proposed, but one of the simplest forms, and a sufficiently accurate one, is the well-known $1 + 0{\cdot}1v$, where v is the peripheral speed in metres per second. Since 1 metre per second is $60 \times 39{\cdot}37/12$ — practically 200 ft. per minute, the above expression, with S introduced, becomes $1 + 0{\cdot}1S/200$, or $1 + S/2{,}000$, or $(S + 2{,}000)/2{,}000$. The "equivalent surface" is then $\pi DL(S + 2{,}000)/2{,}000$, which means that, as S increases, the temperature rise for a given loss per actual square inch of πDL diminishes in the ratio $(S' + 2{,}000)/(S'' + 2{,}000)$, where S' is the old speed, and S'' the new and greater speed. The watts per equivalent square inch are thus given by dividing the total watts by $\pi DL(S + 2{,}000)/2{,}000$, and, since K is the temperature rise in degrees Fahrenheit for 1 watt per equivalent square inch, the formula for temperature rise, in its most elementary form, is $R = K \times \text{total losses} \div \pi DL(S + 2{,}000)/2{,}000$.

It should be noted that K depends on the units chosen. The total losses do not depend on these units, as they will always be measured in watts; and the ventilation factor is a pure multiplier, so that K depends on the units of temperature and length. Should these be changed, K, as regards its numerical value, will vary inversely as the square of the unit of length, and also inversely as the unit of temperature. Thus, if centimetres and degrees centigrade be used instead of inches and degrees Fahrenheit, then since 1 cm. is $1/2{\cdot}54$ in., and 1° C. is 9/5 F., K for the new units will be $2{\cdot}54^2 \times 5/9 = 3{\cdot}6$ times K for the old units.

IV.

The composition of the total losses must now be determined. They consist, as has already been said, of friction losses and contact drop losses. Friction losses are given by the product of: Total area of brushes used in square inches, pressure per square inch, coefficient of friction (these three giving the tangential force at the revolving surface, in pounds), and peripheral speed in feet per minute (this giving, with the previous three factors, the foot-pounds per minute to be dissipated). If this be divided by 33,000, and multiplied by 746, the friction loss is then given in watts. This, in symbols, gives friction loss $= AP\mu S \times 746/33{,}000$ watts. From what has been said already, this is the same as $(qC/\Delta)P\mu S \times 746/33{,}000$ watts. The contact drop loss is simply qEC watts, and, therefore, the total loss is $qC\{(P\mu S \times 746/33{,}000\Delta) + E\}$.

Hence, $$R = K \cdot \frac{qC\{(P\mu S \times 746/33{,}000\Delta) + E\}}{\pi DL(S + 2{,}000)/2{,}000}.$$

or $$RDL/qKC = \{(P\mu S \times 746/33{,}000\Delta) + E\}\pi(S + 2{,}000)/2{,}000$$
$$= \{(P\mu S \times 746 \times 2{,}000/33{,}000\pi\Delta) + 2{,}000E/\pi\}(S + 2{,}000).$$

This means that L is known in terms of known or specified quantities. The expression reduces to

$$RDL/qKC = (11{\cdot}4P\mu S/\Delta + 637E)(S + 2{,}000),$$

which is a perfectly general formula, applicable to slip rings or to commutators, bearing in mind what has already been said about L and q for the case of slip-rings.

V.

Investigating this further for commutators, and consequently inserting 2 for q, the expression becomes

$$RDL/KC = \frac{28{\cdot}8P\mu S/\Delta + 1{,}274E}{S + 2{,}000} \quad . \quad . \quad . \quad (1)$$

This can be put into a somewhat different form. The right-hand side contains, in addition to quantities depending on the physical properties of the brush chosen, only S, which depends only on D and N. Now, D is generally a standard dimension for a given frame size, and is, therefore, readily ascertainable. Dividing both sides of (1) by D gives

$$RL/KC = (28{\cdot}8P\mu S/D\Delta + 1{,}274E/D)/(S + 2{,}000)$$
$$= (28{\cdot}8P\mu\pi N/12\Delta + 1{,}274E/D)/(\pi DN/12 + 2{,}000)$$
$$= (NP\mu/\Delta + 1{,}274 \times 12E/28{\cdot}8\pi D)$$
$$\div 12\pi DN/28{\cdot}8 \times 12\pi + 2{,}000 \times 12/28{\cdot}8\pi$$
$$RL/KC = \frac{NP\mu/\Delta + 169E/D}{0{\cdot}03471DN + 265{\cdot}5} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Whichever of these two forms is found to be the more convenient may be used, as they are equivalent to each other. Of the quantities on the left-hand side, R is specified, or, if not, has some recognised limiting value, such as 72° F.; C is specified, and K is known from experience for the type of commutator used. On the right-hand side occur P, μ, Δ and E, all of which are data supplied by the makers of the brushes used: S, in (1), is known from D, which is given by the frame size of the machine, and N, which is specified; D and N occur directly in (2).

Therefore, L is known when K is known; and here occurs a considerable difficulty. For pound, inch and degree Fahrenheit units, K varies generally between 20 and 50, the former value being obtainable in very well-ventilated, short, open commutators, while the latter limit is approached in the case of commutators having just the opposite characteristics. No general rule can be given; this again is a case where each designer, knowing his own line of machines, will be able to insert suitable values from experience, after a few trials from actual results to show approximately where each type of commutator used lies on the range 20-50. It is likely, too, that machines with interpoles will be found to have K less than those without interpoles, as the commutation losses referred to earlier, which are not included in the general formula developed above, must be accounted for by K, and correctly designed interpoles will reduce these losses. The value of K even depends on L itself to some extent, particularly where there is a considerable radiating surface in the commutator arms. This has not been included in the radiating surface introduced into the formula, and as it becomes a less proportion of the total as L increases, K will tend to increase as L increases. It is, therefore, a matter of some skill to judge of the value of K for each case, but frequent use of the formula will soon make fairly certain the value which will fit any case in question. Nothing more definite about K can be said, therefore, than that it is likely to be somewhere between 20 and 50 for pound, inch and degree Fahrenheit units.

Having thus obtained a value for L, the commutator dimensions are completely determined, as D is known. The brush dimensions can then be calculated, as soon as the type of brush-holder is known; and that is likely to be a standard for the size of machine in question. L/m gives the total amount of L actually covered axially by brushes, so that, using brushes of some standard width W, $B = L/mW$ gives the number of brushes in a row, and the total number of brushes on the commutator is $2pB = 2pL/mW$. Half of these, or pL/mW brushes, carry the total armature current C with a density in their contact surface Δ, hence, introducing T, the brush thickness, $TW \cdot pL/mW = TpL/m$ is the total brush area to carry C, so that $C/\Delta = pLT/m$, or

$$T = mC/pL\Delta = C/pBW\Delta \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This means that T is definitely known, because m, C, p, L, and Δ are all known. If brush sizes are rigidly standardised, T may be slightly modified to allow a standard size of brush to be used as a rule without undue heating, but in large machines with a large number of brushes, it is often worth while to use a special thickness of brush to save commutator copper.

It is now seen that the method of determining commutator dimensions here employed is to take the standard constants for the brush selected, to discover L from these and the speci-

fied data, the formulæ showing that there is only one value of L for a given case, and that this depends only on the kind of brush used; and then to consider the size of brush which will fit the other data. The value of L can be found quite apart from any knowledge of brush dimensions, except in so far as these are implied in Δ, and afterwards the implicit values of W and T can be made explicit, as they are fixed by quantities then completely known, there being again only one set of values which will meet the requirements. If the selected brush is used with the best values of its various properties and physical conditions, then the value of L thus determined is the most favourable possible.

VI.

It will be useful to take some actual examples of various kinds of brushes, and to investigate their effect on the dimensions calculated from the formulæ. Select, say, as data for these happen to be readily available, (1) a copper Morganite link *CM* brush, (2) a Morganite link 1 brush and (3) a Battersea link *C*6 brush. These have properties, under average conditions, as follows :—

	Link *CM*.		Link 1.		Link *C*6.
P	$2\frac{1}{2}$	...	$3\frac{1}{2}$	...	$2\frac{1}{2}$ lb. per sq. in.
μ	0·25	...	0·15	...	0·28
Δ.....	100	...	50	...	35 amp. per sq. in.
V	0·25	...	0·70	...	1·20 volts.

Equation (1) then becomes, for each of these,

$RDL/KC=(0{\cdot}18S+320)/(S+2{,}000)$ for link *CM*.
$RDL/KC=(0{\cdot}30S+890)/(S+2{,}000)$ for link 1.
$RDL/KC=(0{\cdot}58S+1{,}530)/(S+2{,}000)$ for link *C*6.

Equation (2) then becomes, correspondingly,

$RL/KC=(N/\Delta+67{\cdot}6/D)/(0{\cdot}0556DN+425)$ for link *CM*
$RL/KC=(N/\Delta+225/D)/(0{\cdot}0662DN+506)$ for link 1.
$RL/KC=(N/\Delta+290/D)/(0{\cdot}0496DN+379)$ for link *C*6.

Or, inserting the standard value of Δ in each case,

$RL/KC=(N+6{,}760/D)/(5{\cdot}56DN+42{,}500)$ for link *CM*.
$RL/KC=(N+11{,}250/D)/(3{\cdot}31DN+25{,}300)$ for link 1.
$RL/KC=(N+10{,}150/D)/(1{\cdot}74DN+13{,}265)$ for link *C*6.

If for any reason, such as a consulting engineer's specification, it becomes necessary to use some other density than the standard, the general formula is always available for the insertion of the modified figures. Specifications containing densities less than the standards at which brushes may be worked clearly lead to unnecessarily long commutators.

As is well known, a brush like link *C*6 with a high resistance contact is necessary on high-voltage machines, and is not disadvantageous on medium-voltage machines; a brush like link 1 is useful on high-speed commutators, and even on medium-speed machines with interpoles can be used up to the highest voltages with advantage because of the low value of its losses; while a brush like link *CM*, with a very low contact resistance, and therefore with only very moderate inherent commutating properties, has extensive uses in the direction of reducing the otherwise excessive length of commutator on very low-voltage machines, provided the electrical design is such that it can suitably be used. It may, in fact, replace quite satisfactorily copper gauze brushes in many cases. The three general classes of brushes chosen represent therefore three very distinct, but in their various spheres equally useful, types.

The pressure put down for link 1 is higher than for the other two, because owing to the low value of μ, the loss, even with the increased pressure, is comparatively small, and by working at a high pressure the contact drop is reduced, so that the total loss does not change very much. Other things being equal, a high pressure is advantageous, because it gives a firmer contact between brush and commutator, and so tends to counteract any tendency to vibration which may be present. For final calculations, the question of minimum total losses may be considered with advantage in special cases, and the exact pressure may be calculated, from curves usually supplied by the brush makers, which, with the peripheral speed of the commutator in question, will give the best result. The variables and their interdependence are too complicated, however, to be usefully discussed in the present article, which gives guidance for average cases; is universally useful for approximate estimates; and covers probably four-fifths or more of actual final designs.

VII.

A graphical comparison of the three types of brushes is most easily obtained by using the expressions derived from equation (1), as RDL/KC can be plotted for the three cases against S. Thus, for a given set of values of R, D and C, comparative values of L can be shown, if K be constant. It has already been stated that K may vary with L, but on the assumption that the change is not great, RD/KC may be considered as a constant for a given case, so that the curves would show how L varies as the type of brush is changed. The result of plotting RDL/KC, *i.e.*, $(28{\cdot}8P\mu S/\Delta+1{,}271V)/(S+2{,}000)$, which may be shortly written as $f(S)$, against S itself for link *CM*, link 1 and link *C*6 is shown in Fig. 1. It will be noted that the equations in each case are of the form $(aS+b)/(S+2{,}000)$, where a and b are constants for each case. This may be written $a(S+b/a)/(S+2{,}000)$. When $S=0$, $f(S)$ is always equal to $b/2{,}000$, and when $S=\infty$, $f(S)$ is always equal to a. Friction losses, denoted by aS, are proportional to S, and as the ventilation factor goes up more slowly than S, commu-

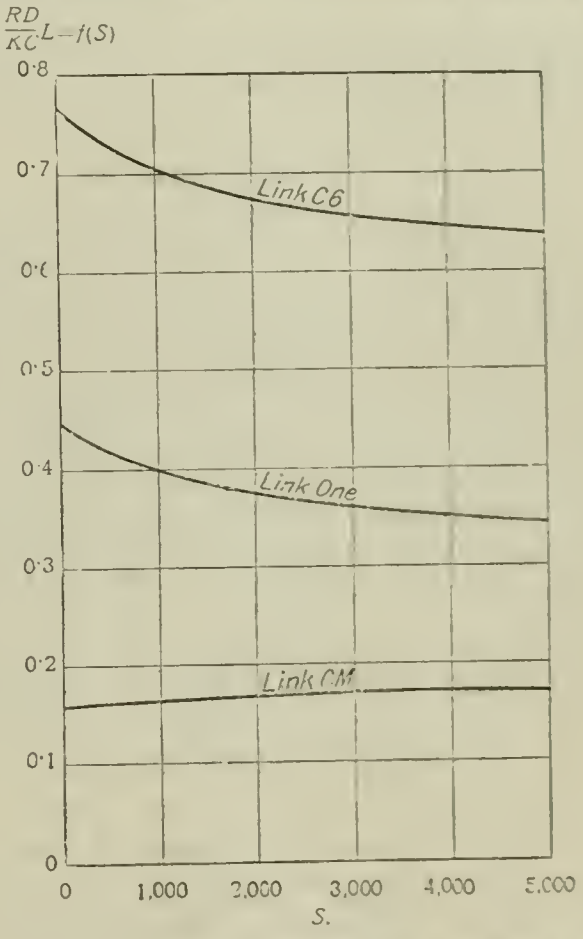


Fig. 1.—Curves Showing Influence of Type of Brush on Length of Commutator.

tators with large friction losses will tend to get hotter for a given D, L and C as the speed increases, or will require a greater L for a given R, D and C for increased S: while on the contrary contact drop losses, represented by b, are constant, and, therefore, cause less and less temperature rise for a given D, L and C as the speed increases, or will require a smaller L for a given R, D and C for increased S. The ratio of the two determines whether the total curve comes down or goes up as S becomes greater. If $b=2{,}000a$, the curve becomes a horizontal straight line, with $f(S)$ constant; if $b<2{,}000a$, $(S+b/a)/(S+2{,}000)$ is always less than unity, but is always getting more nearly equal to unity as S increases, so that the curve gradually rises from $b/2{,}000$ to a, as shown for link *CM*; if $b>2{,}000a$, $(S+b/a)/(S+2{,}000)$ is always greater than unity, but is also always getting more nearly equal to unity as S increases, so that the curve gradually falls from $b/2{,}000$ to a, as shown for link 1 and link *C*6.

The relative heights of the curves show that at, say, $S=2{,}500$,

the lengths of commutators for a given R, D and C, with a possible after-correction introduced for the change of K due to change in L, are as 0·170, 0·365 and 0·660 respectively for link CM, link 1 and link $C6$, or approximately as 1 : 2 : 4. The advantage of link CM becomes somewhat less proportionately at high peripheral speeds owing to its curve rising while the others fall, but it is clear that whenever such a brush as link CM can be used it should be used, as the saving in copper is enormous. As to just when such a brush may be used, each designer knows best himself.

VIII.

One or two numerical examples may be useful, as giving an idea of actual dimensions. The values of K used are probably quite wrong for many cases, but they give results which are comparatively correct.

1. A 200 kw. six-pole generator, 100 volts × 2,000 amperes, R = 72°F.; D = 25; revs. per min. = 350; S is, therefore, 2,300. Say, K = 35, and use link 1 brushes, giving $f(S)$ = 0·367.

$$72 \times 25L/35 \times 2{,}000 = 0{\cdot}367.$$
$$L = 0{\cdot}367 \times 35 \times 2{,}000/72 \times 25 = 14{\cdot}3 \text{ in.}$$

Say, m = 1·22; then $T = 1{\cdot}22 \times 2{,}000/3 \times 14{\cdot}3 \times 50 = 1{\cdot}14$ in.

Actual length of brushes per row = 14·3/1·22 = 11·7 in.

Thus, it would be suitable to use 8 brushes per row, $1\frac{1}{2}$ in. wide × $1\frac{1}{8}$ in. thick, link 1 grade.

2. The same generator, but 500 volts × 400 amperes, with link $C6$ brushes, giving $f(S)$ = 0·665.

$$72 \times 25L/35 \times 400 = 0{\cdot}665.$$
$$L = 0{\cdot}665 \times 35 \times 400/72 \times 25 = 5{\cdot}2 \text{ in.}$$
$$T = 1{\cdot}22 \times 400/3 \times 5{\cdot}2 \times 35 = 0{\cdot}9 \text{ in.}$$

Actual length of brushes per row = 5·2/1·22 = 3·95 in.

Thus it would be suitable to use 4 brushes per row, 1 in. wide × $\frac{7}{8}$ in. thick, link $C6$ grade. Should this thickness of brush be too great for this 500-volt machine—*i.e.*, should it cover too many segments or be otherwise unsuitable—some modification would be made, such as using a higher value of Δ, or working with a greater value of L than is necessary for mere heating considerations, or any other device which may occur to the experienced designer as meeting the difficulty.

3. A 10 kw. four-pole generator, 5 volts × 2,000 amperes, R = 72 F.; D = 9; revs. per min. = 600; S is therefore 1,400. Say, K = 15. Then $f(S)$ = 0·385 for link 1, and 0·168 for link CM; compare the effect of using the two kinds.

$$\text{For link 1, } 72 \times 9L/45 \times 2{,}000 = 0{\cdot}385.$$
$$L = 0{\cdot}385 \times 45 \times 2{,}000/72 \times 9 = 53\tfrac{1}{2} \text{ in.}$$
$$\text{For link } CM, \ 72 \times 9L/45 \times 2{,}000 = 0{\cdot}168.$$
$$L = 0{\cdot}168 \times 45 \times 2{,}000/72 \times 9 = 23\tfrac{1}{2} \text{ in.}$$

This means that with link 1 brushes the machine is practically impossible from a mechanical point of view, except with two commutators and very special shaft and bearing arrangements, whereas with link CM brushes, even if two commutators have to be used, the machine is easier by far to design from a mechanical point of view. The saving in brush gear, as regards both holders and supporting arrangements, is also very great with the link CM brush. Thus, therefore, is the sort of case in which a brush of this kind is invaluable.

Say, m = 1·16;

then, $T = 1{\cdot}16 \times 2{,}000/2 \times 53\tfrac{1}{2} \times 50 = \frac{7}{16}$ in. for link 1.

and $T = 1{\cdot}16 \times 2{,}000/2 \times 23\tfrac{1}{2} \times 100 = \frac{1}{2}$ in. for link CM

The actual cost of brushes would probably be not very different in the two cases, as although brushes of link CM type cost much more than brushes of link 1 type, there are only about half as many of the former as of the latter.

4. For a line of six-pole machines, say, with K = 40, and R = 72°F. the length of commutator per 100 amperes, dependent on D only, with a possible after-correction again for the dependence of K upon L, is a useful quantity, and can easily be expressed. Using link 1 brushes:—

$$72DL/40 \times 100 = f(S).$$
$$L = 55{\cdot}5f(S)/D \text{ per 100 amperes.}$$

which, for ordinary values of S, becomes very nearly

$$L = 20/D \text{ in. per 100 amperes,} \quad \ldots \quad (4)$$

and, for box-type holders, with m = 1·22,

$$T = 1{\cdot}22 \times 100/3 \times (20/D) \times 50,$$

or,

$$T = 0{\cdot}040D. \quad \ldots \quad (5)$$

The thickness, since L is proportional to C, is independent of current altogether. The brush contact area per electrical pole is thus, per 100 amperes, $3 \times \{(20/D)\,1{\cdot}22\} \times 0{\cdot}040D$, or just 2 sq. in., which for 100 amperes corresponds to the standard Δ = 50, on which the formula is based.

These two equations (4) and (5) reduce the expressions to their simplest possible form, due to having specified nearly everything, and to the fact that they refer to a very definite single case, and they give a very good rule for a first approximation to commutator dimensions, the constants being modified as required to suit the type of commutator used, the brushes to be fitted, and the other variables entering into the case.

IX.

It is frequently useful to be able quickly to estimate the weight of copper required for a commutator, so as to get some idea of the cost of its active material should the length, or some other circumstance, make it very different from a standard size.

If there be s parts in the commutator, and d be the radial depth of the copper, and l its overall length, which will be $< L$ as a rule, then, if the mica between the segments be $\frac{1}{32}$ in. thick, the volume of copper in the ring, which has a mean diameter of $D - d$, a radial thickness of d, an axial length of l, and s gaps in it axially, each of a volume $dl/32$, is

$$[\{\tfrac{1}{4}\pi(D-d)dl\} - sdl/32] \text{ cubic in.,}$$

and, as 1 cubic in. of copper weighs 0·32 lb., the weight of copper in the commutator is

$$0{\cdot}32\pi(D-d)dl - 0{\cdot}32sdl/32,$$
$$= dl\{1{\cdot}005(D-d) - s/100\},$$

or, with sufficient accuracy,

Total weight of copper in any commutator

$$= dl\{D - d - s/100\} \text{ lb.}$$

Should it be necessary to use pure mica in a large commutator, owing to it having been expressly specified or for some other abnormal cause, the cost of the mica becomes an important consideration, as pieces of a size suitable for putting between the segments are very expensive, costing probably 10s. or more per lb. The specific gravity of mica is about 3, so that 1 cubic in. weighs about 0·11 lb., and, if there are s pieces $\frac{1}{32}$ in. thick, of length l and depth d, with an allowance of about 5 per cent. each, say, on l and d to allow for subsequent machining, the volume of mica is about $1{\cdot}10sdl/32$ cubic in., which will have a weight of $0{\cdot}11 \times 1{\cdot}10sdl/32$ lb. Hence, with sufficient accuracy, and including the machining allowance,

Total weight of mica between segments in any commutator

$$= dls/265 \text{ lb.}$$

X.

In conclusion, it may be said that while certain important points have necessarily had to be left vague in the present article, owing to the utter impossibility of making a general statement about the cooling qualities of all types of commutators, it is believed that the methods indicated are capable of application with great ease and simplicity by anyone having the necessary additional information, and, therefore, are likely to be of general service. They respresent merely a convenient statement, in a compact form, of certain well-known facts, and hence contain nothing essentially new or exclusive in the way of information. The results of experience are required in order to convert them into a complete statement of any given case, and each designer using them will be able to fill in the gaps for himself to suit his own line of machines.

CORRESPONDENCE.

"SPEEDING-UP" IN ENGINEERING FACTORIES.

TO THE EDITORS OF THE ELECTRICIAN.

I have read Mr. Rankin's reply to my criticism with much pleasure. It is not my intention to belittle his work in any way, although he has apparently assumed it is. I believe this discussion can be carried on by both sides with perfect frankness and I trust without involving any personal bitterness.

If Mr. Rankin means that I "am prejudiced against the case" for the *unjust* employer, I agree, but not otherwise. I might easily retort that he is absolutely prejudiced for the employer and that whether or no, the attitude of his own men, as revealed by himself, shows that they, who have experienced his working ideals, believe that he is. The fact remains, however, that for increased earnings I demand increased quality of product and, like Mr. Rankin, I "stand up for the reasonable thing," in the way of good work, honest dealing, and a strict, but sane, shop discipline. The author justly says: "Sympathy does not imply agreement," yet he has throughout interpreted my sympathy for the misguided labourer as the most complete endorsement of views which I can hardly be accused of holding, in the light of my previous letter.

Mr. Rankin thinks "there is a course which, if followed, should satisfy both employer and employé." I claim that straight piecework meets this in the fairest way; Mr. Rankin even now can only assert that "the workers referred to are *fairly* well satisfied." He admits that in the extreme case he saves only 7·5 per cent. in labour cost, although it costs the man the difference between 83 per cent. and 100 per cent. on his rate of pay. This paltry saving is not worth the discontent and complication it entails, and its effect of further increasing the marginal return of the business is insignificant compared with the very large increment due directly to production at high velocity.

Mr. Rankin says he fully explained his scheme to the men before its application; "nothing was hidden from them." Very well, let us refer to the abstract. On page 111 we read, "In the first department no open opposition was experienced, but in the second there was what was referred to in the example" ("malingering," the author calls it). Again "in the next department, the first serious trouble was experienced"—a threatened strike and a weak compromise. The next department, No. IV., had a strike. When department III. was again taken up it also replied by a strike. So the more the system was experienced the more it was disliked, in contrast to my own experience with unlimited straight piecework.

I do not agree that the "satisfaction or otherwise" of the men "was their own affair largely." It is just there that our author went wrong, because he failed to realise that workmen are human beings and therefore susceptible to all sorts of subtle psychological influences which stimulate or destroy their working efficiency. Why do these same "malingering" men cheerfully endure the misery of the trenches and fight so hard? It is because they are inspired by their superiors—who are usually sportsmen in the best sense—with a high ideal of national duty. When the workmen of the country are handled on the same enlightened principle and are regarded as freemen of a free nation and not as slaves condemned by hunger to surrender soul and body for 9, 10 or 12 hours per day, a higher standard of commercial morality will be formed amongst them, for it will at last have become apparent amongst employers. I repeat, Mr. Rankin's troubles should not have arisen. However great his results may have been, they would certainly have been greater had he undertaken his task in the right spirit. I am sure that Mr. Rankin's interest in cheap production has caused him to overlook the fact that high wages, stop watches or bonus systems are but empty shells if the kernel of humanity is taken from them.

I did not condemn the stop watch, *per se*, but its abuse in practice. For 30 years American labour has been exploited largely on the evidence of the stop watch. Small wonder Congress has had to consider the extraordinary Bill referred to in your recent Leader. I know something of the effects of stop-watch speeding-up in this country, and I am convinced that intelligent, synthetic price fixing is essential as a check on its misleading results. The man who accepts his stop-watch records, however skilled the observer may be, without this check, is acting by rule of thumb, just as would be the designer who accepted laboratory figures without a theoretical study as a basis for design.

It is true that the methods and equipment furnished by the employer regulate the minimum standard of ability amongst the working force, but I fail to see that the worker is thereby obliged to deliver more work while his pay remains at the same level. If the employer intimates—as he does by adopting such bonus systems as Mr. Rankin's—that increasing output is of diminishing utility per unit to him, notwithstanding that it is produced by the peak units of the worker's physical and nervous energy, I consider the worker is perfectly justified in regarding his health and comfort as essential factors affecting his efficient economic service to the State—which includes and is greater than his service to the individual employer. This idea of diminishing utility is the basis of progressive taxation, and if truly applying in the case under review, should also be the basis of *progressive* piecework. But is it true? If not then still less is it true that piecework prices should be automatically cut as production increases. The argument about the consumer is beside the point, as, in any case, the piece cost is lowered considerably, as another correspondent showed. While employers hold that it is business to act themselves on the theory of scarcity, but roguery for the labourer to rely on the lumps of labour which floats about buoyed up by wage-fund fallacies, I must maintain that equally with the workers, they are ignorant of the elements of economics.

Mr. Rankin, I fear, has generalised upon an all too scanty acquaintance with the physiological and psychological effects of fatigue upon the workers' efficiency and therefore upon the efficiency of the works of which they are units. Six minutes per hour may have been excessive or far too little time to allow for rest; it all depends upon the kind of work, the temperament and physique of the individual and the co-incidence or otherwise of the strain of the work with his "critical point." The author takes credit for the celerity with which the system was installed, but F. W. Taylor himself warns his followers repeatedly against this temptation. Taylor's initial progress was painfully slow because, like Mr. Rankin, he did not at first realise the nature of fatigue. Considering the amount of work which has been done in recent years on this subject, I do not see that the author need have lost a day in applying its results.

I would remind Mr. Rankin that one of the most thoughtful writers has said "Scientific management itself is something immensely larger than any of the factors which compose it. It is a philosophy, not a new routine." That is the spirit which is necessary. In conclusion, I wish to quote (with her own italics) a short paragraph from Miss Goldmark's book on "Efficiency." Speaking of speed as being a function not only of quantity but of quality, she says: "Just in proportion as this function of speed is developed, *subject to the capacities of the human agent*, instead of as a *drive* of those capacities, it counts as a gain. Just so soon as the function of speed is dissociated from its effects on the worker, we revert to the old system of pace-making and speeding. Such a reversion was seen in the case of the Bethlehem Steel Works. When the ownership of the works passed into the hands of Chas. M. Schwab in 1901 the efficiency engineers were discharged: but the machinery of their system was kept. Bonuses, premiums and other inducements for great exertions on the part of the workers were continued, but without the spirit which had previously made these conditions part of a larger system, as in the case of Schmidt, the pig-iron man. The result was a return to the system of 'drive' such as the world has seldom seen excelled. . . . Its mechanical features, such as timing operations by a stop watch and the like, are easily copied, and unless they are correctly applied the workers can thereby be exploited more relentlessly than ever before." It is this exploitation of the worker, for which Mr. Rankin, though he

little realises it, is heading, and I hope this discussion may help him to steer his course safely between the Scylla of driven slaves and the Charybdis of malingering workmen.

Manchester, May 22. H. AMBROSE CARNEY.

ENGINEERING INDUSTRY AFTER THE WAR.

A meeting was held in the hall of the Royal Technical College, Glasgow, on May 16th, under the joint auspices of the Institution of Engineers and Shipbuilders in Scotland, the West of Scotland Iron and Steel Institute and the Glasgow Chamber of Commerce to confer as to the policy to be adopted by the engineering industry and its protection after the war. The purpose of the meeting was to discuss questions of policy to meet foreign competition after the war.

Mr. T. C. ELDER, of the B.E.A.M.A., in opening the discussion, delivered an address on "Engineering Industry in the Economic War," an abstract of which appeared in our issue last week.

Sir ARCHIBALD DENNY said the shipowners had formed a powerful committee to discuss the problem before them, and he hoped that other interests would follow their example. Their object was not to smash the German Empire but to ensure that they should not be again attacked unfairly or found unprepared either in commercial or military war. He did not say they should forswear all future trade with Germany, but their future dealings with her, if they had any, would be with their eyes wide open; they would be armed at every point to resist insidious trade penetration. Although born and brought up a Free Trader he had seen the unfairness of their trading system with protectionist countries, but he had not yet made up his mind as to what was the most effective weapon against organised dumping. There was no doubt that they must organise themselves for the protection of their industries, but their federations heretofore had suffered from lack of loyalty among employers themselves. Half of their labour troubles arose from faulty or tactless management, and interchange of information and experience in this connection would tend to eliminate the mutual jealousies from which they at present suffered. Artisans of mature years were under no delusions as to the dangers in front of them, but, unfortunately, these men, although he believed in a majority, were apt to be under the sway of the inexperienced minority who were the talkers. He hoped the experienced men would let their influence be felt more in the evolution of a sane and patriotic trade policy. They would then come to see that the "ca' canny" policy which raised the cost of living and decreased the value of the sovereign was a gross blunder. He agreed that every endeavour should be made to get business men to go into Parliament. Parliamentary life meant self-sacrifice to a busy business man, but they must find men willing to make the sacrifice. While desirous, however, of receiving assistance from the Government, he preferred that they should fight their own battles without the deadening hand of the Government official being constantly upon them. His great hope was in the organisation of the employers, and if they got their employés to join with them in the common object of economical production they would have no reason to despair.

Mr. J. W. MURRAY, President of Glasgow Chamber of Commerce, urged the need for the establishment of a Ministry of Commerce.

Sir JOHN COWAN emphasised the need for up-to-date equipment and organisation.

Mr. LAMBERTON, of Coatbridge, referred to the problem of restriction of output and repeated the figures recently given by Sir William Beardmore in London, which showed that women with a few months' training could do double the work previously done by artisans on certain machines. The economic education of the British workman was all wrong, and he urged the men's leaders to revise their views in the interests of national industry.

Mr. BEN SMITH, of the Amalgamated Union of Labour, said he recognised the need for action against German competition, but there should be no idea of either the employer or the employé being the top dog. Effective industrial organisation could only be obtained by unity and co-operation between employers and men.

LEGAL INTELLIGENCE.

Scobie v. London County Council.

Last week Mr. Justice Bray and a special jury heard an action by Mr. Stuart Hamer Scobie, a private in the 2nd Canadian Infantry Brigade, for the recovery of £500 damages for personal injuries which he alleged that he had suffered through the negligence of the London County Council's servants. On Oct. 11 last plaintiff, while on leave from the front (where he had been wounded) a tramcar belonging to defendants ran into him in the Kennington-road as he was crossing the road and knocked him down. Plaintiff alleged that the car was being driven at an excessive speed, and he complained that when his right arm was pinned beneath one of the wheels of the car defendants' servants improperly refused to back the car so as to release his arm. They attempted to raise the wheels with a jack, which broke, and the wheel fell on his arm. The result was that the arm was so injured that it had to be amputated.

Defendants denied that the conduct of their servants was in any way negligent, but the jury awarded him £500, and judgment was entered for this amount, with costs.

J. W. Knowles v. Electrolytic Plating Apparatus Co. (Ltd.)

Last week the Court of Appeal (the Lord Chief Justice, Lord Justice Warrington and Mr. Justice Lush) delivered judgment in the cross appeals against a decision of Mr. Justice Bailhache at Birmingham Assizes. The action was brought by Mr. Knowles to recover £105 on a cheque issued by the Electrolytic Company. It appeared that Messrs. Shaws (Ltd.) sold a quantity of nickel anodes to Messrs. A. S. Smith & Sons, who in turn sold them to the Electrolytic Company. The last-named company, at the request of Messrs. Smith & Sons, sent a cheque direct to Messrs. Shaws, and it was handed to Mr. Knowles, a debenture holder of Messrs. Shaws. Alleging that the anodes were not up to sample, the Electrolytic Company stopped the cheque. Mr. Knowles commenced proceedings, alleging that the Electrolytic Company could not refuse to pay Shaws for the goods, but should claim for damages against Messrs. Smith, the sellers of the goods; and the Electrolytic Company counterclaimed for alleged breach of warranty. Mr. Justice Bailhache held that Mr. Knowles was not entitled to his money, and the Electrolytic Company could not succeed against Mr. Knowles on the counterclaim. Against this decision both parties appealed, but their lordships dismissed both appeals with costs.

The Lord Chief Justice said to succeed Mr. Knowles would have to show that Shaws (Ltd.) supplied nickel anodes, whereas it seemed a fact that what they sold to Messrs. Smith was scrap nickel. Consequently, the Electrolytic Company did not receive value, and were entitled to stop the cheque. On the other hand, to succeed in their counterclaim against Shaws for alleged breach of warranty the Electrolytic Company would have to prove that Messrs. Smiths bought the nickel as their agents. Seeing that it was a well-known fact that the Electrolytic Company could only use anodes containing not less than 96 per cent. of nickel, it seemed improbable that Messrs. Smiths, had they been acting as agents for the Electrolytic Company, would have bought for their principals scrap nickel containing 91 per cent. of nickel. Consequently, Messrs. Shaws could not be sued by the Electrolytic Company for breach of warranty.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 SPECIFICATIONS.

4,263 BABCOCK & WILCOX (LTD.) (B. & W. C.) Air-cooled tanks for electrical apparatus.

5,630 MELLEN-JACKSON. (Submarine Signal Co.) Mounting of electric oscillators for submarine sound signalling.

The oscillator is mounted in the casing, the diaphragm of which is itself tuned to the vibrations of the oscillator, the diaphragm being fixed in the skin of the vessel or upon a mounting carried by the vessel.

5,723. BENTLEY. Magneto-electric machines.

5,757 DOLTER & PLUMER. Machines for internally shaping telegraph insulators and the like.

5,918 B.T.-H. Co. (G.E. Co.) Electrical apparatus having windings or other portions in which high potentials may occur.

The invention is for preventing, or at least delaying, the spreading of dangerous frequencies through electrical apparatus and to restrain the energy oscillation of any section in which, for which purpose the sections of these are constructed and arranged that the different sections have materially different resonance frequencies. So different that the frequency at which energy in one section oscillates cannot readily pass over the boundary and cannot readily come into that section over them.

6,542 MACKENZIE. Electric signalling systems for railways.

7,016 DE CASTRO. Process for the manufacture of tapes containing parallel electric wires. (9,5,16.)

7,311 GUNDRUM, Combined generator and rectifier for the production of unidirectional high-tension impulses of low capacity as used for X-ray work.

The invention is for the purpose of obtaining unidirectional high tension discharges through a focus tube, and consists of the combination of a mercury jet interrupter, arranged in such manner as to reverse periodically the direction of the magnetic field of a primary coil, with a rotary rectifier driven in synchronism with said interrupter.

7,[illegible] B[illegible] Internal-combustion engines.

9,197 DUNCKLEY. [illegible] Boilers.

13,[illegible] B[illegible] Electric [illegible]

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after the acceptance of Complete Specifications. Those marked * are open to inspection 1 month after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

April 17, 1916.

5,582 BEAN & HEPWORTH. Electrodes and plates for storage batteries, and for vats and tanks used in connection therewith.

5,596 DOWSEY & KEARTON. Interconnecting telephone systems.

5,606 WEBSTER. Electrical means for indicating or transmitting movements.

5,628 MARSHALL. Electrolytic coating articles with nickel or nickel-iron alloy.

5,631 BOWELL & WILCOX. Signalling apparatus.

5,634 BOWELL & WILCOX. Signal detectors or transmitters.

5,637 ROBERTS & TAYLOR. Means for signalling on single lines of railway.

5,613 B.T.-H. Co. (G.E. Co.) Dynamo-electric machines.

April 19, 1916.

5,646 BAILEY. Electric [illegible]

5,653 BAILEY. Collecting [illegible]

5,673 O'DONNELL. Railway [illegible]

5,[illegible] M'LEOD. [illegible]

5,[illegible] KEARTON. [illegible]

5,[illegible] METALLURGISCHE GESELLSCHAFT & SIEMENS. Electrolytic extraction of zinc.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	263	Benjamin Electric Works, London. Illustrated	54
Imports and Exports of Electrical Manufactures	264	An Economical Night Light. Illustrated	56
Educational	264	**Electric Vehicle Progress Supplement—No. 28.**	
Business Notices	264	Electric Tractors in Lumber Yards. Illustrated	1*
Liquidations, Bankruptcies, &c.	264	Tractor Haulage Problems. Illustrated	2*
Electricity Supply	265	Storage Battery Locomotives. Illustrated	4*
Traction Notes	265	Recruiting by Electric. Illus.	6*
Empire Notes	265	More Boots' Electrics. Illus.	6*
Miscellaneous Notes	266	An American View of Electric Wheel Chairs	8*
Tenders Invited	266	Electrics in Sheffield	8*
Tenders Received & Accepted	267	City Notes	271
Municipal Accounts	267	Electrical Companies' Share List	272
Companies' Meetings and Reports	267		
The Round Table	49		
Single and Polyphase Brake Solenoids. Illustrated	50		
The G.E.C. Cadet Corps. Illustrated	51		

COMMERCIAL TOPICS.

Trading with the Enemy. The "London Gazette" of May 19th contained further additions to the statutory list of persons and firms abroad with whom trading by persons and firms in the United Kingdom are prohibited from trading, and it is also announced that persons abroad can apply to the British consular officers for information as to names on the list, and that the Foreign Department is prepared to inquire of H.M. representatives abroad for the names of substitutes for any firm on the list. If the applicant wishes this to be done by telegraph he must undertake to pay the cost.

A Royal proclamation was issued on Tuesday consolidating the proclamations previously published prohibiting trading with persons or firms of enemy nationality or association. The consolidated statutory list of such persons and firms, appended to the document, now occupies 26 columns of the "London Gazette," and includes over 1,000 names of individuals and concerns located in European, Asian, African and American countries.

* * * *

Important Chemical Trade Combination. It is announced that Messrs. Brunner, Mond, & Co. (Ltd.) and the Castner-Kellner Alkali Co. (Ltd.) have, owing to the altered conditions expected after the war, entered into an agreement for mutual co-operation, &c. Under the agreement (which covers a period of years) the Kellner Company will allot to Brunner, Mond & Co. 250,000 shares of £1 each, and Brunner, Mond & Co. will allot to the Castner-Kellner Alkali Co. 200,000 shares of £1 each.

The terms of the agreement between the companies have not been disclosed, but it is understood they provide for mutual co-operation in technical and commercial matters, which it is hoped will result in improved efficiency and economy. The directors of both companies have in mind the altered conditions which must arise after the termination of the war, and they believe that the agreement will not only avoid wasteful and unnecessary capital expenditure, but will more effectively assist the maintenance of the country's foreign trade in chemicals. It seems to us that the directors of the two companies have adopted a very wise course, and we should like their example to be followed by others, including electrical engineering firms.

* * * *

Empire Trade After the War. At the recent conference of the Australian Chambers of Commerce resolutions were unanimously passed in favour of a preferential tariff within the Empire and with the Allies, fair and reasonable treatment of neutrals, and surtaxed tariffs against enemy countries. The conference also recommended the amendment of the naturalisation laws, compulsory registration of aliens throughout the Empire, and the adoption of special means to prevent dumping of enemy goods after the war.

Nationalisation of Railways. At the recent annual conference of the [illegible] Engineers and Firemen a resolution was passed urging the Parliamentary Committee to press forward at once the demands for nationalisation, and to obtain by legislation complete control of the railways for the people.

In the resolution the belief was expressed that [illegible] admitted success of Government control of the railways, nationalisation would be most advantageous to the community. The conference also considered that the appointment of an advisory committee and a Minister of Railways responsible to Parliament was necessary to ensure the success of the industry and to guarantee that the interests of the community and railway employés would be adequately protected. It was further resolved that as the present industrial truce was responsible for withholding from railwaymen generally of higher wages and better conditions of service, the future costs of improved conditions should be deducted from the purchase price of the railways when the transfer from private to national ownership became an accomplished fact.

* * * *

Science in Industry. At the last meeting of the Central Executive Committee of the Employers' Parliamentary Association a resolution was passed urging (1) the necessity of increasing the number of chemists trained in research work; and (2) the necessity of making special effort to enlist the co-operation of manufacturers who hitherto have been lamentably apathetic in regard to scientific industrial research and training.

* * * *

Reforms After the War. The members of the Manchester Chamber of Commerce were recently invited to express their opinions upon the following statement of the views of the chamber:—

That this chamber is convinced of the need for improved scientific education, especially in its highest branches; better organisation of individual industries; general amendments of patent laws; improvements of transport and banking facilities; desirability of the appointment of a Minister of Commerce; the extension of the system of Trade Commissioners; and thorough reorganisation of the consular service.

But exceeding in urgency any of these desirable reforms this chamber considers it to be essential that after the war the same facilities for trading with the British Empire shall not be allowed to our enemies as those granted to our Allies and to neutral nations, and particularly that steps shall be taken not only to render dumping and a return to pre-war trade conditions impossible, but also effectually to eliminate enemy influences so actively in operation prior to the war.

This chamber also urges that immediate consideration be given by his Majesty's Government to the desirability of preferential reciprocal trading relations between all parts of the British Empire, and, as far as possible, with our Allies.

In an accompanying letter it was pointed out that until the Board were satisfied that the statement broadly expressed the views of the majority of the members did they propose to adopt it as a resolution for submission to the Board of Trade and as expressing the opinion of the chamber. The voting papers were to be returned by noon on Monday, and members were asked to put "Yes" or "No" against the paragraph.

* * * *

Trading With Firms in British Protectorates, &c. As doubts have arisen as to whether firms in this country are at liberty to trade with specified firms in the British colonies not possessing responsible government and protectorate, the Secretary of State has explained that the Trading with the Enemy (Extension of Powers) Act and the Proclamations and Orders of Council under it, do not apply to trade between firms and persons resident, or carrying on business, within the Empire.

Arrangements have been made for the liquidation of the enemy firms in British colonies and protectorates under the direction of the local Governments. Trading with all firms in the colonies and protectorates which are allowed to continue carrying on business is legitimate.

* * * *

British Chemical Manufacturers. At a representative meeting of manufacturers in the chemical and allied trades held in London on Tuesday it was decided to form an association of British Chemical Manufacturers in order to meet German competition after the war, and a Committee was appointed to deal with the preliminary work.

Dr. Charles Carpenter, who presided, said German undertakings on a large scale had decided still further to strengthen their position by uniting. If the chemical industry in the United Kingdom was to be made

what it once was it could only be by pooling their resources of money, men, ability and brains.

Sir WILLIAM PEARCE, M.P., pointed out that in Germany chemists during training took up research work—a work which we as a nation had failed to recognise as being of enormous importance; while Sir EDWARD EVANS said that they must be so organised as to be able to make demands and not requests to the Government.

Mr. J. F. L. BRUNNER said they should insist on the Government thoroughly equipping the Imperial College at South Kensington, which would in the future be one of the most valuable assets of the chemical industry in the country.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From May 15, 1916, *to* May 20, 1916.

In view of the increased interest which is being taken in the subject of the importation into and the exportation of Electrical Manufactures from the United Kingdom, we resume our weekly lists. (*See also* note at foot of Exports.)

IMPORTS.

BRISTOL.—*Canada:* Unenumerated, 7 pkgs.
HULL.—*Sweden:* Elec. machinery, 130 pkgs.
LIVERPOOL.—*Spain:* Elec. carbons, 10 pkgs.
LONDON.—*U.S.A.:* Elec. machinery, £4,849; elec. lamps, £616; carbon candles, £56; telephone material, £18; wire and cable, £91; electrodes, 124 pkgs.; unenumerated, £1,696—196 pkgs. *Holland:* Elec. lamps, £2,788—311 pkgs.; elec. bulbs, 63 pkgs.; unenumerated, £209. *France:* Elec. machinery, £183; unenumerated, £346. *Switzerland:* Elec. machinery, £67; carbon candles, £1,376; wire and cable £93; unenumerated, £314. *Denmark:* Unenumerated, £1,175. *Japan:* [illegible] 1710. *Canada:* Unenumerated, £30. *India:* Elec. switches, 12 pkgs.
SOUTHAMPTON.—*France:* Elec. cables, 35 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Elec. machinery, £218; unenumerated, £16. *Melbourne:* Elec. machinery, £165; wire and cable, £8,113; elec. meters, £168; unenumerated, £456. *Sydney:* Elec. machinery, £521; wire and cable, £10,797; unenumerated, £1,712. *Wellington:* Elec. machinery, £122; wire and cable, £243; unenumerated, £206. *Perth:* Unenumerated, £133. *Christchurch:* Unenumerated, £265. *Lyttelton:* Elec. machinery, £151; unenumerated, £10. *Brisbane:* Wire and cable, £3,305; unenumerated, £301. *Dunedin:* Wire and cable, £339. *Newcastle:* Elec. machinery, £63. *Adelaide:* Wire and cable, £340; unenumerated, £511. *Hobart:* Unenumerated, £2,000. *Gisborne:* Elec. cable, £203. *New Plymouth:* Elec. machinery, £116; unenumerated, £24. *Launceston:* Wire and cable, £1,200.
AFRICA.—*Durban:* Unenumerated, £583. *Cape Town:* Wire and cable, £940; unenumerated, £87. *Port Elizabeth:* Wire and cable, £1,856; unenumerated, £254. *East London:* Unenumerated, £142. *Beira:* Unenumerated, £183.
EGYPT.—*Alexandria:* Unenumerated, £98. *Port Sudan:* Elec. cable, £273. *Port Said:* Wire and cable, £145.
MALTA.—Unenumerated, £85.
SUMATRA.—*Medan:* Unenumerated, £32.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Wire and cable, £67; unenumerated, £1,928. *Calcutta:* Wire and cable, £479; telegraph material, £10; unenumerated, £2,319. *Madras:* Elec. machinery, £511; unenumerated, £412. *Bankok:* Unenumerated, £386. *Singapore:* Unenumerated, £596. *Penang:* Wire and cable, £98; telegraph material, £21; unenumerated, £30.
COCHIN CHINA.—*Saigon:* Unenumerated, £28.
JAPAN.—*Yokohama:* Unenumerated, £414.
CHINA.—*Shanghai:* Unenumerated, £61.
U.S.A.—*New York:* Unenumerated, £56.
SOUTH AND CENTRAL AMERICA.—*Buenos Ayres:* Unenumerated, £1,802. *Valparaiso:* Unenumerated, £20. *Rio Janeiro:* Elec. machinery, £2,599. *Santos:* Unenumerated, £300. *Monte Video:* Unenumerated, £75. *Rosario:* Elec. machinery, £67; wire and cable, £610; unenumerated, £1,542.
HOLLAND.—*Amsterdam:* Unenumerated, £331.
FRANCE.—*Paris:* Unenumerated, £102. *Dieppe:* Elec. machinery, £247. *Bordeaux:* Wireless telegraphy apparatus, £1,150; unenumerated £39. *Calais:* Wire and cable, £189. *Boulogne:* Unenumerated, £2,292. *Havre:* Unenumerated, £17. *Marseilles:* Unenumerated, £128.
GREECE.—*Piraeus:* Elec. machinery, £50; unenumerated, £174.
NORWAY.—*Trondhjem:* Elec. machinery, £114.
CANADA.—*Montreal:* Machinery, £761; unenumerated, £303. *St John:* Unenumerated, £195.
MOROCCO.—*Tangier:* Unenumerated, £31.

FOREIGN GOODS (duty paid and free).

Bordeaux: Unenumerated, £471. *Bombay:* Unenumerated, £465. *Bristol:* Unenumerated, £173. *Durban:* Unenumerated, £96. *Hong Kong:* Unenumerated, 107. *Sydney:* Unenumerated, £217. *Wellington:* Unenumerated, £47. *Paris:* Unenumerated, £40. *Melbourne:* Elec. machinery, £1,232; unenumerated, £391. *Piraeus:* Unenumerated, £21. *Calcutta:* Unenumerated, £16. *Christchurch:* Unenumerated, £41. *Marseilles:* Unenumerated, £632.

FOREIGN FREE GOODS (entered in transit on through Bills of Lading).

New York: Unenumerated, £5.

IN TRANSIT.

Hong Kong: Elec. lamps, £987. *Shanghai:* Elec. lamps, £1,500. *Natal:* Elec. lamps, &c., £3,260. *Calcutta:* Elec. lamps, &c., £132. *Invercargill:* Elec. lamps, &c., £86. *Lyttelton:* Elec. lamps, &c., £320. *Napier:* Elec. lamps, £39. *New Plymouth:* Elec. lamps, £30. *Trinidad:* Elec. lamps, £37.

NOTE.—**The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."**

EDUCATIONAL.

Research Scholarships in Technology.—Eight research scholarships in technology are being offered at the Manchester School of Technology (University of Manchester).

Three of the value of £100, two of £75 and three of £50 (all with fees remitted) will be awarded on or about July 3 next. The scholarships are tenable during the academic year 1916-17 in the Manchester School of Technology (Faculty of Technology in the University of Manchester). Applications must be received on or before June 21, and forms of application &c., can be obtained from the Registrar.

Victoria University, Manchester.—The late Miss Charlotte Emily Beckwith, of Southport, bequeathed one-half of the residue of her estate (about £8,000) to the Victoria University of Manchester in aid of the "John Henry Beckwith Scholarship" founded by her mother.

BUSINESS NOTICES.

Messrs. Ikin & Eads (Ltd.) have formed a separate company to control their electric heating department, which will be known as Qulad (Ltd.), 45-57, Marylebone-lane, W. Telephone, Mayfair 3582.

Mr. Sherard Cowper-Coles, the inventor of the Sherardising process, or vapour galvanising process, for rendering iron and steel non-corrosive by forming on the iron or steel a zinc iron alloy, notifies that he is now able to supply furnaces for all classes of work. The furnaces can be either gas heated, electrically or heated by coke or coal.

Messrs. Peckham, Ducamp & Co., electrical engineers, 90, Charing Cross-road, London, W.C., notify that they are agents for Messrs. Sanders & Co. (Wednesbury), Messrs. Holroyd & Co. (Milnrow) and Messrs. Sabroe & Co. (Aarhus, Denmark). Telegraphic address, Switches Ox London; telephone, Gerrard 8,984.

Mr. August Eckstein, electrical engineer, of Fallowfield, Manchester, has changed his name to Mr. Arthur Erskine.

Plant Wanted.—Mr. Jno. F. Wake, Darlington, advertises for a three-phase turbo-generating set of about 1,500 kw., also several engines and generators from 50 to 100 kw., &c.

LIQUIDATIONS, BANKRUPTCIES, &c.

Meetings of the creditors and shareholders of the Cedes Electric Traction (Ltd.) were held on Friday last under the compulsory winding-up order made on April 18.

A statement of affairs showed a deficiency of £10,833 as regards creditors and of £7,001 as regards shareholders.

Mr. H. E. BURGESS, official receiver, said that the company was formed in 1910 to manufacture and sell motor cars. Most of the issued share capital was held by the Austrian Daimler Motor Co., who granted the company the sole right to manufacture and sell their electric vehicles. In 1914 the financial position became difficult, and arrangements made for the company's business to be taken over by a new company were stopped by the war. The company had been carried on at a loss throughout. For 1913 the loss was £7,000, for 1914 £7,395 and for 1915 £14,061. The liquidation was left in the hands of the official receiver.

The adjourned first meeting of contributories will be held to-day (May 26) at the office of the official receiver and provisional liquidator, Mr. H. E. Burgess, 33, Carey-street, London, W.C.

A meeting to receive an account of the winding up of the General Electrolytic Parent Co. (Ltd.) (in vol. liq.) will be held at the offices of Messrs. F. J. & C. Poole, 4, Lacey-street, Widnes, on June 20.

The Torbinia Engineering Co. (Ltd.) is being wound up voluntarily for reconstruction, and Mr. F. L. D. Snell, Regent House, Kingsway, London, W.C., has been appointed liquidator, with authority to consent to the registration of and enter into an agreement with the Torbinia Engineering Co. (1916) (Ltd.) Meeting of creditors at Regent House, Kingsway, on May 29.

A meeting to receive an account of the winding up of the Accessories Mfg. Co. (Ltd.) (in vol. liq.) will take place at 8, Queen-street, London, E.C., on June 20.

Claims against the M.C. Truck & Engineering Co. (Ltd.) are to be sent by June 20 to the liquidator, Mr. C. Cooper, 30, Moorgate-street, London, E.C.

Claims against Universal Cheap Cables (Ltd.) are to be sent by June 20 to the liquidator, Mr. H. E. Oldham, 30, Bush-lane, Cannon-street, London, E.C.

Claims against Arthur Faraday Hawdon, electrical engineer, Yetholm, Elmfield gardens, Gosforth, are to be sent by June 5 to Mr. C. Woollett, 30, Mosley-street, Newcastle-on-Tyne.

Enemy Firms Wound Up.—Claims against the Allolit Co. and Otto Rosenthel are to be sent by June 10 to the controller, Mr. H. Hartley, 70A, Basinghall street, London, E.C.

Claims against the Rhenish Rubber & Celluloid Co. (1908) (Ltd.) are to be sent by June 30 to the controller, Mr. J. S. Cotman, 10, Coleman street, London, E.C.

Up to date the Board of Trade have ordered the winding-up of 157 businesses controlled by alien enemies. The following are included in the latest list: Oberfelt & Co. (Successors) (J. Fellner), incandescent gas-mantle merchants, 81, Fenchurch street, London, E.C. (Controller: Wm. McLintock, 168, Fenchurch street, E.C.); Bernard Ullmann & Co., bronze powder manufacturers, 90, Chiswell street, London, E.C. (Controller: W. H. King, 13, Basinghall street, E.C.); Max Schubert, manufacturers' agent and importer, 31, Aldermanbury, London, E.C. (Controller: C. B. Smith, 79, Bishopsgate, E.C.); Isaria (Ltd.), dealers in electric meters, &c., 208, Tower Bridge-road, London, S.E. (Controller: J. S. Pitt, 140, Leadenhall street, London, E.C.)

ELECTRICITY SUPPLY.

EXTENSIONS.

Aberdeen.—The Electricity Committee have decided to purchase land at Clayhills for the purpose of extending the electricity works.

A request for a supply of electricity for the new shipbuilding works at Torry was remitted to a sub-committee to consider and report.

Carnarvon.—The Council has obtained sanction to borrow £2,680 for additional plant for the electricity works.

Islington (London).—The Borough Council proposes to apply to the L.C.C. for sanction to borrow £1,500 to cover the additional cost, owing to the increase in the price of materials, especially copper, of the scheme for laying mains to Flower's-mews, Highbury Corner, and Studd-street, which was estimated in May, 1914, at £7,564, and subsequently revised at £9,076 in July last.

West Ham.—The L.C. Board has sanctioned the borrowing of £14,850 for the electricity undertaking.

A sum of £5,400 is for feeder cables, £3,000 for general mains and cables, £350 for switchgear, £300 for protection gear, £5,000 for sub-stations, transformers and switchgear, £450 for wet air filter, and £3,000 for additional connection to water mains. The total amount applied for was £26,775.

Willesden.—The Electricity Committee has entered into a contract with Messrs. F. E. Berwick & Co. for a supply of energy for three years, and the L.C. Board have sanctioned the borrowing of £500 for the extension of mains necessary.

GENERAL.

Accrington.—The Tramways and Electricity Committee has entered into a five years' agreement for an additional supply of electrical energy to the Calico Printers' Association.

Bethnal Green (London).—The Borough Council have appointed Mr. Harold W. Couzens, M.I.E.E., consulting electrical engineer to undertake half-yearly inspections and tests of the plant and apparatus used in connection with the Council's electricity undertaking, to furnish reports thereon, and give such general advice on all electricity matters (except the establishment of a wiring and fitting department) as the Council may from time to time require until March 31, 1920, at an annual fee of 200 guineas, payable half-yearly, plus 5 per cent. on capital expenditure on plant and mains incurred on the advice and under the supervision of Mr. Couzens, and subject to the appointment operating from March 31, 1916.

Consideration of a proposal to establish a wiring and fitting department has been deferred for the time being.

Croydon.—The Council has decided to add a special war charge of 10 per cent. to all accounts for lighting, heating and power supplies as from the June meter readings.

A similar percentage is to be added to the public lighting account, and the tramways will be charged an increase of ¾d. per unit on all units above 10,000,000. The Electricity Committee states that owing to the loss (£3,600) on the past year's working, there was no alternative but to increase the charges, especially as there would probably be an increase of £6,000 in the cost of coal and materials during the current year.

Hornsey.—In a report on the question of reducing the electricity consumed by the darkened street lamps, the Borough Engineer states, as regards are lamps (of which there are 58), that the provision of small side-arm lights for post-midnight hours had enabled the ares to be dispensed with.

They used only 36 pairs of side lights, in which the consumption of current per lamp had been reduced by one half. The present cost of current was £55. 3s. 3d. a year, against £203. 18s. 2d. in normal times.

Rawtenstall.—The Council have approved an agreement for the supply of electrical energy to Haslingden.

The Tramways and Electrical Sub-Committee have been instructed to prepare a statement of the further plant required at the electricity works at Hareholme, obtain tenders for same, and submit them to a future meeting.

Ripon.—In order to form a syndicate for the purpose of establishing electricity supply works in this town, a meeting of gentlemen interested was recently held.

The scope and objects of an electricity scheme were reported upon by an electrical engineer, who pointed out that so long ago as 1908 the question of electricity supply was discussed by the Council, but no move had been made, and the powers of the Corporation had now lapsed. It was urged that the present was an opportune time to introduce electric lighting, as the scheme of the Gas Committee for the extension of the works was not likely to be carried out in the absence of borrowing powers. If the project was to materialise by the autumn of 1918, a move must be made now. It was stated that £4,000 was the likely maximum sum to be raised by local subscription to carry the scheme through.

It was decided to approach the Council and ascertain if they would be willing to make an agreement with the syndicate, at the same time inquiring whether the municipal authority would be likely to oppose the application for electric lighting powers.

Sheerness.—The local electric supply company has increased the charge for electric current supplied to the sewage works by 15 per cent.

Stafford.—The maximum charge for electric current for power has been increased from 2½d. to 3d. a unit as from July 1.

Street.—The Urban Council have decided to employ an electric motor in place of the present oil engine at the low-level reservoir pumping station, and Messrs. Christy Bros. & Co. have been entrusted with the work.

Tynemouth.—The Electricity Committee has adopted the revised wiring rules made by the Institution of Electrical Engineers, and the local wiring contractors have been requested to conform thereto in future.

TRACTION NOTES.

Bolton.—The Council has decided to establish an electric charging station for battery vehicles at Spa-road works.

The attention of the various committees of the Corporation is being drawn to the advantages of substituting electric vehicles for other types of vehicles.

East Ham.—The Council is recommended to authorise the tramways engineer and manager to employ women tramcar conductors in the event of his not being able to otherwise fill vacancies caused by the existing employés being called up for military service.

Motor Omnibuses in Croydon.—The Council have passed the following resolution :—

The use by any omnibus of any route that has not been used within two years prior to March 1, 1916, without the consent of the Corporation or if unreasonably withheld of the L.C. Board, is forbidden under penalties.

Women Tramway Workers.—At the conference of the Amalgamated Association of Tramway and Vehicle Workers in Sheffield on Monday the question of employing female labour and auxiliary workers on tramcars was brought up by Mr. J. E. Corren, of Birmingham.

Mr. CORREN said it constituted a serious problem for the future, as in Birmingham and district they were told by the officials they were not going to have men as conductors again. All over the country there was a doubt whether the women would go after the end of the war, and it was a question that would have to be fought. In Birmingham the position of the men was one of grave concern, for it was menaced by the women. A resolution was passed protesting against the employment of women drivers, and the conference declared it would not allow it to come to pass except under the gravest national crisis.

The above statement has been denied by the tramways manager, Mr. A. Baker.

EMPIRE NOTES.

Australasia.—Mr. Wm. Corin is preparing a report upon the subject of the electric lighting of Singleton (N.S.W.).

Whangarei (N.Z.) Council expects to have its electric light and power system in operation before next winter.

Mr. Gordon Faine estimates the cost of an electric lighting scheme for Barcaldine (Queensland) at £5,819. The Council is applying for a loan of £6,000.

The Chief Engineer to the N.S.W. Public Works Dept. has prepared a report on the proposal to construct new underground electric railways in Sydney. The works recommended in the report include the electrification of the inner zone suburban railways to Parramatta, Hornsby, Sutherland and Bankstown; the construction of the City Electric Railway, and electric railways to the eastern, western and northern suburbs; the construction of two long-span cantilever bridges across the harbour of 1,600 ft. and 1,350 ft. centre spans respectively; the electrification of the outer zone suburban railways to Penrith, Campbelltown, Waterfall, the Hawkesbury River, and other small branches in the suburban area; and the construction of underground tramways. The total approximate cost, which has been approved, is £20,000,000, exclusive of land resumption. The report also contains recommendations regarding the Sydney Harbour (North Shore) bridge.

Electricity in Canadian Farming.—It is reported that a project is being evolved for the purpose of popularising the use of electrical energy among the farmers in Manitoba.

It is proposed to buy electric power from the City of Winnipeg, which has a large hydro-electric station on the Winnipeg River, and distribute this power by means of transmission lines through the more thickly settled parts of the province.

India.—"Capital" (Calcutta) states that in view of the growing demand for electric power in Mysore two projects have been formulated to supplement the existing power works at Cauvery Falls.

These are known as the Shimsha and Kedadatu schemes, and are estimated to cost £446,600 and £200,000 respectively. Increased production up to 40,000 H.P. is provided for, with a further possible increase up to 50,000 H.P.

MISCELLANEOUS NOTES.

Controlled Establishments.—The Minister of Munitions has made further orders under the Munitions of War Acts 1915-16, under which 131 additional establishments have been declared "controlled" establishments. The total number of controlled establishments is now 3,577.

Electrical Contractors and Labour Shortage.—A member of the Liverpool branch of the Electrical Contractors' Association recently sent a letter to the Minister of Munitions (Mr. D. Lloyd George), pointing out that through the large number of electrical workers who had either been called to the colours, or else who were engaged on war work, there was a great shortage of labour, and unless the Government sanctioned a scheme for the training of women in certain branches of electrical work many contractors would be forced into bankruptcy.

The writer pointed out that the trade unions had refused to allow women to be trained and join their unions, so that a Government measure making an arrangement between masters and men was (in the writer's opinion) absolutely necessary.

The reply on behalf of the Minister of Munitions has been received by the Liverpool Electrical Contractors' Association. The department pointed out that the matter was not one for the Ministry of Munitions, but should be arranged with the local technical school authorities.

No decision was arrived at by the association beyond arranging for a further communication to be made to the Minister of Munitions.

Tribunal Cases.—At Cheltenham last week the borough electrical engineer (Mr. W. J. Bache) applied for the exemption of 10 of the employés of the electricity department.

At a previous sitting Mr. Bache had asked for five to be retained, and the Tribunal, eliciting that there were five others to be applied for, the application was postponed in order that all 10 cases might be dealt with together. Before the war 45 men were employed by the undertaking, about 30 being of military age. Seventeen had gone to the war, and there were now 32 men left, with two women. Mr. Bache explained that the present application was in respect of two charge engineers, the works superintendent, the sub-station man and jointer, three stokers, an engine driver and a clerk. The first five were absolutely essential; the three stokers he could not replace; if the driver were taken he would have to rely on a woman to take his place; and as to the clerk, it would take a woman two or three quarters to learn his work. The Tribunal granted exemption to nine of the employés so long as they remain in their present occupation; and to the clerk exemption was granted till July 31.

Mr. McCormick, general manager of the Light Railway Company, secured the exemption of a motorman (married), on the ground that he was indispensable in a certified occupation.

At Surbiton an application was made for the exemption of the head clerk and accountant at the local electricity works. It was stated that applicant had been in his present position since the commencement of the undertaking, and therefore had intimate knowledge of that special work. Two assistants and a junior clerk had enlisted, and applicant was the only man left who could take the place of the engineer and manager in the latter's absence. Three months' exemption was granted.

At Southwark on Tuesday Samuel Vousden, of Ryan & Vousden, porcelain and stoneware electrical insulator manufacturers, applied for exemption. He was an ironmonger's assistant before the war, but had started business since the war began with his brother-in-law. The articles produced were made entirely in Germany before the war, and since they commenced business they were inundated with orders for Government departments and private works. He was granted conditional exemption.

TENDERS INVITED.

C.I. Exhaust Pipes, &c.

The Electricity Committee of the Corporation of DUBLIN invite estimates for the supply, delivery and erection of certain Cast-iron Exhaust Pipes and Supports for 1,500 kw. Pelliss engine. Details of work, specification, &c., from the city electrical engineer, Mr. Mark Ruddle, Pigeon House Fort Electricity Works, and tenders, addressed to the chairman, Electric Supply Committee, Lord Edward-street, Dublin, by noon on Tuesday, May 30. *See an advertisement.*

Telegraph and Telephone Material.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, Perth (W. Australia) requires tenders by 3 p.m. June 7, for the supply of 15 tons of Galvanised Iron Wire (Schedule 508, W.A.), for the AUSTRALIAN COMMONWEALTH Postmaster General's Department. Specifications from office of Deputy Postmaster-General, Perth, W.A.

Telephone Exchange Building.

Tenders are required by the Commissioners of H.M. WORKS AND PUBLIC BUILDINGS for the adaptation of the Liberal Club, Milnsbridge, Huddersfield, for use as a telephone exchange. Forms of tender, &c., from the Secretary, H.M. Office of Works, Storey's gate, London, S.W., to whom tenders by 11 a.m. June 5.

Wiring, &c.

Tenders are required for an Electric Light Installation for the EXETER Guardians' Institution in Heavitree-road. Contractors willing to tender are invited to send their names to Mr. R. M. Challice, 7, Bedford-circus, Exeter, by May 27.

Electric Lorry.

SYDNEY (N.S.W.) Council require tenders by 3 p.m. June 20 for the supply of a 2 ton Electric Lorry. Specification, &c., from the City Surveyor.

Electrical and General Stores.

LIVERPOOL OVERHEAD RAILWAY Co. require tenders by 10 a.m. May 31, for 12 months' supply of Electrical Fittings, India Rubber, Iron and Steel, Oil, Packing, Waste, &c. Forms of tender, &c., from the General Manager.

The METROPOLITAN ASYLUMS BOARD require tenders by 10 a.m. May 30 for supply of Electricians' and Engineers' Ironmongery and General Stores. Forms of tender from the Boards Offices, Embankment, London, E.C.

Jointers' Tools, &c.

The Chairman, NEW ZEALAND PUBLIC SERVICE STORES TENDER BOARD, Wellington (N.Z.), will receive tenders until 1 p.m. May 31 for the supply of (1) 18 Jointers' Tool Boxes (containing all tools used for jointing Lead-covered Cables), and (2) 6 tons of Sulphate of Copper. Particulars from the Office of the Controller of Stores, Post and Telegraph Department, Wellington; the District Store Keeper, Post and Telegraph Department, Christchurch; or the Telegraph Engineers at Auckland and Dunedin.

Street Lighting, Generating Plant, Gas Engines, Dynamos, &c.

OAMARU (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1. 1s. for each contract.

PAHIATUA (N.Z.) Borough Council requires tenders by noon July 10 for (contract No. 1) Overhead Wires, Poles and Street Lamps; (No. 2) Gas engines, Producers, Dynamos and Auxiliary Apparatus; (No. 3) Accumulators. Specifications and plans from the Town Clerk, Pahiatua.

Electric Lamps, Lamp-Holders, &c.

Tenders will be received until 11 a.m. June 14 by the VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, for the supply of 5,000 6-volt, and 1,000 110-volt Electric Lamps for signal system (Contract 29,912); and 1,000 Lamp holders (Contract 29,913). Specifications from the offices of the Commissioners.

TENDERS RECEIVED AND ACCEPTED.

TYNEMOUTH.—The Electricity Committee has accepted the tender of the Macintosh Cable Co. for supply of 220 yds. of three-core cable.

MELBOURNE (VICTORIA).—The Council has accepted the following tenders :—

Noyes Bros., 6,000 yds. 0·05 sq. in. three-core lead covered cable, £1,968 : Australian General Electric Co., 100 lanterns, with reflectors and globes and 50 spare globes. £308. 0s. 5d.

Meter Contracts.—Messrs. Chamberlain & Hookham (Ltd.) have received contracts for meters for the ensuing 12 months from Southampton and Falkirk Councils.

Government Contracts.—The following tenders were accepted by the British Government Departments during April :—

War Office.—Dorman & Smith, distribution boards, &c. ; Hewson Mfg. Co., Marshall, Sons & Co. and Ransomes, Sims & Jefferies, battery boxes ; Evershed & Vignoles, bridge meggers ; Craigpark Electric Cable Co., General Electric Co., Johnson, Matthey & Co., Johnson & Phillips, Liverpool Electric Cable Co. and [illegible] Rubber Co., elec. cable and wire ; Babcock & Wilcox, [illegible] ; D. P. Battery Co., elec. secondary station ; Mather & Platt, [illegible], Peebles (Ltd.), engines, dynamo, switchboard, &c. ; Austin Motor Co., generating sets ; Honig & Mock, elec. lamps ; Dixon & Corbett, [illegible] ; British Westinghouse Elec. & Mfg. Co., elec. equipment of Fareham (Hants) power house ; T. Cooke & Co., elec. lighting, telephones, &c., Cannock Chase, and elec. lighting Kinmel Park ; G. E. Taylor & Co., elec. lighting of sheds, Netheravon ; Ellis & Wood, Hobs, Normanton ; Foote & Milne, ditto, Osterley Park, and ditto at [illegible] ; S. Dixon & Son, ditto, Thetford.

India Office.—Siemens Bros. & Co., cells ; Edgerton, Hoop & Co., switchboard ; British Elec. Transformer Co., transformers ; E. Pollard & Son, Shropshire Iron Co. and Callenders Cable & Const. Co., wire.

Post Office.—Grindlay, Ross & Co., elec. lighting, Bolton new post office ; General Electric Co., testing apparatus ; Telegraph Construction & Maintenance Co., telegraph cable ; London Electric Wire Co. & Smiths and Telegraph Construction & Maintenance Co., telephone cable ; Siemens Bros. & Co., dry cells ; London Electric Wire Co. & Smiths, telephone cords ; Doulton & Co. and Taylor, Tunnicliff & Co., insulators ; Bullers Limited, telegraph ironwork ; British Thomson-Houston Co., Edison & Swan United Elec. Light Co. and General Electric Co., incandescent elec. lamps : F. Smith & Co. (inc. in London Electric Wire Co. & Smiths), bronze wire ; Rylands Bros. and Whitecross Co., iron wire.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Accrington.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £164,301 (increase £3,896), of which £107,159 is outstanding.

Year's revenue was £35,043 (compared with £28,802 in 1914-15), and working and general expenses were £25,598 (£21,613), leaving gross profit £9,445 (£7,189). After meeting capital charges, &c., the net deficit was £2,987 (£3,073). Average price obtained was 1·146d. (0·966d.) per unit, and working expenses were 0·912d. (0·818d.). Units generated were 7,486,279 (7,242,252) and sold 6,734,932 (6,342,554). Total maximum supply demanded was 3,207 kw. (as in previous year), and the plant capacity is 4,888 kw. (also as in previous year).

Belfast.—The accounts of the electricity department for the year ended March 31 show a profit of £17,000 (an increase of 30 per cent. over that of the previous best (£13,175 in 1913-14).

Units supplied for lighting and power (exclusive of tramways) were 9,149,000 (against 8,193,000 in previous year), an increase of 11½ per cent., and receipts for same were £80,650 (against £63,669), an increase of over 26 per cent. The tramways took 3½ per cent. less current than in 1914-15, but paid £5,400 more for it. As, however, the tramway undertaking is only charged with the cost of production, that figure only shows the enhanced cost of manufacture. The total receipts (including traction revenue) were £114,650, and expenditure was £68,579 (against £56,374), the chief increases being in coal and oil, and an addition of over £1,000 in half-pay to reservists and volunteers. The average price for coal was 31 per cent. more than in the previous year. The greater portion of the increase in output is due to increased use of electric power. Many applications for current have been received, which owing to the restrictions placed upon capital expenditure cannot be granted.

Bournemouth.—The report of the general manager of the Corporation tramways (Mr. I. Bulfin) for the year ended March 31 states that the net profit was £14,132 (compared with £9,083 in 1914-15).

Traffic receipts were £107,818 (increase of £5,472 over those of previous year) and car-miles run 1,670,702 (decrease 144,930). Receipts per car-mile were 15·49d. (against 13·52d.) ; working expenses £51,796, or 7·44d. (against 7·27d.) per car-mile. Gross receipts (including interest and rents) were £108,518. Capital charges were £37,385 (against £35,612), leaving net profit of £19,337, from which had to be deducted £4,173 (against £2,352), allowances to members of staff who had joined H.M. Forces, and £1,032 (£1,188) capital charges and deficit on running of 'buses, leaving net profit £4,132. Mr. Bulfin recommends the placing of £10,000 to renewals and £1,000 to reserve. The total receipts of the 'buses were £1,035, and running expenses £1,151.

The Council adopted the recommendation of the Tramways Committee that Mr. Bulfin be congratulated on the result of the year's working, having regard to the exceptional circumstances of the year.

Leeds.—The accounts of the Corporation tramways department for the year ended March 31, 1916, show total capital expenditure £1,748,445 (increase £69,602). £502,190 has been applied to reduction of debt, and there is a balance in the redemption fund of £254,383.

Revenue was £475,505 (against £434,510 in previous year), and working expenses were £236,226 (£228,134). Accident insurance and compensation required £4,386 (£6,726), interest £39,163 (£36,690), redemption fund £62,806 (£55,790), and net interest and redemption fund (Sovereign-street estate) £5,200 (£5,200), leaving net surplus £71,821 (£81,567). Passengers carried were 103,453,801 (95,639,268), and revenue car-miles run 9,405,121 (9,522,737). Total revenue was 12·134d. (10·950d.), and working expenses, including power, and permanent way renewals, were 6·943d. (6·671d.).

In his report the general manager (Mr. J. B. Hamilton) says the addition to traffic revenue was due partly to the higher earnings of the industrial population and partly to the restriction of railway services. Car-miles run were actually less, owing to shortage of men, hence the higher average receipts per car-mile. The conveyance of minerals for the Leeds Fireclay Co. over the lines commenced in October last. The Corporation have statutory powers to carry goods and minerals on the tramway lines, and it is expected that these powers will prove very useful in the future. Total working expenses (49·67 per cent. of gross receipts), including war bonus, are the lowest on record. The net surplus (£71,821) carried to relief or rates makes the total devoted to that purpose £1,065,587. Units used were 20,007,207, including 10,043,630 generated by the tramway power station, and 9,963,577 purchased from the electricity department (compared with 6,290,325 and 13,822,631 in previous year). Allowances to dependents of soldiers, &c., amounted to £13,270. The reserve fund now amounts to £22,145. The rail-less traction routes from Guiseley terminus to Otley and Burley were put into operation on Sept. 9 and Oct. 22 respectively. On extensions of track 213 joints have been Thermit welded and 33 joints have been welded on reconstructed tracks. The 3,000 kw. turbo-alternator was put on the load about the beginning of November, and it is proving economical in the production of current. The result of the department's handling its third party risks has been satisfactory. The premium payable on the insurance basis would have been £5,263, while the cost of meeting all claims plus an estimate for outstanding claims, has been £2,634. There were 323 female conductors at March 31, and they were doing very well.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Co. (Ltd.)

The eighty-fifth annual ordinary general meeting of this Company was held on Wednesday last, Sir JOHN WOLFE BARRY, K.C.B., the Chairman of the Company, presiding.

The SECRETARY (Mr. A. R. Hardie), having read the notice convening the meeting and the report of the auditors,

The CHAIRMAN said : I presume, gentlemen, that you will take the report as read ; it has been circulated. (Hear, hear.) It now becomes my duty to offer a few remarks on the report and accounts. When I had the pleasure of addressing you last year I stated that, owing to the abnormal conditions under which we had been working since war broke out, no useful purpose would be served by attempting to compare in detail the various items of receipts and expenditure. As, unfortunately, these conditions continue to prevail, I again propose to review the matter in a more general way. You have now had the accounts in your hands for some time, and have had the opportunity of considering them, and I feel sure that you will have come to the conclusion that the result of the year's operations is a remarkable one. The gross revenue for the year ended Dec. 31, 1915, was in excess of any hitherto attained by the Company, and amounted in round figures to £2,104,000, which shows an increase of £458,691, as compared with the preceding year. On the other hand, the total expenses were about £72,000 more

than those for last year, which again were considerably higher than the total shown in normal times. Included in the present figures, however, is an amount of £36,642 for special payments to the staff and other expenses in connection with the war. The bulk of this in respect of the former is in recognition of the particularly onerous duties performed by the staff entailed by the war, and as an allowance towards meeting the exceptional conditions which prevail in various parts of the world served by our cable system. Last year the stockholders were good enough to approve of the action of the Directors in contributing towards some of the principal patriotic war funds of Great Britain and our Allies. We have made some further contributions this year which are included in the figure just quoted, and we have every confidence that this action will have the full and unanimous approval of the stockholders. (Hear, hear.) You will have noticed that the large sum of £307,037 appears in this year's expenses for income tax payable in England and excess profits duty. Notwithstanding these heavy additional taxes and the increased expenses to which I have referred, the final amount available for distribution, after providing for interest on the 4 per cent. Debenture Stock and dividends on the 3½ per cent. Preference Stock, is £821,637, or £113,895 in excess of that for 1914. Under these favourable circumstances, therefore, the Directors consider that they were fully justified in recommending the payment of a final dividend of 2¼ per cent., making 6 per cent. for the year, as against 5 per cent. which has been paid for many years past, while maintaining the usual bonus of 2 per cent., making a total distribution of 8 per cent. for the year, free of income tax. The sum of £460,000 has been transferred to the General Reserve Fund, and the balance proposed to be carried to the next account amounts to about £26,600.

I have referred at recent meetings to the renewal of some of our older sections of cable in the Red Sea, and to new cables which have been laid between Gibraltar and Alexandria and from Aden to Colombo. These operations have entailed a very large expenditure, amounting in the aggregate to nearly £1,400,000, and this sum has been charged against the general reserve fund during a period covering the last five years, the final instalment of £200,000 being included in the accounts now before you. Although it is difficult under the existing circumstances to obtain a reliable valuation of the reserve fund investments, it has been considered advisable, as a result of the approximate valuation made, to increase the provision for investment fluctuations, and a further sum of £125,000 has accordingly been taken from the general reserve fund for this purpose, making a total provision to date of £450,000. Notwithstanding the above-mentioned extensive withdrawals from the general reserve fund, I am pleased to say that this fund has been well maintained, and that the balance remaining is £1,805,945, or rather more than it was before the heavy withdrawals on account of the new cables, &c., to which I have referred. I think, therefore, it is a matter for mutual congratulation that this Company has attained its present high position, for it is not only sound financially, but in other respects as well. I believe that at no period in its history has this Company stood so well in the eyes of the Government and of the public as it does to-day. (Hear, hear.) The foresight exercised in laying additional cables to provide in advance a margin of carrying capacity beyond our immediate requirements has stood us in good stead. It has enabled us to maintain an efficient system for the Government, and, subject to the conditions which have necessarily been imposed upon commercial correspondence, a continuous and trustworthy service has also been available, notwithstanding the unprecedented volume of traffic which we have had to dispose of. The principal factors which have caused the increase in the number of words carried during the year are the interruption of the Indo-European Telegraph Co.'s line to India, and also that the carrying capacity for commercial work of the Great Northern Telegraph Co.'s route to China and Japan has been greatly reduced on account of Governmental requirements.

Although the Government have permitted the use of nine codes, which has to a considerable extent restricted the use of plain-language telegrams, still the amount of work transmitted over our cables has shown a large increase, so that when any of our main cables have become interrupted from one or other of the natural causes to which they are subject, some delay to commercial traffic must necessarily result. I am glad to say, however, that so far we have been able to maintain a constant service throughout our system, and notwithstanding the great pressure of business which we are experiencing, we have been able to devise plans, on especially favourable terms to the Government, for the distribution of news from the various Government departments to the outlying possessions of the Empire, by which means our Overseas Dominions are kept in touch with the developments of events at home and in the different theatres of war. We have also granted facilities to soldiers, sailors and nurses of His Majesty's Expeditionary Forces by which they are able to telegraph between the United Kingdom and British Colonies, Dominions and Dependencies, and between the Dependencies, and so far as they are under the control of the Associated Companies, these apply to France and her dependencies as well as to Salonika and other places. Bank remittance telegrams, which may include a code word or group in the text, are also accepted for or from the troops at quarter rates between the United Kingdom and the various regions where our forces are operating, and between several Colonies and Dependencies. Means have also been adopted to cheapen the telegrams of our South African and Australasian Forces by code addresses denoting the various units. On certain specified conditions free transmission has been granted to messages of inquiry concerning wounded or sick soldiers, sailors and nurses. (Hear, hear.) I may mention that many of these free telegrams are of considerable length; some of them have contained over 1,000 words. Similar facilities have also been granted to the British Red Cross Society for messages relating to inquiries concerning the wounded, and administrative business between Great Britain and the various places abroad occupied by our active forces. We regret that owing to the necessity of providing for the urgent demands of Government traffic from time to time, and the possibility of congestion on our main lines of communication from possible temporary interruption, we do not yet feel justified in re-introducing "week-end" telegrams; but we are doing all in our power to improve the service of "deferred" telegrams, subject, of course, to the greater demands of Government and ordinary commercial work. Other facilities have been introduced in the interests of our customers, which, however, I need not refer to in detail. The granting of further concessions does not rest solely with these Companies, but the public whom we serve may rest assured that their interests are not overlooked, and that we endeavour to meet their claims so far as they are consistent with those of our Government departments, whose demands, particularly in these times, must always take first place. It is fortunate that we have been able to continue our duty as public servants in a satisfactory manner during a period of such exceptional stress, and I feel sure you will agree with me when I again express the view that great credit is due to our Managing Director, Sir John Denison-Pender, and the staff at home and abroad, for their devotion to the service of the Company and of the country. (Cheers.)

I would also like to take this opportunity of publicly acknowledging the great assistance and courtesy which we have received from the Foreign Office, the Admiralty, the War Office, the Post Office, and the other great departments of the State; and it is gratifying to feel that the services which we have thereby been able to render to them are appreciated. I now beg to move that the printed report and accounts of the Directors for the year ended Dec. 31, 1915, submitted to this meeting, be and the same are hereby received and adopted; that the dividend of 3½ per cent. less income tax, paid in respect of the preference stock of the Company be approved; and that in accordance with the Directors' recommendation, a dividend be and is now declared of 2¼ per cent. with a bonus of 2 per cent., both free of income tax, on the ordinary stock of the Company, making, with previous payments by way of dividend on account, a total distribution of 8 per cent., free of income tax for the year.

The VICE-CHAIRMAN AND MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) seconded the resolution, which was carried unanimously, as was also a resolution that the Directors' fees be paid free of income tax.

The retiring Directors, Lord Allerton and Mr. J. C. Denison-Pender, were re-elected, and the auditors were re-appointed.

A cordial vote of thanks to the Directors and staff at home and abroad for the wonderful work they had achieved during the past year was cordially agreed to; and in returning thanks the Chairman said it was a great satisfaction to the Board to feel they had the unanimous approval of the stockholders, and an even greater satisfaction to know that the Government departments, one and all, appreciated the public nature of the Company's service.

The proceedings then terminated.

Eastern Extension, Australasia & China Telegraph Co. (Ltd.)

The eighty-second ordinary general meeting of this Company was held on May 23, under the presidency of Sir John Wolfe Barry, K.C.B., the Chairman of the Company.

The GENERAL MANAGER AND SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the auditors' report, and the report of the Directors was taken as read.

The CHAIRMAN said: The report and accounts show that the gross receipts for the year 1915 amounted in round numbers to £970,000, against £819,000 for 1914, showing an increase of £131,000. The satisfactory feature of this increase is that it is not only spread over the whole of our extensive system, but is particularly noticeable in our important local traffics between India and Australia, China, Japan, and other countries. The working and other expenses amounted in round numbers to £386,000, against £364,000 for 1914, showing an increase of £22,000, which is fully accounted for by "the special payments to staff and other expenses in connection with the war." Included in this debit is this Company's proportion of the further contributions made by the Associated Cable companies to war relief funds during the past year, which I have no doubt will meet with the same warm approval by the shareholders as on former occasions. (Cheers.) I entered so fully at our last general meeting into the effects of the war on the work of our Company that I need not now recapitulate them. Sufficient to say that the work has been well and successfully carried out.

The net profit for the past year was, roundly, £563,000, and, after adding £31,000 brought forward from the preceding account, there remained an available balance of £594,000. Out of this balance—i.e., £594,000—provision has been made for the payment of interest on the 4 per cent. Mortgage Debenture Stock, amounting to £30,096, for income tax payable in England, and excess profits duty, amounting to nearly £86,000, the three interim dividends already paid, amounting to £112,500, and the £200,000 carried to the general reserve fund. Under these favourable conditions your Directors consider the Company justified in paying an extra 1 per cent. dividend, and therefore recommend the declaration of a final dividend of 2¼ per cent., with a bonus of 2 per cent., amounting together to £127,500, and making with the three interim dividends a total distribution of 8 per cent. for the year 1915, payable free of income tax. The balance proposed to be carried to the next account amounts to nearly £39,000. Turning now to a matter which is somewhat personal to the Board, I would point out that the shareholders are also asked to approve the proposal that the Directors' fees should be

paid free of income tax, as is the case in respect of the shareholders' dividends and bonuses, and is also the case with respect to all salaries of our staff at home and abroad. (Hear, hear.) The course proposed is one which obtains in many companies of the highest standing, and the Board now submit it to the meeting for their approval, and I shall move a separate resolution, as it is a personal matter, after the resolution approving the report and accounts has been passed. It seems to be reasonable that the Directors should no longer remain alone among those who conduct the affairs of the Company in respect of liability to income tax (hear, hear), and the shareholders will perhaps be surprised that the anomaly has existed so long.

The usual additions have been made to the maintenance ships, insurance and depreciation funds, and in addition to the £200,000 already referred to, the general reserve fund has been credited with, roundly, £41,000 in connection with the closing and disposal of the Banjeewangie-Roebuck Bay cable, the maintenance of which was no longer necessary owing to the establishment of improved means of communication with Australia. On the other hand, the general reserve fund has been debited with £74,685 for partial cable renewals carried out during the year, £11,382 representing the loss incurred on the sale of investments, and £25,000 as a further provision on account of investment fluctuations, bringing the total provision against depreciation up to £225,000. The net result of this is that the general reserve fund is increased by, roundly, £130,000, leaving it, at the end of last year, at £786,000. The shareholders will have seen from the printed report that the Australian Commonwealth Government has concluded an agreement with the Company enabling us to deal direct with the public in Melbourne as at Sydney, Adelaide and Perth, and an office has accordingly been opened by the Company for the reception and delivery of telegrams in Melbourne. Some years ago the Company was temporarily allowed to open a public office in Melbourne to the great satisfaction of the telegraphing community, but after a year or two it had to be closed on account of the conditions which at that time the Government wished to impose upon the Company not being acceptable. Before I conclude I should like to bear testimony to the whole-hearted and zealous way in which our staff at home and abroad has carried out its duties in times which involve great responsibility and much labour, and I associate with that the name of our general manager, Mr. Hesse. I now beg to move the adoption of the report and accounts, and the payment of a final dividend of 4s. 6d. per share, together with a bonus of 4s. per share, tax free, making, with the three interim dividends already paid, a total distribution of 8 per cent. for the year.

The VICE-CHAIRMAN AND MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) seconded the resolution, which was carried unanimously.

The retiring Directors, Sir John Denison-Pender and the Right Hon. Lord Inchcape, were re-elected, as were the retiring auditors.

A cordial vote of thanks to the Chairman, Directors, General Manager and staff at home and abroad was carried unanimously, and the proceedings terminated.

West African Telegraph Co. (Ltd)

The thirty-first ordinary general meeting was held on Wednesday last, Sir JOHN DENISON-PENDER, K.C.M.G., Chairman and Managing Director, presiding.

The SECRETARY (Mr. John Cambrook), having read the notice convening the meeting and the auditors' report,

The CHAIRMAN said : Gentlemen, I do not propose to go in detail into the report and accounts, which have been in your hands for some time, but I will just make a few remarks on some of the figures.

The total gross revenue for the year 1915 differs little with that of 1914, being £55,389, against £55,523, or a reduction of £134. The receipts, however, from messages amounted to £44,472 ; that is £1,869 more in 1915 than for the preceding year 1914—the first year which includes war traffics—while interest and dividends on our reserve fund have improved to the extent of £294, owing to this fund being increased. The course of exchange adversely affected the revenue for 1915, and on comparing the two years we find this loss amounts to no less a figure than £2,297, causing the decrease stated in gross revenue, notwithstanding the actual increase in message receipts. The total expenses for the year were £30,675, an increase of £4,506 over 1914. Nearly £1,000 of this increase represents our proportion of additional expenses incurred at a station worked by another Associated Company, and of the expenses of which station we pay a percentage of the total, while the expenses attending maintenance of cables were also £1,673 higher this year than last year. The Exchange, for the year 1915, alone reduces our available receipts by £821, by comparison with 1914. This year's revenue is debited with £747, in respect of special war payments to staff and our share of contributions made by the Associated Cable Companies to National and International Benevolent Funds connected with the war, which action your Directors feel sure has the whole-hearted support of the shareholders.

Thus the net available balance representing the profit on the year's working amounts to £25,347. Although we cannot show any largely increased traffic owing to the war, we do not escape excess profits duty, and this duty, together with income tax, absorbs £2,112, while the dividend at the rate of £4 per cent. per annum will take £9,243. 12s., leaving £13,991, or very nearly £14,000, out of which we propose to place £13,000 to reserve fund, which will then stand at the substantial figure of £327,000, leaving £991 to be carried forward to 1916. It must be remembered the reserve fund figures as given in the report and accounts represent the cost price, and, as we all know too well, the market value of these gilt-edge securities to-day considerably below the figure at which year by year they were purchased. I will now propose the adoption of the report and accounts.

Sir HENRY C. MANCE, C.I.E., M.Inst.C.E., seconded the resolution, which was carried unanimously. A resolution in favour of paying the Directors' remuneration free of income tax was also carried unanimously.

Sir Henry C. Mance, C.I.E., was then re-elected a Director of the Company, and Messrs. Deloitte, Plender, Griffiths & Co. were re-appointed auditors. A vote of thanks to the Chairman, the Directors and the staff concluded the proceedings.

The Directors' report stated that the revenue for the year ended Dec. 31, 1915, amounted to £55,389. 7s. 10d., from which was deducted £18,899. 2s. for the ordinary expenses, and £11,770. 3s. 8d. for expenditure relating to maintenance of cables, sundry differences on exchange, income tax abroad, and war payments to staff and other expenses in connection with the war, leaving £24,714. 0s. 2d., to which is added £633. 5s. 11d. brought forward, making a total available balance of £25,347. 6s. 1d. The sum of £2,112. 10s. 10d. had been provided for income tax and excess profits duty, £13,000 had been transferred to general reserve fund, and an interim dividend of 2 per cent., absorbing £4,621. 16s., was paid on Dec. 1 last. The Directors recommended the declaration of a final dividend of 2 per cent., making, with the interim distribution, 4 per cent. (tax free) for the year, the balance (£991. 3s. 3d.) being carried forward.

West Coast of America Telegraph Co. (Ltd.)

The nineteenth ordinary general meeting was held on Tuesday, Sir JOHN DENISON-PENDER, K.C.M.G., the Chairman, presiding.

The SECRETARY (Mr. Frederick L. Robinson), having read the notice convening the meeting and the auditors' report,

The CHAIRMAN said : Gentlemen, the gross receipts for 1915 amount to £65,475, against £61,129 for 1914. Thus we have an increase of £4,346. Taking into account the restriction of facilities which the war has imposed on this Company, compared with the free hand our competitors, the Central & South American Company, have been able to maintain, owing to their being a company owned and worked in the United States of America, we do not look upon this figure as unsatisfactory. The working expenses are also up by £3,161, being £46,215, against £43,054 for 1914, but of this sum repairs to cables (an item I have always asked you to remember may increase or diminish materially in any year, without the Board being able to have any control over it, for the cables must, of course, be maintained) have exceeded by £1,909 the sum expended in 1914. However, this increase this year does not necessarily mean that repairs have been more extensive than usual, but the cost of the cable-repairing ship has increased. For instance, coal has cost very considerably more, insurances are also much higher, and the cost of provisions has also been greater. With regard to new cable, the extra cost, although not as yet felt to a large extent, owing to our stocks on the Coast being enough for the time being, yet when we replace those stocks, as we shall have to do from time to time, we shall have to renew them at very largely increased cost, compared with that of the existing stocks : and not only that, but the cost of sending the cable out to the West Coast has also very materially increased. The war payments to staff, also the contributions to national funds, in which we take a share with the Associated Cable Companies, and with regard to which your Directors feel they have the support of the shareholders, have amounted to £1,732—certainly, a material sum of money, but the expenditure of which has had the most careful consideration of your Board. The duration of interruptions, owing to breaks in the cables, has been, all told, 63 days for 1915, and this might have been extended had not considerable energy been shown by our people on the Coast and by the staff on our repairing ship, in getting on to the repairing work with an absolute minimum of delay. Your capital still remains at £112,520 in ordinary shares of £2. 10s. each, fully paid, income bonds to the amount of £20,000, and a debenture issue of £150,000 at 4 per cent. As stated in the report and accounts we propose to add £5,000 to reserve, which will now stand at £88,168, £6,000 to provision on account of investment fluctuations (the list of investments attached to the report being given at cost price), and to carry forward to next accounts £2,977. 14s. 3d. You will remember that the debentures fall due for repayment Jan. 1, 1917, and your Directors may have to call you together again later on in the year to confirm the necessary arrangements for dealing with the debt. I will now propose the adoption of the report and accounts.

Sir ALBERT J. LEPPOC CAPPEL, K.C.I.E., seconded the motion, which was carried unanimously.

The retiring director, Mr. Francis Alexander Johnston, was re-elected, and the retiring auditors, Messrs. Deloitte, Plender, Griffiths & Co., were re-appointed, a vote of thanks to the chairman and his co-directors terminating the proceedings.

Submarine Cables' Trust.

The forty-fifth ordinary annual meeting of the certificate holders was held on Wednesday, Sir JOHN DENISON-PENDER, K.C.M.G., presiding.

The SECRETARY (Mr. Sidney Collett) having read the notice calling the meeting,

The CHAIRMAN said : Gentlemen, this being a trust company, there is really very little to report, but I may just call your attention to the position as regards the certificates which have been drawn and which still remain to be drawn. Our total receipts for the year ended April 15 last amounted to £25,489, and after deducting £1,510 for expenses and adding

£50 brought forward from last year's accounts, we have an available balance of £24,029. This amount has been dealt with in the following manner: £15,843 has been distributed to our certificate holders in the usual interest, paid half-yearly, at the rate of 6 per cent. per annum net, leaving a surplus of £8,186, which, according to the trust deed, has to be utilised in the acquisition of certificates. Accordingly we have redeemed and cancelled 68 certificates, without, of course, the coupon of reversion: 25 of these were purchased in the open market, seven were acquired by tender, and, as we were unable to obtain any more by either of these two methods, a drawing was held on the 1st instant, when the balance of 36 were drawn in the presence of a notary. These absorbed a sum of £8,109. 4s., leaving a balance of £77. 7s. 2d. to be carried forward to the next account. You will observe that our receipts this year are somewhat more than those of the preceding year. This is accounted for partly by the changes in investments which your trustees had made in the previous year, and which I mentioned to you, when I had the pleasure of addressing you on the last occasion, would result in a small increase—viz., the sale of some of our holding in the Anglo-American Telegraph Co. and the reinvestment of the proceeds in shares of the Great Northern Telegraph Co. Another source of additional income, however, has been in the receipts from the Central & South American Telegraph Co., they having increased their dividend from 6 to 9 per cent., which means an increase to us of about £260 a year as long as they keep up the higher rate.

Before I sit down I may mention, as a matter of interest, that the certificates which we have now acquired amount in all to 1,625, out of the original 4,200, leaving 2,575 certificates still outstanding. There is also one other point which, as a matter of form, I ought perhaps to mention. You will remember I explained to you last year that after the certificates had been drawn, in accordance with the terms of the trust deed, it was noticed that one of the numbers taken out by the notary represented a certificate which had already been drawn and cancelled, so that, in fact, only 60 certificates were drawn on that occasion instead of 61, as shown in last year's report. That, however, has now been adjusted, as you will see from page 3 of the report in your hands for this year, which shows 36 certificates drawn in respect of this year, and one to take the place of the duplicate number drawn last year. The Eastern Telegraph Co., the Eastern Extension Telegraph Co., and the Western Telegraph Co. have raised their dividends; but the present accounts do not benefit from this increase, which, however, will augment our funds for 1916-17, and I hope future years. I may also mention that the present market value of the securities of the Trust shows an appreciation over their original capital. I now move the adoption of the report and accounts.

Sir ALBERT J. LEPPOC CAPPEL, K.C.I.E., seconded the motion, which was carried unanimously.

Messrs. Deloitte, Plender, Griffiths & Co and Messrs. Cane, Jackson, Jefferys & Freeman were elected auditors, and a vote of thanks to the Chairman and the Trustees terminated the proceedings.

Great Northern Telegraph Co. (Ltd.)

At the meeting in Copenhagen on May 6 the CHAIRMAN (Consul-General W. Weimann), in rendering an account of the working during 1915, said that unfortunately they had again to review the events of the year with the war as the dark and terrible background, and for the same reasons as those given a twelvemonth ago, the directors had been obliged to fix the date of the meeting later than customary. Happily they were once more able to state that the strict neutrality observed by the company and the correctness of its service were being rewarded by the continued confidence of its concessionary Governments. Apart from the cables between Denmark and Russia, which they had been unable to repair since they became interrupted in November, 1914, seven of their cables in Europe had suffered 11 interruptions, whilst in the Far East 19 breaks had occurred in nine cables. Considering the dangers to navigation in the European seas spanned by their cables, it was indeed fortunate that the interruptions during 1915 had been less numerous than in the last few years. In Europe the s.s. "H. C. Oersted" had been on active service for 140 days, of which 32 were for the account of others, whilst in the Far East the "Store Nordiske" and "Faraday" had been occupied for 171 days, for 103 of which they were engaged for account of other parties. The Vladiwostock and Kiachta routes had been in satisfactory working order, but unfortunately the decrease in the traffic transmitted by those lines between Europe and the Far East since the beginning of the war had continued, and had been even more perceptible towards the end of the year. In those circumstances they had provisionally returned to the Imperial Russian Telegraphs the wire between Petrograd and Irkutsk, which some years ago was placed at the disposal of the company's offices at the two places above mentioned, and was reserved for the transmission of the Far Eastern traffic. The wire is now fully used for the huge internal correspondence of Russia. The automatic instruments lately introduced at their principal offices in Europe had demonstrated their great value during the war; but for those instruments the work would have proved overwhelming for the staff. They had only recently commenced to introduce similar instruments in the Far East, where working conditions differed in several respects from those existing in Europe.

They naturally continued to watch with the closest interest the development of wireless telegraphy, but hitherto they had had no occasion for occupying themselves actively therewith apart from the installations on board the cable steamers during later years. A change in this passive attitude may, however, be brought about in the near future, as they were negotiating an arrangement with the Danish Government by which the company was to undertake the establishment of wireless communication within the Faeroe Islands and the working of the stations on behalf of the Government. Circumstances permitting, two stations were to be erected in the course of the current year, one at Thorshavn (Stroemoe) and the other at Tveraa (Suderoe); the former would be open also for communication with ships at sea. The scope of the scheme was purely local, and as the traffic to be transmitted was insignificant, they did not expect to derive pecuniary benefit from the arrangement. Their main purpose in proposing to saddle themselves with that wireless service was to facilitate the fulfilment of a natural wish of the Danish Government—viz., to give to the inhabitants of Suderoe the benefit of telegraphic communication with the rest of the world.

Owing to the restrictions imposed upon all telegraphic communications by the belligerents, it had been necessary to suspend the meteorological cable reports from Iceland and the Faeroe Islands, with which they had supplied several meterological institutes in Europe and America since the opening of the Iceland cable. In order, however, not to discontinue the service completely, and as the said reports, even if delayed, were not without scientific interest to the institutes, they had arranged for the distribution of the reports by mail at a charge which barely covered the company's out-of-pocket expenses. The International Telegraph Conference which was planned to take place in Paris last year—the 50th since the foundation of the Telegraph Union—has been deferred *sine die*, the present juncture not being suitable for international conferences. During the year, and particularly during the first six months, the telegraphic traffic over the company's European cables had been extraordinarily heavy, and as a consequence the working zeal of the staff at the majority of their European stations had been tested most severely. The employés had, however, everywhere performed the very strenuous task imposed upon them with a good will and with unflagging ardour; but now that certain classes of traffic were decreasing, owing to circumstances in connection with the war, they might hope to obtain a well-earned respite shortly. They regretted to have to announce that Commodore E. Suenson, owing to failing health, had resigned the chairmanship of the company as from Jan. 1, at the same time accepting the post of honorary chairman. The directors had elected Mr. W. Weimann as chairman. Notwithstanding the fact that international telegrams were amongst the few commodities the prices of which had not been enhanced by the war—except perhaps indirectly through the prohibition of code telegrams—the receipts were even greater than those of 1914, owing to the extraordinarily heavy traffic. On the other hand, the war had naturally caused the expenditure to increase, particularly under the items "salaries and wages" and "rates and taxes." Last year the directors found that the revenue warranted the payment of an extra 2 per cent. dividend, and, notwithstanding the uncertainty which must of necessity prevail as regards the future, the board considers that the same dividend as last year may safely be paid for 1915. The distribution of a total dividend and bonus of 22 per cent. is consequently proposed. The value of the reserve and renewal fund has depreciated during the year to the extent of about £233,200, and in those circumstances they could but recommend the placing of a somewhat higher amount than usual—viz., £138,888, 17s. 9d.—to that fund. In view of the necessity of replacing the cable steamers "H. C. Oersted" and "Store Nordiske" by new boats in the near future, it is proposed to add £27,777, 15s. 7d. out of revenue to the renewal fund for cable steamers. They asked the shareholders to allow the pension fund, besides the usual contribution, an additional sum of £11,111, 2s. 2d., of which it stood in need. The increase of the receipts was about £198,500. The rise in "salaries and wages" was about £22,900 and in "rates and taxes" £21,900.

ANCHOR CABLE CO. (LTD.)—The report for 1915 states that the profit after making provision for war taxes and contingencies, amounted to £17,251, and with amount brought forward, £32,129, the total is £79,380. Interest on debenture stock absorbs £2,250, depreciation £20,000, written off investments £107, leaving £57,023. It is proposed to pay a dividend of 20 per cent. (£13,068) and to carry forward £44,023.

ANGLO ARGENTINE TRAMWAYS CO. (LTD.)—The gross receipts during 1915 amounted to £2,709,615. 0s. 5d. and working expenses to £1,786,740. 0s. 11d. Adding interest on investments, &c. (£45,637. 8s. 10d.) and amount brought forward (£96,408. 14s. 9d.) and deducting interest and charges (£970,801. 18s. 11d.), the balance is £91,119. 18s. 2d. During the year there has been a further fall in receipts, which have declined from £2,850,995 in 1914, to £2,709,615 in 1915. By the exercise of strenuous economies the expenditure in 1915 has been reduced by £94,256, and now probably represents the minimum compatible with efficiency, while the position is aggravated by the continuous rise in the cost of fuel upon which the price paid for electric current is based. In these circumstances, and having regard to the difficulty of forecasting the results of the present year, the directors are unable to recommend the payment of a dividend on the ordinary shares, and the balance has therefore been carried forward.

ELECTRIC CONSTRUCTION CO. (LTD.)—The net profit for the past year, after providing £9,647 19s. for debenture interest and £7,500 for depreciation, is £13,211 10s. 1d. With £7,171 7s. 10d. brought forward the amount available for distribution is £20,712 17s. 11d. Deducting interim dividend of 7 per cent. per annum on the preference shares, paid in November last (£2,197 6s.), there remains £18,515. 11s. 11d. The directors recommend payment of a dividend at rate of 7 per cent. per annum on the preference shares for six months ended March 31 (£2,197 6s.), and a dividend at rate of 7½ per cent. per annum on the ordinary shares for year ended March 31 (£16,815), the transfer of £12,664 4s. 10d. to general reserve fund, leaving to be carried forward (subject to excess profits duty and assessment under Munitions of War Act) £16,839 1s. 1d. Notwithstanding the very high price of materials and an all round increase in the cost of manufacturing, the net profits for the past year are satisfactory. The improved results are due principally to a larger volume of orders having been handled through the

unremitting efforts of the staff and workmen. Unexecuted orders at the beginning of the new financial year exceeded those on hand a year ago.

INDO-EUROPEAN TELEGRAPH CO. (LTD.)—The report for the year ended Dec. 31, 1915, states that, owing to the continued interruption of the company's route during the whole of the year, the company's actual receipts were confined to local traffic. In consequence of the war, it has been impossible to make final arrangements for the re-establishment of the company's route. Under the existing arrangements with other companies and administrations, this company's receipts for 1915 have not been prejudicially affected, but the directors foresee a diminution in the receipts for 1916. The directors hope shortly to conclude an agreement for the acquisition of a substantial interest in a prominent manufacturing firm, under which that firm will manufacture and develop apparatus for radio-telegraphic transmission and reception covered by the several patents now owned by the company; these will under the proposed agreement be transferred to that firm. The revenue from message account and other sources amounts to £204,189. 19s. 10d., compared with £189,383. 18s. for 1914, an increase of £14,806. 1s. 10d. The expenses are, on commercial and general account, £58,441. 19s. 7d., and on maintenance account £23,776. 0s. 11d., a total of £82,218. 0s. 6d., against £88,395. 8s. 3d., a decrease of £6,177. 7s. 9d. The revenue account, therefore, shows a balance of £121,971. 19s. 4d., which sum is carried to profit and loss account, 1915, and after deduction of income tax and payment of excess profits duty for 1914 is reduced to £101,705. 5s. 3d. To this is added £20,952. 4s. 9d. from 1914, making a total of £122,297. 10s. Deducting £35,000 provided for investment fluctuations, £15,000 provided towards excess profits duty for 1915, and the interim dividend of £10,625, there remains £61,672. 10s. An interim dividend of £2. 12s. 6d. per share (tax free) was recently paid. This payment, amounting to £44,625, the shareholders will be asked to confirm in the form of a final dividend and bonus of £1. 17s. 6d. per share (tax free), amounting to £31,875, with a special distribution of 15s. per share (tax free), amounting to £12,750. The latter sum is derived from interest on unappropriated investments and advance accounts, and it would be necessary to provide out of profit only £31,875, by which sum, therefore, the balance of £61,672. 10s., above referred to, would be reduced. It is proposed to provide a further £10,000 for wireless and other technical development work, carrying forward £19,797. 10s. to the credit of 1916.

KALGOORLIE ELECTRIC POWER & LIGHTING CO. (LTD.)—The accounts for the past year show a profit of £7,439 (including balance brought forward), after adding a further £7,000 to debenture redemption fund, and writing off £6,500 for depreciation. Preference dividend to Sept. 30 last absorbs £6,000, and dividend tax in Western Australia £300, leaving £1,139 to be carried forward.

LIMA LIGHT, POWER & TRAMWAYS CO.—The profit and loss account for 1915 shows that the total profits were £p183,715; deducting bond service (£p60,030), interest, discount and exchange (£p17,508), European expenses (£p1,858) and provision for bad and doubtful debts (£p3,000), the net profit was £p101,318. The balance brought forward was £p50,077, making £p151,396. The board placed to reserve and redemption fund £p29,000, to reserve for bad and doubtful debts £p13,000, to amount written off value of shares owned by Empresas Eléctricas Asociadas in other companies £p29,000, leaving £p80,396, which it is proposed to carry forward.

LISBON ELECTRIC TRAMWAYS (LTD.)—At the meeting last week the chairman (Mr. L. Breitmeyer) said that their traffic receipts still continued to establish a record. The number of passengers carried during the past year was 67,101,249, earning Es.2,022,142$93.5, an increase of 3,343,212 passengers and Es.83,932$14.2 in receipts. The expenditure had unavoidably increased, due mainly to higher cost of coal, labour and other supplies. The coal supply, especially, had become a very serious one, and during the current year the price delivered in Lisbon, on account of the excessive freights, had gone up to nearly £5 per ton, against about 22s. 6d. in pre-war times and an average of 42s. for the past year, and there was no sign at present of any reduction. The quality of the coal obtainable was also inferior, and therefore did not do the same work as formerly, but they had to take what the collieries gave them. The coal consumption came to about 20,000 tons yearly. Among the many possible remedies they were studying was the feasibility of substituting partially or entirely, wood for coal. The increase in expenditure and the falling off in the rate of exchange had reduced the profits by some £25,060, compared with the preceding year, and the directors had therefore reluctantly been compelled to reduce the ordinary dividend from 6 to 4½ per cent. Should conditions remain as unfavourable as at present the question of approaching the Camara in Lisbon for permission to increase the company's fares would have to be considered.

PRITCHETT & GOLD & ELECTRICAL POWER STORAGE CO. (LTD.)—After providing for debenture interest, &c., the accounts for 1915 show a net profit of £9,662, including £1,545 brought forward. A dividend of 15 per cent. is recommended on A ordinary shares, with transfer of £2,000 to general reserve and £1,000 to reserve for depreciation of investments, carrying forward £2,494, subject to income and excess profits taxes.

REUTER'S TELEGRAM CO. (LTD.)—The net profits for the year ended Dec. 31 last, after payment of current charges and deducting rebate on unexpired subscriptions to news services, amounted to £3,942. 9s. 1d., and with £4,849. 1s. 9d. brought forward the total is £8,791. 10s. 10d. In order to set out the investments at Stock Exchange prices at Dec. 31, 1915, a sum of £2,065. 19s. 1d. has been written off their previous valuation, which deducted from £8,791. 10s. 10d. leaves £6,725. 11s. 9d. at credit of profit and loss account. It is proposed to carry forward this sum to the next account. The directors have continued their policy of adapting the finances of the company to the altered conditions imposed by the war, and their efforts have been so far successful that they have not only re-established an equilibrium in the accounts, but have also converted what threatened to be a heavy loss into a profit. This has been achieved by effecting economies in the private telegram department and by finding new sources of revenue to take the place of income formerly derived from the codes, which, as reported last year, were suppressed by the censor at the beginning of the war, and which, despite frequent applications to the authorities concerned, have not been restored. The economies introduced have necessitated a retrenchment of no less than £36,000 a year, but the board have been careful not to jeopardise in any way the value of the agency's vast network for the supply of news, which they have maintained in the highest state of efficiency. Mr. Walter F. Bradshaw, manager and secretary, resigned his office last year, and in October Mr. Roderick Jones, formerly general manager in South Africa, was appointed general manager of the company, and Mr. S. Carey Clements manager and secretary. The directors are satisfied that the company has already retrieved the position so seriously prejudiced by the outbreak of war, and believe that under the new management the shareholders may look forward to a return to prosperity.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—The report of the Directors for the year ended Dec. 31, 1915, states that the gross earnings amounted to £641,581. 6s. 6d., whilst the gross maintenance and other charges in Argentina and London were £447,809. 16s. 9d., leaving a profit for the year of £193,771. 9s. 9d. Deducting interest on debenture stock and dividend on the preference shares to Dec. 31, 1915, and the interim dividend on the ordinary shares (£72,100), and adding amount brought forward (£6,502. 12s. 9d.), there remains an available balance of £128,234. 2s. 6d., which the directors recommend shall be appropriated as follows: Staff provident fund, £2,000; reserve fund, £20,000; depreciation of securities account, £19,000; final dividend of 5s. per share on the ordinary share capital, making, with the interim dividend paid on Nov. 1 last, a return of 8 per cent. for the year (tax free), £81,000; leaving to be carried forward £6,234. 2s. 6d.

WEST LONDON & PROVINCIAL ELECTRIC SUPPLY CO. (LTD.)—Mr. H. Kahn, who presided at the meeting last week, said that the whole of their income was derived from its investment in the Chiswick Electricity Supply Corporation, of which undertaking it owned the whole of the share capital. The balance available for distribution was £3,038, including the profit for the current year of £2,645. 10s. That profit was smaller than that of 1914 by £665. 12s. 4d., mainly owing to the fact that they received 5 per cent. dividend from the Chiswick company instead of the 6 per cent. paid last year. Nevertheless, the directors proposed to pay a dividend of 6 per cent. on the cumulative preference shares for the year 1915, leaving £93. 8s. 8d. to be carried forward. The gross revenue of the Chiswick Corporation had increased by £257 to £19,626, and the number of consumers by 61 to 2,778. After payment of debenture interest, &c., the balance was £3,575. 9s. 1d., against £4,736. 11s. 11d., but before arriving at the figure £1,431. 4s. 1d. was written off for depreciation, against £312. 5s. 10d. in 1914. Under the circumstances the Corporation decided to pay a dividend of 5 per cent. (against 6 per cent.) and to carry the balance of £435. 9s. 1d. to depreciation reserve account. The year had been a most difficult one. Everything seemed to have conspired to make the lot of those conducting an electric light concern an unhappy one. On the one hand, owing to the Defence of the Realm Act, one of the most profitable sources of revenue—namely, shop window and outside lighting—had been practically done away with, and in Aberystwyth, where the Chiswick Corporation supply the street lamps on the front, that source of revenue was for the time being extinct, and, on the other hand, coal and oil had gone up in price tremendously. Coal, for which the Corporation used to pay 18s. per ton, now costs 28s., and for oil fuel, which used to range from 60s. to 70s. per ton, it has to pay 124s. to 140s. To meet the situation, the Corporation had been compelled to raise its price for current by 10 per cent. and to fix a minimum payment per quarter of 13s. 4d. per consumer, and unless in the near future some reduction occurred in the prices of fuel—which seemed very unlikely—the Corporation might be forced to make a further increase in its charges. The second Diesel engine mentioned was working satisfactorily at Aberystwyth, and they were installing a new one at Chiswick, which would be ready for use in about a fortnight's time.

CITY NOTES.

MEMORANDA (May 24).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 58 Consols Pay Day, June 1. Stocks and Shares Ticket Days, May 30 and June 14. Pay Days, May 31 and June 15. Price of silver, 34 3/16d.

ADELAIDE ELECTRIC SUPPLY CO. (LTD.)—An interim dividend of 5 per cent. (tax free) has been declared on the ordinary shares.

AUCKLAND ELECTRIC TRAMWAYS (LTD.)—An interim dividend of 7d. per share (less tax) has been declared on the ordinary shares.

BOMBAY ELECTRIC SUPPLY & TRAMWAYS CO. (LTD.)—A dividend on the ordinary shares at rate of 7 per cent. (tax free) for the year ended Dec. 31, has been declared.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units sold to consumers during the five weeks ended March 31, 1916,

amounted to 2,122,507, compared with 1,579,169 units in the corresponding five weeks of 1915.

CALGARY POWER CO. (LTD).—The gross earnings for 1905 amounted to $289,613, an increase of $58,427 over 1914. Net earnings (after deducting all operating and other expenses), amounted to $237,159, an increase of $56,952. After paying interest charges ($156,966) the balance is $80,193, which has been transferred to surplus account.

DEUTSCH-ATLANTISCHE TELEGRAPHENGESELLSCHAFT.—It is announced that the "net profit" of this company for 1915 was £74,000, and a dividend of 6 per cent. has been declared. Inasmuch as the company's cables have been cut since August, 1914, the only source of profit during the year must have been the Government subsidy.

DOULTON & CO. (LTD.)—A dividend of 5 per cent., less tax, on the preference shares for year ended Dec. 31 last, payable June 6, has been declared.

GENERAL ELECTRIC CO. (OF SWEDEN).—The net profit for the past year was £255,000 (an increase of over 100 per cent.) and a dividend of 12 per cent. (against 9 per cent.) has been declared.

HUELVA GAS & ELECTRICITY CO. (LTD.)—The company intimates that the interest due 15th inst. on the debenture stock will be passed.

MIRRLEES, BICKERTON & DAY (LTD.)—A dividend of 7½ per cent. has been declared on the ordinary shares for the year ended March, the same as for each of the last four years. The net profit, after providing for depreciation and directors' fees, was £16,101, making, with £1,730 brought forward, £17,831. A sum of £5,000 is being placed to reserve, and £2,037 carried forward.

ROBERT W. BLACKWELL & CO. (LIMITED & REDUCED.)—A petition for confirming a resolution reducing the capital of this company from £250,000 to £50,000 will be heard by Mr. Justice Astbury on May 30.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date May 23, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	18½d.
Solid Drawn Copper Tubes	21d.
Brazed Copper Tubes	21d.
Brazed Brass Tubes	20½d.
Brass Wire	18¾d.
Copper Wire	21d.
Rolled Brass	18½d.
Brass Sheets	18½d.

	per ton.
Copper Sheets	£174 0 0
Spelter	£95 0 0

	per ton.
English Lead	£33 5 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£110 0 0
Clean Brass Scrap	£69 0 0
Braziery Copper Scrap	£100 0 0
Old Lead	£28 0 0
Old Zinc	£63 0 0
Hollow Pewter	£120 0 0
Black Pewter	£85 0 0
Gun Metal	£80 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date May 23, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£70 0 0
Clean Copper	£110 0 0
Braziery Copper	£95 0 0
Gun Metal	£84 0 0

	per ton.
Old Lead	£26 10 0
Tea Lead	£24 0 0
Old Zinc	£63 0 0
Hollow Pewter	£135 0 0
Shaped Black Pewter	£95 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £90; Commercial Tinman's Solder, £115; Blowpipe Solder, £125.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, May 23. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., May 23.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	7⅛	5 13 5	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	9½	6 3 1	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅛	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	[illegible]	5 0 0	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	7 3 3	..
5	5%	Do. Ord.	3[illegible]	7 [illegible]	Aug, Feb
5	4½%	Do. City Pref.	2[illegible]	8 9 5	Jan, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅛	[illegible] 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12⅛	6 [illegible] 3	Feb, Aug
10	6/0	Do. 6% Pref.	10⅛	[illegible] 16 4	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10[illegible]	6 16 [illegible]	Mar, Sept
10	6%	Do. 6% Pref.	10[illegible]	[illegible] 16 4	Feb, Aug
St.	4½%	Do. 1st Deb.	86½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	97	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	76½	5 17 8	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6/-	London Elec. Supp. 6% Pref.	4[illegible]	6 19 5	..
St.	4%	Do. 4% Mort. Debs.	82[illegible]	4 17 [illegible]	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2[illegible]	6 1 0	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	[illegible] 11 6	Jan, July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 [illegible]	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db St.	9[illegible]	5 [illegible] 9	Mar, Sept
[illegible]	6%	North Metropolitan E. P. Supp. 6% Pref.	1	6 [illegible]	Apl, Oct
4	5%	South London E.S. Ord	3⅛	6 10 7	Mar, Sept

† Ex dividend or Interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., May 23.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5[illegible]	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5[illegible]	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp 4½% Db. St.	72	6 5 0	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1[illegible]	7 6 4	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅝	6 7 3	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4[illegible]	5 10 9	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Deps.	73½	6 1 11	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	73	7 17 10	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	69⅝	5 14 11	..
St.	4%	Do. do. Assented Def. Ord.	64½	6 4 0	..
St.	4½%	Do. 4½% Pref.	80½	5 11 10	Jan, July
St.	4%	Do. 4% Deb. St.	75¼	5 5 7	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	70[illegible]	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅛	6 1 4	Jan, July
St.	4%	Do. 4% Pref.	64½	6 4 3	Mar, Sept
St.	4%	Do. 4% Debs.	71½	5 11 6	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25½	3 18 5	Feb, Aug
St.	3½%	Do. 3½% Pref.	62½	5 11 2	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	60	5 16 8	Feb, Aug
St.	3½%	Do. 3½% A Debs.	66	5 6 1	Jan, July
St	3½%	Do. 3½% Debs.	67	5 4 6	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 0	May, Nov
St.	4½%	Do. 4½% First Pref.	71	6 6 9	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	107	5 12 2	Jan, July
St.	4%	Do. 4% Debs.	73½	5 8 10	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	72	5 11 1	Jan, July
St	4%	Do. 4% Guar. Stock	66⅛	6 1 0	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2⅝†	5 14 3	Apl, Oct
1	6%	Do. 6% Pref.	1[illegible]	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1[illegible]	5 17 11	Mar
100	5%	Do. Prior Lien Debs.	90½	5 10 6	Jan, July
1	6%	Do. 6% Pref.	[illegible]	6 17 2	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10[illegible]	7 1 2	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5[illegible]	5 15 8	Jan, July
1	6%	British L.M. Ericsson Mfg. Co. 6% Pref.	[illegible]	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2[illegible]	6 15 3	April
100	6%	Do. 6% Prior Lien Debs.	100[illegible]	5 19 1	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65[illegible]	6 1 8	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	12½	6 2 5	Jan, July
5	5%	Do. 5% Pref.	4½	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	[illegible]	7 13 8	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	[illegible]	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	6%	Elec. Construction Ord.	[illegible]	7 7 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	71[illegible]	5 11 6	Jan, July
10	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9[illegible]	6 3 6	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14[illegible]	6 19 2	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4[illegible]	4 14 9	..
St.	4½%	Do. 4½% Db.	87[illegible]	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	10[illegible]	9 9 11	Feb, Aug
10	5%	Do. Pref.	7[illegible]	6 13 4	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	36[illegible]	6 10 2	Mar, July
100	4%	Do. 4% Debs.	95[illegible]	4 6 0	Jan, July
1	7½%	Vickers Ord.	1[illegible]†	4 7 3	May, Aug
1	6d.	Do. 5% Pref.	[illegible]†	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	78[illegible]	5 0 11	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99[illegible]	4 10 5	Jun, Dec
St.	4½%	Willans & Robinson B.Cm Pref. x d & [illegible] u	41†	10 1 3	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	100[illegible]	5 19 1	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	22[illegible]	6 15 3	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69[illegible]	5 15 4	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7[illegible]†	6 13 4	May, Nov
10	10%	Do. 10% Pref.	14†	7 2 10	..
5	5/0	Direct Spanish 10% Pref.	7[illegible]	6 13 4	..
10	4%	Direct United States	6[illegible]	6 9 4	Ja,Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	147	4 15 3	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	63[illegible]	5 10 11	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	77[illegible]	5 3 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77	5 3 11	Feb, Aug
10	7%	Do. Ord.	14[illegible]	4 18 3	Ja, Ap, Jly,O
10	22½	Gt. Northern Tel. Co. ex C[illegible]	35[illegible]	6 1 5	Ja, My, Jly
25	13%	Indo-European	42[illegible]	6 14 9	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2[illegible]	4 10 2	April
1	7%	Do. 7% Pref.	1[illegible]	3 14 8	July
10	1%	West India & Panama Ord.	[illegible]	10 9 8	May, Nov
10	6%	Do. 1st Pref.	7[illegible]	7 12 11	May, Nov
10	8%	Western Telegh. Co.	14[illegible]	5 9 10	Mr, Jly, O, Dec
St.	4%	Do. 4% Deb St.	77[illegible]	5 3 7	Jan, Dec
..	4½%	Western U[illegible] 50 yr. Bds.	93	4 11 10	May, Nov.
		Telephones.			
1	7½d.	Ilent[illegible] Video Telephn. Ord	[illegible]	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	1[illegible]	5 8 6	Apl, Oct
St.	4%	Do. Db. St.	79[illegible]	5 1 5	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6[illegible]	6 8 0	Apl, Oct
5	5%	D[illegible] 5% Cum. Pref.	4[illegible]	5 10 4	Jan, July
St.	4½%	Do Deb. Stk.	84[illegible]	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12[illegible]	4 17 3	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10[illegible]	5 18 6	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	82[illegible]	6 1 9	Ja,Apl,Jly,O
..	4%	Do. $100 Pref	70[illegible]	5 14 1	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	124	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4[illegible]	6 10 8	Mar, Sept
St	5%	Do. 5% Debs.	95[illegible]	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10[illegible]	5 19 6	..
St	4½%	Do 4½% Deb[illegible]	85	5 5 11	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6[illegible]†	7 8 5	May, Nov
5	5%	Do. 5% Pref	4[illegible]	5 14 3	Mar, Sept

† Ex dividend or Interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,985. [Vol. LXXVII. No. 9.] **FRIDAY, JUNE 2, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d.. or 20 cents, or 1fr.. or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 273
Arrangements for the Week.. 276
Telephonometry. By B. S. Cohen. Illustrated.—*Concluded*..... 277
Notes on Design of Electromagnetic Machines. By Stanley Parker Smith, D.Sc. Illustrated..... 280
Patents in 1915..... 282
The Shildon-Newport Railway Electrification. Illustrated. *Continued*..... 284
Training Munition Workers.. 289
DESIGN OF ELECTROMAGNETIC MACHINES..... 290
REVIEWS..... 291
Relativity and the Electron Theory [Cunningham].
REVIEWS—*Continued.*
Overhead Transmission Lines and Distributing Circuits: Their Design and Construction [Kapper]: Reviewed by Gisbert Kapp.
Institution of Electrical Engineers.—*Discussion*..... 292
Effect of the Rebellion in Dublin on the Dublin United Tramways. Illustrated.. 292
Interlinking of Electric Supply Undertakings..... 293
Physical Society..... 294
LEGAL INTELLIGENCE..... 294
PARLIAMENTARY INTELLIGENCE 295
The "Electrician" Commercial and Industrial Section.. 297-306

NOTES.

The Uneconomical Small Station.

THE lack of economy in coal consumption in small steam generating stations is shown very clearly by the figures which we publish elsewhere in connection with Stoke-on-Trent. In the case of Longton, in which the units generated during the year only amounted to 37,920, the coal per unit was as high as 21½ lb. At Stoke, with nearly double the output, the coal per unit was 13¾ lb., and even at Hanley, with 849,332 units generated, the coal per unit was 12 lb. As against this we have a coal consumption of 2¾ lb. per unit with an output of 9,960,796 units at the modern power house. The effect of running the turbine plant at the power house was to change the net loss of £6,162 in 1913-14 to a net profit of £71 in the following year. The Council now have under consideration the putting down of another turbine set, and this will bring about a sufficient saving of coal to pay the capital charges on the new plant. It might be thought that such figures are merely isolated cases. This, however, is not so by any means. There are numbers of comparatively small stations in the country in which the coal consumption is necessarily very high. If these could only be supplied in bulk from the large undertakings there would be a great saving to the country in coal.

Goods Traffic on Tramways.

WE have on many occasions pointed out the possibility of developing to a larger extent the handling of goods traffic on tramways, and thus tapping a source of revenue which would be very acceptable to tramway undertakings at the present time. We are glad to see, therefore, that a movement is being made in this direction in both Leeds and Bradford. At Leeds it seems that quite a considerable amount of business is being done with the carriage of fireclay and coal for the Leeds Fireclay Company. At Bradford, again, a special lorry has been constructed, as was described in a recent issue, capable of running both by means of the trolley and by accumulators. Owing to the great difficulty of transport during the war there seems to be a particularly good opening for vehicles of this class, and for the development generally of goods traffic. In some towns the electricity works are not provided with a railway siding and consequently all coal has to be carted, which is now particularly difficult owing to the shortage of labour. In many such cases it should be possible for the tramways to come to the assistance of electricity works so placed and to transport the coal from the railway sidings into the electricity works at a comparatively small cost.

Patents in 1915.

THE annual report of the Comptroller-General of Patents is usually a document which gives interesting information as to the trend of invention. The report this year, which we give in abstract in another column, is rather a commentary upon the effects of war than anything else. The number of applications during the past year was 18,191, as against 30,077 in 1913. Of course, the reduction is to some extent due to the fact that applications from enemy states only assumed a very small proportion, but apart from that, undoubtedly the chief reason is that the war necessarily has a blighting effect upon industrial progress. With regard to applications from enemy States, these were allowed to proceed when war broke out, but formal acceptance was not issued. It was felt, however, before long that in this way a large accumulation of patents was arising, which might be of importance to the trade of this country, and consequently such applications, although not sealed are now published. This undoubtedly is a wise step to have taken, for many inventors in this country would otherwise be working in the dark. It is to be hoped that the next report will see us engaged once more in peaceful industrial pursuits.

The Whitsun Holiday.

ON paper the granting of a day's holiday means a reduction of output corresponding to the time actually lost. Actually such a holiday means a diminution of output very much greater in proportion. According to the Minister of Munitions the short break at Easter meant a reduction of output equal to that of a whole week's work under normal conditions. For this reason we are pleased to note that it is proposed to abandon the idea of a holiday during the coming Whitsun, and we hope that this will apply equally to all classes of labour. The postponing of the holiday to the end of July does not appeal to us very strongly, for, in any event, a holiday is due the first week in August, and if it be the intention to make the one holiday serve a double purpose, we think that a statement by the Minister of Munitions to this effect will avoid the possibility of any misunderstanding later. The present attitude

both of employers and employees is praiseworthy, and we would not have the relations strained by taking advantage of ambiguity in depriving a large section of our people of a holiday which they have certainly earned and to which they are assuredly entitled.

The Provision of Skilled Labour for Munitions.

We are informed by the Ministry of Munitions that there is at the present time a great disparity of skilled labour for use in the production of munitions of war. The exigencies which have given rise to this shortage of an important branch of labour need not be discussed here, for they are well known; but it is satisfactory to record that steps were taken nearly 12 months ago by the Ministry of Munitions, in co-operation with the engineering firms and the educational authorities in different parts of the country, to contribute towards this deficiency by the establishment of training centres through which persons drawn from the non-engineering trades might pass. In another column we give particulars of the results which have so far been achieved in the accomplishment of this desirable object. We are asked especially to emphasise the fact that it has not been, and will never be, the intention of the Ministry of Munitions to employ this training organisation, which it has now successfully set up, for the production of "engineers" from drapers, artists, and the flotsam and jetsam thrown up by this war. It is necessary to refer to the matter in this way, because we gather that in some quarters this type of trained munition worker has been looked upon with some suspicion, probably not so much by the employers themselves as by some of the charge hands and ordinary workers. Such an attitude where it has been taken up, may be considered as distinctly unpatriotic. It is a class of criticism which does no good, because it has nothing else to offer in place of the type of munition worker which the Ministry has at any rate succeeded in producing. We should prefer to see and hear more of the manufacturers and engineers with whose hearty co-operation the work of the Ministry of Munitions in this direction has been brought to a practical issue. If the output of munitions is liable to be prejudiced by small matters and such an event as the Whitsun Holiday, this reveals a condition of things which, to say the least of it, may be considered serious. In the national interests it is, therefore, highly desirable that the work of the Ministry of Munitions to supply the gaps in the ranks of skilled labour should be judged rather by results than by any problematical influence which the introduction of this class of improvised, but none the less efficient, worker may have upon industry in the future. The results undoubtedly justify the means, without producing any hardship, and that in itself should be enough under present conditions.

Merchant Shipping Convention Act (1914).—By an order in Council it has been decided that the provisions of this Act shall not come into operation until Jan. 1, 1917.

Verband Deutscher Elektrotechniker.—The annual general meeting will be held at Frankfort-on-the-Main on Sunday, and members will be mainly occupied with Papers on substitutes for scarce electrical engineering materials.

"The Architect in Relation to Electric Lighting."—In reference to our leading article on this subject last week our attention has been called to the fact that C.T.S. wires, as well as Henley's and Stannos, can be conveniently used for concealed work where there is but little space available. We are interested to note according to the latest pamphlet describing the system that "it can be installed direct in new plaster." As is well known, C.T.S. is made by the St. Helens Cable & Rubber Co.

Newcastle Electric Supply Co.—The "Colliery Guardian" states that owing to an extension of plant at one of the stations owned by this company, Messrs. R. H. Longbotham & Co., of Ings Foundry, Wakefield, have purchased the smaller Parsons turbo-generators with condensers. These range from 2,500 kw. to 5,000 kw., and are being replaced by units of much greater power.

Daylight Saving.—In France the Senate Committee rejected by five votes to three the proposal for daylight saving. The reasons for its rejection were doubtful economy, and serious inconvenience. The committee considered it was "not wise to regulate artificially the lives of persons who go to bed too late at the expense of the portion of the population which already carries out daylight saving."

Hysteresis and Hardness.—In a Paper on "Surface Tension Effects in the Inter-crystalline Cement in Metals, and the Elastic Limit," read before the Institute of Metals by Mr. F. C. Thompson, B.Sc., it is stated that for the samples of iron tested the hysteresis loss per cycle $e=300B^{1.5}$, where B is the Brinell hardness. The Brinell hardness factor is generally expressed by the ratio of the load on a steel ball of given diameter to the area of the curved surface of the impression it makes on the material.

Exposition Internationale de Lyon, 1914.—We have received a pamphlet entitled "La Science à l'Exposition," edited by Mr. Jean Mascart, Director of the Observatory at Lyon, and Professor of the Faculty of Sciences. The book is divided into two sections, the first dealing with astronomical, meteorological and wireless telegraph matters. The second portion contains a description of the geological formations of the district and the growth of the City of Lyons, besides matters of astronomical and other interest.

State Recognition of Engineering.—A largely attended meeting (organised by the British Electrical & Allied Trades' Association, held at Liverpool on Empire Day, unanimously passed the following resolution:—

That the indispensable military services rendered by the engineering industry and its fundamental importance in the future as the basis of defensive power and of prosperous economic development, entitle it to special State recognition in any reform of national and Imperial commercial policy, and to the patriotic support of all public and private users of plant and machinery throughout the Empire.

Destructor Products.—"The Times" Engineering Supplement refers to the experience gained at Paisley. The report of the sanitary inspector for 1914 shows that a revenue of £428 has been obtained from the sale of "residual products." Some of these were as follows: Clinker £224, mortar £48, old tins and scrap metal £110, waste paper £15, other refuse £22. During the last two years waste paper and broken glass has increased in value, and by the use of the vertical shaft type of furnace the working costs of the destructor have been reduced. The prospects for remunerative working appear to be greatly improved.

Ionisation by Collision.—The "Physical Review" publishes a Paper by K. T. Compton on "The Theory of Ionisation by Collision," in which the errors in the constants in Townsend's equations are referred to. As is well known, Townsend assumed that the collisions were inelastic, and although, with the exception of helium (and probably other inert gases), the curves obtained agree generally with theory, the constants differ from the correct values in most cases by over 100 per cent. In the present Paper the more important results of a study of velocity distribution are given, and expressions for α are obtained which agree better with the facts than any formula yet suggested.

Storage Battery Car.—The "Electric Railway Journal" refers to the low operating costs of the 50 ft. 30-ton Edison storage battery passenger car of the Cambria & Indiana Railroad. During a series of runs of 738 miles the total cost, including platform labour and power, was 7d. per mile. The general manager of the company believes that the car with its present battery equipment is capable of an increased mileage up to 50 per cent., which will reduce the cost per mile materially. After three years of experience, the railway company are

ordering an additional car of somewhat smaller size. This car is to be 35 ft. 8 in. long, equipped with 165 Edison A 10 cells, and four Westinghouse motors.

The Corrosion of Steel.—A Paper entitled "The Theory of the Corrosion of Steel" was read by Mr. L. Aitchison, B.Sc., recently before the Iron and Steel Institute, from which it is concluded that corrosion takes place purely by the action of the ferrite, or solid solution. It is pointed out that the fact that steels formed, as they invariably are, of carbides embedded in a matrix of some carbon-free material renders it almost certain that the action going on in a steel is a galvanic one. The couples consist of the carbide on the one hand, and the ferrite, or solid solution, on the other. Carbides in all steels probably possess very similar electrical properties, and consequently the electrolytic solution pressure will be the same, or nearly so. On the other hand, the solid solution, ranging from pure iron to an alloy containing many per cent. of some second element, will have varying electrical properties. The corrosion should, therefore, vary a great deal with composition.

Sampling and Analysing Flue Gases.—A bulletin on this subject by Messrs. H. Kreisinger and F. K. Ovitz, issued by the Bureau of Mines, is written in plain and non-technical language, as far as possible, so that it may be readily understood by persons who have not had the advantage of a technical education. Whenever possible, illustrations of apparatus and methods of handling have been used rather than elaborate descriptions.

The material presented is arranged in two parts. The first part contains the description of the apparatus and the methods used in sampling and flue gases. The second part gives experimental results obtained with the different methods of sampling and collecting flue gas that are recommended in the first part of the report. Only simple apparatus and methods are considered, as they are accurate enough to show the large heat losses due to the use of too much air, and are also sufficiently accurate to indicate any incomplete combustion losses of economic importance. Without doubt the loss due to large excess of air is the greatest one in the boiler room, and can usually be greatly reduced by making proper use of gas analysis. Before engineers in the isolated industrial plants can be induced to analyse for carbon dioxide, they must learn to appreciate the great possibilities of reducing loss from large excess of air. Furthermore, in the face of the great difficulty of obtaining a fair average sample, discussed in the second part of the bulletin, it is doubtful whether more delicate apparatus for analysis and more refined methods would be of much advantage. A useful list of references to publications on fuel technology issued by the Bureau is given in conclusion.

Electric Steel Furnaces.—The following table on the use of the Héroult electric steel furnace throughout the world is given in the "Iron Age":—

Countries.	Annual capacity.		Increase in 1915.	Number of furnaces.
	1914.	1915.		
	Metric tons	Metric tons	Metric tons	
United States	141,200	371,500	230,300	40
Germany	385,750	403,750	18,000	17
Great Britain	77,000	189,800	112,800	20
Canada	6,000	21,600	15,600	3
France	194,500	234,800	40,300	11
Belgium	30,000	30,000	...	2
Luxemburg	40,000	43,600	3,600	2
Austria-Hungary	61,500	74,100	12,600	10
Switzerland	2,500	2,500	...	1
Italy	41,000	54,000	13,000	4
Russia	30,000	30,000	...	3
Sweden	6,000	14,700	8,700	2
Total	1,015,450	1,470,350	454,900	115

In increased tonnage in 1915, the Héroult furnaces of the United States lead with 230,300 tons. In total capacity Germany is first. The marked increase in England's Héroult furnace capacity is to be noted.

Engineering and the Empire.—At a meeting at Liverpool on the 26th inst., Mr. T. C. Elder delivered an address with the above title.

In the discussion which followed, one of the speakers stated that a most interesting scheme had been in operation during the past few years in connection with the University of Pittsburg. Industrial research had been undertaken by research fellows appointed for the purpose of a particular research, and the research had been financed by the firms interested. If the work was to be done properly, a grant, say, of £50,000 a year should be made to the Institution of Electrical Engineers and to the other engineering institutions to enable research work to be carried out in suitable laboratories. It was a well-recognised characteristic of many firms that they would not take up a process or a manufacture until it had shown itself a commercial success, which might be all very well from the business standpoint of making money, but making money was not the first object of a manufacturer; the first object was to make good machines, and the business man would then make certain that they were sold so as to ensure a good return. If progress was to be made in manufacture, highly trained technical men must be available both as leaders of industry and in the research laboratories. One could spend tens of thousands of pounds in laboratories, either for a works or for a university, but they were useless without the right men to work them. These men were not produced in a year or two; they were the product of many years' education and selection, and the second urgent question that we should face was the shortage of men who could carry on research work, and who could man the testing and research laboratories of the future. We felt the need of such men to-day in fighting the war, but what was true about the war was of still greater importance in the industrial war of the future, and every effort should be made to bring home to the public the enormous importance of this question.

Manufacture and Uses of Alloy Steels.—An informative report on this subject by Mr. H. D. Hibbard has come to hand from the Bureau of Mines. In an introductory note it is stated that the report is issued as a contribution to the increase of efficiency in the preparation and utilisation of the mineral resources of the United States. The author defines alloy steel as "steel containing one or more elements other than carbon in sufficient proportion to modify or improve substantially and positively some of its useful properties," and the report deals exclusively with alloy steels which agree with this definition. Each of the following alloy steels is dealt with in a way that will be appreciated by the practical engineer: Simple tungsten steels, simple chromium steels, manganese steel, simple nickel steels, nickel-chromium steels, silicon steels, high-speed tool steels, chromium-vanadium steels. To give an idea of the breadth of treatment we take at random from the contents the several items on high-speed tool steels given below:—

Manufacture of high-speed tool steel; composition of high-speed tool steels; carbon in high-speed tool steel; tungsten in high-speed tool steel; chromium in high-speed tool steel; molybdenum in high-speed tool steel; vanadium in high-speed tool steel; cobalt in high-speed tool steel; copper in high-speed tool steel; sulphur and phosphorus in high-speed tool steel; stellite; heat treatment of high-speed tools; theory of high-speed steels; testing and using high-speed steel; machine-tool design; patents on high-speed steels; miscellaneous uses of high-speed steels; and bibliography on high-speed tool steels.

Those who want information on the subject will find this 76-page bulletin invaluable.

Variations in Nocturnal Transmission.—Earlier in the year before the Institute of Radio Engineers, New York, Messrs. A. H. Taylor and A. S. Blattermann read a Paper on the above subject. The authors describe experiments on night transmission, on wave-lengths of 500, 850 and 1,500 metres between two inland stations 1,250 km. apart. The bibliography of wave absorption is first considered critically. The average transmitting current was 12 amperes and the decrements varied from 0·09 to 0·18, the effective height of the transmitting antenna being 27 metres, and receiving was effected by means of an audion tested against a constant exciting circuit. In making audibility measurements by the shunt-to-telephone method the true impedance at the audio frequency in question was used. Observations were made hourly during the night, with 15-minute periods near sunset and sunrise. The curves of signal strength are not symmetrical about the solar midnight. In general, the fluctuations of the 500-metre wave follow those of the 1,500-metre wave, but not necessarily *vice versa*. The 850-metre wave does not seem to fluctuate in marked synchronism with either of these. This is explained on the basis of definite wave interference. Short waves are superior by night, long waves by day, generally. The disappearance of the ice sheet between the stations and the breaking up of the soil seems to account for a spring drop in transmission. Cloudy days markedly favour the following night transmission. Fading and "freak" effects are more numerous on short waves, thus favouring the interference explanation. It is suggested that future observations should be almost continuous on long wave-length range, of high power, reciprocal between stations, and in various directions.

OBITUARY.

J. E. M. Stewart.—The death is announced of Mr. J. E. M. Stewart, late chief assistant of Leicester Corporation electricity supply department. Mr. Stewart had been in failing health some time before his resignation in December, and his death occurred at a nursing home in Bournemouth. Mr. Stewart was chief assistant engineer at Leicester for a number of years. He was 45 years of age.

PERSONAL.

Mr. J. L. Holmes, Rangoon municipal engineer, is at present at home on leave, and he is investigating the various systems of street lighting. The present electric system is considered too expensive, its cost having reached over £13,000 a year with the existing carbon lamps. The London agents of the municipality are Messrs. Ogilvy, Gillanders & Co., 67, Cornhill, E.C.

Marylebone (London) Electric Supply Committee have given permission to the general manager of the electricity undertaking, Mr. A. H. Seabrook, to take up a Commission in a special branch of the Army where his general mechanical engineering experience, and the special experience he has gained on munitions work during the last 10 months, will be utilised.

Second Lieut. Thomas Challoner, of the Glamorgan Fortress Royal Engineers, and before the war engaged in the Cardiff branch of the British Westinghouse Co., has been awarded the Military Cross.

Royal Engineers (T.F.)—The following appointments have been made :—

London Electrical Engineers : Sapper R. W. T. Corbett, F. C. Stephens (Captain, Reserve of Officers, Union Defence Forces, S.A.), and Sergt. S. P. Rigden (from H.A.C.) to be Second Lieutenants (on probation). Second Lieutenant F. C. Stephens to be temporary Lieutenant.

Tyne Electrical Engineers : Captain G. A. Bruce to be Major and remain seconded. Lieutenant (temporary Captain) N. H. Firmin to be temporary Major (correction of entry in "London Gazette" of Jan. 18). Second Lieutenant (temporary Captain) W. G. Ward to be Lieutenant (temporary Captain).

APPOINTMENTS VACANT.

A shift engineer is required for small traction and lighting station. Applications to the Manager, Great Grimsby Street Tramways Co., Cleethorpes, Lincs. *See advertisement.*

A stoker is advertised for, accustomed to mechanical and hand-fired furnaces. Applications to Mr. G. G. Bell, engineer and manager, Hammersmith Electricity Department, 85, Fulham Palace-road, London, W.

A mains engineer is required by Eastbourne Electricity Committee. Salary £156. Applications to the Borough Electrical Engineer by 5 p.m. June 9.

Holyhead Urban Council require a shift engineer, not eligible for enlistment. Wages 32s. 6d. per week. Applications to Mr. P. Williams, Electricity Works, Holyhead, by June 4.

Dundalk Electricity Committee require an assistant engineer. Salary £100. Applications to the engineer and manager by 5 p.m. June 12.

The Governing Body of the Manchester Municipal School of Technology invites applications for the appointment of vice-principal. Salary £500 a year. Conditions from the Registrar, to whom applications by June 19.

INSTITUTIONS AND SOCIETIES.

The Royal Society.—Amongst the Papers read at last Thursday's meeting were the following : "The Transmission of Electric Waves around the Earth's Surface," by Prof. H. M. Macdonald, F.R.S. : "A Critical Study of Spectral Series. Part IV.—The Structure of Spark Spectra," by Prof. W. M. Hicks, F.R.S.

Tramways and Light Railways Association.—The eighth annual congress will be held at the Westminster Palace Hotel, S.W., on June 30 at 2.30 p.m.

Manchester Steam Users' Association.—The 61st annual report of the Committee of Management states that at the close of 1915 the number of boilers enrolled and the revenue for the year were the highest ever attained.

The total number of boilers under inspection on Dec. 31 last was 10,793, an increase of 401 over 1914. The revenue was £22,641. 16s. 6d., an increase of £1,382. 15s. 5d., and the net surplus was £2,109. 11s. 3d. The total of the reserve fund now stands at £50,325. The past year was the busiest the Association has ever experienced, and the inspectors have been working at exceptionally high pressure, so that it was frequently difficult to meet all the demands made upon them. In addition to the ordinary thorough examinations required of the boilers of members, a very large number of new and also of second-hand boilers were examined on behalf of H.M. Government and industrial firms mainly connected with the manufacture of munitions of war. The gross total of examinations made in 1915 was 22,297. Among the abnormally large number of second-hand boilers, and other vessels for steam pressure, examined as to their fitness for purchase, many were found unfit and were rejected, while others had to undergo structural alterations or repairs to render them suitable. The ever-increasing cost of coal, added to the difficulties in obtaining supplies, has led to many inquiries as to how economics might be effected in the generation or use of steam.

The Committee report that a tube in a water-tube boiler while at work drew out of its hole in the upper drum, due to overheating. Unfortunately one of the attendants in his excitement climbed up a ladder into the cloud of steam, where he was seriously scalded, and died a few days later. A second man, who was in the stokehold at the time, left it by the proper exit and got out uninjured. The overheating was due to scale in the tube, which had not been cleaned as often as necessary. After 61 years of immunity the Committee regret that the first fatality has occurred in connection with a boiler having the Association's guarantee, but no discredit or blame attach to the Association in connection with the accident. Outside its ranks the Association has noted throughout the United Kingdom during the year the occurrence of 48 explosions, killing 22 persons and injuring 54 others. Of these, 19 killing 12 persons and injuring 21 others, may be termed "boiler explosions proper," while the remaining 29, killing 10 persons and injuring 33 others, may be termed "miscellaneous" explosions, *i.e.*, those arising from steam pipes, stop valves, kiers, stills, drying cylinders, bakers' ovens, &c. At the visit of the British Association to Manchester in September last, a Paper was read by the Chief Engineer on the "Fatigue of Metals," and the members present expressed their hearty appreciation. Eleven of the Association's staff have joined the Colours, and the Committee regret to state that one has been killed in action and another died from disease contracted in Military Service. At the special request of H.M. Government one of the inspectors was granted leave and was appointed inspector of boilers by the War Department.

ARRANGEMENTS FOR THE WEEK.

TUESDAY, June 6th.

Royal Institution.

3 p.m. At Albemarle-street, W. Lecture on Optical Research and Chemical Progress (Lecture II.), by Dr. T. M. Lowry, F.R.S.

Rontgen Society.

8.15 p.m. Meeting at Institution of Electrical Engineers, Victoria Embankment, W.C. A Paper on "Homogeneity of Visible Radiation," by Prof. J. W. Nicholson, M.A., D.Sc.

1st LONDON ENGINEER VOLUNTEERS.

Commanding Officer, Lieut.-Col. C. B. Clay, V.D.

Orders for the week.

Officer for the Week.—Platoon Commander A. Gerard.
Next for Duty.—Platoon Commander W. J. A. Watkins.
Appointment.—Sergeant C. Clayden to be Battalion Sergeant Cook.

Saturday, June 3rd.—Parade at Headquarters, 2.45, for ceremonial Drill. Uniform. Every member is urged to attend.

Monday, June 5th.—Technical for Sections 1 and 2, No. 3 Company, 46, Regency-street, S.W. ; Squad and Platoon Drill, Sections 3 and 4, No. 3 Company ; Signalling Class and Recruits.

Tuesday, June 6th.—School of Arms, 6 to 7 ; Lecture, Company Commander Castell, "Bridging" ; Recruits, 7.15 to 8.15.

Wednesday, June 7th.—Platoon Drill, No. 1 Platoon, No. 1 Company.

Thursday, June 8th.—Platoon Drill, No. 5 Platoon, No. 3 Company ; Shooting for Sections 3 and 4, No. 3 Company, Miniature Range ; Recruits, 5.45 to 7.45 ; Instructional Class, 5.45.

Friday, June 9th.—Technical for Sections 3 and 4, No. 3 Company, 46, Regency-street, S.W. ; Squad and Platoon Drill, Sections 1 and 2, No. 3 Company.

Sunday, June 11th.—Entrenching at Otford, parade Victoria (S.E. & C. Railway Booking Office), 8.35 a.m. Uniform, haversacks, and water bottles. Midday rations to be carried. Railway vouchers will be provided.

Otford Camp.—On and after Saturday, June 3rd, there will be a standing camp at Otford, see Monthly Orders.

Musketry.—For Nos. 1 and 2 Companies, see Notice and Tables A and B at Headquarters.

Note.—Unless otherwise indicated, all drills, &c., will take place at Chester House. Nos. 1 and 2 and 3 and 4 Sections, No. 3 Company, will in future be known as Platoons Nos. 9 and 10.

TELEPHONOMETRY.*

BY B. S. COHEN.

(*Concluded from page* 245.)

Summary.—After a brief introduction, the author deals with standard cable measurement and transmission testing. A new device termed a telephonometer is then described, and the results of tests given in the form of tables are compared.

Description of a Telephonometer.

Early Experiments.—An attempt was made some years ago to find a substitute for the voice and ear in telephonic volumetric measurements. Firstly a comparison was made of various words used in balancing lines, circuits and apparatus, and it was found that the words 1, 2, 3, 4, 5 gave substantially the same results as sentences such as "Mary had a little lamb." When this had been ascertained, a series of oscillograms was made for the words 1, 2, 3, 4, 5 as uttered by various observers, and a mean wave obtained combining all these words. An analysis of this wave gave a fundamental of comparatively small volume and 145 ∾, and a large 6th harmonic 20 times the volume of the fundamental, in addition to many other harmonics mostly greater in volume than the fundamental.

It was hoped that a wave representing the fundamental and the 6th harmonic would give results approximating to speech. This, however, was found only to be correct when used for comparing types of lines and circuits where relative results are not much affected by frequency changes. The results with receivers and transmitters were unsatisfactory. The question was reopened some two or three years ago, and considerable progress has been made towards a solution, although it has only been possible to experiment in the intervals from other more pressing work.

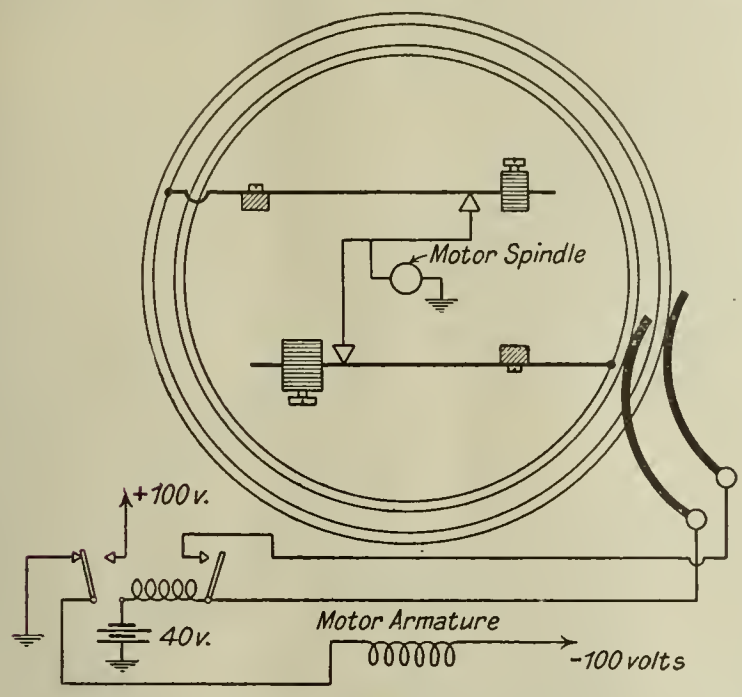


Fig. 4.—Rhythmic Interrupter Governor.

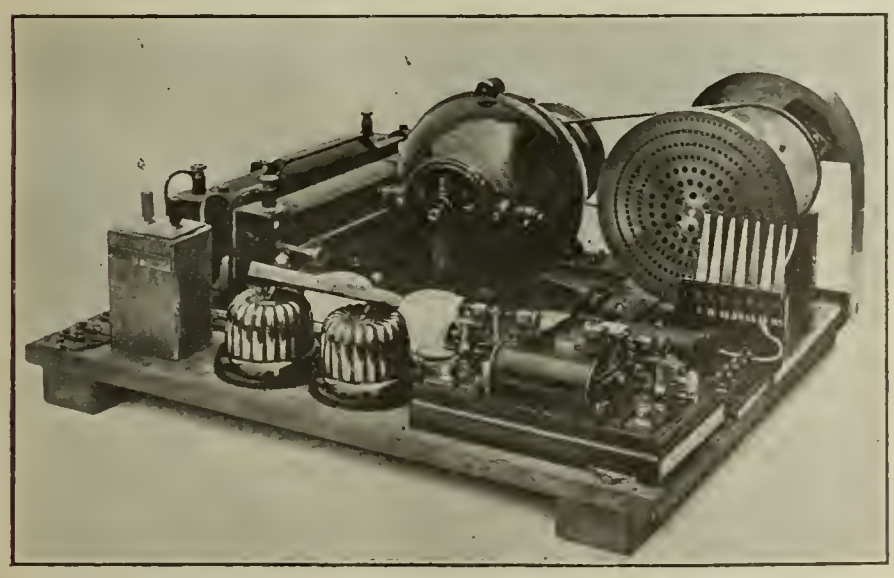


Fig. 5.—Rhythmic Interrupter. (Front view.)

Description of Apparatus at Present Under Trial as a Substitute for the Voice.—When the matter was reopened it was considered that the problem could be better tackled by experimenting with a wave containing the majority of frequencies of telephonic importance rather than attempting to use a wave containing only a few frequencies. As the result of considerable research the following arrangement was devised:—

An interrupter is varied in speed at a regular rate so as to go through a complete cycle of frequency from 700 ∾ to 1,400 ∾ and back again in the space of 0·7 second. This is attained by driving the interrupter from a motor which has attached to its shaft a centrifugal governor which cuts in and out extra voltage on the armature. Fig. 4 illustrates the arrangement. A disc on the motor shaft carries two weighted contact springs connected to slip rings. One spring is lightly and the other heavily weighted, and they rest normally on a pair of contacts connected to earth through the motor spindle. The springs are connected through the slip rings to a relay and thence to earth, and the motor armature, to 100 or 200 volts, according to the relay position.

At slow speed both springs are connected to earth, the relay is energised and the armature gets 200 volts. The speed increases and the heavily weighted spring flies off its contact first, but nothing happens until the light-weighted spring breaks from earth at the top frequency of the interrupter. Then the relay is released, and as the armature is only on 100 volts the motor drops in speed. Directly the drop occurs the light-weighted spring earths again, but the relay is not affected until the heavy-weighted spring earths, when the cycle is repeated. The field of the motor has a P.D. of 200 volts across it continuously.

Fig. 5 shows the complete arrangement with motor, governor, interrupter and relay. The interrupter can supply at any speed a series of seven frequencies simultaneously. In practice the square wave from one set of studs only is used. This apparatus, which I have termed a rhythmic interrupter, supplies a wave, rhythmically varied in frequency, to a non-resonating receiver. This consists of a modified electromagnetic receiver with a special diaphragm carrying a damping spring. The receiver is so adjusted that no resonance points occur between 700 ∾ and 1,400 ∾ (*i.e.*, the range of the interrupter). It has been found possible to use a receiver which has one resonance point in the before-mentioned range by applying a wave-smoother to the circuit as described further on. In order to test the sound output of the receivers with different frequencies, various mirror attachments to the diaphragm were tried, such as Irwin's optiphone, Duddell's mirror attachment, &c., and the best and simplest of these devices, due to Prof. Kennelly, of Harvard University, and termed by him a diaphragm exploring mirror, is illustrated in Fig. 6. The arrangement consists of a short length of phosphor-bronze strip under tension, and carrying a minute triangular mirror, the apex of which rests on the diaphragm.

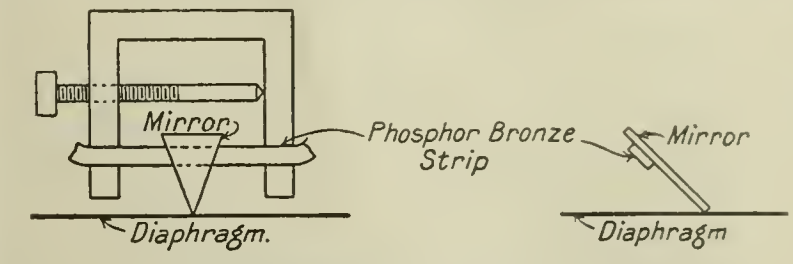


Fig. 6.—Kennelly Mirror for Diaphragm Research.

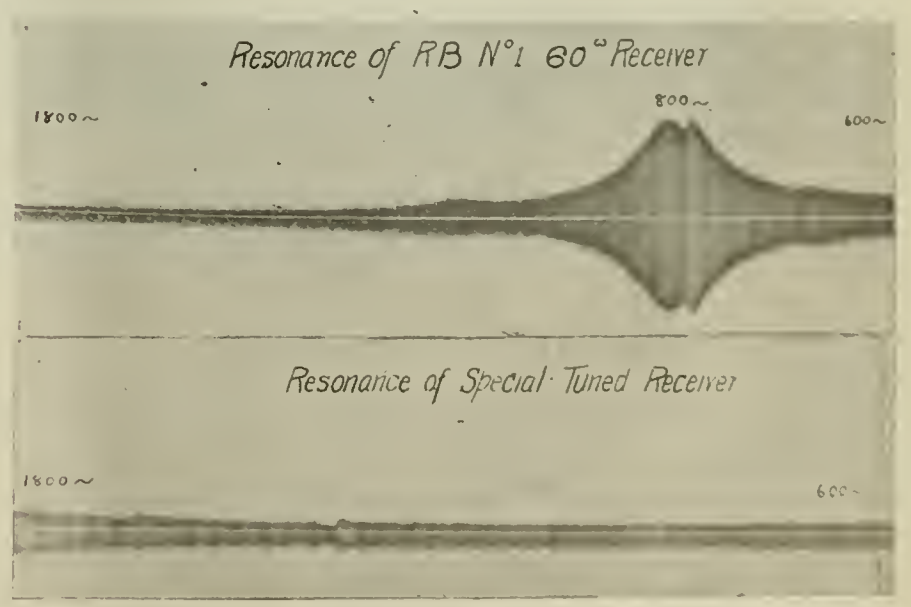


Fig. 7.—Resonance Curve.

* Abstract of a Paper read before the Institution of Post Office Electrical Engineers.

With the help of this device receivers have been tuned to give no resonance points over a considerable frequency range.

Fig. 7 shows firstly the resonance oscillogram of an ordinary untuned 60 ω receiver. Resonance peak at about 800 ∾. The lower curve is for the specially-tuned electromagnetic receiver. Both curves cover a range of frequency from 600 ∾ to 1,800 ∾. A tuned receiver connected to the rhythmic interrupter as described takes the place of the human voice.

We must now consider the apparatus to take the place of the ear. This measuring apparatus must be sensitive enough to give a good reading at the end of a long length of standard cable approaching the commercial limit, and at the same time should be so ballistic as to give a steady deflecti n when actuated by the comparatively slowly pulsating rhythmic current.

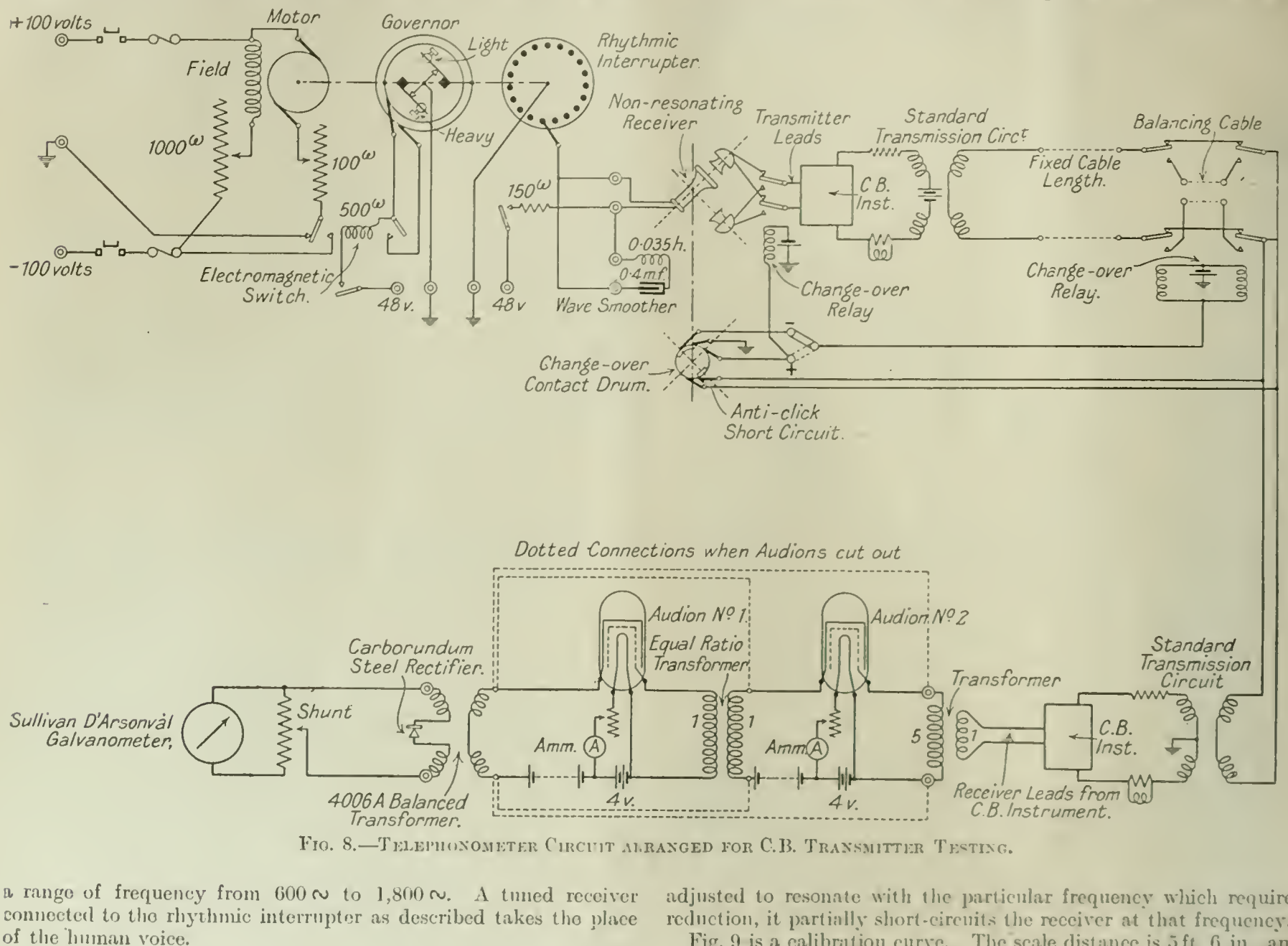


Fig. 8.—Telephonometer Circuit arranged for C.B. Transmitter Testing.

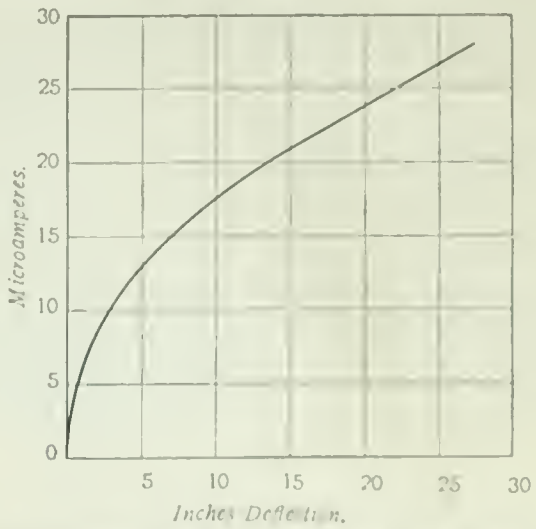


Fig. 9.—Telephonometer Receiving Apparatus using one Audion and unshunted Sullivan Galvanometer. (Scale distance 5'6").

The arrangement adopted consists of a sensitive Sullivan-D'Arsonval galvanometer connected through its shunt to a carborundum-steel rectifier (*see* Fig. 8). This rectifier is at the centre of one winding of a balanced 1 to 1 transformer. The other winding is connected through one or more audion gas discharge relays, and thence to the high winding of a 1 to 5 step-up coil. The low side of the latter is connected to the receiving end of the standard cable. This apparatus gives a steady deflection when the rhythmically varying receiver is sounding into a transmitter under test, and is also extremely sensitive.

If the howling receiver has a resonance point, the wave smoother previously referred to is used. This consists of a variable capacity and fixed low resistance inductance bridged across the circuit. When adjusted to resonate with the particular frequency which requires reduction, it partially short-circuits the receiver at that frequency.

Fig. 9 is a calibration curve. The scale distance is 5 ft. 6 in., and the curve given is for the unshunted galvanometer and using one audion. It will be noticed that 20 microamperes gives about 14 in. deflection. In making actual telephonic tests an equal deflection method is used, rendering calibration unnecessary. For example,

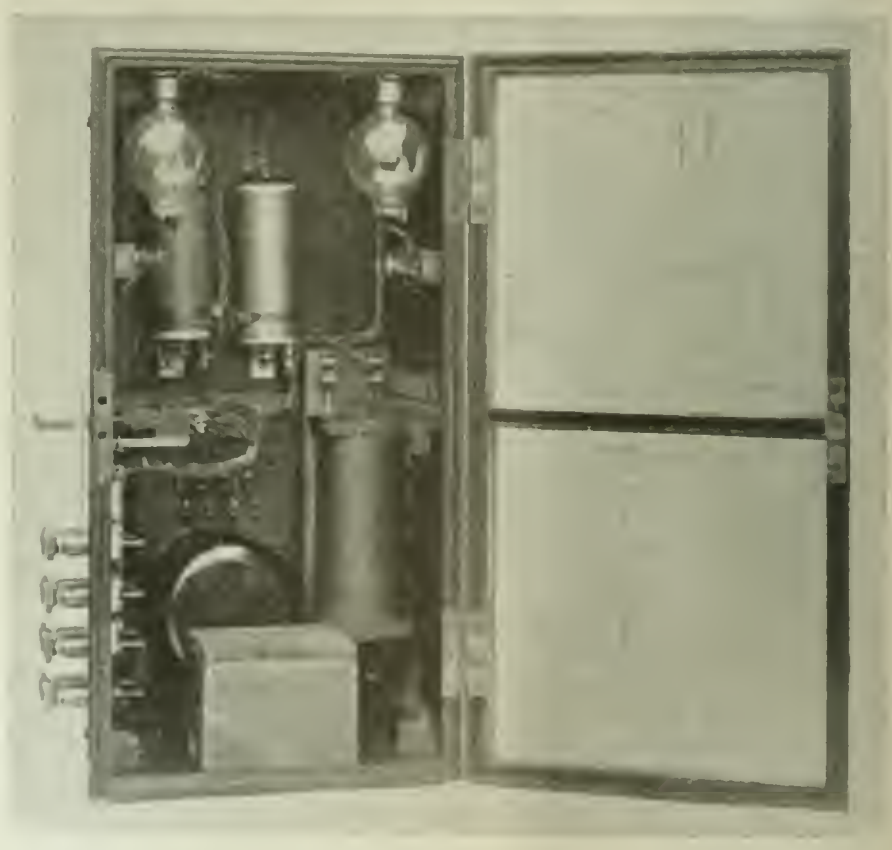


Fig. 10.

assuming a test of transmitters, if the deflection with a standard transmitter through 35 M.S.C. is 50 cm., the cable length is varied when the circuit is changed over to the transmitter under test until the deflection is again 50 cm. The cable change equated to standard is then the standard cable value for the transmitter under test.

The howling receiver is carried on a swing arm so that it can face either of the transmitters, and these are carried on adjustable arms so that the gaps between the receiver and the transmitters can be made equal. As the swing arm is rotated from one transmitter to the other it opens and closes contacts to effect the necessary change over in the circuit. Fig. 10 shows two audion relays, transformer and rectifier in case. I have termed the complete apparatus a telephonometer.

Table I. gives results obtained in comparing various types of lines by standard cable measurement, telephonometer and calculation.

Table I.

Line under test.	Equated length in M.S.C.		
	By speech (mean of a number of balances).	By telephonometer (single test).	By calculation from the measured A.C. constants.
20 lb. artificial cable (No. 5), mica condensers, 20 miles virtual length.	21·4	21·2	21·2
400 lb. artificial aerial line, 200 miles virtual length, insulation resistance 1Ω per mile	6·7	6·4	6·3
The experimental 20 lb. cable, 8 pair multiple twin, 37 actual miles	35·5	35·8	35·2
40 lb. artificial cable, 32 miles virtual length	26·1	26·25	26·2
70 lb. artificial cable, 32 miles virtual length	22·0	21·9	21·95

The artificial aerial line was tested between two 20-mile lengths of standard cable in order to eliminate terminal reflection losses. The calculated value allows for the transition loss between the aerial line and the cable. As the application of the telephonometer to transmitter tests is a far more difficult problem, it is not proposed to go into any further detail regarding line tests, but to deal with transmitter testing. Table II. gives the result of a number of tests of transmitters of both C.B. and L.B. types when compared by the telephonometer and also by the ordinary speech measurement.

Table II.

Transmitters under test.	Relative transmission efficiencies.		Difference S—T M.S.C.
	By speech (S) M.S.C.	By telephonometer (T) M.S.C.	
R.B.1,C.B., solid backs, all compared against C.B. standards—	3 observers, 6 balance tests.		
a	+ 1·3	+ 1·9	−0·6
b	− 2·1	− 2·0	−0·1
c	− 0·8	− 0·7	−0·1
d	− 3·5	− 3·0	−0·5
e	− 1·6	− 1·0	−0·6
f	− 4·0	− 4·0	0
g	− 2·0	− 2·5	+0·5
h	− 1·5	− 1·5	0
Inset transmitters, all compared against C.B. standards—			
k	− 9·0	−10·7	−1·7
l	− 9·0	− 9·2	−0·2
m	− 9·3	− 7·7	+1·6
n	− 9·6	− 9·2	+0·4
o	− 9·8	− 8·2	+1·6
p	− 7·9	− 6·7	+1·2
q	− 9·8	− 8·9	+0·9
r	−10·3	−12·9	−2·6
s	−13·5	−14·2	−0·7
t	− 9·8	− 9·2	+0·6
u	− 8·9	− 6·8	+2·1
v	−11·3	−10·2	+1·1

+ signifies better and − worse than the V.O standards.

The results indicate that the apparatus described is capable of comparing the voltmetric efficiency of telephone lines and transmitters with a high degree of accuracy and at a considerable saving of time, &c., over the ordinary standard cable measurement.

The apparatus is particularly suitable for the rapid testing of telephone apparatus in bulk. The application to receive measurement is under consideration. In conclusion, it should be emphasised that the ordinary S.C. measurement is not displaced for the initial determination of the efficiency of any new type of apparatus, and that actual speech is also necessary for the determination of articulation.

I am indebted to the staff of the Research Section, and particularly to Mr. E. J. Barnes, for assistance in the development of the Telephonometer.

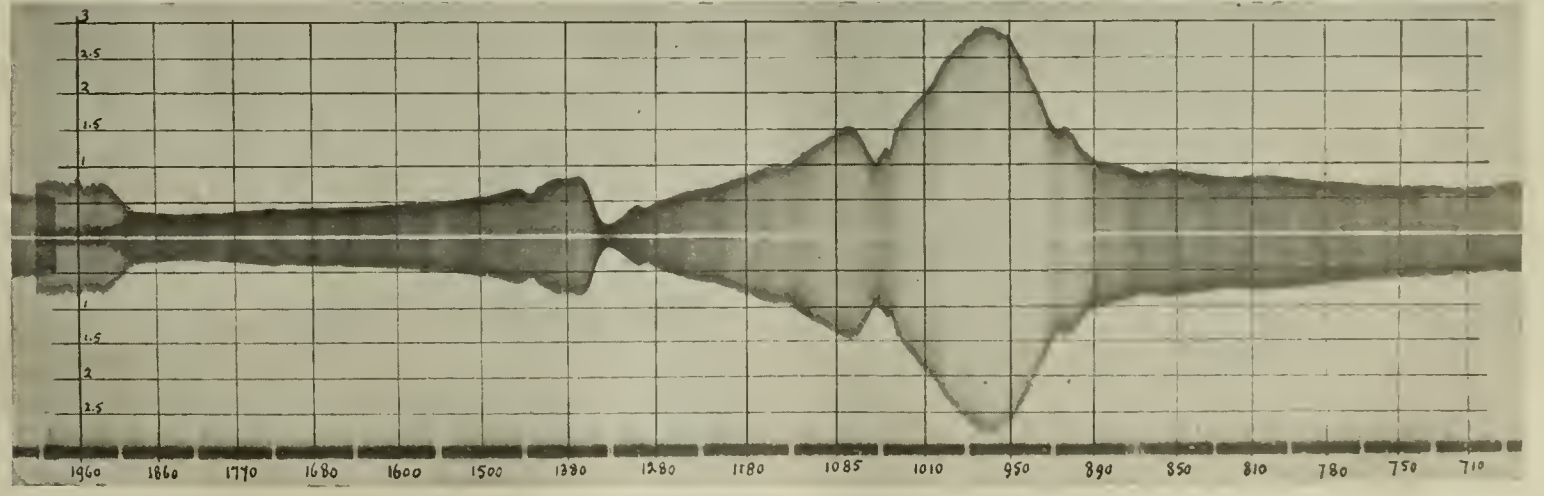


Fig. 11.—Resonance of C.B. Solid Back Transmitter.

It will be noted from this table that the agreement between the speech and telephonometer tests is striking when it is borne in mind that a variation of the order of at least 1 M.S.C. may be expected when repeating the speech tests of any C.B. transmitter, and that with inset transmitters this variation will be increased. There will also be a range of several M.S.C. with different speakers. The speech tests are the mean values for three observers, making six complete balances, and such a set of balances occupies three men for the space of one hour, or three man-hours. The telephonometer test, on the other hand, takes an observer about 5 minutes, and most of that time is occupied in connecting up the transmitter under test. Furthermore, the telephonometer is far more sensitive for small alterations in transmission volume than the S.C. measurements. A change of less than $\frac{1}{4}$ M.S.C. is readily detectable.

Fig. 11 is of interest, as it shows the resonance points for an ordinary C.B. transmitter between 700 ∽ and 1,900 ∽. It will be noted that the main resonance point occurs at about 960 ∽, and this point occurs about the same place in practically all samples of No. 1 C.B. transmitter tested. In some cases, however, this is the only resonance point, whilst the example shown has quite a number of smaller points. The method of taking this oscillogram may prove of interest. The oscillograph is a Blondel, arranged to photograph on a slowly-revolving drum covered with sensitised paper. An alternator is used to supply current to the tuned receiver which actuates the transmitter. No mouthpiece was used, and the receiver and transmitter were butted up close. The resonance frequency of the enclosed air was well above the highest frequency applied. The alternator was brought to the maximum frequency and then the driving motor shut off, so that the frequency rapidly fell and at the same time the recording drum was started. A second oscillograph vibrator was used to record frequency and paper speed. The gaps occur every 1·23 seconds and the fine lines every 106 cycles of the alternator.

NOTES ON DESIGN OF ELECTROMAGNETIC MACHINES.

I. CONTINUOUS-CURRENT MACHINES.

BY STANLEY PARKER SMITH, D.Sc.

Summary.—In the first part of the article the author deals with the principles underlying the design of continuous-current machines, and in the second part he applies these principles to the design of a 350 k.w., 500-volt generator running at 200 revs. per min.

PART I.

In responding to the request of the Editors of THE ELECTRICIAN to discuss the underlying principles of electric machines and modern methods of design, the author has no intention of attempting a complete or exhaustive treatment of the subject, but rather to emphasise points which experience has taught him are of fundamental importance to the designer, manufacturer and user of electrical generators and motors. Our electrical literature is by no means poor in the matter of authoritative treatises on machine design, and as examples one need only mention Mr. Hawkins's well-known work on "The Dynamo," which has been consistently revised and brought up to date, or Prof. Miles Walker's new book on "The Design and Specification of Dynamo-electric Machinery." Every designer has his own way of doing things; nevertheless, it is possible that these articles may throw new light on old subjects, such as armature windings. We shall give first a general discussion of principles and then apply these to an actual design. It is almost superfluous to mention that the clearer fundamental principles are understood, the easier it will be to produce competitive designs.

All electric machines are based on the underlying principles governing the conversion of mechanical into electrical energy. The laws on which this conversion of energy depends are :—

(i.) The mechanical force exerted by a magnetic field on a conductor traversed by an electric current.

(ii.) The E.M.F. induced in a coil moving in a magnetic field.

The relation, if any, between these two fundamental laws is of chief interest to the physicist. The problem for the engineer is their application to electric machines.

1. E.M.F. Induced in a Coil Moving in a Pulsating Field.

Experiment has shown, and experience has confirmed, that the E.M.F. induced in a coil is proportional to the rate of change of flux linking it, or

$$e=-T_c\frac{d\Phi}{dt}10^{-8} \text{ volts}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where T_c denotes the number of turns in series linking the flux Φ. The direction of the induced pressure is such as to produce a current tending to prevent the change of magnetic linkages, and accounts for the negative sign in equation (1).

Now, the flux linking a coil may change in two ways :

(i.) Supposing the flux constant in value, the coil can move through the flux.

(ii.) Supposing the coil stationary, the flux can vary in amount.

In the general case, when both these modes of change occur together, we can write

$$\frac{d\Phi}{dt}=\frac{\delta\Phi}{\delta x}\frac{dx}{dt}+\frac{\delta\Phi}{\delta t},$$

where $\frac{\delta\Phi}{\delta x}\frac{dx}{dt}=\frac{\delta\Phi}{dx}v$ is due to the coil moving in the flux at the uniform velocity v centimetres per second, and $\delta\Phi/\delta t$ is due to the flux pulsating.

All modern types of electrical machines are constructed in accordance with the heteropolar arrangement—that is, with alternate north and south poles. This yields on no-load a flux distribution over the armature periphery similar to curve B in Fig. 1. In this figure, B denotes the flux-density in lines per square centimetre in the air-gap and Y the pole-pitch in centimetres.

In a heteropolar machine, then, the flux linking a coil at any instant is represented by the shaded area in Fig. 1, or

$$\Phi=\int_x^{x'} BLdx,$$

where L denotes the core-length in centimetres over which B extends.

Substituting for the flux, we get the general expression for the pressure induced in a coil rotating in a pulsating flux as follows :—

$$\begin{aligned}
e&=-T_c\frac{d\Phi}{dt}10^{-8}\\
&=-T_c10^{-8}\left(v\frac{\delta\Phi}{\delta x}+\frac{\delta\Phi}{\delta t}\right)\\
&=-T_c10^{-8}\left\{v\frac{\delta}{\delta x}\int_x^{x'}BLdx+\frac{\delta}{\delta t}\int_x^{x'}BLdx\right\}\\
&=-T_cvL10^{-8}\int_x^{x'}\frac{\delta B}{\delta x}dx-T_cL10^{-8}\int_x^{x'}\frac{\delta B}{\delta t}dx\\
&=-T_cvL10^{-8}(B_{x'}-B_x)-T_cL10^{-8}\int_x^{x'}\frac{\delta B}{\delta t}dx\\
&=e_r+e_p \text{ volts}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)
\end{aligned}$$

where $e_r=-T_cvL10^{-8}(B_{x'}-B_x)$ is the pressure induced by the movement of the coil in the flux, or, in short, the E.M.F. due to *rotation*; and $e_p=-T_cL10^{-8}\int_x^{x'}\frac{\delta B}{\delta t}dx$ is the pressure induced by the varying flux, or, in short, the E.M.F. due to *pulsation*.

Both these pressures are induced simultaneously in the same winding when it moves in a pulsating flux, like the rotor of an induction motor, but only the E.M.F. of rotation e_r can assist in

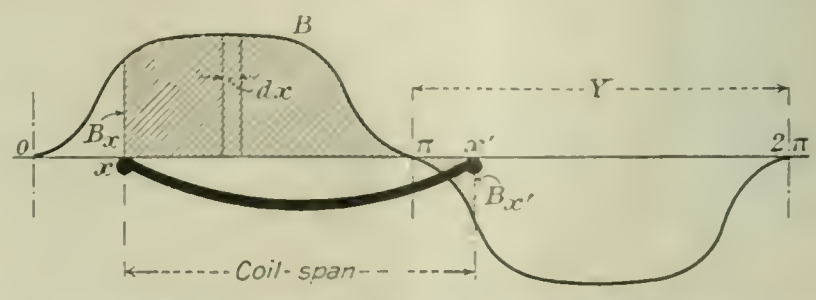


Fig. 1.—Flux Distribution over Armature Periphery of Salient Pole Machine.

the conversion of mechanical into electrical energy, or vice versa. The E.M.F. due to pulsation e_p is the means whereby electric energy is transformed from one system to another, as in the static transformer and in certain types of machines.

2. E.M.F. Induced in a Winding Rotating in a Steady Flux.

When the flux is produced by a continuous current and is, therefore, steady, as in continuous-current or synchronous machines, $e_p=0$, and we have for the instantaneous E.M.F. in a coil

$$e=e_r=-T_cvL10^{-8}(B_{x'}-B_x). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Let D = diameter of armature in centimetres,
$2p$ = number of poles in the machine,
$Y=\pi D/2p$ = pole-pitch in centimetres,
n = speed of armature in revs. per second

and $f_r=pn$ = speed frequency,

then $v=\pi Dn=2Ypn=2Yf_r$ centimetres per second.

The expression for the E.M.F. induced in a coil due to rotation then becomes :

$$e_r=-2f_rTYL10^{-8}(B_{x'}-B_x) \text{ volts}. \quad . \quad . \quad . \quad (4)$$

With a full-pitch coil, $B_{x'}=-B_x$,

so that $e_r=4f_rTYLB_x10^{-8}$ . . . . . (4A)
$=\text{const.}\ B_x$

Thus, the E.M.F. due to rotation at any instant is proportional to the flux density in which the coil-sides are moving, so that e_r in a full-pitch coil is represented by the same curve as B. Moreover, since e_r changes sign with B, the pressure goes through a complete cycle every pole-pair, or p cycles in each revolution. Hence, at n revolutions per second, the E.M.F. e_r passes through $pn=f_r$ cycles per second; consequently,

we call f_r the frequency corresponding with the speed, or, briefly, the *speed frequency*.

With a group of m coils in series (Fig. 2) the instantaneous value of the E.M.F. due to rotation will be

$$\Sigma_a^m e_r = -T_c v L 10^{-8}\{(B_{a'}+B_{b'}+\ldots.B_{m'})-(B_a+B_b+\ldots.B_m)\},$$
$$= -T_c v L 10^{-8}\{\Sigma_a^m B_{x'} - \Sigma_a^m B_x\} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

With full-pitch coils $\Sigma_a^m B_{x'} = -\Sigma_a^m B_x$,

so that:
$$\left.\begin{aligned}\Sigma_a^m e_r &= 2T_c v L 10^{-8}\Sigma_a^m B_x \\ &= 4 f_r T_c Y L 10^{-8}\Sigma_a^m B_x.\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (5A)$$

Since the E.M.F. induced in each coil of the winding alternates at the speed frequency f_r, the pressure induced in a group of coils in series does likewise. Consequently, if permanent connections are made to any part of such a winding, an alternating pressure will be obtained, the instantaneous value of which is given by equation (5). This leads to the important class of machines known as synchronous machines or alternators.

On the other hand, if the armature be made to revolve, and connection be made to it by means of fixed brushes which rub on the conductors as they pass by, the conditions will be entirely altered. Assuming the armature winding to be distributed uniformly over the whole periphery and closed on itself (as in a lap or wave winding), then, at all speeds of the armature, as a conductor leaves one brush, a new conductor enters at the other brush, so that the group of coils between two fixed brushes remains constant and always occupies the same position in the field. Since the field is steady, $\Sigma_a^m B_x$ thus remains constant; consequently the E.M.F. $\Sigma_a^m e_r$ will be constant during a complete revolution of the armature, and will never be interrupted since the winding is closed. With such an arrangement, therefore, the pressure between the brushes will be constant for any given speed, field excitation and brush

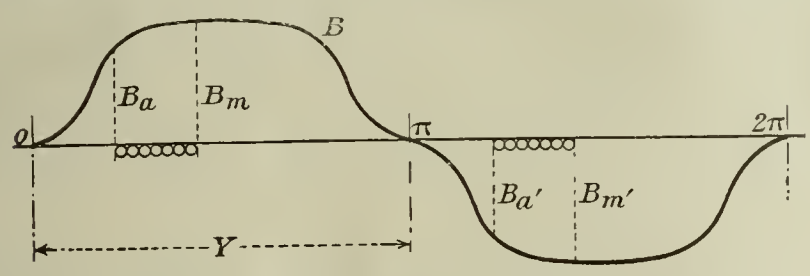


Fig. 2.—Group of Coils in Field of Salient Pole Machine.

position. Hence, to obtain a continuous pressure from a heteropolar machine, brushes are fixed to a stationary field system to make a sliding contact with a revolving winding distributed uniformly over the armature and closed on itself. In practice, the coils are joined to a commutator with which the brushes form the sliding contact. This extra complication is solely due to mechanical requirements, and even at its best this arrangement is much inferior to the method of obtaining an alternating pressure by means of permanent connections to the armature winding, through slip-rings if necessary. (In a similar way, if the flux pulsates with a frequency f, then the pressure at the fixed commutator brushes will pulsate at frequency f, though its magnitude depends on the speed, as in all alternating-current commutator motors.)

This leads to the fundamental difference between the synchronous and the continuous-current types.

In the *synchronous* machine, $\Sigma_a^m e_r$ is the pressure induced in a particular set of coils—*i.e.*, the pressure between points fixed with respect to the armature winding. This is an alternating pressure.

In the *continuous-current* machine, $\Sigma_a^m e_r$ is the pressure induced in a part of the armature winding always occupying the same position in the field—*i.e.*, the pressure between points fixed with respect to the field. This is a continuous pressure.

In the present article we shall deal with the continuous-current machine.

3. E.M.F. at the Commutator Brushes.

We have seen that if connection is made to a revolving winding by means of fixed brushes, the term $\Sigma_a^m B_x$ remains the same under all conditions (at no-load), in consequence of which the pressure $\Sigma_a^m e_r$ between the commutator brushes is constant. In this way a continuous pressure is obtained, which we shall denote by E_c.

In Fig. 3, suppose one commutator brush to be fixed at O and the other movable. Then with the brushes at O and x, we have for the shaded area

$$\int_o^x B_x dx = x \,.\, B_{\text{mean}_x},$$

where B_{mean_x} denotes the mean flux-density over the part x. Assuming, further, the winding to be distributed uniformly over the periphery, we have also

$$\Sigma_a^m B_x = m \,.\, B_{\text{mean}_x};$$

whence
$$\Sigma_a^m B_x = \frac{m}{x}\int_o^x B_x dx.$$

So that equation (5A) for full-pitch coils becomes

$$\Sigma_a^m e_r = E_c = 4 m T_c f_r \frac{YL}{x}\int_o^x B_x\, dx\, 10^{-8}. \quad . \quad . \quad . \quad . \quad (6)$$

As the movable brush passes from O to π, the pressure E_c increases, as shown by the curve E_c in Fig. 3. This curve is almost a pure sine wave due to the fact that the harmonics in the B-curve are greatly reduced in the integral curve E_c, since the integral $\sin nx dx = -\frac{1}{n}\cos nx$. The maximum value of E_c exists between the brushes when they are a pole-pitch apart, and situated in the geometrical neutral zones O and π. If the

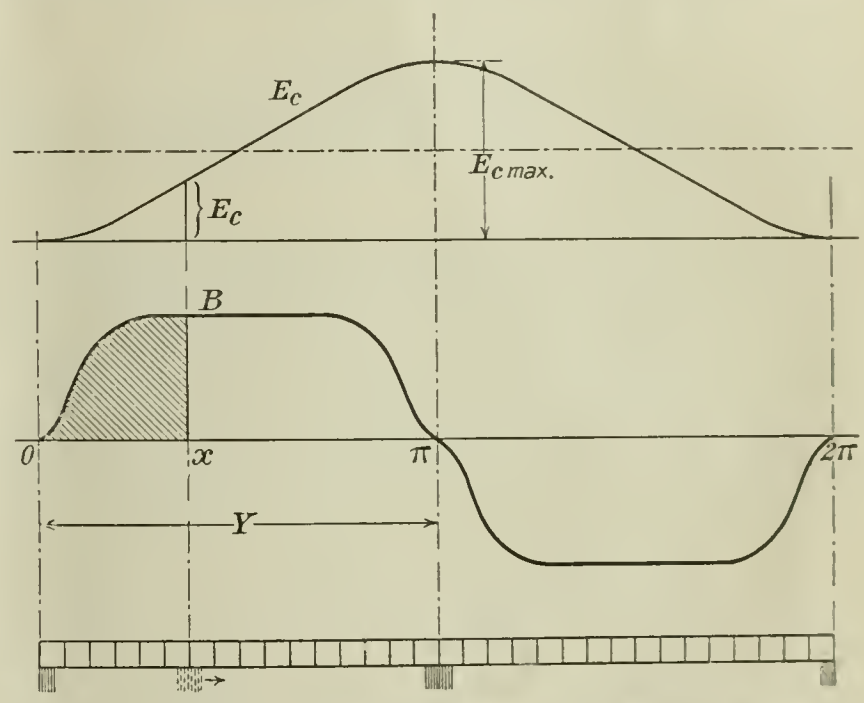


Fig. 3.—Potential Curve of Commutator with Uniformly Distributed Winding.

(Potential curve E_c is derived by integrating flux-density curve B.)

brushes are rocked away from the neutral zone through the angle β, the pressure between them will be approximately $E_c = E_{c\max.}\cos\beta$. This is why the brushes in a continuous-current machine are a pole-pitch apart, and fixed in the neutral zone wherever possible.

In actual machines, where the conductors are placed in slots, the quantity $\Sigma_a^m B_x$ does not remain quite constant, unless the slots are skewed, in consequence of which the pressure between the brushes pulsates slightly. This effect, however, is seldom important.

To calculate the continuous pressure induced at the commutator brushes when the brushes are a pole-pitch apart, and the coils span a full pole-pitch, we have, by substituting $m \,.\, B_{\text{mean}_x} = \Sigma_a^m B_x$ in equation (5A),

$$E_c = 4 m T_c f_r Y L B_{\text{mean}_x} 10^{-8}$$
$$= 4 T f_r Y L B_{\text{mean}_x} 10^{-8},$$

where $T = m \,.\, T_c$ = turns per armature circuit.

$$= \frac{C \,.\, T_c}{(2a)} = \frac{\text{total armature turns}}{\text{number of parallel armature circuits}},$$
$$= Z/4a,$$

where $Z=2CT_c$ stands for the total number of armature conductors.

Substituting for T, we get

$$E_c=\frac{Z}{a}f_r Y L B_{\text{mean}_x}10^{-8}.$$

With the brushes in the geometrical neutral zone, B_{mean_x} has its largest value, or

$$B_{\text{mean}_x}=\frac{\text{flux per pole}}{\text{area of pole}}=\frac{\Phi}{LY}$$
$$=B_{\text{mean}},$$

where $\Phi=Y\,.\,L\,.\,B_{\text{mean}}$=useful flux per pole.

Hence, with full-pitch coils and the brushes fixed in the geometrical neutral zone, the continuous pressure at no-load is

$$E_c=\frac{Z}{a}f_r Y L B_{\text{mean}}10^{-8}$$
$$=\frac{Z}{a}f_r\Phi 10^{-8}$$
$$=\frac{p}{a}\,n\,Z\Phi 10^{-8}\text{ volts.}\quad\ldots\ldots\quad(7)$$

The effect of shortening the coil-span—a practice which is sometimes resorted to—is usually quite negligible when the reduction in the span does not exceed one or two slot-pitches, which is seldom the case.

(*To be continued.*)

PATENTS IN 1915.

We give below an abstract of the thirty-third report of the Comptroller-General of Patents Designs and Trade Marks, Mr. W. Temple Franks, C.B.

The War and Legislation.—Reference was made in my report for last year to the passing of the Patents, Designs and Trade Marks (Temporary Rules) Acts, 1914, and the Statutory Rules and Orders made thereunder. During 1915, 154 applications were made under these Acts and Rules for the avoidance or suspension of patent rights. In the case of 117 applications, licences have been granted or are in course of being granted. In one case the patent has been suspended, and four licences under patents have been avoided. Six applications have been refused and seven withdrawn or abandoned. In 11 cases the applications have been returned as not being required by reason of the patents having expired or for some other cause. The remaining cases are pending. Four applications for the avoidance or suspension of trade marks were made during the year, of which two were refused, and the remaining two are pending. By an Order in Council, dated January 7 these Acts and Rules were extended to the Isle of Man. Experience of the working of the Patents, Designs and Trade Marks (Temporary) Rules, 1914, disclosed a slight ambiguity in the wording of the rules, and it was thought desirable to issue a further rule. Upon the outbreak of war all applications for patents, designs and trade marks filed by subjects of any state at war with His Majesty were allowed to proceed, as usual, down to the time of acceptance, but formal acceptance was not issued. The result of this, so far as patents were concerned, was an accumulation of unpublished specifications, some of which, it was felt, might be of importance to the trade of the country. Moreover, until such specifications were published, they could not be cited as anticipations of later applications. It was decided, therefore, to accept and publish these specifications, but to suspend, until otherwise directed, all further proceedings thereon. The suspension of proceedings upon these applications will only be recalled or discharged upon proper terms, including, if thought fit, the release of the applicant of the privileges and rights which he would otherwise have under sec. 10 of the Patents and Designs Act, 1907. This change of practice was made on June 1.

An Order in Council was issued on October 14, amending the Defence of the Realm Regulations, providing that where an application has been made, whether before or after the date of the making of the order, for the grant of a patent or the registration of a design in the United Kingdom, and the Comptroller-General of Patents, Designs and Trade Marks is satisfied that the publication of the invention or design might be detrimental to the public safety or the defence of the Realm, or might otherwise assist the enemy or endanger the successful prosecution of the war, he may delay the acceptance of the complete specification filed with the application for the patent, or, as the case may be, the registration of the design, and in such case may, by order, prohibit—(*a*) the publication or communication in any way of the invention or design; (*b*) application being made for the protection of the invention or design in any enemy or neutral country; and (*c*) application being made for the protection of the invention or design in any allied country or in any of His Majesty's Dominions without the permission of the Admiralty and Army Council. It was further provided that no person should apply for the grant of a patent in respect of any invention or the registration of a design in any foreign country, or in any of His Majesty's dominions, unless he has left at, or sent by post to, the Patent Office a notice of his intention, together with a provisional specification describing the nature of the invention, or, as the case may be, a representation or specimen of the design, nor until after the expiration of one month from the time when such notice was given, and if during the said month the Comptroller-General is satisfied that the publication of the invention or design might be detrimental to the public safety or the defence of the Realm, or otherwise assist the enemy or endanger the successful prosecution of the war, he may make a like order as in respect of cases in which application is made for the grant of a patent or the registration of a design in the United Kingdom. Before exercising any of his powers under this regulation as respects any matter the Comptroller has to consult with the Admiralty and Army Council and may not act except upon the request of the Admiralty or Army Council. This Order in Council has thrown a considerable amount of additional work upon the office, as, apart from the consideration of every application for a patent or registration of a design relating to munitions of war every application for a patent or registration of a design abroad must be submitted to the Comptroller before it is made. As a consequence of this Order in Council it was found necessary to give the Comptroller power to extend the time for the acceptance of any complete specification which was delayed under the provisions of the Order in Council. This was done by the Patents, Designs and Trade Marks (Temporary) Rules, 1915 (Second Set), dated October 19. An Act (5 and 6 Geo. 5, c. 85) was passed on November 23, suspending the operation of sec. 27 of the Patents and Designs Act, 1907, during the continuance of the war, and for a period of six months thereafter. The Trading with the Enemy Amendment Act, 1916, although not coming strictly within the scope of this Report, was introduced into the House of Commons in December, and received the Royal Assent on January 27, 1916. Sec. 6 of this Act provides that "if the benefit of an application made by or on behalf or for the benefit of an enemy or enemy subject for any patent is, by an order under the Trading with the Enemy Amendment Act, 1914, or this Act, vested in the custodian, the patent may be granted to the custodian as patentee, and may notwithstanding anything in sec. 12 of the Patents and Designs Act, 1907, be sealed accordingly by the Comptroller-General of Patents, Designs and Trade Marks, and any patents so granted to the custodian shall be deemed to be property vested in him by such order as aforesaid."

Deposit of Documents Relating to Foreign Patents, Designs and Trade Marks.—The number of documents, relating to foreign patents, designs and trade marks, deposited for record under the arrangements referred to in my last report showed a considerable decrease, only 286 deposits being made as compared with 815 in 1914. The following list shows the number of notifications deposited in respect of each country: Germany 93, Belgium 75, Austria 51, Hungary 29, France 14, Turkey 14, Russia 3, Italy 2, Luxemburg 1, Roumania 1, Sweden 1, Switzerland 1, United States of America 1.

General Business.—The number of applications for patents during 1915 was 18,191, against 24,820 in 1914, and 30,077 in 1913. There were 13,242 provisional and 10,461 complete specifications, as compared with 16,590 and 16,443 in 1914, and 19,073 and 19,309 in 1913. The patents sealed were 11,457, as against 15,036 in 1914, and 16,599 in 1913. For designs there were 18,130 applications, of which 17,390 were registered. In 1914 these figures were 34,354 and 33,362, and for 1913, 40,429 and 39,275. There were received 6,057 for trade marks, of which 3,241 were registered. In the two previous years 8,317 and 9,689 applications were received, 4,408 and 5,071 were registered.

The receipts from patent fees were £256,723, as compared with £287,118 in 1914, a decrease of £30,395, from designs fees £5,441, as compared with £7,585, a decrease of £2,144, and from trade marks fees £12,868, as compared with £16,139, a decrease of £3,561. The receipts from the sale of Patents Office publications (which are paid over to the Stationery Office) were £7,384, as compared with £11,551, a decrease of £4,167. The total receipts were £282,471, as compared with £322,829, a decrease of £40,358. The total expenditure on behalf of the Office was £188,172, as compared with £194,767, a decrease of £6,595. The surplus of receipts over expenditure was £94,298, as compared with £128,062, a decrease of £33,764.

Free Library.—The number of readers who made use of the Library was 87,625, as compared with 140,418 in 1914. The number of volumes added to the Library was 4,081, of which 680 were volumes of patent specifications or patent journals, and 193 were trade catalogues. The remaining 3,208 volumes were scientific text-books or periodicals, 2,412 being obtained by purchase and 796 by gift or exchange. The number of works in the Library at the end of the year was 52,717, and the approximate number of volumes (exclusive of duplicates) was 159,000.

Since the outbreak of the war the Library has been closed to the public after office hours. An arrangement has, however, been made by which readers, who are unable to attend during office hours, and are engaged upon work in connection with which access to the books and records in the Library is important, can obtain special tickets of admission for Saturday afternoons between 1 p.m. and 6 p.m. The new "relative" shelf classification of the Library has been extended from GR Electricity and Magnetism to GV Electric Batteries. R Sanitary Engineering and Public Hygiene has been completed. PM—Q Military and Naval Sciences have been set up in part in the new class order. Progress has also been made in U Architecture and V Agriculture. The duplicate sets of foreign patent specifications continue to be largely used. 204 searches were made through the German specifications in 1915, as com-

pared with 312 in 1914. The printing of the Library Series has been discontinued for the present.

Sale Branch.—During the year 174,836 Patent Specifications, 4,472 Abridgment Volumes, 46,930 "Illustrated Official Journals," and 28,827 "Trade Mark Journals" were sold, as compared with 245,118, 5,888, 53,251, and 32,680 respectively in 1914.

The number of deposit accounts increased from 518 to 543. Of the depositors, 49 live in London, 164 in other parts of the United Kingdom, and 330 abroad.

The number of specifications of expired patents reprinted at the cost of the office under the arrangement recommended by the Departmental Committee of 1900 was 379, and the net cost was about £425. In addition to these, 1,349 specifications were reprinted for official purposes.

Patents.—The renewal fees amounted to £183,929, as compared with £185,074 in 1914, a decrease of £1,145, and the sealing fees to £12,837, as compared with £14,681, a decrease of £1,844.

The total number of applications received during 1915 was 18,191, being 6,629 less than in 1914, and the lowest number received in any one year since 1887. The proportion of complete to provisional specifications filed on application was only 37 per cent., as compared with 50 per cent. in 1914.

This decrease is, of course, due to the continuation of the war, but in making comparisons it should be remembered that the figures for 1915 relate to a full year of war, as against five months of war in 1914. The applications received from women inventors numbered 268, as compared with 347 in 1914. The applications made by way of communication from abroad numbered 948, as compared with 1,291 in 1914. Under the provisions of the International Convention for the Protection of Industrial Property, 1,555 applications were made in this country, as compared with 2,909 in 1914. The number of applications post-dated in consequence of disconformity between the complete and provisional specification was 200, and the number of applications for patents of addition 401, as compared with 286 and 715 respectively in 1914. The number of cases in which complete specifications were filed in respect of cognate provisional specifications was 305, as compared with 455 in 1914. Typical specimens were furnished in connection with applications for chemical inventions in seven cases; 26 sample bottles and eight dyed or printed specimens being filed. Of the complete specifications filed upon applications made in the year 1914, 725 were reported as wholly anticipated, 8,142 as partly anticipated, and 4,019 as not anticipated. Of those anticipated, 8,179 were amended without a hearing taking place, and 417 after a hearing and decision. In 200 cases a reference to a previous specification was inserted. The total number of patents which expired in 1915 was 16,662, and the total number of new patents sealed 11,457. The number of applications made for the restoration of patents which had lapsed in consequence of the non-payment of renewal fees was 26, of which one was subsequently withdrawn, and seven are still pending. In each of the remaining 18 cases the patent was restored. There were 22 hearings before the Comptroller. The final figures for 1914 are as follows: Applications, 35; patents restored, 32; applications withdrawn, 3.

Under the provisions of sec. 26, which empowers the Comptroller to revoke a patent upon application made within two years from the date of the patent by any person who would have been entitled to oppose its grant, there were 11 applications. In two cases the patent was revoked (by consent), and in two orders were made requiring an amendment of the patentee's specification. Two applications were withdrawn, and the remaining five are still pending. There were hearings before the Comptroller in seven cases. Under the provisions of sec. 26 (3), two offers to surrender patents were received. In one case the patent was revoked; in the other the offer was unnecessary, and was therefore withdrawn. The number of applications made under sec. 27 for the revocation of patents worked exclusively or mainly outside the United Kingdom was three, and hearings took place in all these cases. One application was dismissed, and on the remaining two, which referred to one patent, an order was made revoking the patent. The number of hearings upon oppositions to the grant of patents was 57, as compared with 111 in 1914. There were 16 appeals to the Law Officer in these oppositions, with the result that in seven cases the Comptroller's decision was supported, in two reversed, and in one varied. Two appeals were withdrawn or abandoned, and four are still outstanding. There was only one hearing in connection with oppositions to the amendment of specifications. Under sec. 73 of the Act there were 122 hearings, as compared with 167 in 1914. There was one appeal to the Law Officer, which was dismissed.

The hearings fixed under sec. 7 and 8 of the Act numbered 2,622, but 1,508 of these were rendered unnecessary by reason of the abandonment of the application or amendment of the specification by the applicant. Inall of the remaining 1,114 cases formal decisions were given by the Comptroller, and in two cases there was an appeal to the Law Officer. In one of these the appeal was withdrawn and the other the decision of the Comptroller was supported. Two petitions for extension of term, one relating to a patent of the year 1901, and the other to a patent of the year 1902, were lodged during the year. The former of these was subsequently abandoned and the latter is still undecided.

Designs.—The number of applications to register designs received during the year was 18,130, including 582 sets, as compared with 34,354, including 913 sets, in 1914. A "set" is a number of articles of the same general character ordinarily on sale together, or intended to be used together, all bearing the same design, with or without modifications not sufficient to alter its character or not substantially affecting its identity. Of the above mentioned 18,130 applications, 9,535 were applied for in Classes 13, 14 and 15 (Printed or Woven Designs on Textile Goods), as compared with 19,617 in 1914.

During the year, 1,095 applications for registration of designs were objected to by the Comptroller. The objections, other than those on account of similarity to designs already registered, were chiefly on account of want of subject matter or want of substantial novelty. The applicants in 605 cases acquiesced in the objections raised by the Comptroller without applying for a hearing. In 207 cases the applications were allowed after correspondence to proceed, and of these, 180 related to Classes 13, 14 and 15, in which the applications were allowed to proceed on a disclaimer that the public right to the use of the applicants' own earlier registrations, after the expiration of the copyright, was not prejudiced. In 10 cases the applications are still under consideration. In 270 cases the applicants were accorded hearings, with the result that nine applications were accepted without alteration; 135 were refused, 120 were accepted subject to modification; and 6 are still under consideration. In the remaining three cases, an extension of time in which to apply for a hearing has been allowed at the applicants' request. There were four appeals from the Comptroller's refusal. In three cases the appeals were allowed, and one was dismissed. In the case mentioned in my last Report as still under consideration, the appeal was dismissed. There were 56 applications by registered proprietors to cancel their registrations under Designs Rule 53. Under the provisions of sec. 58 of the Act, one application was made for the cancellation of registration on the ground that the design was used for manufacture exclusively or mainly outside the United Kingdom, and the registration was cancelled. The number of designs of which the copyright was extended for a second period of five years was 1,874, and the number of which the copyright was extended for a third period of five years was 380.

Trade Marks.—The number of applications made in 1915 for the registration of trade marks (including 79 applications made to the Cutlers' Company, of Sheffield) was 6,057, as compared with 8,317 in 1914. The receipts from various sources on account of trade marks amounted to £12,867. 17s. 2d., including a sum of £4,438. 12s. for renewal fees.

By an arrangement sanctioned by the Treasury, the Cutlers' Company retain the whole of the fees received by them in any one year (ending June 30) up to £400, together with one-half of the fees above that amount. For the year ending June 30, 1915, the fees received by the Cutlers' Company amounted to £241. 18s.

During the year 3,191 trade marks were advertised, and 3,241 registered.

There were 1,056 hearings under sec. 53 of the Act.

The notices of opposition to the registration of trade marks under sec. 14 of the Act numbered 122, and 31 cases were heard. There were five appeals to the Court. In one case the Comptroller's decision was upheld, and four appeals were withdrawn; there was also one appeal to the Board of Trade, in which the Comptroller's decision was upheld. There were 12 appeals to the Court, and 22 to the Board of Trade from the decision of the Comptroller under sec. 12 of the Act. Of the appeals to the Court, the Comptroller's decision was reversed in five cases (one of which has gone to the Court of Appeal), and in one case the Comptroller's decision was upheld. The other six cases have not yet been determined. Of those to the Board of Trade, 15 were heard, two being allowed, 12 dismissed, and one has not yet been determined. Of the remaining seven cases, one was subsequently withdrawn, three have not yet been heard, and three were referred to the Court. Of the three cases referred by the Board to the Court, two were subsequently withdrawn, and the other has not yet been heard. There were 44 special applications made under sec. 9, sub-section 5, of the Act. Of these, 21 were reported to the Board, who authorised the advertisement of four applications, and the remaining 17 are under consideration. Of the other 23 applications, two were made direct to the Court, and have not yet been heard, two were deemed to be withdrawn under Rule 38 owing to the failure of the applicants to state a case, two were withdrawn, two were altered to ordinary applications, and the remaining 15 are not yet ready for report to the Board. There were 10 applications for special trade marks under sec. 62. All of these were reported to the Board of Trade who accepted one application. Four applications were deemed to be withdrawn under Rule 44, owing to the failure of the applicants to state a case, and the other five are under consideration.

Large Scale Electric Heating Plant.—The "Sanitary Record" describes an electrical heating system on a large scale, which has been installed in a school. The building has a cubical content of 780,000 cubic ft., and a total of 752 kw. in heaters is installed. The current enters the building at 2,200 volts, and is reduced to 440 for heating at full capacity, and to 220 when less is demanded. The air is heated to 60 deg. by grids automatically controlled, then washed and humidified, and again heated by a second battery of grids. Thermostats in each room control dampers. The plant occupies a comparatively small space in the basement, and it is calculated that the life of the equipment will be five to eight times the life of a steam plant. The labour required is said to be almost negligible.

THE SHILDON-NEWPORT RAILWAY ELECTRIFICATION.

(*Continued from p.* 249.)

The track rails are bonded at the joints with stranded copper bonds fitted under the fish plates, two bonds each of 0·169 sq. in. section being fixed at each joint. They are also cross bonded between the two rails at intervals of 300 ft., and between the two inner rails of adjacent tracks at the same space interval, the bonds in the 6 ft. way being midway between those in the 4 ft. way.

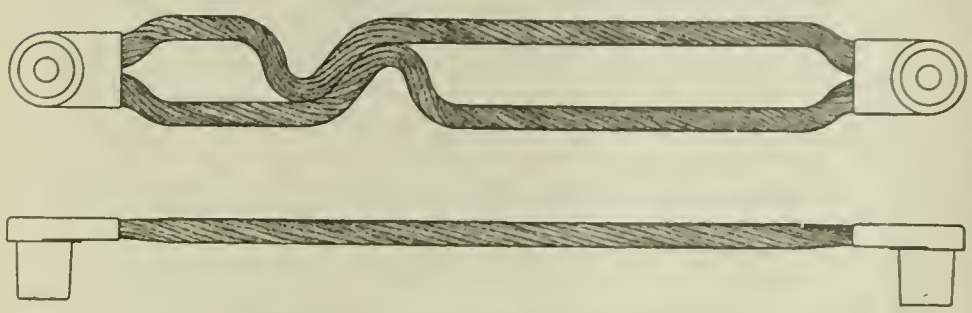


Fig. 11.—Detail of Track Bond.

In consideration of the heavy mineral traffic, great flexibility was required in the track bonds. They were therefore made up of compound strand (24/7/0·0285 sq. in.), and had solid terminals for expansion by compressors. Approximately 34,000 of this type of bond were used.

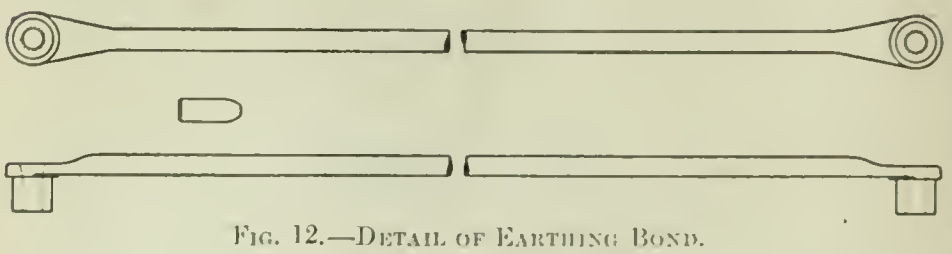


Fig. 12.—Detail of Earthing Bond.

The earthing bonds were of the pin terminal type, 2/0 S.W.G., 0·08245 sq. in. area, and were used principally for earthing the structures to the rails. Figs. 11 and 12 show the two types.

The track and earthing bonds were manufactured and supplied by the British Insulated & Helsby Cables (Ltd.), Prescot.

Sub-stations.

The power supplied to the overhead line is obtained from two sub-stations, viz., Aycliffe Sub-station and Erimus Sub-station. Power to these sub-stations is obtained from the interconnected mains system of the North-East Coast Power Companies, through the Cleveland and Durham Electric Power Company. The voltage of supply being 20,000 volts, three-phase for Aycliffe Sub-station, and 11,000 volts, three-phase for Erimus Sub-station, the frequency being 40 cycles. At the sub-stations this power is converted by means of six-phase rotary converters to 1,500 volts, direct-current, this being the supply voltage to the overhead line.

Rotary converters were installed on account of their high efficiency and large overload capacity.

It was then necessary to decide whether the 1,500 volts should be generated in the armature of a single rotary or by connecting two rotary converters together in series to form one unit. The scheme of connecting two rotary converters in series to generate 1,500 volts was eventually adopted, as it enabled the machines to be designed with a reasonable commutator speed, and a very conservative value of voltage between commutator bars. Three 800 kw. units were installed, two at Aycliffe and one at Erimus, each consisting of two 400 kw., 800 revs. per min., 750 volt, 40 cycle, six-phase commutating pole rotaries, connected in series to generate 1,500 volts.

The machines were designed and tested to operate normally at 95 per cent. leading power factor, and to withstand an overload of 50 per cent. for two hours, 100 per cent. for 10 minutes, and 200 per cent. momentarily. The machines were subjected to a high potential test of 5,000 volts for five minutes. On account of the high voltage on the commutator, these machines were specially designed to avoid damage due to flash-over, occasioned by short circuits on the system. The operating parts of the brushgear were entirely enclosed, as seen in Fig. 13, the distance between brush arms was made as great as possible, and the commutator was completely screened by arc-proof insulating material from the armature and frame of the machine.

Tests were carried out to determine what load could be suddenly thrown on and off these sets without flashing. Five times full load was thrown on and automatically tripped off with a breaker seven times, and three times out of the seven the machines stood this severe test without flashing. Fig. 16 shows an oscillogram which was taken during one of the tests when the rotaries did not flash over.

The B.T.-H. Co. are at present installing at Erimus another set, but of 1,200 kw. capacity, consisting of two 600 kw. rotary converters coupled in series to form one unit.

The extra high-tension switchgear installed in each of the above sub-stations is of the ironclad type, manufactured by A. Reyrolle & Co. The special feature of this gear is the enclosure of all live parts in iron chambers, the whole being run in solid with compound, thus securing perfect immunity from shock risks and dispensing with the necessity of cleaning operations on high-tension work. The oil switches are of the draw-out type, giving special facilities for the rapid inspection of switch contacts, whilst perfect interlocking of the parts obviates errors in manipulation or accidental contact with live conductors. The space occupied by this type of switchgear is comparatively small, and it has been fitted in a special chamber on the switchboard gallery in each sub-station, with the instruments and control gear mounted on a wall immediately in front.

1,500-*volt Direct-current Gear.*—A special feature of the transmission scheme is the high voltage direct-current gear. This switchgear has been designed somewhat on the lines of that usually adopted for high-tension alternating-current boards, that is to say, the apparatus is of the remote controlled type, and is mounted in cell structure built up of brick walls with moulded stone division slabs, each equipment being thus entirely separated from its neighbour.

The individual cells are built up on the cubicle system, that is to say, special compartments are provided for:—

1. 'Bus bars and isolating switches (top cubicle).
2. Circuit-breakers (intermediate cubicle).
3. The bottom cubicle contains the operating mechanism for the isolating switches and circuit-breakers: also the connecting cables passing up to the circuit-breaker units.

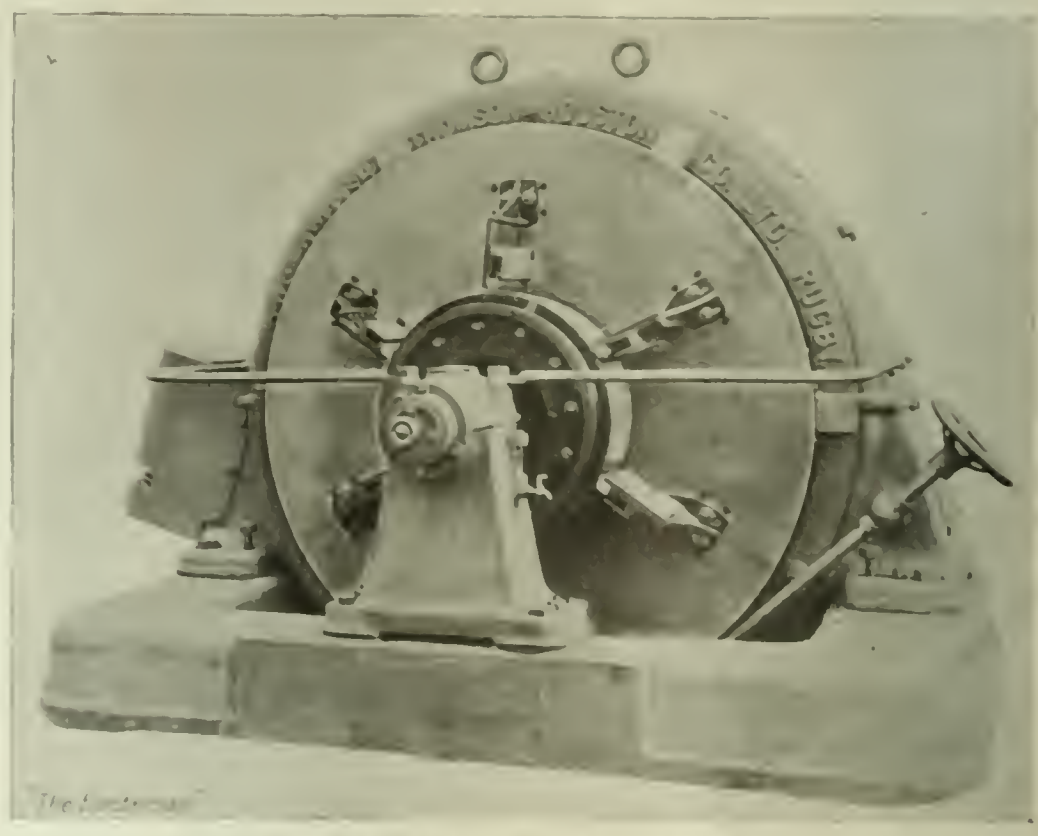


Fig. 13.—View of Rotary Converter.

From this it will be seen that no high-tension gear is accessible below the circuit-breaker cubicle. Further, when it is desired to work on the circuit-breakers these can be entirely disconnected from the 'bus bars by means of 'bus bar isolating switches. The general details are shown in Figs. 14 and 15, the former showing the front of the board and the latter the back.

The circuit-breakers and 'bus bar isolating switches are mounted on polished white marble panels built into the cell structure, suitable angle iron supports being provided for bolting into the brick division walls.

The 'bus bar isolating switches are of the high-tension rotary type,

that is to say, the contact units are mounted on porcelain insulators carried on moulded stone slabs forming part of the cell structure. The contact blades are fixed on porcelain insulators of the sleeve type carried on a rotating shaft fixed to the cell structure by means of stout wrought-iron brackets.

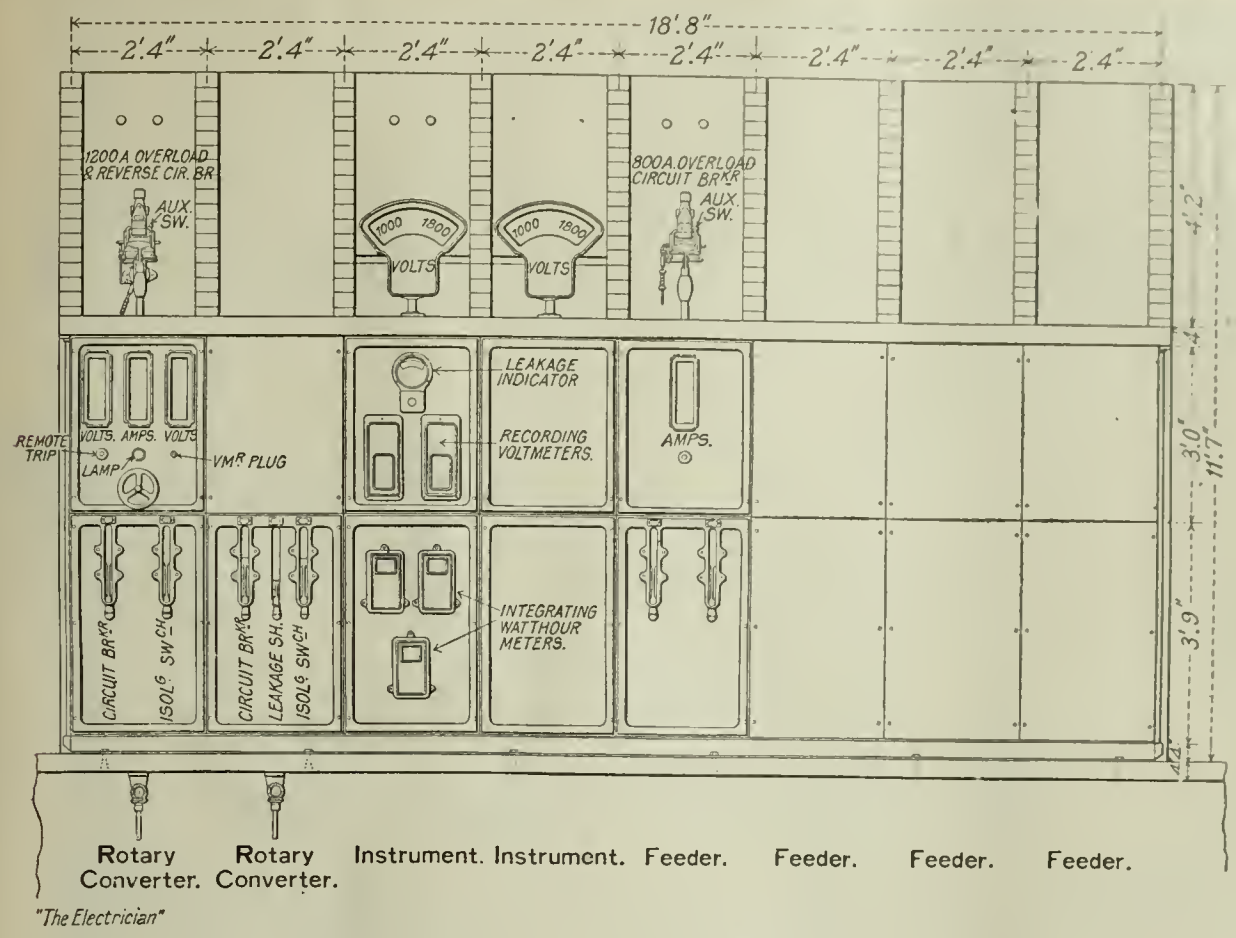


FIG. 14.—FRONT VIEW OF 1,500-VOLT D.C. SWITCHGEAR AT AYCLIFFE.

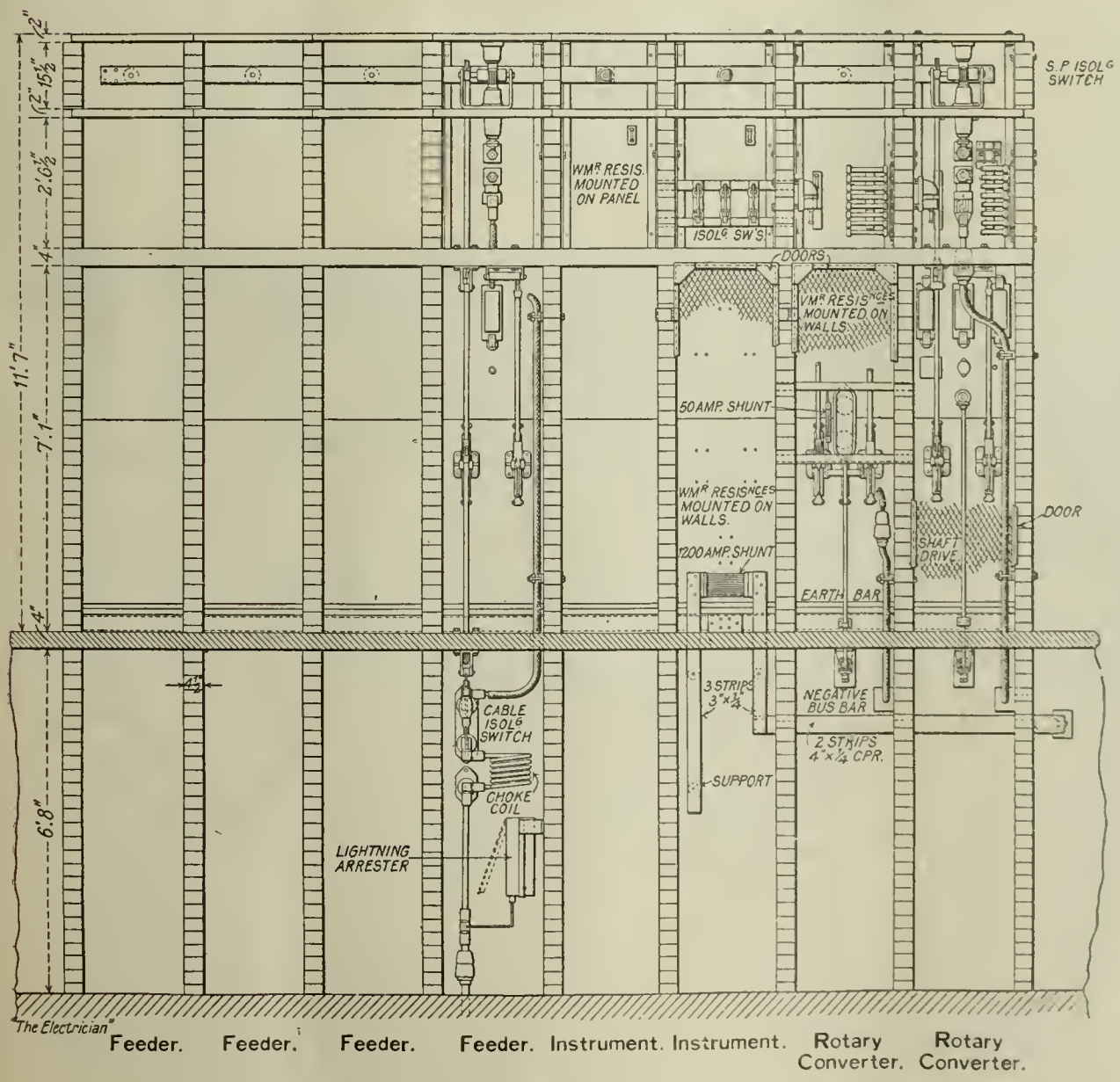


FIG. 15.—BACK VIEW OF 1,500-VOLT D.C. SWITCHGEAR AT AYCLIFFE.

The circuit-breakers included in this scheme are specially designed for high voltage work, the break being exceedingly large and quick. The breakers are of the brush contact type with auxiliary copper sparking tips, and special carbon blocks to take the final break. These blocks are designed with an ample margin of contact area, and in addition are fitted with magnetic coils in order to take care of the breaking of the arc. On service this device has been found to give exceedingly good results.

The feeder circuit-breakers are of the plain overload type, and are designed to give a very heavy setting in order to take care of the momentary overloads experienced in a traction system of this description.

The machine circuit-breakers are of the overload and reverse-current type. In conjunction with the reverse-current a special single-pole relay of the differential type is provided, so that in the event of the rotary converter coming up of the wrong polarity it is impossible to close the circuit-breaker on to the bus bars. This relay is coupled up across the main contacts of the circuit-breaker, and operates on to a shunt-trip coil fixed to the circuit-breaker release mechanism. This shunt-trip coil is also arranged for operating from the over-speed device on the rotary converter sets.

For the metering of the power in the sub-stations, integrating wattmeters are fitted on the extra-high-tension rotary equipments, and on the direct current side two-wire integrating watt-hour meters are fitted on the instrument panel. Three of these meters are furnished for check purposes, and are operated from the same shunt, the shunt being fitted in the negative bus bar between the machines and the feeders.

The control panels are of cast iron, and form the front section of the bottom cubicles. On these panels are mounted the operating handles for controlling the circuit-breakers and bus bar isolating switches. The arrangement of these panels is very clearly illustrated in Fig. 15, from which it will be seen that practically no exposed part projects beyond the surface of the panel, other than the operating handles. Further details are seen in Fig. 17. The instruments are of the vertical edgewise type, and are arranged for mounting behind the panel, a suitable slot with glass front being provided in the panel for these meters. The instruments themselves are carried on porcelain insulators fitted to the back of the panel casting.

Starting Gear.—The starting gear on the three 800 kw. rotary sets, that is to say, two at Ayeliffe sub-station, and one at Erimus sub-station, is of the controller type, the machines being arranged for tap starting. These controllers are mounted at the end of the machine frames and direct on the main floor of the sub-station, the connections being taken straight down and carried on the basement floor. With regard to the larger sets furnished in Erimus sub-station, these rotaries are of the self-synchronising type, the starting gear consisting of oil switches mounted in the transformer chamber and operated direct from the switchboard gallery, two oil switches being furnished for each rotary converter, one for the main rotary connections and the other for the starting motor. The operating mechanism for these oil switches is of the signal lever type, the operating shafts being carried on the underside of the basement floor.

In conjunction with this latter starting gear an operating handle is provided for controlling the series switch on the direct-current side of the rotary converter ; this handle is mounted alongside the operating handles of the starting switches, and a system of interlocks is furnished for these three units arranged so that :—

1. Before closing the starting motor switch the other two switches must be "off."

2. Before closing the main oil switch the starting switch must have been closed.

3. The closing of the series switch automatically opens the starting switch.

In conjunction with this starting gear an instrument panel is fixed alongside the operating handles. This panel contains an alternating-current voltmeter to indicate that the rotary is in synchronism before closing the main starting switch. A direct-current voltmeter is also fitted to indicate the voltage of each rotary before closing the series switch.



Fig. 16.—Oscillogram of Test on Rotary Converter.

In connection with the 800 kw. rotary sets, field splitting switches are provided of the remote controlled type arranged for operating direct from the switchboard gallery. These switches are mounted in the basement floor in the same structure as the main series switch supplied in connection with each rotary. This structure consists of marble panels completely covered in with expanded metal screen-

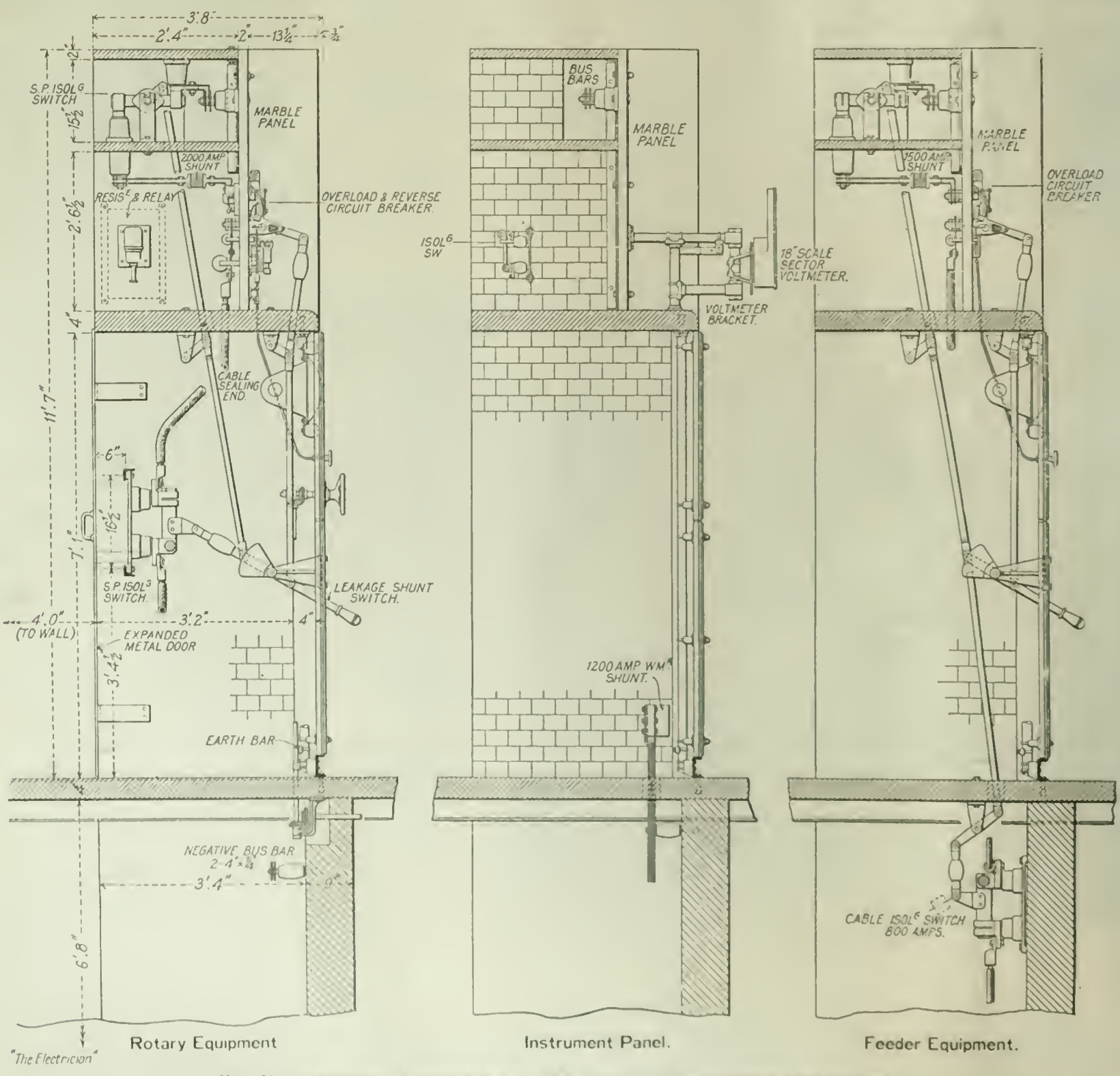


Fig. 17.—Sectional side views of 1,500-Volt D.C. Switchgear at Aycliffe.

The operating handles for controlling these switches are mounted on cast-iron pedestals fixed immediately in front of the direct-current control board.

The rheostats for the rotaries are mounted in the basement floor, and are controlled by operating hand-wheels fixed on the machine.

control panels, bevel gearing being provided for coupling up the control handwheel on the switchboard gallery to the rheostats in the basement.

The lighting switchboard is of the standard flat back type, consisting of black enamelled slate carried on a pipe framework structure, arranged for bolting to the sub-station wall, and is fixed on the

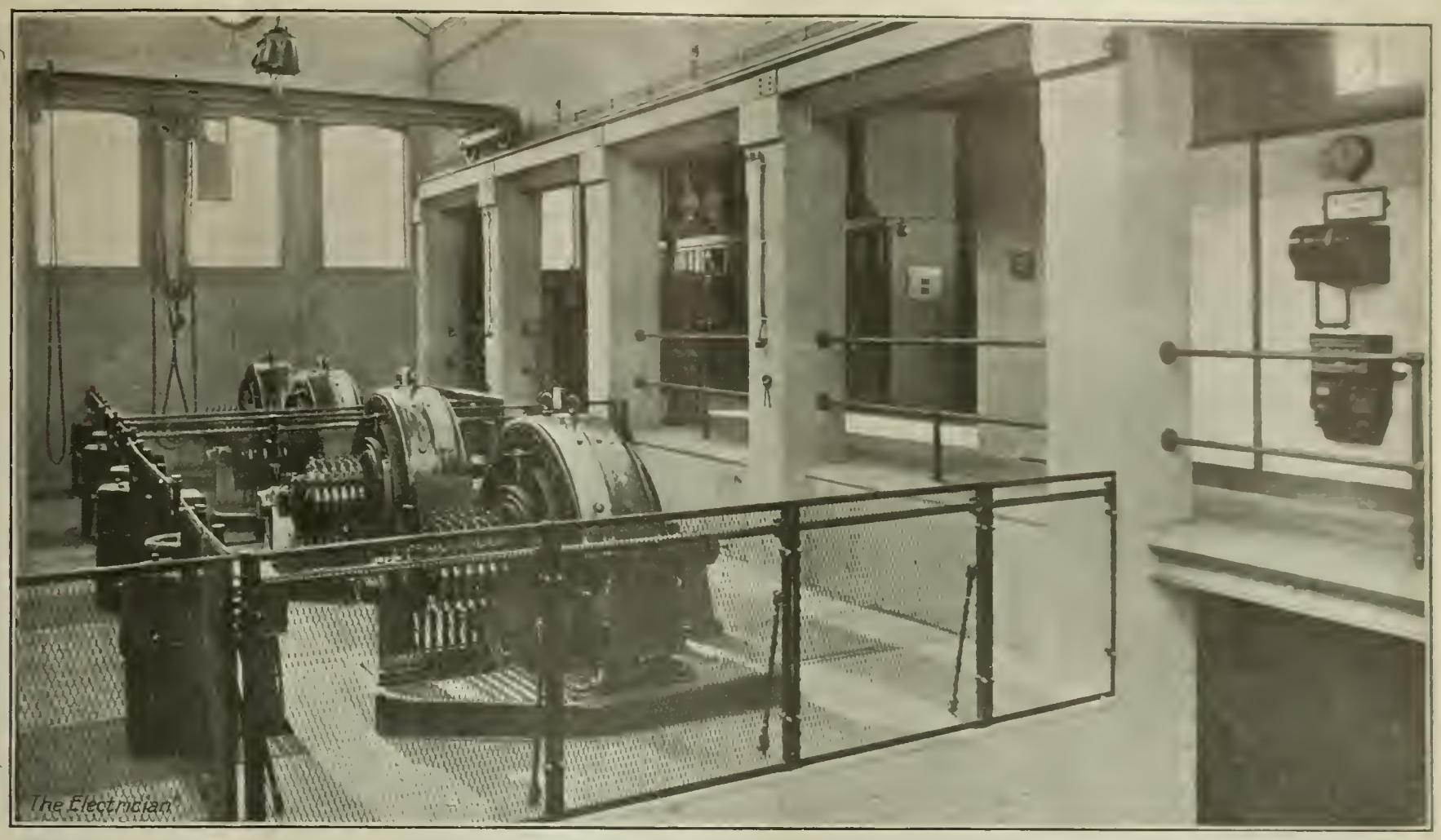


Fig. 18.—General View of Interior of Aycliffe Sub-station.

110-*volt Switchgear.*—For the lighting of each sub-station, and also for controlling the portable air compressor, two 20 k.v.a. three-phase transformers have been supplied. These transformers are coupled up in parallel on the extra-high-tension side, with the main step-down transformers for the rotaries. On the low-tension side, however, a change-over switch is provided so that either of the two auxiliary transformers can be coupled up to the lighting circuit at will, 110 volts being the lighting voltage.

switchboard gallery at right angles to the main direct-current control board.

As mentioned above, in addition to supplying the lighting, this board also supplies power to the portable air compressor set, and a spare circuit is provided for the future installation of ventilating fans.

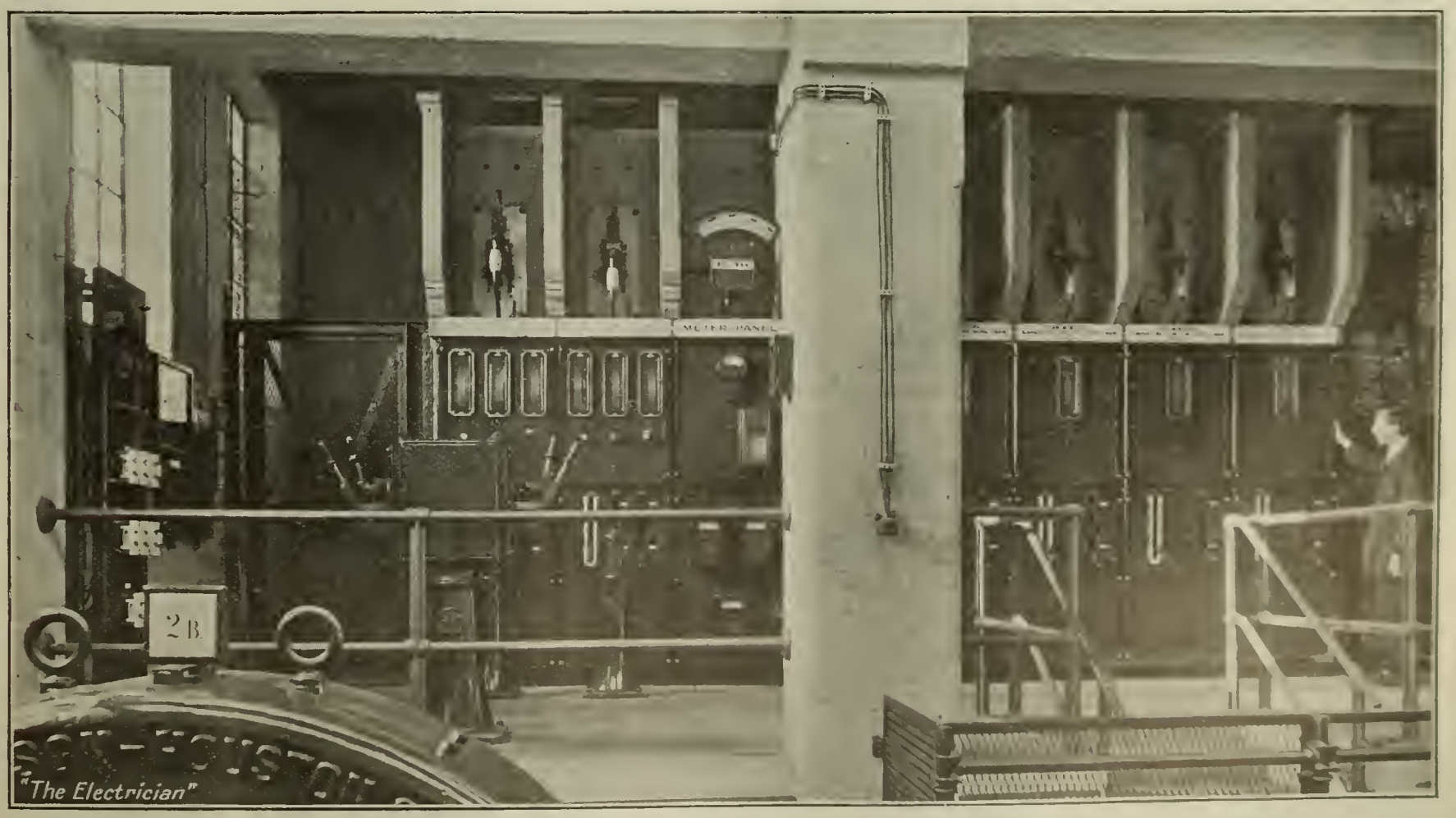


Fig. 19.—Direct-current Switchboard at Aycliffe Sub-station.

Fig. 18 shows a general view of the interior of Aycliffe sub-station, in which a portion of the high-tension alternating-current switchboard can be seen, and Fig. 19 gives a view of the direct-current switch-

REFERENCES.

A. Ammeter.
V. Voltmeter.
F. Fuses.
S.P.S. Single-pole switch.
I.S. Isolating switches.
R. Resistances.
O.S. & I. Oil switch and isolators.
S.C. Starting controller.
W.M. Watt meters.
Rh. Rheostat.
V.M.P.S. Voltmeter plug socket.
B.V. 'Bus-bar volts.
M.V. Machine volts.
F.R.S. Field-splitting and reversing switch. 100 a.
A.S. Ammeter shunt.
M.S. Meter shunt. 1,200 a.
D.R. Differential Relay.
R.C.S. Reverse current coil.
Mg.B. Magnetic blowout.
O.T.C. Overload trip coil.
R.V. Recording voltmeter. 0—20 volts.
L.A. Leakage ammeter (at Aycliffe only. 0—5·0—50 a.)
C B Circuit-breaker. Machine 1,200 a.
T C S Trip coil switch.
S.E. Starting and equaliser switch 500 a.
S C Starting and series switch. 500 a
C.Bx. Cable box.
W T T. Wattmeter testing terminals.
R.C. Reactance coil (shown by an X ϟ v., tappings only).
S.H Switch handle.
I.S.H. Isolating switch handle.
T.L.F. Time-limit fuses.
V.M.P. Voltmeter plug.
M.T. Main transformer.
Aux T. Auxiliary transformers.
L Lamp.
L A S Leakage ammeter shunt. (Aycliffe only).
Mg. Machine Feeder Shunt.
Sh.T Shunt trip coil
Rs. Resetting device for machine C B
B A Battery for alarm Bell.
T B Tripping battery (to give duplicate supply).
B C S Battery change-over switch.
T.C. Trip coil (30 volts).
T.C S Trip coil switch.
A B S. Alarm bell switch.
F T L. Fuses' time limit.
A.P. Ammeter plug.
O.R. Overload relay.
S C R. Split conductor relay (Aycliffe only).
S.P C.T. Split cond. current protection trans. (A. only).
S C.T. Secondaries of protection transf.
O.C.T. Overload current transformer.
W.C.T. Wattmeter current transformer.

NOTE.—Of the two E.H.T. feeders at Aycliffe and Erimus, only the connections for one are shown here, both being alike.

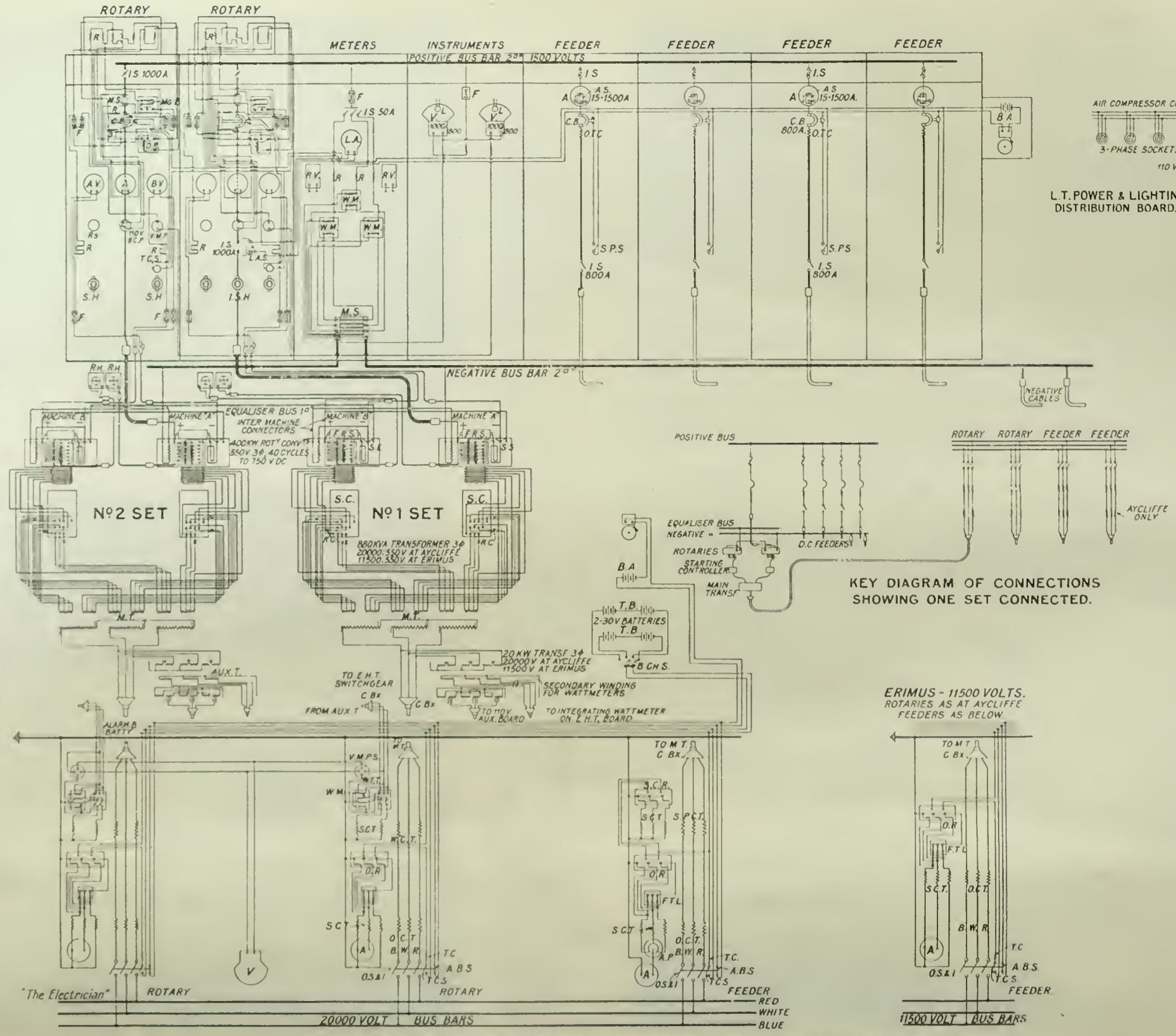
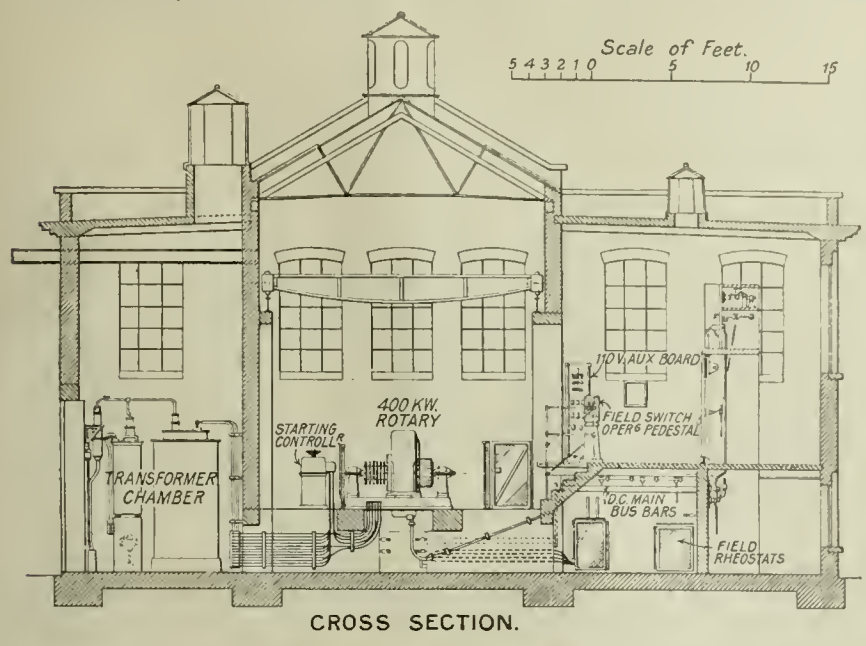


FIG. 20.—DIAGRAM OF CONNECTIONS AT AYCLIFFE AND ERIMUS SUB-STATIONS.

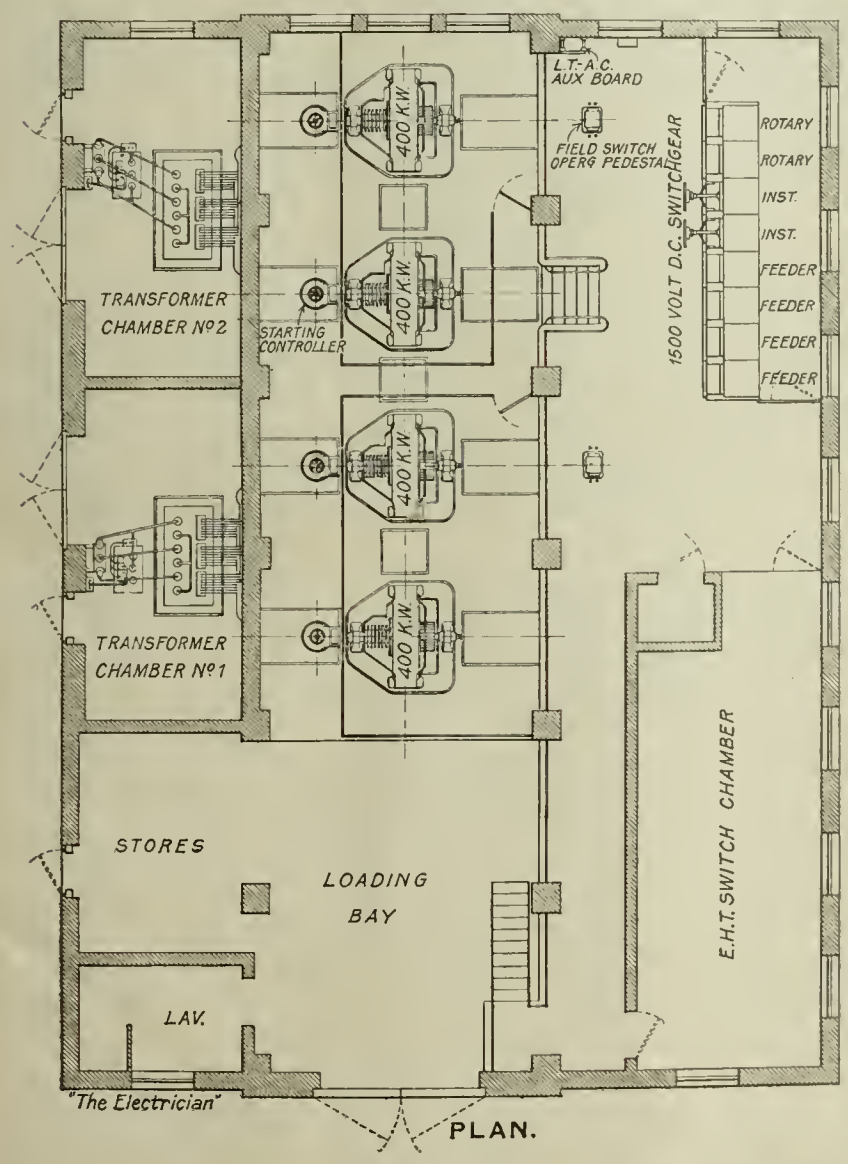
board. A plan and section of the sub-station are shown in Fig. 21. It will be noticed that this being a high-tension sub-station, the machines are enclosed by expanded metal screens. The rotary converters were built by the British Thomson-Houston Co. (Ltd.), the transformers being of the British Westinghouse Company's make. The rotaries are of the self-synchronising type, and are started by oil-immersed drum-type starting switches.

The Erimus sub-station is generally similar, and two rotary sets are also fitted, but in this case one is of 1,200 kw. capacity.

Two auxiliary transformers are installed in each sub-station connected directly across the high-tension terminals of the main trans-



CROSS SECTION.



PLAN.

FIG. 21.—CROSS-SECTION AND PLAN SHOWING GENERAL ARRANGEMENT OF AYCLIFFE SUB-STATION.

formers. A feature of interest in connection with these is the fact that they are fitted with a double secondary winding, one section being used exclusively for metering, and the other for supplying lighting and auxiliary power in the station for portable air compressors, &c.

The 20,000-volt switchgear at Aycliffe is of the Reyrolle iron-clad wall-operated type. The high tension overhead transmission lines and the cables to the sub-stations were supplied by the British Insulated and Helsby Cables (Ltd.).

The Erimus sub-station is supplied at a pressure of 11,000 volts between phases through underground cables connected to the power companies' system in the Middlesbrough district, the alternating-current switchgear being of the same type as that of Aycliffe. The direct-current switchgear at both sub-stations is of the brick cell type. Fig. 20 shows a diagram of connections of Aycliffe and Erimus sub-stations.

Each sub-station is connected to the overhead track by four positive feeders consisting of paper insulated bitumen sheathed single-wire armoured cables, each of 0.5 sq. in. section, laid in wood troughing run in with bitumen.

There are two negative cables at each sub-station connecting the track rails to the negative bus bar, these cables being similar in size and type to those used on the positive side.

A hand-operated travelling crane is fitted in each sub-station by Herbert Morris (Ltd.). Each is of the single girder type, of 16 ft. 11 in. span, and of 5 tons capacity. The motions are hand-operated from the floor. The lifting gear consists of a travelling spur-gear pulley-block, with gears cut from the solid, and a box is attached which collects the slack end of the load-chain when the load is raised. An automatic brake is provided, with power proportional to the load.

(To be concluded.)

TRAINING MUNITION WORKERS.

We were afforded an opportunity on Monday last of visiting one of the centres in the London district which has been established by the Ministry of Munitions with the assistance of the London County Council for giving training to unskilled persons who are desirous of doing munition work. The scheme is a general one, in which the educational authorities in various parts of the United Kingdom are co-operating, and already there are 64 training centres in London and the provinces. The class of student taken varies considerably as to profession, trade and social status, but each person taking the course has no previous knowledge of workshop practice. It is very creditable that since July, 1915, when the movement was first inaugurated, up to the present time, upwards of 10,800 applications have been registered, quite apart from those who have been rejected as unsuitable. It should be noted that only those who during the first two or three days show any aptitude for the work are allowed to continue the course of training. In each case the instruction is free, and in the Metropolis the normal course is six weeks, consisting of six days a week, four hours per day, or 144 hours of training in all. The student gives an undertaking to make use of the knowledge at the end of the course in any munitions factory in which employment can be obtained. Both male and female students are allowed to take up the work. The work includes exercises in bench and vice work, turning, drilling, millings, &c., the object being to give the student an elementary "machine sense." The students turned out may be divided into three main classes: (1) General class, those who are trained to operate some specific machine, such as a drill, a capstan lathe, a slotter, a miller, &c.; (2) those who qualify as tool setters; (3) those who qualify as gauge makers; there is also a fourth class which includes a course of lead burning. The following statistics may be regarded as typical of the work undertaken and the results achieved:—

—	General course.	Lead. burning.	Tool setters.	Gauge makers.	Total.
No. in attendance during week ended 20/5/16...	391	38	36	36	611
No. certificated up to 20/5/16.....	2,897	75	38	28	3,038
No. refused certificates and withdrawn.....	936	26	1	11	974
Certificated—					
No. known to have entered factories or H.M. Forces	2,564	75	37	27	2,703
No unplaced	333	...	1	1	335
Uncertificated—					
No. known to have entered factories ...	76	...	...	...	76
Second and subsequent placings.....	76	2	2	...	80

After a visit to the largest of the training centres in London, we were given an opportunity of passing through a large munition works in which 95 per cent. of the employees are students who have gone through the course, particulars of which are outlined above. The manager informed us that the class of labour was highly satisfactory, and that the product of the works was everything that could be desired. One of the secrets of success has been the closer dissecting of operations and a greater degree of specialisation. By this means tool setters, tool makers and charge hands have been trained from the ranks of the unskilled.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*

Advertisement Rates, &c., forwarded on application.

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.

THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*

BOILER FEED WATER. By F. A. Anderson. Price 6s. nett.

LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.

ELEMENTARY THEORY OF ALTERNATE-CURRENT WORKING. By Capt G. L. Hall, R.E. 3s. 6d. nett.

ELECTROMAGNETIC THEORY. By Oliver Heaviside. Vol. I. Price 12s. 6d. Vol. II. Price 12s 6d. Vol. III. 21s. nett. [postage 3d.

COMMON BATTERY TELEPHONY SIMPLIFIED. By W. Atkins. *Third issue* 3s. nett.

ELECTRIC CRANES: THEIR DESIGN, CONSTRUCTION AND APPLICATION. By H. H. Broughton, M.I.E.E. Price 25s. nett, postage 9d. (abroad, 1s. 8d.)

ELECTRICAL TESTING FOR TELEGRAPH ENGINEERS. By J. Elton Young. Price 10s. 6d. nett, post free 11s

STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Price 7s. 6d nett.

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie A.M.Inst.C.E. Price 10s. 6d. nett, postage 6d. (abroad, 1s.)

"THE ELECTRICIAN" PRIMERS (84 Primers in all, and a GLOSSARY). Single Primers 3d. each post free. *In One Complete Vol.*, 10s. 6d. *nett, or Three Separate Vols. (Vol. I.* 3s, 6d. *nett ; Vol. II.*, 6s. *nett ; Vol. III.*, 4s. 6d. *nett).* Prospectus free. The Primers are revised or re-written as new printings are called for, and new Primers are added from time to time. Five New Primers: Gas Engines (No. 52), Oil Engines (No. 52A), Common Battery Telegraphs (No. 60A), Electric Clocks (No 79), Electric Impulse Dials (No.79A), now ready. Revised Primers, 1914 and 1915: No. 29 (Management of Dynamos and Electric Machinery); No. 46 (House Wiring for Electric Light); No. 63 (Repairing Submarine Telegraph Cables); No. 42 (Electric Ignition); No. 49 (Steam Engines); No. 54 (Comparative Advantages of Steam and Producer Gas for Power Production); No. 59 (Diplex and Quadruplex Telegraphy); No. 61 (Automatic Telegraphic Apparatus).

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation.*

A VALUABLE WORK.

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE.
By W. R. COOPER, M.A., B.Sc.

NEW EDITION: Price **10s. 6d.** nett, post free.

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers. Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

DESIGN OF ELECTROMAGNETIC MACHINES.

We have arranged with Dr. S. P. SMITH, of the City and Guilds (Engineering) College, to contribute to our columns a series of articles entitled "Notes on Design of Electromagnetic Machines." The articles will embrace practically the whole of dynamo-electric machinery, and an endeavour will be made to keep each article complete in itself. The first article is intended to be completed in six issues, and the commencement of the first part is given elsewhere. It deals with the fundamental principles underlying the design of continuous-current machines, and these principles are applied in the second part of the article to the design of a 350 kw. generator running at 200 revs. per min.

Authoritative treatises on the subject, such as "Parshall and Hobart," "Hawkins," "Walker" and "Arnold," are available for the specialist, but between the elementary books and those standard works there is a gap which students and young designers have difficulty in bridging. The notes by Dr. SMITH are intended as a suitable introduction to the standard works, and the latter will, therefore, be more intelligible to those who are properly grounded in the elementary principles of the subject.

In addition to serving this purpose the articles will be found to contain much that is likely to interest and to be of use to older and more experienced designers. For instance, many readers will doubtless be surprised to learn of a further extension to the theory of armature windings, a subject which they thought completed years ago. It will be seen that Dr. S. P. SMITH by no means accepts this view, and regards the ordinary rules for the connections of lap and wave windings simply as arithmetic relations for obtaining a closed winding, without any direct bearing on the working conditions.

His argument on which is based the theory of armature windings is very simple, and serves to explain why only special cases of these general rules provide satisfactory windings. Starting from the fact that when the sum of all the pressures induced in a number of coils is zero, and therefore no current will circulate when the coils are joined in series to form a closed winding, the closed lap or wave winding is seen to consist of one or more such systems, which may or may not be electrically independent of one another. If all these systems are identical, then it is proper to join them in parallel either permanently by equi-potential connectors (phase tappings or equalising rings), or temporarily by commutator brushes. If they are not identical, then it is obvious that circulating currents will flow between the several circuits when they are joined in parallel; and if this connection is made by means of commutator brushes, the carbons are improperly called upon to carry equalising currents due to the dissymmetry of the winding, in addition to their proper function of collecting the current. In many cases, sparking at no-load is traceable to the equalising currents due to unlike circuits being joined in parallel.

Although novelty is not claimed for the rules developed for obtaining symmetrical circuits, it is hoped that the simple treatment will make them appreciated more widely, for there is no doubt that a better understanding of the circuits in a closed winding will save much needless worry

and expense to designers and builders of commutating machinery.

The series-parallel winding, or the wave winding with more than two circuits, to give it a logical name, is an excellent example of the application of Dr. Smith's theory of armature windings. Many manufacturers will doubtless recall very bitter experiences when reminded of this type of winding, but we venture to think that after reading the article referred to, the probable cause of past failures will become evident. As a proof of the progress made in this direction, and of the soundness of the author's conclusions, we have a comprehensive summary of the combined experience of Continental firms with series-parallel windings.

There are two reasons for this remarkable progress after such bitter experiences: (i.) The strict adherence to the rules for making the windings quite symmetrical, (ii.) the use of equalising rings. The use of equalising rings on series-parallel windings comes from the well-known pioneer of so much in armature windings, the late Dr. E. Arnold, who obtained a British patent for them in 1901, and which has consequently now expired. By the use of equalisers it would appear that Arnold hoped to free the designer from the restrictions imposed upon him by the conditions of symmetry, a hope which experience has not realised, to judge from modern practice. Though the practical applications of the series-parallel winding are reduced to very narrow limits by these conditions, we think nevertheless that the designer can make good use of the four-circuit winding in an 8-pole machine, or the four or six-circuit winding in the 12-pole machine.

REVIEWS.

[Copies of the undermentioned works can be had from The Electrician Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

Overhead Transmission Lines and Distributing Circuits: Their Design and Construction. By F. Kapper. Translated by P. R. Friedlaender, M.I.E.E. (London: Constable & Co.) Pp. x.+300. Price 16s. net.

The title of this book is somewhat misleading, as the term "design" to any electrical engineer must include the electrical as well as the mechanical design. A more appropriate title would have been the Statics and Construction of Overhead Lines, since the book deals mainly with mechanical matters, and there is very little in it referring to the electrical part of the subject. That little is not very helpful, and in some cases the terms employed are a too literal translation from the German to be obvious to the English reader. Thus the author speaks of "safety networks" when he means guard wires; or of "laying an earthed wire" when he means the connection to an earth plate. To speak of laying of an earthed wire conveys to the reader the idea that the wire itself takes the place of the earth plate. Nothing is said as to earth resistance or its measurement. One may doubt whether the author's recommendation to lay the wire to the earth plate in an iron tube for mechanical protection would be a very efficient arrangement for the discharge to earth of high-frequency surges. It is obvious that in the author's view mechanical safety is paramount, and the electrical aspect of the problems unimportant.

The same impression is given by the section on spacing of three-phase lines. The necessity of so spacing that the swaying of the wires in the wind shall not bring them into contact is clearly explained, and then we get three different formulæ where the spacing is represented as dependent on voltage and span. A table is given worked out on the basis of the formula $D=0{\cdot}018S+4\sqrt{E}$, where D is the distance between wires in inches, S is the span in feet, and E the E.M.F. in kilovolt. This formula takes no account of the diameter of the wire, nor of the altitude at which the line is placed, nor of the atmospheric condition as to temperature and humidity. All these points have long ago been carefully studied by American engineers, and especially by Mr. Mershon, but there is no reference to the very important experimental research made and the practical results obtained, by this engineer. A modern book should include these things, and it is for this reason that the reviewer fears the electrical part of the book under review will not be very helpful to the reader.

A much more favourable opinion may be given as regards the purely mechanical part of this treatise. Here we find detailed information as to qualities of line material, namely copper, aluminium, bronze, steel and coppered steel; also insulated cables for crossing other lines and finally iron and steel wire rope for suspending conductors. In discussing sag and stress, and the influence of temperature, the author makes the usual assumption of a parabola instead of a catenary, and the influence of wind is taken as represented by a pressure of 20 lb. per sq. ft. On this basis a table is worked out giving the horizontal force acting on the masts of a three-phase line having various spans (from 49 ft. to 1,300 ft.), and conductors of various cross section (from 0·0093 sq. in. to 0·105 sq. in.). As affecting strength of masts we have the usual tables of moments of inertia-discussion of bending, sheering and compressing stresses, the design of struts and guy wires and other matters all necessary for the design of the line with due regard to mechanical stability. The formulæ deduced are of the kind found in any engineering pocket book, but it is useful to have them collected in a handy form, and to be shown their application by numerous examples taken from practice: mostly German. The commercial side of the problem receives some recognition by the author in the discussion of the most economical span, and in quotation of the cost actually incurred in the erection of various high-tension lines.

The section on distributing circuits is mainly concerned with the overhead mains for public supply in small towns and villages, and contains many details as to wall and roof supports, leading-in wires, insulators, street masts, branch circuits from distributing masts, arc lamp masts and suspension of arc lamps over the middle of the street and other technical matters. There is also a diagram giving the cost of house connections, meters, distributing system and street lighting for small communities ranging from 250 to 4,500 inhabitants. Where rules and regulations are quoted these are mostly taken from the "V.D.E.," and the German law as to way-leaves is quoted. The English law is referred to by way of comparison, and some parts are quoted from Mr. Welbourn's Paper before the Inst.E.E., read in January, 1914. Gilbert Kapp.

Relativity and the Electron Theory. By E. Cunningham, M.A. Monographs on Physics. (London: Longmans, Green & Co. 96 pp. 4s. net.)

This monograph is described as "an attempt to set out as clearly and simply as possible the relation of the principles of relativity to the generally accepted electron theory, showing at what points the former is the natural and necessary complement of the latter." The author regards the (electromagnetic) principle of relativity as an attempt to see what are the conclusions to be drawn from an admission of our inability to identify the ether. He shows that the FitzGerald Lorentz contraction of all matter in the direction of its motion through the ether, when logically interpreted, amounts to the same thing as the principle of electromagnetic relativity as formulated by Einstein—*i.e.*, that it is impossible, by any optical or electrical experiment, to discover motion through the ether. In fact, it accepts the negative results of the experiments of Michelson and Morley, Rayleigh and Brace, Trouton and Rankine, Lodge, and Trouton and Noble as an experimental basis for a new system of dynamics, of which the constancy of the velocity of light is the very foundation. The extraordinary consequences of this assumption have been pointed out on many previous occasions, and the author does not repeat them here. They land us in a wonderland, where all our notions of space and time are grotesquely transfigured. But, fortunately, the bulk of them remain inaccessible to experimental tests, and the apparent change of mass of a fast

electron remains the only fact hitherto discovered which lends some plausibility to what has been described as the "latest fashionable craze" of science. Mr. Cunningham presents the various arguments clearly and with considerable force. It is somewhat remarkable that in dealing with ether stress, as exemplified in a train of plane waves of light and the field of a moving point charge, the author arrives at the conception of an "emission" of ether from each electron with the velocity of light. This is substantially Ritz's assumption, and possibly points the way towards a new solution. E. E. F.

INSTITUTION OF ELECTRICAL ENGINEERS.

Exclusion of Alien Enemies.

A special general meeting of corporate members of the Institution was held on Thursday, May 25, to discuss and, if thought fit, pass a resolution to exclude alien enemies from membership.

The President (Mr. C. P. Sparks) said it would be remembered that when the Council came before the members some months ago suggesting a proposed alteration of the Articles of Association, it was decided to hold an informal meeting to discuss the matter. This was held on March 8, a number of amendments were brought forward, and a small Committee was appointed to boil the matter down, so as to submit the question at issue to a postal vote. The vote was taken, and the details of the result were as follows: Cards issued, 3,244; cards returned, 1,470. In favour of (*a*) to expel members who are subjects of enemy countries or states 1,320, against 88; in favour of (*b*) to expel members who being naturalised British subjects have retained enemy nationality 1,307, against 79; in favour of (*c*) not to expel members who are naturalised British subjects and were formerly subjects of a country or state now at war with Great Britain and Ireland but who have under the laws of such country or state definitely lost their alien nationality, provided they are able to prove this to the complete satisfaction of the Council 1,081, against 264; in favour of (*d*) that no person shall after the.....day of..... 19....., be eligible for election as a member of the Institution who is a subject of any country or state with which the United Kingdom of Great Britain and Ireland is or shall have been at war on or after the date mentioned 1,120, against 200.

The solicitor drew up the following resolution, which he would put to the vote at a later stage:—

"That the following words be added to Article 41 of the Articles of Association, namely: 'On and after the 15th day of June, 1916, no person, whether a naturalised British subject or not, who is or shall be or has or shall have ever been a subject of a country or state, then or thereafter at War with His Majesty or his successors, shall be or continue to be or be eligible for election as a member of any class of the Institution, provided nevertheless that the above disability shall not apply to a person who, having at any time been a subject of such a country or state as aforesaid, shall have become and shall be a naturalised British subject, and shall prove to the satisfaction of the Council that under the laws of such country or state he has ceased to be and is not a subject thereof.'"

This resolution was submitted to Mr. J. Austen Cartmell (Junior Counsel to the Treasury), who said he was of opinion that the Institution could legally alter the Articles of Association as proposed. So far as concerned persons hereafter seeking to become members, the case was reasonably clear. There might be some difficulty with regard to existing members, whom it was now proposed to disqualify. His (Mr. Cartmell's) view was that no existing member could complain of the alteration, even if it divested him of what were at present vested rights, unless the alteration violated some statutory provision or principle of law. The proposed alteration, in his opinion, did not violate any statutory provision or principle of law. Every member of a company became such on the terms of the Articles, which formed a contract between himself and the company, and which might be altered so as to affect existing rights. In affecting the alteration the following obligations must be borne in mind: (*a*) The provisions of the Memorandum of Association must not be altered under colour of altering the Articles; (*b*) statutory rights must not be interfered with; (*c*) the power to alter the Articles must not be used so as to commit a fraud on the minority. The power appeared between the company and its members to be unlimited. In the present case neither (*a*) nor (*b*) would apply; the alteration would not affect anything which was thereby prohibited. Under (*c*) an argument might be raised, but he was of opinion that such an argument would fail, and that no Court would hold that an attempt of the majority of the members of the company to purge the company of all enemy taint was fraudulent or oppressive upon the minority whom it sought to exclude. In view of the above considerations, he was prepared to advise the Institution to proceed with the proposed alteration. But litigation might ensue. If an action was brought by an excluded member, and he was (contrary to Mr. Cartmell's anticipation) to succeed, the relief would be an injunction to restrain exclusion and possibly some damages. But, in view of the wide power of expulsion given by Art. 41, such damages, he apprehended, would be little more than nominal.

The President then moved the resolution as set out above.

Mr. C. H. Wordingham, in seconding the motion, said it gave him great pleasure to do so, and he called upon all those whose sentiments were anti-German to vote for it, whether they were, like himself, extremists, or whether they were only moderate. The resolution did not go so far as he would like it to go, but he was convinced it went as far as it was possible for the Institution legally to go. He would have liked to have seen all naturalised aliens submitted to a close inspection so that it might have been ascertained, as nearly as possible, whether or not they might be presumed to be loyal to the country they had adopted. He was sure a number of naturalised aliens would have come out triumphantly from such an ordeal. There were naturalised aliens among them who had lost their nearest and dearest in this war, and who were prepared to lose their own lives. There were others who had given abundant evidence that they had the interests of this country at heart. Such men would have gained from such a scrutiny as he would have liked to have seen. There were, however, unquestionably, a very large number of naturalised aliens who masqueraded as Englishmen and were infinitely more dangerous than those who had not become naturalised, and who were admittedly enemies. Those who agreed with the views he had expressed were in antagonism to a principle which could not be attacked by that Institution, but could only be attacked by Parliament. He held that no foreigner should be admitted to the privileges of a British born subject. No amount of legal verbiage could give to any foreigner the glorious privilege of being born a Briton and having British blood flowing in his veins. He asked those who were Britons to support the resolution and vote for it.

Capt. O. T. O'K. Webber (Dublin) said he and his companion, Mr. Harriss, were there in pursuance of a resolution adopted unanimously by the Local Section at Dublin on March 10, that the membership of the Institution of any citizen born of alien enemy parentage, naturalised or not naturalised, shall forthwith cease, and that after the termination of the war no such citizen shall be eligible for membership, and further that no citizen of the Empire or of allied or neutral nations being a member of any grade of the Institution who becomes an agent for any firm, owned or controlled by a citizen or citizens of an enemy nation or nations, shall automatically cease to be a member. They had just heard that the resolution actually before the meeting went as far as it lawfully could do, and it left nothing more that he could do. He agreed with every word the previous speaker had said.

The President said what was actually before them was to vote on the resolution he had read—Aye or Nay. They could not consider amendments. He understood that Capt. Webber would take that resolution on account. If it did not go far enough there was nothing to prevent them considering further proposals at a future meeting.

Mr. C. A. Baker said he was one of the scrutineers of the ballot. Some returns from Scotland and Ireland were accompanied by letters saying that sufficient time had not been allowed, but, by the secretary's courtesy, every answer was dealt with and recorded.

Mr. C. C. Atchison (Rochdale) said he did not think the resolution went far enough, but he accepted it on account. They had inserted the thin end of the wedge, and he had pleasure in supporting the resolution.

The resolution was then put and carried by 41 votes to one, and the President announced that a further special general meeting of the corporate members would be held on June 15 at 5.15 p.m. for confirming it.

EFFECT OF THE REBELLION IN DUBLIN ON THE DUBLIN UNITED TRAMWAYS.

On Easter Monday, at 12.30 p.m., immediately after the Sinn Feiners occupied the principal public buildings, the tramway company started withdrawing their cars from the city, and at 2.30 p.m. most of the cars were got safely to their different depots. In Sackville-street one of the Howth cars was stopped, and the motorman and conductor were covered with revolvers and ordered to leave. An attempt was made to upset this car by hand to form a barricade for Earl-street, but this attempt failed, and a charge of dynamite was put underneath it and exploded, but did little or no harm. Eventually this car was burnt, due to the adjoining houses having caught fire and fallen upon it. Another car was caught on the South Quays and was also burnt in the same way. Minor damage to four or five of the cars was done by rifle fire. The trolley wires suffered most severely; several miles of wire were brought down all over the city by rifle fire, and tramway standards were damaged by shell fire. At the corner of O'Connell Bridge and North Quays a shell passed right through a standard; subsequently this pole, as well as the others damaged, were filled up with concrete reinforced with steel rods on site.

The day after the outbreak the Sinn Feiners surrounded the power station, and eventually entered and ordered the men out. All the men coming in carried revolvers, and some of them a revolver in one hand and dagger in the other. They gave the engineer on watch an hour to clear out under penalty of death, and ordered that the whole system was to be shut down. This was exactly what it had been decided to do. The Sinn Feiners were apparently satisfied that their wishes were carried out, as they did not return, and the staff was allowed to remain in occupation of the station in its shut-down state throughout

the whole disturbance, notwithstanding the heavy rifle fire in the district, which was one of the worst and was the last to give out. No attempt was made to do any damage to the power station, nor, indeed, was any direct attempt made to damage the cars, except from the Sinn Feiners' military point of view. One of the motormen, in getting his car away from the danger zone, was shot and seriously wounded. Another of the men, when coming from a city depot, was shot dead by rifle fire from the General Post Office. Several of the tramway employés were shot by stray bullets in the vicinity of their own homes.

repaired and the service restored as far as it would be allowed by the military authorities, who had drawn a cordon around the whole city, and would not allow the cars to pass more than two bridges, one on the south side and one on the north side.

The total damage to the rolling stock, including the two cars destroyed and injuries to six other cars—mainly breaking of glass by rifle fire—did not much exceed £1,500. The total damage to the overhead system amounted to about £500. Considering, however, the amount of property the company had throughout the city—the various depots and large number of cars—the company may be con-



Destruction of Tram Car during the Revolt in Dublin, April, 1916.

The loss included the two cars referred to and the damage to the overhead system. The loss of traffic was the most serious that the tramway company has experienced. On May 2nd, immediately after the burning of the General Post Office, the fires in the power station were re-started, and on May 3rd most of the system was in working order.

Sniping was very prevalent throughout the whole of the system, which made it uncomfortable for the men repairing the overhead wires; but by May 5th practically every feeder was temporarily

gratulated on their good fortune. The actual stoppage of the system was from 12.30 p.m. on Easter Monday, April 24th, until May 3rd.

The accompanying illustration shows the Howth car which was burnt. This car, as well as a smaller one destroyed on the South Quays, was eventually towed home on its own wheels. The field coils were destroyed, but the armatures are apparently not very much the worse. Notwithstanding that the metal melted from all the bearings, the trucks are not beyond repair. No damage appears on the trucks as the result of the attempt to blow the car up.

INTERLINKING OF ELECTRIC SUPPLY UNDERTAKINGS.

Practical Steps in Lancashire and Cheshire.

Within the last few days a letter has been addressed from the Board of Trade, Railway Department (Coal) to electric supply authorities, drawing attention to the very considerable saving that could be effected by the adoption of arrangements for interconnection and joint working of electric supply undertakings. The Board have further intimated that they are prepared to assist in securing the agreement of all parties interested in any such proposed scheme.

This letter serves to emphasise and give added point to a movement which has just been started in Lancashire. In the discussion at Manchester on Mr. E. T. Williams' recent Paper to the Institution of Electrical Engineers, Mr. Robertson, the chief electrical engineer of Salford, in pointing out that a national bulk supply scheme as proposed by Mr. Williams was not feasible at the present time, threw out the suggestion that a scheme for interconnecting the principal supply undertakings in the industrial districts would be of enormous benefit, and referred particularly to the advantages of such a scheme for the Lancashire and Cheshire districts.

The matter was taken up forthwith by the Municipal Electrical Association of Lancashire and Cheshire, and at a meeting held in the School of Technology under the chairmanship of Mr. S. L. Pearce on May 9, and attended by a large majority of the chief engineers of the electric supply undertakings (municipal, company and railway) interested in the matter, the following committee was formed to prepare a scheme for the interconnecting (where possible from an engineering point of view and commercially feasible) of the principal supply stations of the two counties.

A committee was formed as follows:—

Mr. S. L. Pearce, Manchester (Chairman).
Mr. B. Welbourn, Prescot Electric Light Co. (Vice-Chairman).
Mr. J. A. Robertson, Salford (Hon. Secretary).
Mr. C. C. Aitchison, Rochdale.
Mr. S. E. Britton, Chester.
Mr. H. Dickinson, Liverpool.
Mr. E. H. Edwards, South Lancashire Tramways Co.
Mr. R. Blackmore, Stalybridge.
Mr. J. Purrett, Lancashire Electric Power Co.
Mr. S. J. Watson, Bury.
Mr. P. P. Wheelwright, Blackburn.
Mr. Aspinall, Lancashire & Yorkshire Railway.

The area of supply coming within the scope of the committee has been divided into the following districts:—

Manchester Inner District.	Liverpool District.
Manchester Outer District.	North Lancashire District.
Stalybridge and Oldham District.	Cheshire District.

Sub-committees have been allocated to these various districts to obtain the necessary technical data, and this will be compiled and tabulated at an early date.

The central committee will then be in a position to review the whole question and to present their report, including estimates of cost to

the various municipal committees and supply companies. Being assured of sympathetic consideration from the Board of Trade, there should be no difficulty in carrying out the scheme without additional parliamentary powers, and in view of its importance at the present time, it is hoped that the Local Government Board will also lend its assistance to enable the financial difficulties to be overcome.

PHYSICAL SOCIETY.

At a meeting held on May 12, Prof. C. V. Boys, F.R.S., President, in the Chair, a Paper, entitled

"The Latent Heats of Fusion of Metals and the Quantum-Theory,"

was read by Dr. H. S. Allen.

The latent heat of fusion is identified with the energy necessary to counterbalance that of a certain number of "oscillators" concerned in holding together the crystalline structure. Assuming that the energy of an oscillator having a vibration frequency ν is

$$RT\frac{x}{e^x-1},$$

where x stands for $h\nu/RT$, it is found that the atomic heat of fusion of a metal can be calculated with fair accuracy by the formula,

$$AL = cNRT\frac{x}{e^x-1}.$$

Here A denotes the atomic weight, L the latent heat, and c the ratio of the number of oscillators in question to the number of atoms. Thus, the number of oscillators in 1 gramme molecule is Nc, where N is Avogadro's constant. It is found that to the factor c must be assigned a value which is either unity or a simple fraction. The frequency at the temperature of the melting point is calculated by means of the formula of Lindemann. The application of Debye's theory is also discussed.

Dr. P. S. Willows agreed with Dr. Allen that the quantum-theory was still in a very speculative state. He referred to the statement in §1 that "*The energy supplied to melt the solid may be identified with the work that must be done to break the bonds which impart to the solid its crystalline structure.*" This seemed to rule out of consideration the case of amorphous solids. It is supposed that some of the alterations produced in a metal by treatment such as rolling are due to some of the molecules becoming amorphous. Could the theory be extended to deal with the change from the crystalline to amorphous states?

Dr. Allen thought the change from crystalline to amorphous conditions was the same as from crystal to liquid.

Prof. Boys: Would not that imply that there was no latent heat in amorphous material?

Dr. Allen agreed that that would be implied.

A Paper, entitled

"Lenses for Light Distribution,"

was read by Mr. T. Smith.

The principle on which lenses for securing a required distribution of light from a given source have been designed is illustrated by a two-dimensional example. The principle employed is to divide the incident and emergent energy into a number of equal parts and compute the lens system, so that the rays which separate off these portions of incident light from one another are refracted as rays which separate the corresponding portions of the emergent light. The surfaces obtained are in general of varying curvature, and the lenses must, therefore, be moulded. It is shown how the effect of the finite size of the light source may be determined.

Mr. R. S. Whipple asked how the results obtained with lamps designed on the lines discussed in the Paper compared with those previously employed, which had been evolved, he presumed, simply by the survival of the fittest. Were lenses of this type used as first cast or were the surfaces finally worked?

Mr. Smith stated, in reply, that the lamps previously in use gave very unsatisfactory results. Their performances varied greatly among themselves, and there did not appear to be any principle underlying their design. In many cases the lenses were not even symmetrically made, and the number of dioptric elements employed depended entirely on the whim of the maker. Some of these lenses had been ground, but he was not aware that they had been used except by the Admiralty. The new lenses, on the other hand, were giving very satisfactory results, despite the fact that some manufacturers had not yet quite realised the ideal conditions. The lenses were moulded and then, in some cases, glazed by what he believed was a secret process.

A Paper, entitled

"The Choice of Glass for Cemented Objectives,"

was read by Mr. T. Smith.

The strict fulfilment of the mathematical conditions for freedom from colour spherical aberration and coma for objects at varying distances from a thin cemented doublet lens necessarily demands a change in the kinds of glass as the position of the object is changed. The Paper describes a method by which the proper glasses can be determined by using a glass chart on translucent paper in conjunction with diagrams calculated for the purpose as a slide rule. With most glasses the solution to the problem is imaginary, and formulæ are given for calculating the boundary separating real and imaginary solutions by solving a quadratic equation. In practice it is found that the curves for all real images lie very close to one another. Notwithstanding this, a numerical example shows that there will be a perceptible difference in the definition obtained if in place of the theoretically necessary type a kind of glass is substituted which does not differ greatly from the other, and lies on a curve giving perfect correction for another real magnification. It is further shown that when no real solution is forthcoming for a double lens a real solution will in practice be obtained by adopting a triple objective made of the same glasses.

LEGAL INTELLIGENCE.

Zinc Corporation v. A. S. Elmore and Others.

Last week Mr. Justice Astbury heard a motion on behalf of plaintiffs for an injunction to restrain Mr. A. S. Elmore, the British Ore Concentration Syndicate (Ltd.), and the Ore Concentration Co. (1905), Ltd., until trial, or further order, from threatening plaintiffs with any legal proceedings or liability in connection with any of defendant's letters patent.

Mr. Bousfield, K.C., for plaintiffs, read an affidavit by the chairman of plaintiff company (Mr. Govett), in which he said that Mr. Elmore was chairman of each of the defendant companies. The British Ore Concentration Syndicate was the owner of a number of British patents, and the Ore Concentration Co. (1905) was the owner of the foreign and Colonial (including Australian) patents, corresponding to the British patents. Plaintiffs worked defendants' process in Australia until 1911, after which they commenced to work a process owned by Minerals Separation (Ltd.), and that was the patents plaintiffs had worked ever since. An action brought by defendants against plaintiffs for infringement was dismissed. The process alleged in the action to be an infringement of the rights of defendants was in all material respects identical with the process which plaintiffs had been using in Australia since 1911. On Jan. 26, 1916, Mr. Elmore wrote a letter to Mr. Govett, of which, counsel said, plaintiffs complained. In the letter it was suggested that plaintiffs should buy up defendants' patents for £50,000, and that if they did not, the result would be interminable litigation. The letter also said defendants would take proceedings to collect royalties on all plaintiffs' concentrates sent into England. Before the war, remarked counsel, the ore concentrates used to be smelted in Germany, and it was a question now of smelting the concentrates in England. Threats of that sort were preventing arrangements being carried out for the smelting of the concentrates. If defendants had any claim let them say so. In the alternative, plaintiffs asked that defendants should be prevented from making these threats until they were prepared to take proceedings. The process in question had been the subject of long and expensive litigation, in which Mr. Elmore had been defeated. Now they said they would reopen the matter and bring actions in Australia, and if plaintiffs brought their products to England, defendants would make a claim for royalties.

His Lordship: I think it was an unwise letter for Mr. Elmore to write, but he wrote afterwards that he had no desire to threaten you. After that I think it was unwise of you to bring this motion.

Answering the Judge, Mr. Wynne, K.C. (for defendants) said he was willing to undertake to issue no threats pending the trial of the action. Mr. Walter said Mr. Elmore had valuable properties for sale, and it was a business proposal which had been treated wrongly by the other side.

Mr. Justice Astbury made no order on the motion, and accepted defendants' undertaking.

J. C. James v. Leatherhead Electricity Co. (Ltd.)

At Epsom County Court recently plaintiff sought to recover £2, said to have been illegally deducted from his wages. Defendants made a counter claim for £2 for money lent.

Plaintiff said he was formerly employed as shift engineer at the electricity works. On Dec. 29 last an offence was committed at the company's works in respect of the Defence of the Realm Act. A light was on in the battery room for taking the voltage readings, the engineer (Mr. Dixon) having instructed him to send one who was on the switchboard to take the readings. Later he reported that the police were summoning him, and he was fined £2 at the police court. Mr. Dixon advised him to get a solicitor about it, and said that he would pay the solicitor's fee. After the police court proceedings Mr. Dixon gave him two £1 notes with which to pay the fine, saying nothing at the time about it being a loan, or that it would be deducted out of his wages. On Jan. 12, 1916 (four weeks later) his wages were stopped to pay the fine, and he told the manager that if he did not receive his money by 12 o'clock that night, at

the end of the shift, he would leave the works and summon him for the money. The same night he received a document summarily dismissing him. On Feb. 29 the sum of £1. 4s. 8d. was sent to him, being two weeks wages less than the £2 stated to have been lent to him, and 4d. insurance. He denied all knowledge that the £2 was an advance on his wages. He denied that he was told that if any lighting case happened the men would have to bear the brunt themselves. The window had to be open to allow the gas to escape from the battery.

Mr. H. Leslie Dixon, engineer and manager of the Leatherhead Electricity Works, said that two of their men having previously committed offences under the Defence of the Realm Act, it was intimated by word of mouth round the works that in future the company would not pay any fines, and that it would be considered an act of carelessness on the part of any workman who committed the offence. As an act of kindness he offered to pay the solicitor's fee for plaintiff, but told him that he must put up the best defence he could, as he would have to pay the fine. After the case was heard, James came to him and told him that he had been fined £2, so he advanced the money to him without any word of it being a loan, but it was an understood thing that it would come out of his wages.

His Honour said that, having regard to the conduct of Mr. Dixon, acting for the company at the time James was summoned, he must come to the conclusion that the company intended to take responsibility. Again, notices repudiating responsibility in future cases were not put up until James' case had taken place. He, therefore, gave James judgment on both the claim and counterclaim.

Falk, Stadelman & Co. v. General Cable Mfg. Co.

Last week a Divisional Court heard an application regarding a new trial of this action.

Mr. Clavell Salter, K.C. (for plaintiffs), said that a Divisional Court had heard an appeal from the County Court in that case, and had ordered a new trial, and a question had arisen as to whether it was intended that the new trial should be limited to certain issues. The goods were electrical cables, and defendants said there was a *force majeure* clause, and the contract was impossible because of the war. The County Court judge found there was no *force majeure* clause in the contract, but he did not consider whether there was, in fact, *force majeure*. The question of impossibility he decided in favour of plaintiffs, and he then assessed the damages. The Divisional Court took the view that the judge did not properly determine if there was a *force majeure* term in the contract, but that the question of impossibility had been rightly decided, and at the new trial it would not be necessary to further consider the latter question. The order had been drawn up for "a new trial" without any such limitation, and the only point was whether there was power to amend the order.

Mr. Cook Johnson (for defendants) said that the evidence must be the same again whatever happened, because evidence that would go to show that the contract was impossible of performance would also apply to the question of whether there had been prevention by *force majeure* from the carrying out of their obligations. That was the third attempt made to limit the right of his clients to a new trial.

In giving the decision of the Court, Mr. Justice Lush said that while sympathising with the position of plaintiffs they could not alter the order that had been made for a new trial, and the costs of the application would be costs in the cause.

A. Rowett v. St. Austell Electric Light & Power Co.

This action was recently tried in St. Austell County Court. Plaintiff sought to recover £12. 17s., damages to his horse and harness, and personal injuries due to the collapse of one of the company's poles (which carried the wires across Bodmin-road) on Dec. 27 last.

For the defence it was stated that the accident was "an act of God," an unusual storm having blown down the pole and strewn the telephone wires on the road, and the horse became entangled. Plaintiff gave evidence and said that the pole was rotten, and that those who went to extricate the horse received electric shocks.

His Honour Judge Gent declined to admit the plea that the accident was due to an "act of God," and decided that there was negligence on the part of the company. There was plenty of evidence that other people had noticed the condition of the poles and that the attention of the company had been called to them. He gave judgment for plaintiff for £9. 17s., with costs.

Workmen's Compensation.

In the Salford County Court recently a question arose as to whether in assessing or reassessing compensation under the Workmen's Acts war bonuses should be included in the wages or earnings.

The British Westinghouse Electric & Mfg. Co. applied for a reduction in the compensation payable to a mechanic named Frank Bradshaw, who, when he met with an accident in 1910, was earning 31s. a week. As a result of the accident his right leg was amputated above the knee, and in 1912 he accepted a post of assistant storekeeper at 22s. a week and compensation of 6s. Since then his wages were advanced 4s. and a war bonus of 3s. a week added. For the employers it was contended that at most the workman was now entitled to the difference between his present earnings and his earning at the time of the accident, and that the compensation should, therefore, be reduced from 10s. to 2s. a week.

For the man it was contended that as the war bonus was given because of the higher cost of living and the harder work men had to do, and as it was temporary and not permanent, it should not be included. It was also argued that the Court should take into consideration the fact that but for the accident the workman would now be earning 11s. or 12s. at his old work.

The Deputy Judge (Mr. Pope) in reducing the compensation to 2s., said that immediately the war bonus was taken off or his earnings decreased from other reasons the workman could apply to the Court for a revision of the compensation.

Browett, Lindley & Co. (Ltd. & Reduced). A petition for confirming the proposed reduction of the capital of this company from £120,000 to £107,500 will be heard by Mr. Justice Sargant on June 6.

PARLIAMENTARY INTELLIGENCE.

Royal Assent.—On May 17 the Royal Assent was read to the following Acts of Parliament: Summer Time Act, Edinburgh Corporation Order Confirmation Act, Burnley Corporation Act.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by Messrs. Mewburn, Ellis & Pryor, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 Specifications.

3,520 International Electric Co., Roose & Le Noir. Electric signalling.

5,832 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Process for the manufacture of heating conductors for thermic telephones from wires treated by the Wollaston process. (6/2/15.)

5,833 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Sound chamber for thermic telephones and the like intended to be introduced into the auditory passage. (8/2/15.)

5,834 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Construction of heating conductors for thermic telephones. (8/2/15.)

5,835 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Process for the manufacture of heating conductors for thermic telephones from wires manufactured by the Wollaston process. (9/2/15.)

5,836 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Thermic telephones. (10/2/15.)

5,837 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Thermic microphone. (11/2/15.)

5,838 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Thermic telephones. (11/2/15.)

5,839 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Thermic telephone with adjustable sound effect. (12/2/15.)

5,840 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Thermic telephones. (12/2/15.)

5,842, 5,843 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Heating conductors for thermic telephones. (13/2/15) (6/3/15.)

5,844 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Manufacture of heating conductors for thermic telephones from Wollaston wires. (6/3/15.)

5,845, 5,846, 5,847 Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Thermic telephones. (17/3/15.)

6,362 Samaia. Automatic signalling arrangement for tramway lines or electric railways (Patent of addition not granted.)

6,495 Svenska Turbinfabriks Aktiebolaget Ljungstrom. Rotary field magnets. (22/6/14.)

6,586 Van Lynden & Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Thermic telephones and microphones. (Convention Application, 12,256/15.)

6,469 B.T.-H. Co. (G.E. Co.) Controlling mechanism for automobiles.

7,092 Svenska Turbinfabriks Aktiebolaget Ljungstrom. Controlling means for electrically-propelled vessels. (17/9/14.)

Comprises controlling means consisting of a shaft rotatable in two directions from a central or determined position, said shaft being provided with a crank and two cams operating through levers, switches located on each side of the shaft, said crank being connected to a regulating resistance of the motor or motors whereby resistance is switched in when the shaft is in proximity to said central position, this resistance being gradually cut out on movement of the shaft in one direction or the other from the central position, and the switches being simultaneously actuated to drive the motor in opposite directions according to the direction of said shaft.

8,107 British Electric Transformer Co. & McWilliam. Oil-cooled transformers.

8,466 Soc. Anon. des Etablissements L. Bleriot. Electrical installations particularly applicable for use in motor-vehicles. (25/7/14.)

9,519 Payne. Magneto ignition devices for internal combustion engines.

9,635 Cassel. Winding-devices for conductors conveying power to movable electrically-driven machines.

10,026 Scholes. Electric junction box.

12,671 Betulander. Impulse transmitters for automatic telephone systems. (26/1/15.)

12,995 Orange. Electric arc lamps. (12/9/14.)

An electric lamp comprising a sealed envelope containing arcing electrodes of tungsten or other suitable refractory material, a filling of suitable gas and or a quantity of vaporisable material such as mercury, the current conductors being reduced locally in section so as to cut down the loss of heat from the electrodes.

13,555 Hermges. Incandescent electric lamps.

16,614 Etablissements de Dion Bouton (Soc. Anon.). Magneto-electric generators. (17/6/15.)

16,780 Westwood. Switches for electric cycle lamps. (Divided application on 7,909/15. 28/5/15.)

17,333 Cairns & Steel. Joint boxes for electric cables.

1916 SPECIFICATIONS.

3,534 GILES, G. Electrolytic condenser or electrolytic valve. (9/3/15.) 100,157. Comprises a central core of insulating material, in which several aluminium bars or rods are embedded, said bars or rods forming supports for spirally arranged condenser plates and contact terminals for the incoming and outgoing current.
3,780 DOULTON, H. L. & PODMORE. Tools for internally shaping telegraph insulators and the like. (17/4/15.) (Addition to 21,923/14. Divided application on 5,757/15.)

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

April 19, 1916.

5,761 YOANNA. Labelling radiographs. (8/5/15, U.S.)
5,722 KERSHAW. Railway signalling and interlocking apparatus.

April 20, 1916.

5,769 AUTOMATIC TELEPHONE MFG. CO. & GREEN. Mine, &c., signalling.
5,777 SCOTT. Electrically-operated friction hoists.
5,779 STAPLES. Signalling apparatus in mines.
5,807 ANGOLD, DUDDELL, DYKES, HANDCOCK & OLIVER. Distance-operated mechanisms and signals connected to electric supply systems.
5,834 MCLEOD. Preventing rapid exhaustion of primary batteries.
5,841 CHRYST & KETTERING. Electrical systems for engines. (24/6/15, U.S.)
5,842 B.T.-H. CO. & WHITTAKER. Dynamo-electric machines.
5,858 BERRY. Electric fuses.
5,859 BERRY. Electric heat radiators.
5,860 MORDEY. Electric relays and their application.
5,847 KINGSBURY. Illuminated signs or electrographs.

April 25, 1916.

5,874 NEEP & SWITCHGEAR & COWANS (LTD.). Magnetic blow-out fuses.
5,875 DUNGEY. Intercommunication telephones.
5,884 STRUYVEN. Electrically-operated temperature alarms.
5,916 WILSON. Mounting mariners' compasses on lifeboats.
5,933 CAUNTER. Electrical switches.
5,934 B.T.-H. CO. (G.E. CO.) Electric locomotives.
5,945 AUSTIN & TAYLOR. Shields or guards for electric lanterns, electric torches, &c.

April 26, 1916.

5,972 HOLT. Points for tramways, railways, &c.
5,978 BEIJER. Power transmission and control.
6,003 B.T.-H. CO. & PECKHAM. Lighting fittings.
6,005 BURGESS LABORATORIES, C.F. Dry cells, and batteries thereof. (28/5/15, U.S.)

April 27, 1916.

6,031 STEIGER. Electric devices for automatically turning lights on and off. (28/4/15. Switzerland.)*
6,036 WOLTMANN. Electric welding apparatus. (1/5/15, U.S.)*
6,039 MORTLEY. Electrical generators for aircraft.*
6,042 BAUMANN. Dry battery. (4/2/15, Switzerland.)*
6,044 ALLEGRANZA & FORT. Assembling and uniting accumulator plates.*
6,056 DAVISON. Submarine sound signalling apparatus.*

April 28, 1916.

6,079 WOOLISCROFT & DAVIES. Electric switches.
6,082 LEVY. Reflectors and shades for arc lamps, electric lights, &c.
6,089 CHAMBERS. Electrolysis of brine in the manufacture of sodium hypochlorite, and apparatus therefor.
6,091 BLACKMORE, MARSH & WARNE. Acid and fume, gas, water and vapour proof electric lamp-holding device.
6,095 GILL & RICHARDSON. Electrical indicating devices for taxicabs, &c.
6,104 HALL & KIRK. Automatically taking up shrinkage of coils of electric transformers, &c.
6,106 HALFORD. Distributors for magneto-electric machines.
6,114 MASCHINENFABRIK OERLIKON. High power and speed turbine plant. (28/4/15, Switzerland.)
6,129 SPERRY. Operating electrodes for projectors. (28/6/15, U.S.)
6,131 CURTIS. Electrical resistances.

April 29, 1916.

6,150 HALL & KIRK. Automatically taking up shrinkage of coils of electric transformers, &c.
6,151 CROWTHER & ROUTLEDGE. Electro-magnetic guns.
6,160 B.T.-H. CO. (G.E. CO.) Electric motor control systems.

May 1, 1916.

6,196 BOYD. Electric generating systems.
6,181 LEVY & STREET. Arc lamp reflectors.

May 2, 1916.

6,234 SOUTHERN. Electric firing-circuits for guns, mines, torpedoes, &c.
6,238 THOMAS. Miners' electric safety lamps.
6,241, 6,242 FILDES. Electric hand lamps.
6,244 CRAVEN. Plug for telephone switchboards, &c.
6,249 STEVENS. Reversing controller for petrol-electric cars, &c.
6,255 WILSON. Transformers.
6,256 HETTINGER. Aerial conductors for wireless signalling, &c.
6,257 CRACKNELL. Adapting socket for attaching electric shades and lamps combined to lampholders.
6,258 MCINDOE. Combined electric switches and plug couplings.
6,260 COLLIE. Troughing or trays for electric conductors, conduits, pipes, &c.
6,269 BYGRAVE & RELAY AUTOMATIC TELEPHONE CO. Electrical selectors or impulse responders.
6,274, 6,275 STONE. Electric batteries.
6,292 BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. Systems of control. (4/5/15, U.S.)
6,288 CLARKSON-JONES. Making and maintaining electrical communication in the field.

May 3, 1916.

6,302 MANDER. Electric flashlight batteries.
6,315 CLARKE & CROSBIE & SONS. Sparking-plugs and manufacture of same.
6,326 BURROWS & PLUMMER. Electrical measuring apparatus for indicating depth of liquids in tanks, &c
6,328 BURRELL. Automatic telephone systems.
6,329 D'ANTONIO. Telegraphic transmission devices.
6,339 PRICE. Automatic switches or cutouts for use in charging batteries from dynamos, &c.
6,355 ORLING & ORLING'S TELEGRAPH INSTRUMENTS SYND. Telegraphic transmitters and relays.

May 4, 1916.

6,378 MESSERSCHMIDT. Timer or interrupter for magneto. (12/10/15, U.S.)
6,379 MESSERSCHMIDT. Magneto. (29/6/15, U.S.)
6,393 LONDON ELECTRIC SUPPLY CORPN. Automatic chain-grate & [illegible]kers.
6,404 KETTERING. Electrical regulators. (26/6/15, U.S.)
6,405 CHRYST & KETTERING. Systems of electrical generation. (27/10/15, U.S.)
6,406 KETTERING. Ignition systems. (30/8/15, U.S.)

May 5, 1916.

6,467 HOWARD. Dynamo-electric machines.
6,476 BROWN. Vibrating make-and-break devices for electric signalling.
6,483 CAMPBELL. X-ray apparatus. (7/8/15, U.S.)
6,491 GRINSTED & LAIDLAW. Telephone systems.
6,496 NORSK HYDRO-ELECTRISK KVÆLSTOFAKTIESELSKAB. Receptacles for chemical purposes. (12/5/15, Norway.)
6,516 HAY. Production of sine-wave and like smoothly varying E.M.F.s.

May 6, 1916.

6,530 SPENCER. Electrically-propelled vehicles.
6,541 SIEMENS & HALSKE AKT.-GES. Electro-magnetic relays. (22/6/15, Germany.)
6,551 BENNETT. Electric lampholders.

May 8, 1916.

6,585 HIGGINS. Magnetically-operated prime mover or motor.
6,589 HENDERSON. Starting and stopping devices for electric motors.
6,594 SOARES. Electric lamps.
6,596 ZWEIGBERGK. Electrical machines for variable-speed gearing.
6,603 GUINNESS. Sparking plugs.

May 9, 1916.

6,616 LANCASTER. Holders for incandescent electric lamps.*
6,619 HUNT. (Bryant Electric Co.) Electric lamp sockets.*
6,629 WARFVINGE & WERNER. Means for telephonic communication to and from moving railway trains, &c. (11/5/15, Sweden.)*
6,637 HAGERTY. Magnetic mat.
6,639 B.T.-H. CO. (G.E. CO.) Electric motor control systems.*
6,651 CUNNINGHAM. Switchboard for telephones or telegraphs.*

May 10, 1916.

6,679 WESTWOOD. Switches for electric battery lamps.
6,682 CALSTON. Railway or tramway switch-operating mechanism.
6,696 VAN DEVENTER. Means for discharging static electricity from moving-picture films, &c. (17/5/15, U.S.)
6,702 STUDT. Electrolytic deposition of copper from acid solutions.

May 11, 1916.

6,720 LOVELL. Mechanical tee-joint for multicore electric cables.
6,735 CHURCHILL & GEERAERD. Electrolytic cells.
6,745 PRIMROSE. Electrical radiators.
6,746 PRIMROSE. Former for electrical radiators, &c.
6,771 SELL. Electric headlights.
6,772 HAND. Mariner's Compass.
6,780 BERRY. Electric heat radiators.

May 12, 1916.

6,809 BOOTHROYD & CALLENDER'S CABLE & CONSTRUCTION CO. Sealing and bonding glands for electrical junction boxes.
6,823 ALLISON & MORRIS & WHITHAM. Automatic machine for manufacture of stems for metallic filament electric lamps.
6,828 ELEKTRO-OSMOSE AKT.-GES. (Graf Schwerin Ges.) Process for purifying fluids. (10/6/15, Germany.)
6,829 BALLANTINE. Manufacture of tungsten.
6,836 PERRETT. Sparking-plugs.

May 13, 1916.

6,849 COWPER-COLES. Method of Suspending metallic articles during electro-deposition.
6,859 WHITE. Carbon holders for electric arc lamps.
6,869 MORRISON. Power-transmission systems. (8/6/15, U.S.)
6,861 CROCKALL. Sparking-plug cutout for internal-combustion engines.
6,867 WELCH. Electric lampholders.
6,874 WESTINGHOUSE MACHINE CO. Motor power plants. (9/1/15, U.S.)
6,897 QUAIN. Electrically-actuated devices for electric alarms, &c.

NEW BOOKS AND NEW EDITIONS.

[Copies of the new books mentioned below can be obtained *post free* from THE ELECTRICIAN Offices on payment of the prices indicated in parentheses. It is only necessary to specify the number when sending remittance.]

673. "Alternating Currents." By H. R. Kempe. 3s. 6d net (3s. 10d.)
674. "A Treatise on Electricity." By F. B. Pidduck. 14s. net (14s. 9d.).
675. "Practical Electric Wiring." By J. M. Sharp. 3s. 6d. net (4s.)
676. "Electric Bells and Telephones." Edited by Bernard E. Jones. 1s. net (1s. 2d.)
677. "British Destiny. The Principles of Progress." By D. N. Dunlop. 3s. 6d. net (3s. 9d.)
678. "Notes on Galvanism and Faradism." By E. M. Magill. 4s. 6d. net (4s. 10d.)
679. "Historical Introduction to Mathematical Literature." By G. A. Miller. 7s. net (7s. 6d.)
680. "Statics: A First Course." By C. O. Tuckey and W. A. Nayler. 3s. 6d. (3s. 10d.)
681. "An Introductory Course of Continuous-current Engineering." 2nd edition. By A. Hay, D.Sc. 6s. 6d. net (7s.)
682. "The Dynamical Theory of Gases." 2nd edition. By J. H. Jeans. 16s. net (17s.)
683. "Harper's Hydraulic Tables for the Flow of Water." 8s. 6d. net (9s. 3d.)
684. "Steel and Its Heat Treatment." By D. K. Bullens. 16s. net. (16s. 9d.)
685. "A Manual of Practical Physics." By H. E. Hadley. 3s. (3s. 3d.)
686. "Interpolated Six-place Tables of the Logarithms of Numbers and the Natural and Logarithmic Trigonometric Functions." 5s. 6d. net. (5s. 9d.)
687. "Text Book of Mechanics." Vol. VI., "Thermodynamics." By L. A. Martin. 7s. 6d. net (8s.)
688. "Industrial Law." By F. Tillyard. 10s. net (10s. 6d.)
689. "Telephones in the Field." By A. G. Grinling. 1s. net (1s. 2d.).
690. "Localisation by X-Rays and Stereoscopy." By J. M. Davidson. 7s. 6d. net (8s.)
691. "Principles and Mathematics of Municipal Administration." By W. B. Munro. 10s. net (10s. 9d.)
692. "The Physico-chemical Properties of Steel." By C. A. Edwards. 10s. 6d. net (11s. 3d.)
693. "The Principles of Apprentice Training." By A. P. M. Fleming and J. G. Pearce. 3s. 6d. net (4s.)
694. "Spon's Electrical Pocket Book." By W. H. Molesworth. 6s. net (6s. 6d.)
695. "Electroplater's Handbook." By J. H. Western. 4s. 6d. net (5s.)
696. "A Senior Experimental Chemistry." By A. E. Dunstan and F. B. Thole. 5s. (5s. 6d.)
697. "A Manual of Practical Physics." By H. E. Hadley, B.Sc. 3s. (3s. 3d.)

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	297	Simplex Electric Sterilisers. Illustrated	59
Imports and Exports of Electrical Manufactures	298	Electric Precision Grinder. Illustrated	60
Liquidations, Bankruptcies, &c.	298	Copper Clad Wire. Illus.	60
Electricity Supply	298	Oil-Immersed Auto-Starters. Illustrated	61
Traction Notes	299	Performance of British Westinghouse Turbines	62
Empire Notes	300		
Miscellaneous Notes	300	Municipal Accounts	302
Tenders Invited	301	Companies' Meetings and Reports	302
Tenders Received & Accepted	301	City Notes	306
The Round Table	57	Electrical Companies' Share List	306
Switching Up-to-Date Again. By W. H. Bray, A.M.I.E.E.	58		
Osram "Atmos" Type Lamps for Street Lighting. Illus.	59		

COMMERCIAL TOPICS.

Charges for Electricity Supply. Owing to the greatly increased charges for coal, oil and engineering stores, and also to higher wages, nearly all electric supply undertakers have been compelled to increase their charges for electrical energy. Owing to the continued upward tendency in the price of materials some supply companies have even been compelled to apply to the Board of Trade for an order to increase the maximum charge allowed by their provisional orders. So far there have been six of these special applications for a variation in the maximum allowed, but up to the present only three have been dealt with by the Board. The application of the Ross Electric Light & Power Co. was granted; in the case of the Newquay Electric Supply Co., a local inquiry was held, but ultimately a compromise was effected and the company was authorised to increase the maximum statutory charge from 6d. to 7d. per unit. A recent application by the Charing Cross, West End & City Electricity Supply Corporation to allow an increase of 10 per cent. was, however, unsuccessful. The City Corporation and several consumers strongly opposed the company's application, and after inquiry the Board refused to sanction an increase. There are three outstanding applications, viz., by the companies supplying at Walton-on-Thames, at Weybridge (into which an inquiry will be held on Tuesday next), and at Caterham, where the time for making objections has not yet expired. We understand that all the local circumstances—the population, location of area of supply, transport facilities, character of the supply, &c., are taken into consideration by the Board, and where an increased charge is allowed it will only be for the period of the war. In the provincial stations in the South of England the difficulty of maintaining a regular supply of coal, apart from its greatly increased cost, is very great, and when it is remembered that the undertakers are under a statutory obligation to give a supply of electrical energy in their areas and that their tenure is a strictly limited one, it is not to be wondered that they are endeavouring to adjust matters so that they shall not be giving this supply at a loss or at their shareholders' expense. The position is so difficult that many of the supply authorities are enforcing the minimum charge to which they are entitled, viz., 13s. 4d. per quarter, *i e*, 20 units at 8d. per unit whether energy of this value be consumed or not.

* * * *

Trade after the War. The Council of the London Chamber of Commerce has adopted the report of its special Committee appointed to consider problems connected with trade during and after the war.

The Committee devoted attention mainly to fiscal proposals, with the object of securing preferential reciprocal trading between all parts of the British Empire and the Allies, with favourable treatment for neutrals, and for regulating the relations with enemy countries. The Committee thought that, broadly speaking, that could all be done by tariffs as a better course than prohibition of imports from any country, which might prove unworkable in practice, and was, in any event, surrounded with difficulties. The Committee therefore recommended temporary tariffs pending a scientific system, which, it was assumed, a Royal Commission would be appointed to evolve. The Government should be urged to endeavour to get allied countries to impose special dues on allied shipping, with five years' preference for British Empire shipping. The main objects to be achieved would be to provide for mutual trading relations between various parts of the Empire, to increase trade between the Allies and the British Empire, to widen the basis of British taxation and produce revenue to assist in meeting the cost of the war, and to penalise the trade and shipping of the present enemy countries with the British Empire and allied countries.

* * * *

The Fall in Copper Prices. The event of the past week has been the rapid drop in the price of standard copper from the high record of £145 per ton, touched on the 16th inst., to £121 5s. on Friday last. With huge contracts outstanding for deliveries of refined metal up to the end of the current year, war needs have undoubtedly been well covered; hence ordinary consumers should have no difficulty in filling requirements in hand-to-mouth fashion at successive concessions. The demand from consumers in this country is now much less insistent and freights between this country and America have come down now that our Government have relaxed their hold on this particular section of the Atlantic carrying trade. These facts have all had their effect on quotations

* * * *

U.S.A. and South American Trade. The United States section of the International High Commission, which has spent two months in a tour of South America, has returned to Washington, and during the tour its members took part in the Pan-American Conference held at Buenos Ayres in April.

In a statement as to the conference Secretary McAdoo said he had the honour and privilege of meeting and conversing with the Presidents of Brazil, Uruguay, Argentine, Chile, Peru, Panama, Cuba and Haiti, and he also met many of the leading statesmen of South America, with whom he discussed questions of national interest. Everywhere he found an earnest desire to strengthen commercial, financial and political relations with the United States, and everywhere there was a genuinely friendly attitude and a complete absence of that suspicion and distrust of the United States which had, until recently, existed to a greater or less degree in some, at least, of the Central and South American countries. This was due primarily to the policies and utterances of President Wilson and to the suggestions made by the United States for mutual guarantees of the territorial integrity and political independence of all of the American Republics. Every leading statesman in South America with whom he talked emphasised the paramount importance of a merchant marine under the flag of the United States, or under the flags of the different American nations, if American financial and commercial relations were to be enlarged upon an enduring foundation. The hope was expressed in every country and was voiced in the resolutions unanimously adopted by the International High Commission that the United States would promptly solve this pressing problem, and there was frank recognition that the United States alone had the financial resources to do so.

Among the other subjects discussed was the completion of an inter-continental railway between North and South America, the control of wireless telegraphy by the various Governments and the connecting up of the ordinary telegraphic systems of the two continents. While it was recognised that the adoption of a uniform gold standard in all of the Central and South American countries, especially under existing conditions, was impossible, nevertheless a great step forward was taken when the conference recommended to the various Governments the adoption of a standard unit of money of account, and recommended that this unit should be based on a gold coin of 0·33437 gram in weight and 0·900 fine. This unit is one-fifth of the gold dollar of the United States, and if adopted by the various States will provide a uniform basis of account for transactions between all of the Latin-American countries and North America.

From the above it will be readily seen that the politicians as well as the manufacturers and exporters of the United States of America are endeavouring to gain an advantage for themselves out of the present crisis, and it would be well if steps were taken to maintain our present trade connections with Latin America. The latest reports on business conditions in Brazil state that the position has now improved to such an extent that European and American exporters are gradually reverting to pre-war conditions in granting credits. Custom House receipts continue to show a marked improvement, and the importing as well as the exporting firms are doing well. In Argentina the dearth of shipping is a serious problem, which has caused a restriction of the grain movement, and this in turn has depressed prices and reduced railway earnings.

* * * *

Electrical Manufacturing Companies in 1916. The reports of the British electrical manufacturing companies recently published tend to confirm the opinion that, notwithstanding labour and transport difficulties, the high price of raw materials, &c., the past year has been a good one for them.

In our last issue we commented upon the excellent record of Callender's Cable & Construction Co., and as the meeting is reported at some length in another column it is unnecessary to make any further reference to it. The meeting of another well-known and old-established British company—that of the Electric Construction Co.—is also reported in this issue. The E.C.C. Co. has also had a good year, and the accounts show a marked improvement on the figures for the year 1914-15. The gross profit was £88,500 (against £72,000), the net profit was £43,200 (against £35,500), and the available balance was £50,712 (against £42,720 in 1914-15 and £34,025 in 1913-14), the dividend being increased from 6 to 7½ per cent., and the amount carried forward from £7,471 to £16,839. Another company—the Lancashire Dynamo & Motor Co., whose record is a very good one, has made substantial progress during the past year. Naturally, the period under review has been a busy and anxious one, and the additional output—partly at Trafford Park, but mainly at the new works—has caused the profit to be more than doubled. The number of persons employed was twice as large as in 1912 and 1913, and the directors state that the current year's orders are not only large, but might be further increased if sufficient labour could be obtained. Women in considerable numbers have been engaged and successfully trained for working the smaller machines in the new works. The net profit was £31,533, against £12,426 in 1914. It is proposed to pay a dividend and bonus of 5 per cent., making 12½ per cent. (tax free) for the year, against 8 per cent. for each of the last two years, and 7½ per cent. for 1912.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From May 22, 1916, *to* May 27, 1916.

IMPORTS.

LONDON.—*U.S.A.:* Elec. machinery, £1,760; elec. lamps, £528; carbon candles, £3,595; telephone material, £42; wire and cable, £404; unenumerated, £3,385 410 pkgs. *Holland:* Elec. lamps, £5,917; wire and cable, 13 pkgs. *Switzerland:* Elec. machinery, £3,200; unenumerated, £30. *Italy:* Elec. machinery, £20—10 pkgs. *Japan:* Wire and cable, £15; unenumerated, £397.
France: Carbon candles, £435; unenumerated, £104.
MANCHESTER.—*U.S.A.:* Elec. fans, 17 pkgs.; telephone parts, 6 pkgs.; unenumerated 36 pkgs.
SOUTHAMPTON.—*France:* Elec. cable, 22 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Unenumerated, £428. *Melbourne:* Wire and cable, £207; unenumerated, £2,846. *Sydney:* Elec. machinery, £472; wire and cable, £1,692; elec. lamps, £139; unenumerated, £1,111. *Wellington:* Elec. machinery, £200; wire and cable, £75; elec. lamps, £313; unenumerated, £1,077. *Perth:* Elec. machinery, £121; unenumerated, £172. *Christchurch:* unenumerated, £241. *Lyttelton:* Wire and cable, £97; unenumerated, £47. *Brisbane:* unenumerated, £30. *Fremantle:* Wire and cable, £256. *Dunedin:* Unenumerated, £152. *Napier:* Elec. machinery, £25; unenumerated, £53. *Adelaide:* Wire and cable, £773; unenumerated, £256.
AFRICA. *Durban:* Wire and cable, £2,185; elec. machinery, £326; unenumerated, £2,592. *Cape Town:* Unenumerated, £146. *Port Elizabeth:* Wire and cable, £1,000; unenumerated, £398. *East London:* Unenumerated, £1,160. *Beira:* Wire and cable, £85; unenumerated, £650. *Zanzibar:* Unenumerated, £65.
EGYPT. *Port Said:* Elec. machinery, £14; wire and cable, £10. *Suez:* Telegraph material, £347.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Wire and cable, £3,835; elec. machinery, £56; unenumerated, £834. *Calcutta:* Elec. machinery, £303; unenumerated, £2,253. *Madras:* Wire and cable, £80; unenumerated, £114. *Karachi:* Unenumerated, £10. *Singapore:* Wire and cable, £24; unenumerated, £75. *Bankok:* Unenumerated, £32. *Ceylon:* Elec. machinery, £67; unenumerated, £177. *Port Swetenham:* Unenumerated, £25. *Kilindini:* Wireless telegraph material, £5,400.
JAPAN. *Yokohama:* Unenumerated, £784. *Tokio:* Unenumerated, £695.
CHINA.—*Hong Kong:* Unenumerated, £725. *Shanghai:* Elec. machinery, £224; wire and cable, £197; unenumerated, £362.
U.S.A. *New York:* Unenumerated, £460.
SOUTH AND CENTRAL AMERICA. *Buenos Ayres:* Unenumerated, £911. *Valparaiso:* Unenumerated, £620. *Antofagasta:* Unenumerated, £173. *Santiago:* Telegraph material, £156; unenumerated, £102.
HOLLAND. *Amsterdam:* Wire and cable, £997; unenumerated, £720. *Rotterdam:* Elec. machinery, £27. *Haarlem:* Unenumerated, £330.
FRANCE.—*Paris:* Unenumerated, £30. *Dieppe:* Elec. machinery, £134; unenumerated, £112. *Calais:* Wire and cable, £220. *Dunkirk:* Unenumerated, £341 *Havre:* Telegraph material, £1,690.
PORTUGAL. *Oporto:* Unenumerated, £170.
SPAIN. *Barcelona:* Unenumerated, £310.
SWEDEN. *Gothenburg:* Wire and cable, £149. *Stockholm:* Unenumerated, £53
NORWAY. *Christiania:* Unenumerated, £158.
DENMARK. *Viborg:* Elec. cable, £59.
LOURENCO MARQUES, unenumerated, £37
PUNTA ARENAS, unenumerated, £108.

FOREIGN GOODS (duty paid and free).

Calcutta: Unenumerated, £201. *Bordeaux:* Unenumerated, £17. *Ceylon:* Unenumerated, £140. *Cape Town:* Unenumerated, £42. *Christiania:* Unenumerated, £668. *Sydney:* Unenumerated, £56. *Wellington:* Unenumerated, £53. *Durban:* Unenumerated, £459. *Karachi:* Unenumerated, £31. *Madras:* Unenumerated, £61. *Port Elizabeth:* Unenumerated, £13. *Vladivostock:* Unenumerated, £20

IN TRANSIT.

Hong Kong: Elec. lamps, £260. *Shanghai:* Elec. lamps, £1,685

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

LIQUIDATIONS, BANKRUPTCIES, &c.

The first meeting of creditors of Russell E. Connold, late electrician, of 6A, The Parade, Canterbury, will take place on June 3 at 68A, Castle-street, Canterbury, and the public examination on June 17 at the Guildhall, Canterbury.

Claude T. J. Vautin, 412, Salisbury House, London, E.C., has been adjudicated bankrupt.

Claims against the Phœnix Electric Heating Co. (1914) (Ltd.) (in liq.) are to be sent by June 17 to Mr. A. E. Tilley, 8, Staple Inn, Holborn, London, W.C. (The business has been acquired by Dowsing Radiant Heat Co., Ltd.)

ELECTRICITY SUPPLY.

EXTENSIONS.

Bo'ness.—The Council have accepted the modified scheme of the National Electric Construction Co. for the extension of the electricity works at £12,300.

Colwyn Bay.—Though the L.G. Board are still unable to sanction the loan for the purchase of land at Bronynant for the proposed new electricity and destructor works, they agree to the Council making the purchase and charging the expenditure to suspense account.

Ilford.—The Council has received sanction to the borrowing of £6,098 (part of £6,565) for mains and £1,650 for the Goodmayes sub-station.

The sum deducted from the original application for mains is in respect of new mains to provide current to private houses, which the L.G. Board is not willing to sanction at present.

An expenditure of £1,199. 18s. 7d., charged in the accounts for the year ended March 31, 1915, in connection with the electricity undertaking, and to which exception was taken by the district auditor, has been sanctioned.

Kingston-on-Thames.—At the last meeting of the Corporation the Lighting Committee reported that they had authorised the electrical engineer (Mr. J. E. Edgcome) to order a new crank-shaft for the two-cycle Diesel engine, in place of the one which was reported at the last meeting to have developed a fracture. The cost would be from £900 to £1,000.

Councillor Tongue took exception to the payment of the subscription of a guinea to the Diesel Engine Users' Association; but Councillor Kerrison said by paying a guinea the Corporation saved £6 on the insurance premium for the Diesel engine and alternator, so that they were £4. 19s. to the good over the transaction.

Leeds.—The L.G. Board recently sanctioned the borrowing of additional sums, amounting to £17,219, for the extension of the electricity generating station.

Walthamstow.—The Finance Committee has applied to the L.G. Board for sanction to borrow £11,240 for a 1,500 kw. Ljungstrom turbine, and a 500 kw. motor converter, with switchgear, &c.

Subject to the approval of the Board the Committee proposes to place the order for the turbine with the Brush Electrical Engineering Co. The engineer states that in order to instal the above plant it will be necessary to supersede gas engine No. 8. A tender for water-softening plant is also recommended for acceptance at £750.

GENERAL.

Birmingham.—At a meeting of the Electric Supply Committee last week it was reported that for the year ended March 31 last the output of electricity amounted to 117,000,000 units, compared with 83,000,000 in the previous year.

The increased revenue, however, had been more than absorbed by the increased expenditure, due principally to the rise in the price of fuel. The surplus profit amounted to £17,097, of which £22,000 was carried to a special fund, and the balance was credited to the rates. The accounts were passed, and will be submitted at the next meeting of the Council.

City of London.—The Board of Trade have refused the application of the Charing Cross, West End & City Electric Supply Corpn. for an order to authorise an increase of 10 per cent. in their charges for electric current.

Cumberland.—The County Council have authorised the Cumberland Waste Heat Owners Co. to lay underground electric cables under the Whitehaven, Egremont and Cleator Moor main roads.

Dublin.—At a meeting of the Electricity Supply Committee last week particulars were submitted of the damage caused to the public arc lighting system during the recent outbreak.

A very large number of the lamps were damaged and most of the

damage was caused by rifle fire. In the majority of cases the lamps were beyond repair. The total cost of making good the damage to the arc lighting system was estimated by the City Electrical Engineer at £1,050.

A list of the consumers whose premises were destroyed by fire was also before the Committee, and it was reported that the electric lighting accounts of these consumers for the past 12 months amounted to £8,072.

A letter was received from the Board of Trade requesting that a notification should be issued to electric light consumers, asking them to practise economy in the use of electric light as a reduction in the quantity of coal supplied to the generating station may have to be made.

Electricity and Gas Supply, &c.—The King in Council on May 23 made the following addition to the Defence of the Realm (Consolidation) Regulations, 1914 :—

Any company, authority or person authorised to supply water, light, heat or power to any factory, building, camp, or other premises belonging to or used for the purposes of the Admiralty, Army Council or Ministry of Munitions shall carry out such works and render such services as the Admiralty, Army Council or Ministry of Munitions may direct for enabling such supply to be given either by themselves or some other such company, authority or person, provided such company, authority or person shall not be required to supply to premises within the area of any other company, authority or person except with the concurrence of the appropriate Government Department.

Keighley.—Last week the Council decided, on the recommendation of the Electricity Committee, to reduce the discount on accounts for electricity supplied otherwise than under sealed agreement from 5 per cent. to 2½ per cent. as from June 30.

The Electricity Committee propose to lay an electric cable to the new military hospital at Morton Banks.

It has been decided to extend the electric supply cables to the Morton Banks Hospital at an estimated cost of £475.

Llanfyllin.—The Council will take a plebiscite on a proposal to establish electricity supply works.

Marylebone (London).—The station superintendent at the Borough Council's electricity works, Mr. T. K. Richardson, is still unable to resume his duties, and his period of sick leave has been extended until the end of July.

Messrs. Price, Waterhouse & Co. have been re-appointed commercial auditors of the electricity undertaking for 12 months, at a fee of 200 guineas.

Stoke-on-Trent.—At the last meeting of the Council it was decided to reply to the North Staffordshire Railway Co. that current in bulk could not be supplied except by special arrangement, with guaranteed minimum annual consumption in units and maximum load in kilowatts, and other usual clauses included.

The charges for street lighting for the current year are to be at the same rate as for the last financial year, less a deduction at rate of £1,000 per annum during the period the Lighting Restriction Order is in force.

The engineer and manager (Mr. C. H. Yeaman) reported that the register required by order of the Ministry of Munitions had been inspected; that when the last groups were called up the working staff would be reduced to unsafe limits, and he was endeavouring to find ineligible substitutes.

The Electricity Committee regards with favour the proposal to supply electrical energy for use in Milton and route thereto, provided the prospective consumers are prepared to provide the line to the power house, and take current when additional plant has been erected therein. Communications from the British Aluminium Co., Bullers (Ltd.) and the Hanley Collieries were considered.

In a report on the plant required to meet the growing load, Mr. Yeaman stated that the load last winter was 4,240 kw., compared with 2,631 kw. at date of the federation, so that the increase was greater than the additional plant capacity of 1,500 kw. provided since that date.

Consumption.—Last year the energy generated was :—

Generating works.	Coal, tons.	Coal cost.	Units generated.	Cost per unit.
Burslem	1,746	£1,206	489,976	8 lb.	0·59d.
Hanley	4,584	3,383	849,332	12 lb.	0·96d.
Longton	365	235	37,920	21½ lb.	1·49d.
Stoke	423	296	68,356	13⅞ lb.	1·04d.
Sub-works	7,118	£5,120	1,445,584	11¼ lb.	0·87d.
Power house ...	11,231	8,612	9,096,796	2¾ lb.	0·23d.
Gross total ...	18,349	£13,732	10,542,380	3·9 lb.	0·31d.

A large saving was possible in the coal bill, the old steam stations taking four times as much coal per unit as the turbine plant. The effect of running the present turbine plant was to change the net loss of £6,162 in 1913-14 to a net profit of £71 in 1914-15. By doubling the available turbine capacity, a saving of 3,300 tons of coal worth £2,640 should be effected, and that sum would practically pay the capital charges on the extension plant. There was 2,000 kw. of available rotary converter and motor generator plant in the sub-works, but only about 1,000 kw. of turbine capacity to supply same. The extension plant would enable the full capacity to be utilised, effecting marked economies. A new 600 kw. rotary was being put down at Longton. Three-phase supply was being given direct to consumers from [illegible] sub-stations in Tunstall, Hanley and Fenton, and there was a growing demand for bulk supply at low prices which could be met advantageously and profitably if further economical generating plant were provided. The proposed extension comprised three new boilers housed in an extension of the boiler room, a 3,000 kw. turbine with condenser and pumps, a new cooling tower with piping and switchgear, foundations, [illegible], testing and erection, estimated to cost £33,000.

The extension scheme was adopted and application has been made to the L.G.Board for sanction to a loan.

TRACTION NOTES.

Astley (Lancs).—The South Lancashire Electric Tramways Co. has been asked to extend its tramway system to this district.

Birmingham.—Owing to a failure of electrical energy, the tramway service, excepting the portion on the Aston and Erdington side, was suspended on Tuesday morning for about an hour and a half.

Erith.—The Urban Council has informed Woolwich Council that it has decided to drop the scheme of municipal motor buses for which they purposed to seek Parliamentary powers.

Hull.—Last week the Lord Mayor (Ald. J. H. Hargreaves), who has retired from the chair of the Tramways Committee in order to become chairman of the Parliamentary Committee, took the opportunity of reviewing tramway affairs during the last three years.

In that time, the Mayor said, the cost of car maintenance had been reduced by £12,000, the hours of labour had been adjusted by a system which did not exist in any other city in the country, and under which the tramway men began duty at a certain time and knew exactly the hour at which their day's work was ended. There was overtime, but it was overtime without compulsion, because volunteers had always been ready to come forward when wanted. Within the last three years the Committee had introduced ½d. stages, with gratifying results, the income per car-mile having been increased from 8½d. to 9½d. The introduction of women conductors had provoked some opposition, and yet none of them would regret an innovation without which the service could not have been continued. They refused to increase the number of women conductors so long as men were available, and since March no women had been put on, while employment had been given to 45 men who had been discharged from the Army. At the end of the last financial year the department had an actual profit of £12,469, of which £10,000 went in relief of rates, and £2,469 passed into the reserve fund, which now stood at £142,000. The Committee were paying £4,078 annually in war bonus and £8,759 per annum to make up the Army pay to the normal wages of the men who had joined the Forces. There was an increase in the coal bill of £1,997 and it should not be forgotten that soldiers were carried for nothing, estimated by the manager as equal to 4,000,000 passengers.

Leicester.—The tramways department has discontinued publishing the weekly traffic receipts, as it is considered the figures are misleading at present, owing to the large increase in expenses.

London County Council.—On Tuesday, Mr. J. D. Gilbert asked what were the number of trailer cars in use on the tramways : what was the number of women now employed as conductors : if preference was given in regard to such employment to widows of men killed and the wives of those injured in the war; and if not, would the Highways Committee consider if a preference could be given to such women.

In reply, Mr. Hume (Chairman of the Highways Committee) said that there were 116 trailer cars in use. There were 739 women employed as conductors and preference was given to the women referred to.

Luton.—The Board of Trade has issued an order prolonging the period from Aug. 11 next to Aug. 11, 1918, for completing the tramways authorised by the Corporation Order of 1905.

New Motor Omnibus Routes. In a circular to local authorities upon the provision in the Local Government (Emergency Provisions) Act, 1916, which makes it unlawful for any omnibus to use a route which has not been regularly used by omnibuses within two years before March 1, 1916, except with the consent of the highway authority, the L.G. Board says :

The highway authorities will no doubt carefully consider in all its bearings any application under the section for consent to establish a new route for omnibuses or similar passenger traffic, and, in exercising their powers under the section, pay due regard to the requirements of the travelling public as well as to the need for economy in road expenditure.

Tramway and Transport Works.—At the annual meeting of the Amalgamated Association of Tramway and Vehicle Workers, which was held at Sheffield last week, a resolution in favour of the amalgamation of all classes of street transport workers was carried. Executive were instructed to ask the Parliamentary Committee of the Trades Union Congress to convene a conference with a view to bring about the amalgamation.

EMPIRE NOTES.

Australasia.—The "Commonwealth Engineer" says Takapuna (N.Z.) Tramway & Ferry Co. has authorised an option to Mr. Paul Hansen to raise the necessary capital for the conversion of the Bayswater-Takapuna tramway to electric traction.

On Sept. 29, 1915, the Federal Council of the Electrical Association of Australia passed a resolution that the association take steps to bring under the notice of the West Australian Government the disadvantages of the electrical system adopted for Perth. The hon. secretary wrote to the Premier of Western Australia setting out the disadvantages which would accrue through the adoption by the Government of Western Australia of an a.c. supply at 40 ∽, and 250 v. The city supplies of Sydney, Melbourne, and Adelaide were all 50 ∽, the Tasmanian Government had adopted 50 ∽ for its Great Lake scheme; that the silver-lead mines of Broken Hill and the gold mines of Western Australia had also adopted 50 ∽, and the Midland Junction workshops (W.A.) had equipment at 50 ∽. The standard voltage in Adelaide was 200, Brisbane 220, Melbourne 200 and 230, and Sydney 240, and that the difficulties in the way of arranging a standard voltage for Australia had been increased by Perth's adopting 250. Perth was placing herself at a disadvantage in competition with the Eastern States, as she would not be able to draw on stocks of motors, lamps, &c., carried in the other States for the electrical materials necessary to ensure the expansion of her own industries. The Premier sent to the hon. secretary a report from his electrical superintendent of tramways, with which report he said he concurred. The Superintendent of Tramways stated that the frequency of 40 had been fixed, and no alteration was possible, and as the City Council had purchased a large number of 250-volt lamps, it would be unreasonable to suggest any alteration in voltage. At a subsequent meeting of the Federal Council of the Association the hon. secretary was instructed to submit (1) that the impossibility of altering the frequency was hardly substantiated; (2) that the only apparent difficulty was that of capital expenditure; and (3) that the justification for the additional capital expenditure could only be determined by the annual savings likely to be effected by that expenditure. The Council further expressed the opinion that the periodicity would ultimately have to be brought into line with the recognised Australian standard of 50 ∽, that the longer this work of standardisation was delayed the more expensive matter it would become; and during the whole period of the delay Western Australia would be handicapped in competition with the Eastern States. The alteration of voltage was of less immediate importance than the standardisation of frequency, but standardisation of voltages throughout Australia was becoming an increasingly urgent matter, and Perth had increased the difficulties by selecting a voltage used by no other capital city in the Commonwealth. The value of the incandescent lamps purchased by Perth Council was a small matter, compared with the annual savings which would result from standardisation. Beyond formal acknowledgments no further reply has been received from the Premier.

Mirboo North (Victoria) Council has agreed to pay a minimum of £100 per annum for public electric lighting if the local dairy company establish the necessary generating plant.

Melbourne, Brunswick & Coburg Tramways Trust is negotiating with the Tramways Board for permission to continue the Trust's electric tramway from Queensberry-street, Carlton to Lonsdale-street, replacing the present cable tram over about half a mile. This would be the first conversion of the cable line tram to electric traction.

When the N.S.W. Government raised its tramway fares last year it was expected that the additional annual revenue resulting would be £200,000. In 11 months ending Feb. 28 the increase was £378,000. A return to the old fares is being considered.

The opening of the first section of the electric tramway, which is to connect Melbourne with Burwood, took place in April. When completed, the line will be about 8 miles in length, and the cost will be about £200,000. Mr. F. A. McCarty will be the general manager and engineer for the Tramway Trust.

A company, to be called Metal Manufacturers (Ltd.), is to be formed in Sydney to manufacture copper utensils, wire, tubes &c. The capital is to be £200,000 and the first directors are Messrs. W. L. Baillieu, H. F. C. Keats, J. M. Niall, J. L. Wharton and Kelso King (Sydney). The company is to be British owned and controlled.

The offer of the Tasmanian Government hydro-electric department to supply the Mount Lyell M. & R. Co. with electric current up to 50,000 h.p. has been accepted by the company.

Zeehan (Tasmania) Council has decided to secure a report from the engineer regarding the renewal of batteries at the electric power station.

India.—"Indian Engineering" says Simla municipality put its new generating plant into use on April 8. It is stated that on April 19 the total demand was nearly equal to the full capacity of the old plant—viz., 790 k.v.a.

"Indian Industries & Power" says electric pumping, as a remedy for water-logging and its attendant evils of malaria, is beginning to attract increased attention at Simla in consequence of the success attending this method of treatment in the Amritsar district. The experiment in Amritsar is still upon a small scale, comprising as it does little more than a score or two of wells out of which water is being pumped by electric power derived from a neighbouring waterfall, but the value for irrigation purposes of the water thus raised affords a very fair return upon the cost of installing and working the plant.

Patents in Canada.—Firms in the United Kingdom having asked H.M. Trade Commissioner in Canada (Mr. C. Hamilton Wickes) what steps they should take to introduce their patents into Canada, the Canadian Manufacturers' Association, Toronto, has undertaken to assist owners of patents, desirous of protecting their rights in Canada, by placing them in touch with reputable Canadian manufacturers who are likely to be interested.

Straits Settlements.—Official statistics of the trade of the Straits Settlements for 1915 show total imports valued at £51,037,000 (increase of £5,377,000 over 1914).

Goods from the United Kingdom amounted to £4,263,000 (decrease nearly 8 per cent.), from U.S.A. £830,000 (increase £240,000) and from Japan £1,740,000 (increase £330,000). Amongst competitive merchandise (1) engines and boilers and (2) electrical machinery, respectively, came to the extent of £50,283 and £30,683 from the United Kingdom, £1,050 and £3,267 from the Continent of Europe, £117 and £933 from Japan and £933 and £1,517 from U.S.A.

MISCELLANEOUS NOTES.

Cable Discounts.—We have received from Messrs. Pooley & Austin, 25, Victoria-street, London, S.W., a leaflet giving a set of single multiplier figures which render the calculation of net cable prices a simple matter.

At present there are so many discounts to be taken into consideration that the calculation in the ordinary way takes some time. The figures given by Messrs. Pooley & Austin thus result in a material saving in office time. A copy of the leaflet will be sent to anyone interested. Until the supply is exhausted, Messrs. Pooley & Austin will also be pleased to send a cardboard slide rule for getting out the prices per yard or per coil when the price per mile is known.

Enemy Firms Wound Up.—The Board of Trade have ordered the winding up of 173 businesses controlled by alien enemies. The latest list includes:—

Ferd Emil Jagenberg (Ltd.), 157, Farringdon-road, London, E.C., manufacturers of paper-working machinery (Controller: H. A. Plumb, 90, Cannon-street, E.C.); Schorch Electrical Co., 35, Basinghall-street, London, E.C., electrical engineers (Controller: C. E. Barker, 21, Finsbury-pavement, E.C.); A. T. Speedometer Co. (Ltd.), 140, Long-acre, London, W.C., manufacturers of speedometers (Controller: F. G. Van de Linde, 4, Fenchurch-avenue, E.C.); Isleworth Rubber Co., Isleworth, Middlesex, manufacturers of and dealers in rubber goods (Controller: S. W. Tubbs, 28, Basinghall-street, E.C.); P. Beirsdorf & Co., 7 & 8, Idol-lane, London, E.C., manufacturing chemists (Controller: R. S. Patterson, 1, Walbrook, E.C.); Richard Klinger & Co., 66, Fenchurch-street, London, E.C., engineers (Controller: H. W. Dunn, 46, Queen Victoria-street, E.C.); Pfeifer & Co., St. Dunstan's House, Cross-lane, London, E.C., agents for sale of chemical products (Controller: A. Dangerfield, 56, Cannon-street, E.C.)

Claims against Richd. Klinger & Co. are to be sent by June 30 to the Controller, Mr. H. W. Dunn, 46, Queen Victoria-street, London, E.C.

Claims against A. Wulfing & Co. are to be sent by June 26 to the Controller, Mr. E. L. Bennett, 31-32, Broad-street-avenue, London, E.C.

Claims against Maschinenfabrik Augsburg-Nurnberg, A.G., are to be sent by June 30 to the Controller, Mr. B. E. Mayhew, Alderman's House, Bishopsgate, London, E.C.

P.O. Servants and the War.—The Postmaster-General (Mr. J. A. Pease), who unveiled a roll of honour at Bromley, Kent, last week, said that between 50,000 and 60,000 Post Office men were serving with the Colours, and it was impossible to fill their places entirely.

There were over 20,000 women at work as temporary helpers, and over 20,000 men were also trying to fill the gap. During the war, through the medium of the Post Office over 450,000,000 letters and 40,000,000 parcels had been sent to the troops in France. Those letters and parcels weighed about 1,500 tons per week. In addition, they sent out for the benefit of the troops at home and abroad and our sailors on the seas books and magazines. About 800,000 books and magazines were being distributed week by week, and on behalf of the troops he appealed for even more to be handed in. The Post Office had given to the signalling department over 11,200 trained telegraphists. They had lost 2,025 men who in August, 1914, were in the employ of the Post Office. In addition 300 men were missing, and 600 postal servants were in the hands of the enemy as prisoners.

P.O. Servants' Wages.—A further report has been presented by the committee appointed, under the chairmanship of Sir George Gibb, to examine the position as to wages and conditions of employment of Post Office servants raised by the Holt Committee's report.

The committee had already disposed of most of the matters in dispute, and they now submit recommendations on all outstanding questions which in their opinion can be usefully dealt with at present. They propose that the Holt Committee's recommendations should be adopted, with modifications in certain cases, in regard to the transfer to other duties of persons suffering from telegraphists' cramp; departmental examinations, tracers and sorter tracers, supervising allowances of postmen, travelling expenses of telephonists, writing duties, writing assistants, movement of assistant engineers, triennial revision of sub-postmasters' salaries, and credit for telegraph work.

Radio-Telegraph Notes.—The "Journal Telegraphique" announces that since Jan. 25 last a radio-telegraph service has been established between Budapest and Barcelona. The charge per word is the ordinary telegraph rate, but there is a reduction of 50 per cent. for press telegrams and a triple rate for urgent telegrams.

The "Wall Street Journal" states that plans have been completed for the construction on Long Island or Connecticut shore (on a line between Sayville and Bridgeport) of a tower 1,000 ft. in height in connection with a radio telegraph station intended to communicate with Buenos Ayres. The system will be owned by the Federal Holding Co., and it is expected to be in operation in a year. It is also stated that a similar tower will be erected near Montevideo, Uruguay.

It is reported that the American steamer "Ventura," which recently arrived at Sydney from San Francisco, picked up wireless messages from the station at Tuckerton, New Jersey, when she was 9,000 miles distant from that place. This is claimed to be a world's record.

Tribunal Cases.—At Blackpool last week Mr. C. Furness, borough electrical engineer, applied for exemptions of 11 men in the electricity department and 12 in the tramways department.

Mr. Birkett (military representative) said men in the electricity department were all engaged in exempted occupations.

Mr. Furness explained that 73 men of the tramways department had joined the Army and 53 from the electricity department. The 11 men in the electricity department were conditionally exempted and 11 tramway men were granted conditional exemption, and one until July 1.

At Lambeth (London) Messrs. Toy & Winslow, electrical engineers, applied for the exemption of Charles A. Winslow, aged 30 years, a brother of one of the partners. Mr. Winslow said his brother was indispensable as he was the only man left who was really reliable. The application was refused, but as it was stated the firm was engaged on Government work, the tribunal suggested they should appeal to the Ministry of Munitions for a badge.

TENDERS INVITED.

Telegraph and Telephone Material.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

The Deputy Postmaster-General, Perth (W. Australia) requires tenders by 3 p.m. June 7, for the supply of 15 tons of Galvanised Iron Wire (Schedule 508, W.A.), for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specifications from office of Deputy Postmaster-General, Perth, W.A.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

The Deputy Postmaster-General, Perth (W.A.), also requires tenders for 6 miles of Wool-covered and i.r. covered wire (schedule 509, W.A.) for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications from Deputy Postmaster-General, Perth, W.A.

The Deputy Paymaster-General, Perth (W. Australia), also requires tenders by 3 p.m. July 12 for supply of 3,000 Dry Cells for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy-Postmaster-General.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

Electrical and General Stores.

The CLYDE NAVIGATION Trustees require tenders by 10 a.m. June 5 for six or 12 months' supply of Electrical Stores, India-rubber, Paints, Varnishes, &c. Specifications, &c., from the Superintendent of Stores, 16, Robertson-street, Glasgow.

Electric Capstan.

MANCHESTER Electricity Committee require tenders by 10 a.m. June 7 for supply of an Electric Capstan for Stuart-street generating station. Specification from Mr. F. E. Hughes, Town Hall, Manchester.

Electric Lorry.

SYDNEY (N.S.W.) Council require tenders by 3 p.m. June 20 for the supply of a 2-ton Electric Lorry. Specification, &c., from the City Surveyor.

Street Lighting, Generating Plant, Gas Engines, Dynamos, &c.

OAMARU (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1. 1s. for each contract.

PAHIATUA (N.Z.) Borough Council requires tenders by noon July 10 for (contract No. 1) Overhead Wires, Poles and Street Lamps; (No. 2) Gas engines, Producers, Dynamos and Auxiliary Apparatus; (No. 3) Accumulators. Specifications and plans from the Town Clerk, Pahiatua.

Electric Lamps, Lamp-Holders, &c.

Tenders will be received until 11 a.m. June 14 by the VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, for the supply of 5,000 6-volt, and 1,000 110-volt Electric Lamps for signal system (Contract 29,912); and 4,000 Lamp-holders (Contract 29,913). Specifications from the offices of the Commissioners.

TENDERS RECEIVED AND ACCEPTED.

WALTHAMSTOW.—The tender of the Paterson Engineering Co. (at £750) is recommended for acceptance for the supply of water-softening plant at the electricity works. The tramways engineer has placed an order with Cammell, Laird & Co., for 18 tramcar axles at £5. 16s. each, and 24 commutators have been ordered from P. R. Jackson & Co., at £5. 10s. each.

FALKIRK.—The Council have accepted the following tenders for electrical supplies:—

Callender's Cable & Construction Co., heavy cables; Liverpool Electric Cable Co. and Callender's Co., small cables; Chamberlain & Hookham, single-phase and d.c. meters; Reason Mfg. Co., electrolytic meters; Ferranti (Ltd.), three-phase transformers; Ross & Co., metal filament lamps; Dussek Bitumen Co., bitumen and compound; Vacuum Oil Co., lubricating oils; Falkirk Iron Co., manhole frames and covers; Aitken Bros., ironmongery stores.

RAWTENSTALL.—The Council have accepted the following tenders:

British Westinghouse Co., transformers and switch panel; W. T. Glover & Co., cable; Oates & Green, conduits; British Thomson-Houston Co., switchgear.

MELBOURNE (VICTORIA.)—The Electric Supply Committee has placed an order with the British Westinghouse Elec. & Mfg. Co. (at £157. 14s.) for an a.c. motor.

METROPOLITAN ASYLUMS BOARD.—The tender of J. W. Gray & Son has been accepted for installing an internal telephone system and to overhaul the electric bells at the Children's Infirmary.

AUCKLAND (N.Z.)—The Drainage Board recently received tenders for centrifugal pumps, electric motors and controlling apparatus for four pumping stations.

Five firms tendered, but three tenders were informal. The tender of D. Riley & Co., at £2,928, was accepted. The amount of the National Electric Co.'s tender was £3,514, and the engineer's estimate was £2,858.

SYDNEY (N.S.W.)—The Council is recommended to accept the tender of New & Sons for coal-trimming chutes for the power house, at £228.

The Committee also recommended that an order be placed with the Australian General Electric Co. for the supply of the extensions to the switchgear in the Town Hall sub-station: One 5,000-volt three-phase motor panel, 2,000 kw., £405; two 5,000-volt three-phase 200-ampere feeder panels, £471; one 600-volt d.c. generator panel, 2,000 kw., £520; four 600-volt d.c. feeder panels, 1,000 amperes, £993; total, £2,389.

Hospital Electro-Medical Outfit.—An order has been placed with Tyler & Freeman for the provision of electrical outfit for the pathological laboratory at the Maudsley Hospital (Denmark Hill), at £199.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Accrington.—The accounts of the Corporation tramways department for the year ended March 31 show total capital expenditure £146,506 (increase £1,935), of which £24,662 has been paid out of revenue, and £23,205 of loans has been repaid.

Revenue was £29,272 (compared with £27,850 in previous year), and working expenses were £19,498 (against £16,438), leaving gross profit £9,774 (£11,412). Interest required £4,375 (£3,997), and repayment of loans, £4,257 (£3,877), the net surplus being £578 (£3,179). Traffic revenue per car-mile was 12·86d. (12·05d.), and total income 13·01d. (12·2d.), while working expenses were 8·67d. (7·2d.). Passengers carried were 4,841,334 (4,637,303), car-miles run (over Accrington system) 539,858 (548,070), and units used 815,506 (831,933).

Liverpool. The accounts of the electric supply department for the year ended Dec. 31, 1915, show total capital expenditure £2,225,938 (increase £2,341), of which £1,430,863 is outstanding.

Revenue was £345,808 and the expenses included generation £60,868, distribution £10,525, rents, rates and taxes £38,439, management £16,497, new services £2,019, new meters £2,011, and special charges £5,798, the amount carried to net revenue account being £209,558. Interest required £65,749, and sinking fund £57,635. The amount transferred to renewal fund was £36,223, and £50,000 has been contributed to general rate. The amount at credit of sinking fund is £213,164.

The tramway accounts show capital expenditure £2,068,453 (increase £6,061), of which £1,212,712 is outstanding. Income was £707,097, traffic expenses were £192,353, general expenses £86,350, general repairs and maintenance cost £80,594, and power £124,106, the balance to net revenue account being £223,692. Interest required £50,084, rent of leased lines £4,868, and sinking fund £64,526. £23,193 has been placed to reserve renewal and depreciation accounts, and £100,000 contributed in aid of general rate. The sinking funds amount to £516,183.

Tynemouth.—The accounts of the municipal electricity undertaking for the year ended March 31, 1915, which have now been issued, show a net profit of £738 (compared with £1,787 for 1913-14.

Revenue was £23,030 (against £21,541), working and general expenses were £2,695 (against £2,818), and capital charges (including £292 capital expenditure out of revenue) were £6,490 (£6,330). Kelvins sold were 4,809,841 (1,296,305). Capital expenditure was £1,790 (making the total £97,174, of which £58,991 is outstanding).

In his report the borough electrical engineer (Mr. C. Turnbull) says the reduction in profit is the natural result of the augmented cost of working, and of the running of the steam plant during the winter months. Increased sales are shown in all departments except public lighting, which has been affected by police restrictions. Sales of electricity in Tynemouth were equal to about 67 kelvins per head of population, a high figure compared with other towns. Eight of the staff have joined H.M. Forces, and two have laid down their lives in the service of their country. The number of small motors connected continues to increase. In this direction it is stated that electricity is affecting the life of the nation to a great extent, by making it easy for small factories to flourish. Electricity supply is thus having a growing effect on the life of the nation as time goes on by encouraging small industries, and checking the tendency for all things to be made in huge factories. Agriculture will also benefit, when Parliament has removed the present restrictions on overhead wires, and it "must be possible to provide cheap supply of current to farms without the payment of excessive wayleaves before we can have the benefit of cheap home-grown food." Railway electrification is proceeding to a greater extent than is generally known, and recent improvements have brought main line electrification appreciably nearer. So far, lines electrified have been chiefly those having heavy suburban traffic, where the change has brought rapid increase in traffic receipts. The public has also benefited by being able to live outside the towns. The North Eastern Railway has electrified a branch with heavy goods traffic, which will provide interesting results. The price of tungsten lamps still keeps high, being about twice as much in Britain as in other countries. The new half watt lamp is also coming into much greater use, but the price is astonishingly high, usual sizes costing 20s. and 30s. each. The electric vehicle in its own line for heavy work at moderate speed seems to be unexcelled. The Edison cell has immense advantages, but here also the price charged is very high. Mr. Turnbull points out that those nations will have most control of the world which control most inventions, and those nations will control most inventions which provide the best education for their people. Germany and the United States surpass us in facilities for higher education, and unless we make greater efforts in the near future we will lag further behind. He cites the fact that for the year 1913 the United States allowed their National Laboratory £140,000 for scientific research, Germany allowed theirs £70,000, while Britain allowed theirs £7,000, in addition to the cost of researches in aeronautics carried out for the Government at the laboratory. The National Physical Laboratory eke out its income by fees obtained for commercial tests, but even with these the allowance is far too small to enable the nation's work to be done properly. Nevertheless the laboratory did work which has earned the admiration of the world, and at present is rendering inestimable service in connection with war service. After citing many instances of American firms who spend large sums in scientific investigation and reap rich wealth from same, Mr. Turnbull draws attention to the disadvantages of our system of weights and measures and coinage. Foreigners will not bother with our catalogues priced out in figures with weights and measures which they cannot understand.

COMPANIES' MEETINGS AND REPORTS.

Indo-European Telegraph Co. (Ltd.)

The forty-ninth ordinary general meeting of this Company (adjourned from April 27) was held on Tuesday, Mr. J. HERBERT TRITTON (the Chairman) presiding.

The SECRETARY (Mr. John I. Bethell) read the notice convening the meeting, and also the auditors' report.

The CHAIRMAN said: This is an adjourned general meeting to take into consideration the report and accounts, the final interim dividend of the same aggregate amount as usual having been declared at our earlier meeting and paid on May 1. The position of the Company has remained unchanged during the year under review. Our communications through Germany were severed on July 31, 1914, and have remained so. Our South Russian and Persian lines have on the other hand done good service, our staff having everywhere remained at their posts. The Odessa-Constantinople cable in which we have a joint interest has been closed down since the entrance of Turkey into the war. There is no prospect of resumption of our main route, and it is the wish of the British Government and the Cable Companies with whom we have working arrangements that we should await the termination of hostilities before we commit ourselves to any definite decision for the re-establishment of our through service to India via Russia, in order that the most suitable route should be determined upon by the administrations and companies concerned in collaboration with ourselves. I informed you at our general meeting last year that we had received an assurance from the British Government that facilities would be given to the Company for the re-establishment of the Indo route and I am now glad to be able to inform you that the Imperial Russian Government has also promised us facilities to the same end, together with an extension of our existing concession. Such extension should render possible the very considerable expenditure on capital account which will be involved in the re-establishment of our route.

You will have observed that the Company's revenue has been maintained—indeed, shows an important increase over that of last year—while the expenses show a decrease. This you will agree is not only a satisfactory but an unlooked-for state of affairs. It is entirely due to a prolongation of the working arrangements with the other telegraph administrations, except for which a large decrease of receipts would have been recorded. We could not hope for a continuance of such more or less artificial prosperity, and I have to inform you that under new arrangements with our friends we consider we are assured of sufficient receipts to provide a dividend of 7 per cent. upon the capital of the Company after payment of all expenses, an arrangement which will continue until one year after the war. I would add that we are of opinion that our Company has been very liberally treated by the Indo-European Telegraph Department of the Indian Government and by the Eastern & Associated Companies, and it is our earnest desire, when the war is over, to re-establish an efficient route which will carry our fair share of traffic. It will remain with your Directors to augment the dividend thus provided by withdrawal from the fund established for the equalisation of dividends. We may well congratulate ourselves that the reserve funds of the Company stand as they do, and that they have been augmented by so large a sum as the result of the year 1915 makes apparent. This augmentation has in part enabled us to subscribe handsomely to War Loans. The shareholders will be gratified to hear that our endeavours to assist the Government of the country have ranged from the manufacture of gauges of microscopic accuracy, which have more than once received high commendation, to subscriptions to War Loans aggregating upwards of £150,000. We hold £50,000 Exchequer Bonds and £96,528 4½ per cent. War Loan, of which £65,195 was subscribed to enable us to convert our Consols. These large sums have been voluntarily provided, but I must also mention the levy of the taxgatherer in respect of excess profits, as to which we have no option, and which necessitates the putting aside out of our surplus the sum of £15,000 for last year's excess.

I must now again allude to the constantly recurring items of depreciation of investments. The £25,000 set aside in 1914, which some thought excessive, has not proved sufficient, and we have now set aside £35,000 for the same purpose. All holders of "gilt-edged" securities are alike affected, and the more prudent the

investment appeared at the time it was made the greater has been the depreciation. There is one other appropriation which we think you will feel no difficulty in providing, viz., £10,000 towards wireless development and research, although last year's vote has not been quite exhausted. It will be apparent to you after what I have said as to the future that we shall not be able to do this out of income for 1916. The Directors are unanimous in thinking, though time alone can demonstrate the value of our opinion, that the shareholders will eventually have no cause to regret the money expended in this direction. During the year further contributions to the British Red Cross Funds and to other funds, having similar objects, have been made.

It now only remains for me to bring to your notice a proposal with regard to the Galletti Company, or rather its patents and other patents owned by the Indo. As you are aware the Indo Company has a predominant interest in the Galletti Company, an investment which stands in the balance-sheet at little more than a nominal figure, though it is largely indebted to our Company. For more than 18 months it has been nothing but a source of expenditure to us, and this in spite of negotiations which at one time appeared likely to offer a solution of what is practically, owing to the war, a dead-lock, but which came to nothing. The Directors have determined to bring to an end this state of affairs, indeed they have no option but to do so in view of the material diminution of the earning power of the Indo Company, which I have just explained to you. They propose, therefore, in the interest of all concerned, and particularly of the Galletti shareholders, before whom there is no other alternative than liquidation, to enter into a new combination of interests with the well-known Company of Creed, Bille & Co. (Ltd.), manufacturers of telegraph apparatus of every sort, whose business is in a highly prosperous position. This company will be enlarged by the issue of additional capital, of which the Indo Company will take up to £30,000 for the development of the wireless side of the business. The patents owned by the Indo Company and those owned by the Galletti Company will be transferred to the Creed, Bille Company, on whose Board the Indo Company will be represented. The value at which these patents are taken is fixed at £105,000, of which the greater part is applicable to the Galletti Company, to be paid in cash by an annual percentage of the divisible profits of the combined undertakings. Facilities are also given for an option to take up 20,000 £1 shares at par, should the issue be advisable, thus enabling Mr. Galletti or others interested to participate in the future development of their patents. The Directors feel that the prospects of the radio-telegraphic and telephonic patents will be enhanced by this arrangement. We hope that in the interest of the War Office and the Admiralty (as we conceive) no difficulty may be found when we make the necessary application to the Treasury Committee for new issues to sanction the scheme. I beg to move the adoption of the report and accounts.

Mr. CHARLES HOLLAND seconded the resolution which was carried unanimously.

The retiring Directors, Mr. J. Herbert Tritton and Mr. Charles Holland, were then re-elected Directors, and Messrs. Kemp, Sons, Sendell & Co. were re-appointed auditors of the Company, and the proceedings terminated with a vote of thanks to the Chairman and Board and the staff.

United River Plate Telephone Co. (Ltd.)

The thirtieth ordinary general meeting was held on Tuesday, the chairman, Sir Geo. Franklin, presiding.

The SECRETARY (Mr. A. H. Dawborn), having read the notice convening the meeting and the auditors' report,

The CHAIRMAN said: Obviously the first remark one would make in moving the adoption of the report and accounts, would be that the result of this Company's working, as of that of all other British enterprises, is to be read in the light of the gigantic struggle in which, as a nation, we are engaged, and which, while profoundly affecting the area of conflict, has influences only in degree less serious upon such parts of the world as Argentina, where British interests and British trade and commerce predominate. As to the telephone system there, when we met last year practically we had arrived at a position of stagnation; in other words, in the year 1914 we just held our own with 1913. This year, 1915, about which we are meeting to-day, the period involved a whole year of war conditions, during which we have added to our system 2,714 subscribers' stations, after deducting withdrawals. We have now 56,582 stations, and consequently our revenue has continued, though slightly, to expand. The gross earnings of the Company for the year amounted to £641,581, as compared with £630,651 in 1914, leaving an increase of £10,930. Maintenance and other expenses of management in Argentina and London have absorbed £447,810, as compared with £455,346 in 1914, showing a diminution of £7,536. The net profit for the year was £193,771, as compared with £175,305 in 1914, or an increase of £18,466. Included in the expenses are customary provisions for maintenance and renewal of plant, the latter item having absorbed during the year £119,542. London expenses, including an item which is very considerable in these days, income tax, amount to £37,802, as compared with £22,296 in the preceding year, showing an increase of £15,506, which is almost entirely due to increased income tax, the annual charge for which has practically doubled. The expenditure on plant, £121,646, compares with £186,065 in 1914, or a diminution of some £65,000. On real estate we have expended £5,476, as compared with £46,605 in 1914, the reduction due to the check in development caused by war conditions. Sundry debtor balances, £28,149, show a reduction of £43,000, due to closer collections of our assets. Securities stand at £108,755, showing a reduction of £22,916, due to the redemption and sale of certain of them. The remainder have suffered a considerable diminution in value since the outbreak of war, and this has necessitated a special transfer to depreciation account from the year's profit of £19,000, thus bringing the value within the current market quotations. Stock of materials, £131,122—a reduction from the previous year of £34,352, due to the necessity of keeping smaller stocks caused by the difficulty of shipment. Some 60 per cent. of the trade to Argentine ports has been under the British flag, and that has practically now been very much curtailed—and, of course, German ships are no longer sailing there—you see at once how the difficulties of tonnage come in. Bills and cash, £160,916, are larger by about £98,000, and may be considered satisfactory.

On the liabilities side of the balance-sheet there is little calling for comment. The reserve fund account and the reserve for renewals, with the transfer now recommended, amount to £945,042, and represent a position of solidity and strength which will enable the Company to fulfil alike its obligations to the Argentine in respect of telephone service and to the shareholders who have staked their capital in the enterprise. Now we come to the all-important figures—the proposed appropriation statement. First there is the final dividend of 5 per cent., free of tax, £81,000. Then, to the staff provident fund we add £2,000. That is the sum which for several years we have been annually setting aside for the benefit of the staff in the Argentine. In some sad cases, where sickness and accident come about, we have found that the funds provided have been a very great blessing indeed. Whether or not the Board will have to consider when times are more propitious that it may not be wise to establish a pension fund in order to provide for those who have to retire from old age, and whether or not that will not also conduce to the interests of the Company, are questions which, I think, may well be considered. The only thing, I think, which prevents action with regard to that is the difficulty of the present times. Then we transfer to reserve account £20,000, to securities depreciation account £19,000, and we carry a balance forward of £9,234. The gravity of the crisis through which Argentina has passed is clearly indicated by the lack of progress on every hand, and we have thus been able to postpone the erection of new buildings and the provision of exchanges required by our ordinary development studies. In other words, the progress of the Company's development has been checked by the check in the trade of the Argentine, and we shall not spend money until the necessity for it arises.

During the past year the Company's consulting engineer, Mr. Gill, of the firm of Messrs. Gill & Cook, has visited the Company's properties and furnished valuable reports upon the potentialities of the vast areas to be ultimately supplied with telephone service by the Company's system, as well as careful estimates of the value of the Company's properties and plant, with rates of depreciation applicable to each. The shareholders will be glad to know that the result of this visit, to be deduced from these reports, is generally to confirm the values appearing in our balance-sheet, and to justify in full measure the policy pursued by the Directors and the Company in the past in making the Company strong. In this connection we are specially indebted to Sir John Gavey, whose wise counsel and technical skill, following upon his visits to the Argentine, have been of the highest service to this Company. Our trunk line system, giving connection to the Federal capital, remains as at the beginning of last year, but we have again extended our lines in the Cordoba district by joining up the Belle Ville district to Villa Maria (a distance of 38 miles), which town is connected to the City of Cordoba, and a short trunk line (25 miles) has also been built in the Province of Buenos Aires connecting up the towns of Tapalque and General Alvear. The common battery boards mentioned last year for our exchanges at Flores, in the City of Buenos Aires, and at Lomas and La Plata (a few miles outside the capital) have been completed, and, with the exception of the last named, brought into service. Only two exchanges in Buenos Aires now remain to be converted into the central battery system, and for one (Belgrano) we have recently accepted a tender for the erection of the necessary building. The other (Barracas) will be dealt with in due course. The automatic installations at Rosario and Cordoba are giving excellent services, but the retention of temporary expert assistance so far necessary makes true comparative costs of working for the present unobtainable.

As to the current year, I am no prophet, and it is especially hazardous to forecast results in times such as these. The prospects of Argentine trade are such, however, as to lead us to hope for figures quite as favourable for 1916 as those we are now considering. Turning aside from the results of the Company's working, we may with advantage consider the conditions prevailing in this great country, upon which the prosperity of our enterprise depends. The paralysis of trade with the Argentine caused by the war is almost past. The harvest for 1915-16, so far as regards wheat, oats and linseed, has been generally satisfactory both in yield and quality, whilst the maize in some districts is thought to have suffered severely from drought and locusts. Still, the area sown is so large and extends over all parts of the Republic that it is hoped the final results will be better than certain recent reports would appear to indicate. Then, again, if you look at the total volume of trade with the Argentine for 1915—that is, the total of the imports and exports together—they amounted to £155,790,000, as compared with £123,230,000 for 1914, equal to an increase of £32,560,000, or 26·42 per cent.; whilst what is called the balance of trade during the year 1915—that is, the excess of exports over imports—was £65,752,000, as against £15,364,000 for 1914, a sure indication of recovering prosperity. Imports have fallen off considerably, and the country's most important source of revenue—namely, Custom House duties and port dues—has consequently suffered. Imports have decreased by £9,000,000 during the past year, while exports have increased by £41,000,000. Imports will naturally remain low during the period of the war, and perhaps for some little time afterwards. Exports, too, may fall off unless something can be done to increase the available tonnage; but notwithstanding this difficulty, there is every indication that Argentina will maintain its position during the current year.

Another feature of improving financial strength is the improvement in the gold position at the end of 1915, when the percentage of gold held against paper currency had increased from 66·4 to 72·4 per cent., so that when it is considered that for the volume of paper currency in circulation in the Argentine practically 72 per cent.—or nearly three-quarters of it—is held in gold by the bank of the nation and by the Caja de Conversion, where the money is deposited, I think that shows, at all events, a very strong position for the future of Argentine trade. No review of the Company's position in the Argentine would be complete without expressing our indebtedness to the local committee and staff. To Dr. Drago, the chairman of the local committee, the members of the committee, Mr. Parker, the general manager, Mr. Roberts, the engineer-in-chief, as well as to the Company's legal adviser in Argentina, Dr. Orma, the shareholders are much indebted for skill and attention of the highest value in guiding successfully the affairs of our Company through perils and difficulties by which enterprise in that country is often threatened. The staff in Argentina also deserves special mention. Quite a number of them, both British and Italian subjects, have come over to Europe and have taken their stand with their brethren in fighting for what they consider to be their liberties, and I say all honour to them. The Directors have put no difficulty in the way, but have facilitated, by financial arrangements and otherwise, the steps which will bring the best results. Seeing that we are in for this great struggle, it is quite clear that we ought to put every ounce of our strength, whether it be in financial or striking power, into it; we ought to do it and to do it at once. In London we greatly value the help of our secretary, Mr. Dawborn, and such of the staff as remain to us from the exigencies of military service. I now move that the report and accounts, including the dividend recommended, be received and adopted.

Sir FREDERICK GREEN seconded the resolution, and after the Chairman had answered a few questions,

Mr. F. GILL said he stayed at Buenos Aires nearly 10 weeks last year. With regard to the plant he thought he might say that, generally speaking, the plant had been well chosen, well constructed and well taken care of. The kind of plant in use was very similar to that which was now being installed in this and other countries. The Chairman had said that Buenos Aires itself was well equipped with modern exchange equipment in the shape of central batteries. A great deal of the capital was invested in underground ducts, underground cables, central battery equipment, and and specially designed telephone buildings. All that made for stability. With regard to the service, he thought he might fairly and, perhaps, favourably compare the service in the City of Buenos Aires itself with that of London, which was not by any means a bad one, and the trunk service was, he thought, a little faster than in this country. No telephone man, however, was ever satisfied with his service and increasing attention was being given to this very important branch of the work here, and he was sure it was also being given in Buenos Aires, and he felt confident that the service would become still better. With regard to the future, their sphere of operations was the Federal capital, the City of Buenos Aires, the Province of Buenos Aires and Rosario and Cordoba. Buenos Aires itself had a population of about 1½ millions—a large field in itself—and the Province of Buenos Aires had a population of another 2 millions. That combined population was roughly about half the population of the whole country; the population was rapidly increasing prior to the war. During the 10 years between 1904 and 1913 the trade of the Argentine—imports and exports—doubled. For some time prior to 1914 there was a very heavy demand upon the Company for telephone facilities, and although that demand slackened during 1914 and 1915, he was quite sure that a heavy demand was coming on the Company again for public service, and that there would be an ample field for a large increase in the Company's sphere of operations. He thought it was becoming recognised that a well-managed, efficient telephone service, which was really desirous of serving the public, was so necessary to a community that it would progress and become more prosperous year after year in spite of revolutions, disturbances and wars. That was the universal telephone law. He did not see that Buenos Aires was any different to other countries in that respect. There was an ample field for the Company, and he felt every confidence in a growing and more prosperous future for it.

The resolution was then carried unanimously.

The retiring directors, Sir Frederick Green and Sir John Gavey, were re-elected, and the auditors, Messrs. Welton, Jones & Co., were also re-appointed.

Votes of thanks to the Local Committee and staff and to the Chairman and Directors were passed, and the proceedings then terminated.

Callender's Cable & Construction Co. (Ltd).

The twentieth ordinary general meeting was held on Thursday, May 25, at Hamilton House, Victoria Embankment, London, E.C., the Chairman, Sir J. FORTESCUE FLANNERY, Bart., M.P., presiding.

The SECRETARY (Mr. Walter Allnutt), having read the notice convening the meeting and the report of the auditors,

The CHAIRMAN, in moving the adoption of the report and accounts, said that the Directors were very glad indeed to be able to meet the shareholders with a report and balance-sheet comparatively so favourable, especially in view of the difficulties with which they had had to contend during the past year. The circumstances of the war were more responsible for the difficulties that had arisen than any cause inside the Company's own organisation. Great pressure had been put upon their various departments, while they had also lost a very large number of their workmen in volunteering for the war. Most serious difficulties had also arisen from the restriction of British tonnage, and that restriction had caused delay in the delivery of their raw material, and had enormously increased the cost. They had also to contend with the postponement of orders. They had to submit to inroads upon their earnings by the Chancellor of the Exchequer, especially in the new legislation which was now before Parliament. Yet they claimed to have overcome those difficulties without resorting to any means of which the shareholders would disapprove. They had made no undue profit out of the nation's need, and he desired to emphasise that fact, because so many allegations were being made at the present time of what was called "profiteering," that was, traders making profits by excessive charges. The interruption of their ordinary trade, due to the war, had enabled them to make very considerable changes at both the factories, some of which would, perhaps, be of advantage after the war. He claimed that the products of their factories were already doing splendid service in connection with the war and the national defence both ashore and afloat. They had set as good an example as they could to their brethren in the electrical trade, and the electrical trade had not been behind any other trade in its patriotic exertions. There had been some difficulty in maintaining their connection for commercial work at home, in the Colonies and in the neutral countries; but they had been able, notwithstanding, to execute such orders as were urgent, and the Directors had been at great pains to keep alive all the world-wide connections which the Company possessed, because they realised that it rested upon them to see that when the war was over the Company would be able to resume its ordinary business with full advantage. The Directors believed that the measures which they had taken were such that when the war was over the Company would be able to continue ordinary business as advantageously as before, both to the customers and the shareholders. Indeed, they had reason to believe their friends were stirring up great reservoirs of orders for their requirements, which would be to the advantage of the Company when the war was over. One of the most serious matters that affected the country at the present time was the question of transport. The German submarine menace had been on the whole an absolute failure, but had caused some embarrassment; also the workmen of the country, including those who built ships and machinery for ships, had been commandeered by the Government in connection with munitions and naval construction for fighting ships, and that had undoubtedly produced a state of affairs which was embarrassing at the present time, and he could see little hope of relief in the near future. They had added a great deal of new plant and new buildings to their two factories at the request of the Government. In addition to erecting new plant, they had also kept the existing plant up to the fullest state of repair and efficiency, and at present they were working overtime at both factories. At one they were working practically continuously night and day. At one of their factories they had not only added accommodation for women workers, but the Government had come forward and were building a hostel at the Company's request. Without such assistance they could not have expanded as they had done the employment of women labour. In regard to the accounts, on Jan. 1, 1914, they started the new year with a floating balance of £124,000 carried forward; on Jan. 1, 1915, that had increased to £163,000, and on Jan. 1, 1916, the carry-forward amounted to £207,000. That was a very large sum in proportion to the other figures, but it was a reserve against the future, which he was sure would have the shareholders' approval. He moved that the report and accounts for the past year be received and adopted.

Mr. T. O. CALLENDER, J.P. (Managing Director), seconded the motion, and said 465 of their permanent employés were now with the Army or the Navy, and a very large number, several hundreds, mostly engaged on their outside contracts, had also joined. He regretted to say that of their 465 permanent employés 11 had been lost at sea or killed in action, and four were missing, and he wished to express their sympathy with the friends and relatives of those who had been lost. Only four of their men had been taken prisoners, so far as they knew, and one of them was Flight-Lieut. Reid, who was captured as a consequence of his heroism in going to the help of a comrade during the aerial attack on Schleswig-Holstein. Of their staff with the Colours 25 had been given commissions. He thanked the Chairman for the kindly references made by him to his own son, who was in the Royal Marines, and who would one day, he hoped, do his bit in the Navy. He was unable, as was his usual custom, to go into matters of detail respecting the Company's business, because, as they knew, theirs was now a controlled establishment, and it had been specially enjoined upon the board that the information which came into their hands was private and confidential. The Chairman had alluded to the great difficulties that had been experienced in carrying out the work of the year, and he could assure the shareholders that they had been considerable. They had had to pay prices for most of the commodities they used such as would have been considered, a few months ago, as absolutely ridiculous. In the early days of the war copper at £50 or £60 a ton was nearly a drug in the market, and now that it was over £150 per ton they would realise how serious the position might become unless it was handled with considerable care. With regard to their oversea trade, they had done some, but not nearly as much as they would have liked, owing to the action of the Government. But he thought the action the Government had taken was quite correct. No one could find fault with most of the regulations which had been issued, although the effect was to hamper and restrict oversea business considerably. They were endeavouring, as far as possible, to open up new fields, and to consolidate fields already opened up. They had with them to-day Mr. Wadham, a partner of a firm in Sweden with whom they were in close touch and who were doing excellent work in connection with Callender's Company and other British firms. As the shareholders might have noticed, the Government had done him (Mr. Callender) the honour of nominating him as a member of the Board of Trade Committee dealing with electrical business after the war, and he did not think, in view of the fact that he was getting

a lot of information from various sources, and would in due course have to make a report thereon, it would, perhaps, be seemly for him to say too much of what he thought on that point. He hoped that when they met next year the position would justify the anticipation of continued prosperity in the future. He thought what was in front of them in regard to the Finance Act was too bad for words. He was using what influence he had, and many of their friends, including Sir Fortescue Flannery, were assisting in endeavouring to combat the decision taken by Mr. McKenna when he introduced the Finance Act to compel companies to make a dual return, so that he could take the Munitions tax or the Finance tax, which ever was the larger. That was a most unfair basis, and it was a breach of the bargain they entered into when they were made a controlled establishment.

The motion was carried unanimously, and the dividend and bonuses, making 20 per cent. in all, were agreed to on the motion of the CHAIRMAN seconded by Mr. C. H. McEuen.

The retiring Director (Mr. John Varley) was re-elected, the auditors (Messrs. James Worley & Sons) were re-appointed, and a vote of thanks to the chairman, directors and staff terminated the proceedings.

CAPE TOWN CQNSOLIDATED TRAMWAYS & LAND CO. (LTD.)—The accounts for 1915 show a debit balance of £816. 11s. 10d., against £1,894. 6s. 9d. for 1914. The operation of the tramways of the Camps Bay Tramway Co. resulted in a profit of £1,486. 1s. 5d., against £1,521. 5s. 1d. in the previous year. The number of passengers carried increased by 54,605 and the receipts by £1,270. 9s., but the heavier cost of operating and of the maintenance of the permanent way made the net profit slightly less than for 1914.

CHESHAM ELECTRIC LIGHT & POWER CO. (LTD.)—The profit for 1915, after meeting all charges (including interest but excluding depreciation), was £1,563. After deducting £500 for depreciation and £152 for proportion of costs of debenture issue, and adding £1,958 brought forward, the available balance was £2,870. A dividend of 4 per cent. was paid, and £2,270 carried forward. Extensions at Berkhampstead and Amersham had been further proceeded with, and the capital expenditure during 1915 was £4,767. Plant additions had been made at Chesham which had been fully warranted by the reduction in the cost of the electricity supplied.

DELHI ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The gross receipts of the tramway undertaking for 1915 were £9,604. 3s., and of the electric supply undertaking (including £2,590. 1s. 9d., current sold to tramways) £20,198. 16s. The latter figure represents an increase of 7 per cent. over the figures for the previous year, while the tramway revenue shows a reduction of 1½ per cent. due to decreased mileage. The net revenue was £10,300. 6s. 9d., compared with £8,163. 6s. 6d. in 1914, and £6,252. 10s. 4d. in 1913. After charging general expenditure in London and Delhi, and debenture and loan interest, the profit for the year was £6,034. 13s. 2d., and with £78. 10s. 8d. brought forward the total available balance is £6,113. 3s. 10d. A sum of £2,217. 11s. has been written off part of preliminary expenses, £2,000 transferred to depreciation reserve and £1,000 to renewals reserve, leaving to be carried forward £895. 12s. 10d. The cost of the upkeep of the cars and permanent way is still heavy, largely due to the increased cost of spares of all kinds. A larger battery has been installed in the power house and the loss on realisation of the old battery (£750) has been charged to renewals reserve account. Owing to increasing demand, it will be nesseeary to provide further generating plant and new rolling stock.

ELECTRIC CONSTRUCTION CO. (LTD.)—At the annual meeting on Tuesday the chairman (Mr. P. E. Beacheroft) said it was extremely gratifying, in view of the abnormally high prices of materials, the higher rates of wages, the difficulties of transport and several other factors which had contributed to an increased cost of production, that they had been able to increase their net profit by 21 per cent., as compared with that of the previous year. The balance at credit of profit and loss account was £43,241, to which had to be added the sum brought forward, making together £50,712. An interim dividend was paid on the preference shares in November, and the directors now recommended a final dividend at rate of 7 per cent. per annum on the preference shares for the six months ended March 31, a dividend at rate of 7½ per cent. per annum on the ordinary shares for the year, and the transfer to the general reserve fund of £12,664, leaving £16,839 to be carried forward, subject to excess profits duty and assessment under the Munitions of War Act. Their financial position at present was stronger than it had ever been before. With regard to their assessment for excess profits duty and assessment under the Munitions of War Act, two years' assessment had to be provided out of the sum carried forward. The Chancellor of the Exchequer required from non-controlled establishments 50 per cent.—now 60 per cent.—of the excess profit earned over the average of two of the three years prior to the war. In his opinion, as matters now stood, controlled establishments were suffering to a larger extent than non-controlled, and he hoped that something would be done to put matters on a more equitable basis. In conclusion, he stated that at the termination of the war he did not think there would be any depression in the electrical industry, and there was every prospect of their meeting next year being held under favourable auspices. The report and accounts were unanimously adopted.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. (LTD.)—Mr. E. Pope, who presided at the meeting last week, said that during the past year they sold more power, but their total net profit was a fraction less than in the previous year. He considered it satisfactory under all the circumstances to be able to say that they did about as well as they had done at any time during recent years. A demand for higher wages was made in January last, and while it was being adjusted many users of current, who also used firewood for steam plant, closed down and ceased operations for many weeks during January and February. Their profit for January fell to about one-third of the normal, and for February also it was much decreased. In the result extra wages were agreed to, and the price of fuel had been increased by 1s. per ton. That meant that every kilowatt of power would cost 0·055d. per unit more to manufacture. There had always been more than usual difficulties in conducting operations at Kalgoorlie, but now that new coal had been added by re-construction the strain was distinctly severe. There was a special shortage of labour due to enlistment and exclusion of aliens. The cost of all engineering supplies had been greatly raised, some goods being as much as 100 per cent. higher than before the war. Timber also had been further increased. Notwithstanding the high rates and charges they expected to have a fairly prosperous year.

LANCASHIRE DYNAMO & MOTOR CO. LTD.—The net profit for the past year was £31,533, against £12,426 in 1914, and with £1 11s. brought forward the available total is £32,651. After paying the preference dividend and a final dividend and bonus of 5 per cent., making 12½ per cent. (tax free) on the ordinary shares (against 8 per cent. in 1914 and 1913), £14,992 was placed to reserve, and £1,450 carried forward.

PEEL-CONNER TELEPHONE WORKS (LTD.)—The net profit for the year ended March 31 was £21,748. 19s. 11d., out of which there has been placed to reserve for depreciation £5,000 and to general reserve £4,000, leaving £12,748. 19s. 11d. Adding amount brought forward (£4,261. 2s. 4d.), the balance available for dividend is £16,950. 2s. 3d. An interim dividend was paid in November upon the preference shares, absorbing £2,500, and the Directors recommend that dividends be now paid as follows: On preference shares (balance) (£2,500) and 2s. per share on ordinary shares (£8,000), leaving to be carried forward £3,950. 2s. 3d. The directors are satisfied with the result, more especially as during the past year the cost of labour and raw materials have shown considerable increases.

RICHARDSONS, WESTGARTH & CO. (LTD.)—The accounts for 1915 show that, after an expenditure of £26,651. 18s. 9d. in maintaining buildings and fixed and loose plant, the profit was £76,241. 10s. 10d. After meeting interest on 4½ per cent. perpetual debenture stock for the year (£15,750), directors' fees (£1,700), writing off £10,780. 0s. 5d. further in respect of cost of starting and developing new business of Heavy Stampings (Ltd.), £25,000 for depreciation and £3,000 written off capital expenditure in 1915, and providing some £2,500 for further [expenditure] on repairs, the credit balance is £17,511. 10s. 5d. The directors regret that they are not at liberty to refer to war contracts, the works being controlled establishments. Admiralty contracts were received early in the year, but the volume of such work invoiced in that year has been insufficient to compensate for the very large amount of mercantile work hung up. Some progress has been made with the pre-war and pre-control civil contracts referred to in the last report. A considerable number of these are being accelerated without loss to the company, but many yet remain to be dealt with.

SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)—At the recent meeting the chairman (Sir Alfred Dent, K.C.M.G.) said that the receipts for the current year continued to improve, and the position at the present time was certainly hopeful. The directors recommended a dividend of 7 per cent., which would leave £1,386 to carry forward. At present there were good reasons for believing that the depreciation of the native copper coins would be arrested at no distant date, and should that change on the company's receipts be minimised or eliminated altogether, their accounts would in future be materially improved. The rise in the silver exchange was also greatly to their advantage. They were looking forward for opportunities to expand the rail-less form of traction, as it was now proved to be so well suited to the narrow streets of the Settlement and to the requirements of the population. They also hoped when the war was over and the disturbance in China had ceased, that the inquiries made as to starting tramways in other townships in the interior might lead to their company being invited to take an interest in such schemes.

WHITSTABLE ELECTRIC CO. (LTD.)—At the recent annual meeting the chairman (Mr. O. C. Wylson) said the whole of the debentures were in the hands of Messrs. J. B. Saunders & Co., the contractors, as security for the payment of the balance of their contract, and Mr. Leech has been appointed receiver on their behalf. It was necessary that those be released at once. He had discussed with Mr. Leech a scheme by which the debentures could be paid off, and the company set on a sound footing. The nominal amount of debentures held as security by Messrs. Saunders & Co. was £10,000, bearing 5 per cent. interest. The actual balance due to Messrs. Saunders & Co. on the contract was £4,878. 10s. 2d., to which a slight addition must be made for interest and costs, say, £5,000 in all. There were ordinary creditors to the amount of £1,772, many of whom would, it was hoped, take debentures in settlement; some had agreed to do so. It was necessary, therefore, to raise a sum of, say, £7,000 to pay off the above and to give them some working capital. It was proposed to reconstitute those debentures by dividing them up into £50 and £5 debentures, so as to bring them within the reach of all. It was further suggested that they should be 6 per cent., instead of 5 per cent., as at present. To relieve the company from the payment of interest during the next two years the debentures would be issued at £44 per £50 debenture, and at £4. 8s. per £5 debenture. That was in effect paying the 6 per cent. interest in advance over the period of two years.

WINNIPEG ELECTRIC RAILWAY CO. (LTD.)—The net earnings from the operations of the combined properties in the past year were $1,331,737 against $1,769,114 for the previous year. The fixed charges (including taxes, city percentages, interest on funded debt, &c.) absorbed $835,635. The surplus earnings were $496,101, which, when added to surplus

brought forward aggregate $1,637,598. Quarterly dividends were declared and paid by the directors at an average rate of 9½ per cent. per annum, amounting to $855,000. The decrease in earnings was due to the general depression following the first winter of the war, coupled with the advent of the jitneys in the spring. The depression was temporary, however, and there has been a gradual advance toward normal conditions.

CITY NOTES.

MEMORANDA (May 30).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 57 11/16. Consols Pay Day, July 5. Stocks and Shares Ticket Days, June 14 and 28. Pay Days, June 15 and 29. Price of silver, 32⅝d.

MACKAY COMPANIES.—The regular quarterly dividend of 1 per cent. on the preferred shares and the regular quarterly dividend of 1¼ per cent. on the common shares in the Mackay Companies will be paid on July 1, 1916. The transfer books will not be closed. Dividend cheques of English and Continental shareholders will be made payable at the option of the payee at the Union of London & Smiths Bank, London, E.C.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.)—A meeting of the holders of 5½ per cent. second mortgage debentures will be held on June 9 for the purpose of approving of the appointment by the company of Sir Leander Starr Jameson as a new trustee, in the place of the late Earl St. Aldwyn, and jointly with Mr. James Rochfort Maguire.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date May 30, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	18d.
Solid Drawn Copper Tubes	20½d.
Brazed Copper Tubes	20½d.
Brazed Brass Tubes	20d.
Brass Wire	17½d.
Copper Wire	20½d.
Rolled Brass	17½d.
Brass Sheets	18½d.

	per ton.
Copper Sheets	£168 0 0
Spelter	£80 0 0
English Lead	£33 0 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£105 0 0
Clean Brass Scrap	£65 0 0
Braziery Copper Scrap	£95 0 0
Old Lead	£27 0 0
Old Zinc	£50 0 0
Hollow Pewter	£115 0 0
Black Pewter	£75 0 0
Gun Metal	£83 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date May 30, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£68 0 0
Clean Copper	£102 0 0
Braziery Copper	£90 0 0
Gun Metal	£82 0 0
Old Lead	£27 10 0
Tea Lead	£25 10 0
Old Zinc	£54 0 0
Hollow Pewter	£135 0 0
Shaped Black Pewter	£95 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £90; Commercial Tinman's Solder, £115; Blowpipe Solder, £125.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, May 30. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., May 30.	Rate per cent Yielded. £ s. d.	Dividend Due.
		Electricity Supply.			
10	6%	Bournemouth & Poole E.L. Ord.	9⅜	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	7⅞	5 13 5	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	9	6 1 6	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅞	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	7⅛	5 0 8	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	7 3 3	..
5	5%	Do. Ord.	3⅛	7 1 7	Aug, Feb
5	4½%	Do. City Pref.	2¾	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅛	6 5 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	11½	6 15 5	Feb, Aug
10	6/0	Do. 6% Pref.	10[illegible]	5 16 4	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	89	5 12 6	Jun, Dec
10	7%	County of London Ord.	10[illegible]	6 16 2	Mar, Sept
10	6%	Do. 6% Pref.	10[illegible]	5 16 4	Feb, Aug
St.	4½%	Do. 1st Deb.	86½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	97	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	7[illegible]	5 17 8	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79[illegible]	5 1 0	Jan, July
5	6/	London Elec. Supp. 6% Pref.	4[illegible]	6 19 5	..
St.	4%	Do. 4% Mort. Debs.	8[illegible]	4 17 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅞	6 [illegible] 9	Mar, Aug.
St.	4½%	Do. 1st Mort. Deb.	89	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	9[illegible]	6 [illegible] 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 9	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	3⅛	6 10 7	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., May 30.	Rate per cent, Yielded. £ s. d.	Dividend Due.
		Electricity Supply—*cont.*			
5	8%	St. James' & Pall Mall Ord.	5[illegible]	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5[illegible]	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	71½	6 5 10	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅝	7 2 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5½	6 7 3	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4[illegible]	5 10 9	Jan, July
		Electric Railways & Tramways.			
[illegible]	5%	British Elec. Traction 5% Debs.	78½	6 1 11	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	74[illegible]	8 0 6	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	69⅜	5 14 11	..
St.	4%	Do. do. Assented Def. Ord.	65½	6 2 7	..
St.	4½%	Do. 4½% Pref.	80½	5 11 10	Jan, July
St.	4%	Do. 4% Deb. St.	76½	5 4 11	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	70⅜	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅝	5 17 9	Jan, July
St.	4%	Do. 4% Pref.	64½	6 4 3	Mar, Sept,
St.	4%	Do. 4% Debs.	74	5 8 1	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25½	3 18 5	Feb, Aug
St.	3½%	Do. 3½% Pref.	62½	5 11 2	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	60	5 16 8	Feb, Aug
St.	3½%	Do. 3½% A Debs.	63	5 11 1	Jan, July
St.	3½%	Do. 3½% Debs.	65½	5 6 10	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	74½	5 7 5	May, Nov
St.	4½%	Do. 4½% First Pref.	71	6 6 9	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	107⅜	5 11 5	Jan, July
St.	4%	Do. 4% Debs.	73½	5 8 10	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	66⅛	6 1 0	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2[illegible] †	5 11 8	Apl, Oct
1	6%	Do. 6% Pref.	1[illegible]	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1[illegible]	5 14 10	Mar
100	5%	Do. Prior Lien Debs.	92	5 8 8	Jan, July
1	6%	Do. 6% Pref.	[illegible]	6 17 2	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10[illegible]	7 2 0	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5[illegible]	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref.	[illegible]	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2[illegible]	6 13 4	April
100	6%	Do. 6% Prior Lien Debs.	100[illegible]	5 19 1	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	68	5 17 8	Jan, July
5	15%	Callender's Cable, &c., Co. Ord.	12[illegible]	6 0 0	Jan, July
5	5%	Do. 5% Pref.	4[illegible]	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	[illegible]	7 13 8	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	[illegible]	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	[illegible]	8 17 9	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	71[illegible]	5 11 6	Jan, July
10	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9[illegible]	6 3 6	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	14[illegible]	6 8 10	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4[illegible]	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	10[illegible]	9 8 3	Feb, Aug
10	5%	Do. Pref.	8[illegible]	6 2 2	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	38	6 6 4	Mar, July
100	4%	Do. 4% Debs.	95[illegible]	4 6 0	Jan, July
1	7½%	Vickers Ord.	1[illegible]	4 5 9	May, Aug
1	6d.	Do. 5% Pref.	[illegible]	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	78[illegible] †	5 0 11	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99[illegible]	4 10 5	Jan, Dec
St.	4½%	Willans & Robinson B.Cm Pref. 4½%	40[illegible] †	10 2 6	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	102½	5 18 6	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	22[illegible]	6 18 2	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69[illegible]	5 14 8	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7[illegible] †	6 13 4	May, Nov
10	10%	Do. 10% Pref.	14[illegible]	7 2 10	..
5	5/0	Direct Spanish 10% Pref.	7[illegible]	6 13 4	..
10	4%	Direct United States	6[illegible]	6 12 0	Ja,Ap,Jly,O
St.	7%	Eastern Tel. Co. Ord.	143[illegible]	4 17 9	Ja,My,Jly,O
St.	17/6	Do. 3½% Pref.	64[illegible]	5 8 3	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	70[illegible]	5 4 6	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77[illegible]	5 3 3	Feb, Aug
10	7%	Do. Ord.	14[illegible]	4 17 0	Ja, Ap, Jly,O
10	22½%	Gt. Northern Tel. Co. ex C[illegible]. 9	36[illegible]	5 19 9	Ja. My. Jly
25	13%	Indo-European	48[illegible]	6 14 9	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2[illegible]	4 4 3	April
1	7%	Do. 7% Pref.	1[illegible]	3 13 5	July
10	1%	West India & Panama Ord.	[illegible]	10 2 8	May, Nov
10	6%	Do. 1st Pref.	7[illegible]	7 12 11	May, Nov
10	8%	Western Telegh. Co.	14[illegible]	5 10 7	Mr,Jly,O,Dec
St.	4%	Do. 4% Deb. St.	77[illegible]	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr Bds.	98	4 11 10	May, Nov.
		Telephones.			
1	7½d.	M[illegible] Video Telephn. Ord	[illegible]	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	1[illegible]	5 4 11	Apl, Oct
St.	4%	Do. Deb. St.	79[illegible]	5 1 5	Jan, July
St.	4½%	Telephn Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6[illegible]	6 4 11	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4[illegible]	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	84½	5 6 2	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12½	4 16 0	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10[illegible]	5 16 4	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	82½	6 1 9	Ja, Apl, Jly,O
..	4%	Do. $100 Pref.	70½	5 14 1	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	124	4 16 9	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4[illegible]	6 5 3	Mar, Sept
St.	5%	Do. 5% Deb.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10[illegible]	5 19 6	..
St.	4½%	Do. 4½% D[illegible]	85	5 5 11	Jan, July
5	9%	Calcutta E. S. Corp. Ord	6[illegible] †	7 8 5	May, Nov
5	5%	Do. 5% Pref.	4[illegible]	5 14 3	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,986. [No. 10. Vol. LXXVII.] **FRIDAY, JUNE 9, 1916.** PRICE SIXPENCE

Abroad 9d., or 20 cents. or 1½., or 90pf.

CONTENTS OF THE CURRENT NUMBER.

NOTES	307
Arrangements for the Week	310
Performance of 30,000-kw. Steam Turbo-Generators. Illustrated	311
Magnetic Amplifier for Radio-telephony. By E. F. W. Alexanderson and S. P. Nixdorff. Illustrated	312
The Shildon-Newport Railway Electrification. Illustrated. *Concluded*	314
Notes on Design of Electro-magnetic Machines. By Stanley Parker Smith, D.Sc. Illus.—*Continued*	320
Imperial College of Science and Technology	323
THE ECONOMY OF TURBO-GENERATORS OF LARGE OUTPUT	324
The Predetermination of Higher Harmonics in the Alternating Current Transformer when the Impressed E.M.F. is a Simple Harmonic Function of the Time. By Geo. R. Dean	325
The Magnetic Hand. By Prof. G. Klingenberg. Illustrated	327
Physical Society	327
CORRESPONDENCE	328
"Speeding Up" in Engineering Factories (R. Rankin).	
Battery-Room Floors. Illus.	328
Science and the State	329
PARLIAMENTARY INTELLIGENCE	329
LEGAL INTELLIGENCE	330
The "Electrician" Commercial and Industrial Section	331-340

NOTES.

The Naval Engagement.

UNLIKE a section of the lay press, we think it unnecessary to strike an apologetic note in referring to last week's naval engagement. When the story comes to be told we venture to think that the day's work will stand alone not only in the records of the Navy but in the record of the war. It may be that the exigencies of the case demand reticence on the part of the Admiralty, but we feel confident that here at least neither shame nor fear accounts for delay in the publication of the truth. At the same time it is a little unfortunate that half-truths from neutral sources are allowed to appear. On another matter we find ourselves completely at variance with certain of our contemporaries. While they mourn our dead, we glory in them, knowing, as we do know, that the spirit of NELSON was with them during the engagement. To condole with the dependents of those who fought well and died bravely would be to presume too much. Rather let us offer our congratulations to those whose privilege it is to be related to heroes. In doing so let us tactfully and humbly beg their acceptance of the means of decent livelihood, means that it would have been unnecessary for us to offer had their men not fought and died for us, or had they fought and fled. This applies equally to the dependents of all those who have fallen. Failing the making of such an offer, we urge those who talk of sacrifice, and make none, quickly to set about enlarging the workhouses, lest the accommodation be insufficient.

Excess Profits.

IT is evident from the recent general meetings of companies that the question of excess profits is one that is troubling the average board of directors. Whether the permissible profit is based on the average of the previous two years, or, alternatively, taken on the basis of 6 per cent. which is allowed by the Finance Acts on the capital involved, there is naturally a feeling that many industrial concerns will suffer considerably. In the case of uncontrolled firms, the Finance Acts enable the Government to appropriate 50 per cent. of the excess profits for the year 1914-15 and 60 per cent. for the year 1915-16. Controlled establishments, however, are in a far less satisfactory position. At first they were permitted to exceed the average profit of the two immediately preceding years by 20 per cent., after which all excess went to the Government. Now, however, such firms are required to send in dual returns, on the basis of both controlled and uncontrolled; the Government then accepts whichever gives them the greater revenue. This seems distinctly unfair to controlled firms. Moreover, the tax is retrospective, so that many firms have been compelled to pay in respect of excess profits for two years from a single year's revenue. Controlled establishments have the one advantage of being able to appeal to the Board of Referees on certain important points, more particularly in regard to depreciation, which is most important in such cases, for undoubtedly many controlled establishments will have put down special plant solely for the purpose of producing munitions, and will probably have increased their buildings also, all of which may be comparatively worthless to them when the war ceases. Uncontrolled establishments have not the same right of appeal, but they may appeal on certain grounds. There is little doubt, for example, that electric lighting companies will have the right to appeal against the 6 per cent. basis on the ground of their very limited tenure. Such companies are under statutory obligations to give a supply, entailing the provision of plant and mains which may be unremunerative for some years, and the capital for which must be secured against compulsory purchase in a limited period. They are, therefore, entitled to special consideration. Generally speaking, however, it being granted that the cost of the war must be borne by everyone, it appears to us that industrial concerns are likely to obtain fair treatment at the hands of the Board of Referees, and will not suffer greater hardship than is necessarily imposed by conditions of warfare.

The Standardisation of Frequency.

THERE seems some fascination in the adoption by a supply authority of some frequency differing from that of other authorities, as if it were a sort of trade mark showing superiority. It is difficult to account, on any other grounds, for the fact that so many different frequencies are to be found. As an example, it may be noted that a frequency of 40 has been adopted at Perth, in Western Australia, whereas the frequency in other parts of Australia appears to be 50 throughout, or at all events in most of the important cases. It would now seem as if the Government of Western Australia is about to adopt the frequency of 40 for general application. This has called forth a protest from the Council of the Electrical Association of Australia which has taken steps to bring to the notice of the

West Australian Government the disadvantages of the electrical system adopted for Perth. Not only is the frequency different, but the pressure is 250 volts, whereas voltages elsewhere are generally lower. The voltage is not nearly so important as the frequency, as it may be changed more easily, but in these days of interlinking schemes and large power networks, it seems pure folly to adopt a frequency which is different from that adopted by neighbouring States. A frequency of 50 has given general satisfaction and there seems to be no particular point in putting forward that of 10. It is only to be regretted that the Association did not take this step years ago before the plant at Perth had reached a capacity of nearly 3,000 kw. A change of this kind is a serious matter when a supply has once become firmly established, but the longer the *status quo* continues the more difficult such a change becomes.

Technical Teachers.

The recent memorial dealing with the future of higher technical education, which was signed by the professors of the Imperial College of Science, and presented to Lord Crewe, follows closely the lines laid down in these columns from time to time during the past 12 months. The chief fault of the memorial is that it lacks vigour, but perhaps this will be overlooked by those for whom the memorial is intended. The section devoted to the question of salaries and pensions is an important one. If we remember rightly, the late Dr. S. G. Rawson spent considerable time in devising a pension scheme for teachers in technical institutions, and, although we cannot at the moment lay our hands on the reference, we believe that a promise to deal with the matter was given by a Cabinet Minister. It would be easy to bring the question of salaries and pensions to the notice of the public if the technical teachers would organise themselves, and endeavour to get active and influential support. We agree that with the poor prospects before the teacher, good men are not likely to be tempted into joining the profession, and when good men do enter the profession they have to find other means of increasing their incomes in order to live decently. As long as associations of teachers are used as a media for obtaining commodities at reduced prices we venture to think, and we earnestly hope, that the influential support will be lacking. Let them organise with the sole object of enhancing the value of their services and of claiming pensions, which are not denied even to very small fry in the employment of the State, and, if need be, let them be prepared to refuse to work under the vexatious conditions imposed by tyrannical local education committees and their satellites, and they will find that the prospects are materially improved.

Tars and Tar Oils as Fuel.—The Paper on "Tars and Tar Oils as Fuel for Diesel Engines," by Mr. C. Day, M.Sc.(Tech.), which was read recently at a meeting of the Diesel Engine Users' Association, has been reprinted by Messrs. Mirrlees, Bickerton & Day.

Electricity in Sewer Construction. The "Sanitary Record" refers to the utilisation of electrical energy in sewer construction, and, apart from pumping purposes, electric motors are used in connection with travelling cranes, for operating compressed air hammers used in driving steel piling, for electric shovels for excavating and on gantries employed to lay the lengths of concrete pipe. The excavated soil is removed in trucks drawn by electric locomotives, and the necessary tools and materials are conveyed to and from the various working centres by the same means. Figures are not available showing the cost per cubic yard handled, but there can be little question that electricity is superior to the old-fashioned methods of carrying out work of this description.

Coefficient of Mutual Induction of Eccentric Coils.—Mr. S. Butterworth, M.Sc., has a Paper in the "Philosophical Magazine" for April dealing with this question. The principle made use of is to treat the mutual induction between the two circles as a potential function of the position of the centre of the moving circle. The various cases for equal and unequal circles are worked out, and the results given in the form of series.

Snyder Electric Furnace.—The "Iron and Coal Trades' Review" refers to this furnace, which is used for making ferro-silicon, which it turns out 97¼ per cent. pure. Four such furnaces are being installed of 1,800 kw. total capacity. In addition, there are being completed two furnaces, each capable of melting 12 tons of steel in 24 hours, for Messrs. Thwaite Brothers, of Bradford, besides others for Messrs. Summerson & Sons, Darlington, and the Daimler Company.

Light Sensitiveness of Copper Oxide.—Mr. A. H. Pfund, writing in the "Physical Review," refers to the increase of conductivity in selenium and stibnite, and states a search was begun for other light sensitive substances. A band of copper $0{\cdot}75 \times 10 \times 150$ mm. was heated in air to 900°C. for about 20 hours, at the end of that time the copper was completely oxidised. Cells were made of this material. The law connecting the equilibrium change of conductivity with the amount of energy absorbed was determined, and found to be the same as for selenium and stibnite.

Bearings of Electrical Machinery.—In the discussion at Nottingham on Mr. A. Gilson's Paper on the above subject, before the Association of Mining Electrical Engineers, Mr. Bakewell considered it was best to bore holes into the bearing castings and allow the white-metal to key itself, especially with malleable-iron bearings. Mr. Church stated that motors fitted with white-metal bearings and ring lubrication had been running for years without any trouble. Another member referred to a case where bronze bearings had been continuously in use for 16 years the wear was remarkably small. Mr. Beardsmore stated that a groove for one-third of the distance down one side of the bearing with two horizontal branches top and bottom, was a good arrangement to distribute the lubricant.

Chicago, Milwaukee & St. Paul Railway.—The "Railway Gazette" states that the past winter, from the railway operating point of view, was, in the Rockies, the worst in the memory of living men, and yet the Chicago, Milwaukee & St. Paul electrification results greatly exceeded expectations. At times, when the severe weather was seriously impeding steam operation, the electric locomotives were moving without trouble. At that time the 115 miles between Three Forks and Deer Lodge, which form the central section of the 400 miles to be electrified, was the only portion in use electrically, and here nine electric locomotives have already replaced 24 steam locomotives of Mallet and other heavy types. The full benefit cannot, however, yet be attained, as the sidings on the division have not been lengthened, and it is hoped to finish this work by July 1, when trains of full length can be taken.

German Scientific Men and the War.—Sir Oliver Lodge has received from Prof. H. A. Lorentz a copy of a letter addressed to the latter by Prof. Max Planck, evidently with a view to publication. This was published in "The Times" on the 5th inst. In it Prof. Planck states that in his view, which is shared by various other German scientific men, the manifesto issued at the beginning of the war by a number of German professors signifies nothing more than an act of defence and protection of the German Army, which is synonymous with the German people, against the bitter accusations brought against it. He concludes as follows:

For the moment we Germans have only one task, so long as the war lasts—to serve our country with all our powers. But what I specially desire to insist on to you in particular is the firm conviction which even the occurrence of the present war can never shake, that there are regions of the intellectual and moral world which lie outside the struggles of nations, and that an honourable co-operation in the maintenance of these international cultural values, and also no less a personal respect for members of an enemy State, are not inconsistent with glowing love and energetic work for one's own country.

Birthday Honours.—The King's Birthday Honours List this year contains the following names, which will be familiar to our readers :—

New Baronets.—*E. W. Moir*, late Comptroller of Munitions Inventions, and now representative of the Ministry of Munitions in the United States.

Sir William Maxwell Aitken, M.P., vice-president of the Demerara Electric Co. and the Camagney Electric Co., &c.

New Knights.—*Dr. Geo. Thomas Beilby, F.R.S.*, a well-known chemist and inventor, and Chairman of the Royal Technical College, Glasgow.

Geo. P. Doolette, of Western Australia, a director of the Kalgoorlie Electric Power & Lighting Corporation.

E. C. Geddes, deputy director-general of Munitions Supply.

G. H. West, deputy director-general of Munitions Supply.

Robert Frederic Stupart, director of the Meteorological Service of Canada.

New C.B.s.—*Hon. Arthur Stanley*, M.V.O., M.P. ; *G. E. P. Murray*, secretary to the Post Office ; *E. B. Phipps*, principal assistant secretary, Board of Education ; *U. F. Wintour*, C.M.G., Director of Contracts, War Office.

Electric Furnaces as Applied to Non-Ferrous Metallurgy. Prof. A. Stansfield, in a Paper before the Institute of Metals, classifies electric furnaces as follows :—

Furnaces for reduction of metals from their ores, and furnaces for heating, melting, refining and distilling metals. Under the former heading there are furnaces for electrolysis of fused salts, and smelting furnaces for production of metals from their ores. The other heading includes furnaces for enamelling and moderate temperatures, electric welding, electric smelting furnaces and refining of gold precipitates. For metals which cannot be conveniently produced by thermal methods electrolytic furnaces are used. Aluminium is one of these metals, and furnaces taking 20,000 amperes at 7 volts are working at the Southern Aluminium Company's works, at Whitney, N.C. Seventy of these furnaces are arranged in series, the E.M.F. being 500 volts. The total plant will contain six of these units, so that 400 furnaces will be in use at one time, and the total production will be 44,000,000 lb. of aluminium per annum. The power consumption will be $1\frac{1}{8}$ kw.-years per 1,000 lb. per annum. The production of sodium and potassium as well as calcium, magnesium, barium, strontium and zinc are next referred to. Dealing with electrothermic smelting furnaces, the production of ferro-tungsten for steel making in France and the United States is mentioned, the annual output by the electric furnace being about 4,000 tons per annum. In Norway and Sweden the electric smelting of zinc ores has been carried out commercially for years, and at Trollhätten, in Sweden, a large plant is in regular operation. The electric furnace does not appear to have any opening for smelting copper, nickel, lead or antimony.

Faraday House "Journal."—In the Summer Term Journal, in addition to particulars regarding the system of training engineers extending over a period of four years, there is the usual register and notices. The editorial notes contains the roll of honour, remarks on "After the War Engineering," and the "Sandwich System." There is an interesting correspondence as to the origin of the Fahrenheit scale in thermometry. It appears that Fahrenheit took a mixture of snow and salt, or snow and sal ammoniac, as giving the "greatest cold," and called it zero, but why he divided the scale between this and boiling point into 212 deg. seems doubtful. According to correspondents his thermometers were not intended to read further than 96 deg. when at first constructed. It is stated that the late Prof. Ayrton suggested that the 180 deg. arose through the fact that changes of state, from one condition to another, and back again, were frequently plotted round a circle. Freezing to boiling point was accordingly taken as 180 deg. However, as mentioned above, the boiling point does not appear to have been used at first. Another suggestion, by Mr. C. Turnbull, is that between zero and freezing point, he simply divided and re-divided the scale, getting $\frac{1}{2}$, $\frac{1}{4}$, and so on to $\frac{1}{32}$. The various explanations still appear to leave the matter "shrouded in mystery."

Alternating-Current Motors.—A Paper on this subject was recently read by Mr. H. C. E. Jacoby before the Association of Supervising Electricians. The Paper dealt with synchronous motors and asynchronous motors. Under the former, motors with self-starting devices were considered, and it was pointed out that polyphase synchronous motors are self-starting under loads of about 10 per cent. of full-load. With regard to asynchronous machines, series, induction, repulsion and compensated repulsion types, were dealt with. Variation of speed of induction motors by varying periodicity, voltage, or resistance was mentioned. While resistance control is satisfactory for crane motors, it is unsatisfactory for fluctuating loads such as lift work. High-speed lifts necessitating two speeds are unsatisfactory when worked by the ordinary induction motor the difficulty apparently being in the switchgear, which should not be too complicated. With regard to single-phase commutator motors the author mentioned the "Wagner," "Century" and "Baudy" motors, and referred to the fact that speed control can be obtained by primary resistance, voltage variation, brush shifting, or by means of stator tappings. The remainder of the Paper dealt with series motors, compensated motors and cascade connection of induction motors.

An Active Modification of Nitrogen. In a Paper read before the Royal Society on this subject, the Hon. R. J. Strutt reaches the following conclusions : (1) The production of active nitrogen in the various regions of the steady discharge is greatest near the cathode, falls off to a minimum in the Faraday dark space, and increases again in the positive column to a value which is constant along that column, but less than that at the cathode. (2) With a given value of the current, much more active nitrogen is obtained from the positive column in a narrow tube than in a wide one. The difference between the potential gradients in the narrow and wide tubes is not large enough to account plausibly for the different yield of active nitrogen, which must rather be connected with the current density. (3) The yield of active nitrogen comes to a limit as the length of positive column traversed by the gas is increased. This is shown to be due to a destructive action of the discharge, which, beyond a certain concentration, destroys the active nitrogen as fast as it is produced. (4) A trace of oxygen (or almost any other admixture) is known greatly to increase the yield of active nitrogen The amount of oxygen required to do this considerably increases the fall of potential at the cathode, but it does not measurably affect the fall of potential in the positive column. (5) Active nitrogen is produced by the spark at atmospheric pressure. That the phenomena are so much less striking than at low pressures is due to the destructive action of the surrounding gas on the active nitrogen after it is produced. (6) The metal scattered from a copper cathode when the discharge passes can be made to emit its line spectrum in a stream of active nitrogen.

Properties of Aluminium.—At the last meeting of the Faraday Society a Paper entitled "The Changes in Physical Properties of Aluminium with Mechanical Work [II. Specific Heats of Hard and Soft Aluminium]," was contributed by Dr. F. J. Brislee. The author gave a series of determinations of the specific heat of hard-worked aluminium and annealed aluminium. The metal was used in the form of rod and wire. It was found that the specific heat of the hard aluminium was higher than for annealed, and this confirmed the view that aluminium is converted into an amorphous form by excessive mechanical work. It was further found that the specific heat underwent a change when the hard-drawn bars and wire were heated to 100°C. A sample of wire was prepared by drawing with the maximum draught possible, whereby a high tensile strength was obtained, but the wire could not be bent without fracture. The worked metal had a tensile strength of 18·4 tons per square inch, and after heating to 100°C. for 10 weeks the tensile strength was reduced to 13·2 tons per square inch, but whereas the original metal was brittle and could not be used, the metal with the lower tensile strength was quite serviceable. The author concludes that it is therefore necessary that the determinations of all the physical constants of metals shall be made upon metals in a perfectly definite state and one which can be reproduced. If this is not done, the results are fortuitous and may differ widely from the true results. At the same meeting Dr. R. Seligman and Mr. Percy Williams presented a "Note on the Annealing of Aluminium." The authors found that hard-worked aluminium which had been heated for 10 hours at 125°C. was less readily soluble in nitric acid than the same metal before heating, but that if the heating were continued for 80 hours, this comparative immunity from attack was lost. They also found that metal which had been freshly annealed at 440°C. was less readily attacked by nitric acid than the same metal which had been allowed to stand for 10 days after annealing.

OBITUARY.

Sir H. F. Donaldson.—We deeply regret to have to record the death of Sir Hay Frederick Donaldson, chief technical adviser to the Ministry of Munitions, who lost his life through the sinking (by mine or torpedo) of H.M.S. "Hampshire" off the Orkneys on Monday evening. He was appointed to the Ministry of Munitions in September last, when he resigned the position of Chief Superintendent of the Royal Ordnance Factories, which he had held since 1903.

Sir Frederick Donaldson, who was born in 1856, was the second son of Sir S. A. Donaldson, first Premier of New South Wales. After being educated at Eton and Trinity College, Cambridge, he served in the shops of the L. & N.W. Railway Co. at Crewe, and from 1884 to 1887 was employed at Goa, in India. Returning to England, he was engaged until 1891 on the works in connection with the construction of the Manchester Ship Canal, and from 1892 to 1897 was chief engineer to the London India Docks Joint Committee. In 1898 he was appointed Deputy Director-General, and in the following year Chief Mechanical Engineer of Ordnance Factories, retaining the latter post until he became Chief Superintendent. He received the K.C.B. in 1911, and was president of the Institution of Mechanical Engineers in 1913 and 1914.

L. S. Robertson.—Another victim of the "Hampshire" disaster was Mr. Leslie S. Robertson, who was also attached to the Ministry of Munitions. He was born in India in 1863, and was the son of the late Sir James Robertson, Governor of Bombay. He was educated at King's College School, London, and later studied under Prof. (now Sir Alex.) Kennedy at University College, London. On leaving Eton he became a pupil at the engineering works of Messrs. Denny, at Dumbarton, and then, after experience at sea, he joined Messrs. John I. Thornycroft & Co. He was well known as secretary of the British Engineering Standards Committee, an appointment he held since 1901. At the Ministry of Munitions he had been acting as assistant to the Director of Production since July, 1915. He also translated M. Bertin's work on Marine Boilers.

William Stanley.—We regret to record the death on May 14 at Great Barrington, Mass., of Mr. William Stanley. He was born in Brooklyn, N.Y., in 1858. He engaged in nickel-plating in New York, where in 1879 he met Hiram Maxim, whose assistant he eventually became. Mr. Stanley worked for a time with the Weston Electric Light Co., of Newark, N.J., and was connected with the Swan Electric Light Co., Boston, Mass. He invented a method of exhausting lamp bulbs, and devoted himself to experimental work on storage cells and other apparatus. The development of the multiple system of alternate-current distribution was due to him, and apparatus at Great Barrington being taken over by the Westinghouse Co. In many ways he was regarded as the originator of alternating-current distribution.

Killed in Action.—In addition to many commissioned engineer officers of the Royal Navy who lost their lives in the naval battle on the North Sea on May 31-June 1, the following Warrant Electricians are reported killed: Laurence Gatt (H.M.S. "Queen Mary"), Arthur C. Worthington (H.M.S. "Invincible"), Arthur Beales (H.M.S. "Indefatigable"), E. G. Goad (name of vessel not stated). The Warrant Telegraphists reported killed include Henry Arberry (H.M.S. "Defence"), Edwin Dymott (H.M.S. "Tipperary") and Harry Burnell (Acting Warrant Telegraphist, vessel not stated).

PERSONAL.

Sir A. F. Yarrow, Bart., has been elected an honorary member of the Institution of Mechanical Engineers.

Royal Engineers (T.F.)—The following appointments have been made:—

London Electrical Engineers: T. L. Barks to be second lieutenant. Sergt. G. O. King and Sapper C. H. Reed to be second lieutenants (on probation).

Tyne Electrical Engineers: Sapper J. R. T. Emerson (from London Electrical Engineers) and Staff-Sergt. A. S. Burdis to be second lieutenants (on probation).

APPOINTMENTS VACANT AND FILLED.

An engineer is required as manager of a telephone system of 500 lines in India; must be capable of reorganising existing system and installing complete exchange. *See advertisement.*

An electrician for London printing works is advertised for.

Dundalk Electricity Committee require an assistant engineer. Salary £100. Applications to the engineer and manager by 5 p.m. June 12.

The Governing Body of the Manchester Municipal School of Technology invites applications for the appointment of vice-principal. Salary £500 a year. Conditions from the Registrar, to whom applications by June 19.

Prof. Arthur Schuster, F.R.S., has been appointed Halley Lecturer at Oxford for 1917.

INSTITUTIONS AND SOCIETIES.

Royal Society.—Amongst the Papers read at last Thursday's meeting of this Society we notice the following: "Further Determinations of Direct Osmotic Pressures," by the Earl of Berkeley, F.R.S., and E. G. J. Hartley; "On the Magnetic Shielding of Large Spaces and its Experimental Measurement," by Prof. E. Wilson and Prof. J. W. Nicholson.

British Association.—The provisional programme is about to be issued of the eighty-sixth annual meeting. It is to be held at Newcastle-upon-Tyne from Tuesday, September 5, to Saturday Sept. 9, under the presidency of Sir Arthur Evans, F.R.S.

The inaugural meeting in the Town Hall will be held on Sept. 5, at 8.30 p.m., when the President will deliver an address. Evening discourses will be delivered by Prof. W. A. Bone, F.R.S., on "Intensified Combustion," and by Dr. P. Chalmers Mitchell, F.R.S., on "Evolution and the War." The following are the presidents of sections: A (Mathematical and Physical Science), Dr. A. N. Whitehead, F.R.S.; B (Chemistry), Prof. G. G. Henderson, F.R.S.; C (Geology), Prof. W. S. Boulton; D (Zoology), Prof. E. W. MacBride, F.R.S.; E (Geography), Mr. D. G. Hogarth; F (Economic Science and Statistics), Prof. A. W. Kirkaldy; G (Engineering), Mr. G. G. Stoney, F.R.S.; H (Anthropology), Dr. R. R. Marett; I (Physiology), Prof. A. R. Cushny, F.R.S.; K (Botany), Dr. A. B. Rendle, F.R.S.; L (Educational Science), Rev. W. Temple; M (Agriculture), Dr. E. J. Russell.

ARRANGEMENTS FOR THE WEEK.

THURSDAY, June 15th.

Institution of Electrical Engineers.

5.15 p.m. At Victoria Embankment, W.C. Special General Meeting of Corporate Members to confirm a resolution expelling enemy alien members.

FRIDAY, June 16th.

Physical Society.

5 p.m. At the Imperial College of Science, South Kensington. Papers on "A Method of Measuring the Pressure of Light by Means of Thin Metal Foil," by Mr. Gilbert D. West, B.Sc.; "The Viscosity of Suspensions of Rigid Particles at Different Rates of Shear," by Edith Humphrey, B.Sc., Ph.D., and E. Hatschek; "Experiments with Mercury Jet Interrupters," by Capt. C. E. S. Phillips, F.R.S.E.; "A Correction of Some Work on Diffusion by Dr. A. Griffiths and Others," by A. Griffiths, D.Sc.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay.

Orders for the week.

Officer for the week, Platoon Commander W. J. A. Watkins.
Next for duty, Platoon Commander N. E. Brown.

Monday, June 12th.—Technical for Platoon No. 9, 46, Regent-street, S.W. Squad and Platoon Drill, Platoon No. 10. Signalling Class and Recruits.

Tuesday, June 13th.—School of Arms, 6 to 7. Recruits, 7.15 to 8.15.

Wednesday, June 14th.—Platoon Drill, No. 2 Platoon.

Thursday, June 15th. Platoon Drill, No. 6 Platoon. Shooting for No. 9 Platoon. Miniature Range. Recruits, 5.45 to 7.45. Instructional Class, 5.45.

Friday, June 16th.—Technical for No. 10 Platoon, 46, Regency-street, S.W. Squad and Platoon Drill, No. 9 Platoon.

Saturday, June 17th.—Probable date of Inspection by Lord French. Special orders will be issued.

Sunday, June 18th.—Entrenching at Otford, parade Victoria (S.E. & C. Railway Booking Office) 8.35 a.m. Uniform: Haversacks and water bottles. Midday rations to be carried. Railway vouchers will be provided.

Otford Camp.—On and after Saturday, June 3rd, there will be a Standing Camp at Otford (*see* Monthly Orders).

Musketry.—For Nos. 1 and 2 Company, *see* Notice and Tables A and B at Headquarters.

Note.—Unless otherwise indicated, all drills &c., will take place at Chester House.

PERFORMANCE OF 30,000-KW. STEAM TURBO-GENERATORS.*

Summary.—An account is given of the official tests on the three 30,000 kw. steam turbo-generators installed last year by the Interborough Rapid Transit Co. Higher efficiencies than those guaranteed under contract were obtained.

The results of preliminary and acceptance tests, showing a water rate of 11·3 lb. to 11·4 lb. per kilowatt-hour for the 30,000 kw. cross-compound steam turbine units of the Interborough Rapid Transit Co. of New York when the machines were running under load conditions and carrying the maximum rated load, were officially confirmed by the records of tests presented in a Paper by Messrs. H. G. Stott and W. S. Finley, Jr., at a recent meeting of the American Society of Mechanical Engineers. According to the summary of test data on this installation shown in the accompanying diagram and Table I., the water rate at the most efficient load—namely, 26,740 kw.—is given as 11·25 lb. per kilowatt-hour with a thermal efficiency for the unit of 24·81 per cent. This remarkable performance is ample proof of the high place which the steam turbine now holds as a prime mover of large rating operated under wide ranges of load, varying between 30 and 60 per cent. of the average.

The three 30,000 kw. units were ordered in 1913 by the Interborough Rapid Transit Co. The first unit was started on December 29, 1914, the second on February 24, 1915, and the third on July 30, 1915. Each unit consists of two elements, a high pressure and a low pressure. The former is practically a typical single-cylinder reaction turbine containing 38 rows of blades, and the low-pressure element is of the double-flow type. The high-pressure rotor is of relatively small diameter, and operates at the maximum speed possible for 25-cycle service. The low-pressure rotor was designed for a speed of 750 revs. per min.

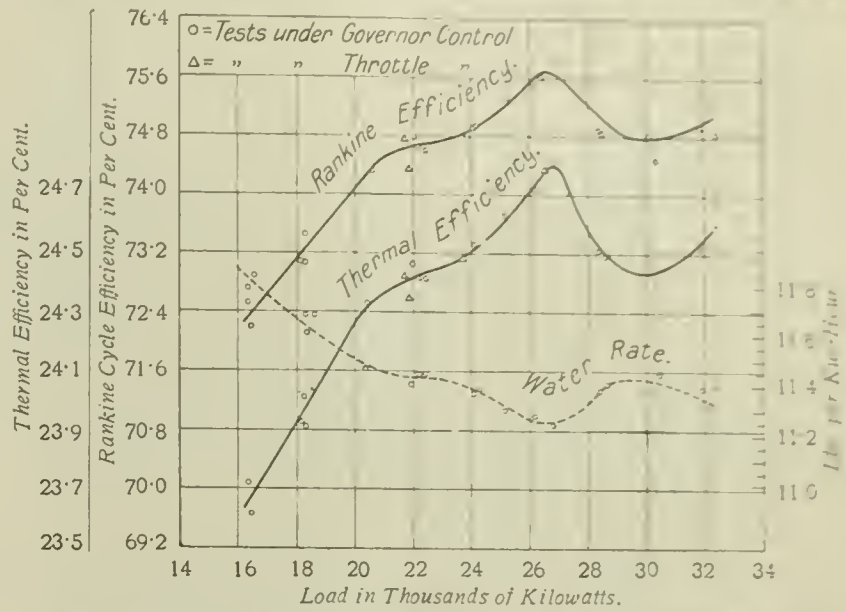
The surface condensers installed consist of two shells, each containing 25,000 sq. ft. of condensing surface. These shells are connected directly to the turbine outlets without an intermediate expansion joint. Duplicate turbine-driven tri-rotor circulating pumps, rated at 37,500 gallons per minute, are used. The hot-well pumps are installed in duplicate, and a single rotary dry-vacuum pump is provided for each unit sufficiently large to handle the dry air from two units, being cross-connected for the purpose.

Results of Tests.

The results of 25 tests are tabulated below and shown by the curves in the diagram. In conducting these tests certain standard conditions under which guarantees had been made were maintained. The data as given have been corrected to such standards, which the authors of the Paper state represent average of operating practice. Attention is called to the following particular features of the curves and data :—

1. With due allowance for the scale of the ordinates, the performance curves may be considered unusually flat, naturally conducive to high plant efficiency.

2. The dip in the curve between 22,000 kw. and 26,000 kw. is a peculiarity which was received at first sceptically, but which was later remarkably checked by repetition of tests that gave the average, including a special series under steady load made three months subsequent to the original series, and given below as Nos. 22-26 in Table I. Various theories have been advanced in connection with this dip, and a series of special tests was made to investigate the relative action of the receiver between the two cylinders as a separator, and the velocities of the steam passing through it, with the idea that this might have some direct bearing upon this dip. Unfortunately, winter load demands terminated further research.



Water Rate and Efficiency Curves for 30,000 kw. Unit.

3. The turning up of the efficiency curve between 30,000 kw. and 32,000 kw. is another peculiarity, accounted for by the turbine designer as follows :—

"Concerning the turning up of the efficiency curve, consideration and figuring indicate that this is actually not an inconsistency, but a new experience. This turbine was designed for higher hydraulic efficiency than probably any machine heretofore built, thus approaching the crest of the efficiency curve. The overload capacity of the machine is small, or, in other words,

* Abstract of a Paper read before the Am. Society Mech. Engs. from the "Electrical World," slightly abbreviated.

Table I.—*Summary of Test Results for* 30,000 *kw. Cross-compound Steam Turbine Units of Interborough Rapid Transit Company.*

† Test No.	Abs. steam pressure at throttle, lb. per sq. in.	Steam temperature at throttle, °F.	Superheat, °F.	Abs. steam pres. primary inlet, lb. per sq. in.	Abs. steam pres. exhaust H.P., lb. per sq. in.	Abs. steam pres. inlet L.P., lb. per sq. in.	Exhaust vacuum, in Hg.	Exh. pres. referred to 30 in. bar, 58·1°F. in Hg.	Load average, kw.	Water per hour, lb.	* Water rate, lb. per kw.-hour.	Rankine* cycle efficiency, per cent.	Thermal* efficiency, per cent.	From Graphic load chart: Ratio of max. load range to average load.	From Graphic load chart: Ratio of av. load range for 2·5 min. periods to av. load.
1	224·3	493·2	101·6	148	10·6	10·2	28·411	1·589	16,342	192,350	11·770	72·540	23·72	65·5	37·2
2	223·3	486·8	95·8	144	11·8	10·0	28·52	1·48	16,447	194,431	11·822	72·222	23·62	63·8	37·7
3	224·1	485·7	94·2	166	...	11·0	28·539	1·461	18,158	212,029	11·677	73·118	23·91	56·2	31·3
4	223·3	489·6	98·4	159	11·8	11·5	28·471	1·529	18,273	212,330	11·620	73·476	24·02	69·5	38·6
5	222·6	496·5	105·7	163	11·8	10·8	28·588	1·412	18,317	213,976	11·682	73·086	23·90	56·8	34·7
6	220·4	510·9	121·0	175	12·7	12·0	28·586	1·414	20·472	234,930	11·476	74·400	24·33	34·2	18·6
7	219·8	519·3	129·5	182	12·8	12·5	28·683	1·317	21,925	250,407	11·421	74·757	24·46	51·1	17·1
8	221·8	518·8	128·0	185	13·5	12·8	28·791	1·209	22,150	253,388	11·439	74·630	24·41	49·2	19·0
9	221·1	501·5	111·2	187	...	13·0	28·744	1·256	22,432	256,716	11·444	74.606	24·41	37·9	20·4
10	221·3	513·9	123·5	194	14·2	14·1	28·902	1·098	24,137	274,971	11·392	74·947	24·52	37·7	15·3
11	220·3	512·9	123·0	196	13·7	13·6	28·882	1·118	24,200	275,593	11·388	74·973	24·52	29·3	13·1
12	220·3	496·8	106·8	197	14·6	14·1	28·896	1·104	25,170	285,184	11·330	75·357	24·63	30·6	13·0
13	217·9	524·3	135·2	211	14·5	14·7	28.761	1·239	26,153	295,373	11·294	75·597	24·72	33·3	11·8
14	224·0	500·0	108·5	215	...	15·0	28·862	1·138	26,740	301,035	11·258	75·840	24·81	...	...
15	221·6	510·0	119·5	210	16·5	15·9	28·862	1·138	28,378	323,353	11·395	74·928	24·51	41·2	13·0
16	220·0	155·5	125·6	211	16·6	16·2	28·812	1·188	28,517	325,072	11·399	74·901	24·49	22·8	7·7
17	220·3	513·0	123·0	210	16·5	16·8	28·78	1·22	30,232	344,787	11·405	74·862	24·48	25·1	10·1
18	217·2	518·0	129·1	206	17·3	17·2	28·801	1·199	30,397	348,018	11·449	74·574	24·39	27·0	9·1
19	217·1	515·4	126·6	212	18·5	18·5	28·623	1·377	31,986	364,280	11·389	74,968	24·52	18·1	7·7
20	218·2	519·5	130·4	209	17·6	18·2	28·75	1·25	32,348	366,572	11·332	75·343	24·64	14·2	7·7
21	216·3	513·3	124·9	209	18·1	18·9	28·765	1·235	32,490	370,335	11·398	74·908	24·52	...	...
22	222·8	518·0	127·0	182	13·9	13·0	28·55	1·45	21,610	246,661	11·414	74·733	24·42	...	...
23	224·0	508·0	116·5	186	14·2	13·3	28·53	1·47	21,800	250,134	11·474	74·412	24·35	...	...
24	222·9	512·0	121·0	194	14·8	13·9	28·92	1·08	23,890	272,335	11·400	74·824	24·48	...	...
25	223·1	515·4	124·3	213	16·2	15·1	28·85	1·15	26,505	298,810	11·274	75·660	24·79	...	...

* As corrected to 215 lb. per square inch or 15·1 kg. per square centimetre abs. press. ; 120°F. superheat ; 29 in. Hg. (736·6 mm.)
† Duration of each test was three hours.

Table II.—*Condenser Test, Summary of Results.*

Pressure at throttle (lbs. per square inch)	220
Temperature at throttle (°F.)	487
Superheat (°F.)	97
Load (average kilowatts)	31,233
Exhaust vacuum (inches mercury)	28·61
Exhaust pressure (inches mercury absolute)	1·39
Corresponding temperature (°F.)	89·4
Mean temperature difference (°F.)	12·9
Heat transferred per hour (B.T.U.)	316,000,000
Heat transferred per unit surface per hour (B.T.U. per square foot)	6,330
Heat transferred per unit surface per hour per degree mean temperature difference (B.T.U. per square foot)	490
Air leakage (cubic foot per minute)	16·88
Condensate (lb. per hour)	357,060
Temperature of hot well water (°F.)	86
Temperature of intake water (°F.)	70·8
Temperature of discharge water (°F.)	80·9
Rise (°F.)	10·1
Circulating water (gallons per minute)	64,700

the amount the turbine is by-passed when the secondary valve opens is small, and the velocity ratio, therefore, is very little lower when full steam pressure is applied to the secondary inlet than when such pressure is applied to the primary inlet. Further, the hydraulic efficiency is nearly the same, so that the Rankine cycle at 32,000 kw. should not be more than 1 per cent. lower than at the point of best efficiency—namely, 26,000 kw. The efficiency at the intermediate overload—say 30,000 kw.—is somewhat worse than this, for while the blading and hydraulic efficiencies remain as high there is a loss due to a certain portion of the steam expanding through the secondary valve to a lower pressure without doing work."

A number of tests were made upon the condensers, auxiliaries, separate and individual, guarantees having been made upon the condenser proper, circulating pumps, dry-vacuum pumps and hot-well pumps. The results of the tests upon the condenser are given in Table II. The guarantees were based upon operation under maximum load—namely, about 32,000 kw.—and the test was made with the turbine carrying as near that load as was possible. The duration of this test was three hours, and the preliminary operation under test conditions was half an hour. No corrections were made in this test, as operating conditions approximated the guaranteed conditions very closely, with the exception that air leakage was high. The tests were made very shortly after the installation of the machine, and little opportunity had been given under operating requirements properly to eliminate this leakage, which has since been done. A permanent gasometer has recently been installed in connection with each unit in order to observe air leakage at regular intervals.

In summarising the results of these tests, the authors stated that the performance in the case of both turbine and condenser showed higher efficiencies than was guaranteed under contract, and the installation has proved to be thoroughly satisfactory in every particular, having fully realised the considerations which governed the selection.

Before the reading of the Paper, Mr. H. G. Stott reviewed the evolution of steam station design since 1900. The station then housed eight Reynolds Allis-Chalmers steam engines of a double combination horizontal-vertical cross-compound design. Each unit was rated at 5,000 kw., with a maximum rating of 7,500 kw. In a space no greater than taken by one of these units a 30,000 turbine unit now stands, operated from the same boilers, now equipped with underfeed stokers and superheaters to give 200° F. of superheat when the boilers are delivering three times their rated output. The boiler pressure is 205 lb. per square inch gauge. The steam engines operated originally on 175 lb. gauge and no superheat. Mr. Stott called attention to the comparison in investments represented by the two types of installations, the cost of engines, generators and condensers being £8 per kilowatt, while the cost of the new turbines and condensers is £1. 8s. per kilowatt. The steam engine water-rate was 17 lb. per kilowatt-hour, as compared with about 11·4 for the turbines operating under similar load conditions.

To enable the reader to compare the actual with the guaranteed performance, we give the latter in the following table:—

Kw. load.	Lbs. of steam per kw.-hour.	Rankine cycle efficiency.	Kw. load.	Lbs. of steam per kw. hour.	Rankine cycle efficiency.
		Per cent.			Per cent.
15,000	12·07	70·73	24,000	11·30	75·56
16,000	11·94	71·51	25,000	11·27	75·76
18,000	11·77	72·54	26,000	11·32	75·42
20,000	11·54	73·98	28,000	11·47	74·44
22,000	11·40	74·89	30,000	11·63	73·41

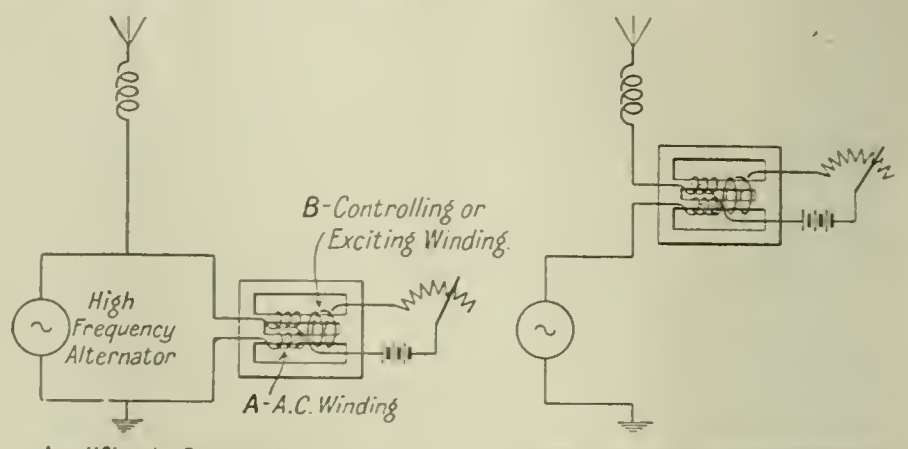
These figures were given by Mr. M. C. McNeil in the "Electric Journal," June, 1915.—Eds. *E.*

MAGNETIC AMPLIFIER FOR RADIOTELEPHONY.*

BY E. F. W. ALEXANDERSON AND S. P. NIXDORFF.

Summary.—An apparatus is described which makes possible radiotelephony and radiotelegraphy on a large scale. It is of the nature of magnetic valve throttling the flow of power from the alternator so that it can be modulated for telephone work.

The magnetic amplifier, constructed as shown in Figs. 1 and 1A, was developed as an accessory to an alternator in order to take advantage of the better mechanical construction of a solid steel rotor and yet produce the results that could be obtained by field control in a machine with completely laminated magnetic circuit. The



FIGS. 1 AND 1A.—COMBINATION OF ALTERNATOR AND AMPLIFIER IN ITS SIMPLEST FORMS.

aggregate of the constant field alternator and the stationary controlling device has, as will be shown, the effect of a machine with variable field excitation. This analogy refers not only to the proportionality between excitation and E.M.F., but to such phenomena as self-excitation and instability. It is shown that the winding B produces no voltages but influences the permeability. If, on the other hand, a current flows in the other winding which gives a magnetomotive force, equal and opposite to the first, the iron is rendered magnetic again. Inasmuch as the two branches of winding A are relatively opposite to winding B, one branch will oppose the ampere-turns of winding B on one-half cycle and the other branch during the next half cycle.

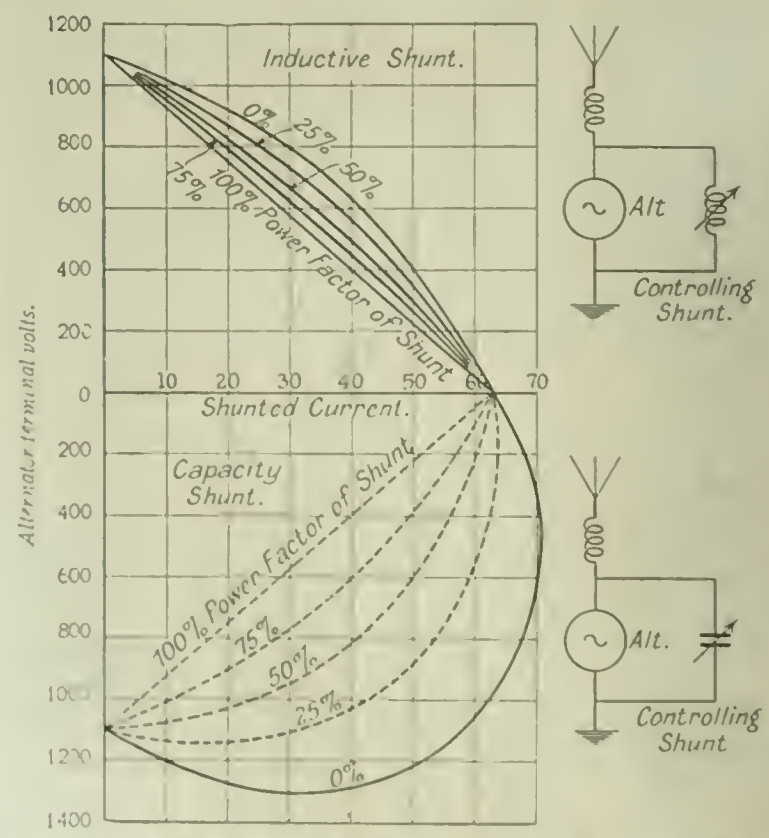


FIG. 2.—CHARACTERISTICS OF ALTERNATOR WHEN CONTROLLED BY VARIABLE SHUNT IMPEDANCE.

When the magnetic amplifier is used in shunt to the alternator (Fig. 1), it has the immediate object of controlling the voltage rather than the current. The combined characteristics can be derived from the characteristics of the alternator when operating on an antenna and at the same time controlled by a variable shunt across its terminals, as shown in Fig. 2.

As indicated in Figs. 1 and 1A, it is possible to connect the amplifier either in series or in shunt to the alternator. Of these two

* Abstract of a Paper read before the Institute of Radio Engineers.

arrangements the shunt connection is preferable because the effect of the amplifier on the alternator is the same as if the E.M.F. of the alternator in the antenna circuit had been reduced, whereas the amplifier in the series connection does not influence the E.M.F. in the antenna circuit but changes the tuning of the antenna. The result of this change in antenna tuning has an undesirable effect upon the speed characteristics of the alternator, because it is found, upon further analysis, that the control does not become effective unless the alternator is operated on the upper or unstable side of the tuning curve of the antenna. If the alternator, on the other hand, is operated on the stable side of the tuning curve, the change in tuning partly neutralises the intended controlling effect.

Ratio of Amplification.—The method of arriving at a theory for the ratio of amplification can be perhaps best explained by a mechanical equivalent: If a throttle valve was to be opened and closed 1,000 times a second, the moving parts would absorb considerable energy. In analogy with this we must ask ourselves, what is the corresponding inertia in our magnetic valve which we must overcome in opening and closing it at the rate of a telephone current. The answer is: The inertia is the energy stored by the change of the magnetic field. The wattless flow of energy is proportional to the energy per cycle and the number of times per second the energy must be delivered and returned. It can, therefore, be said that the ratio of amplification is proportional to the ratio between the frequencies of the radio current and the controlling current.

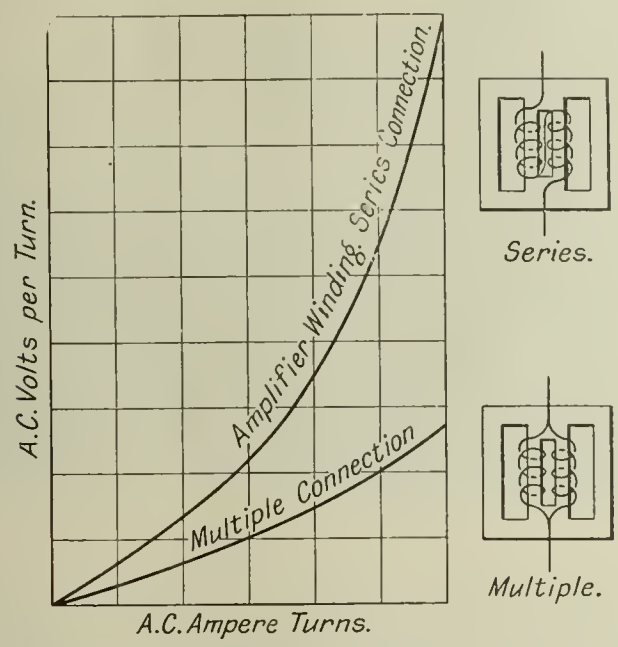


Fig. 3.—Comparative Volt-ampere Curves with the same Direct-current Excitation.

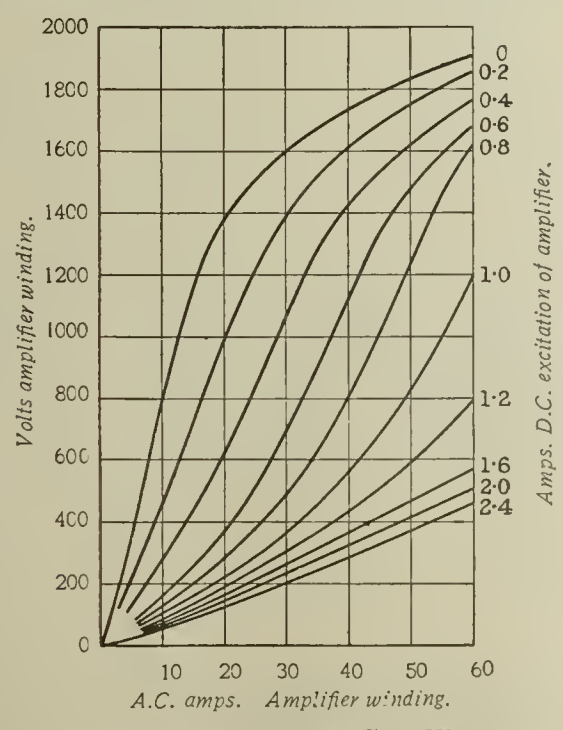


Fig. 4.—Characteristics of Amplifier Coil Windings in Multiple.

The object of the magnetic amplifier when used for radiotelephony is not only to control the radio energy but to produce a telephone current in its true shape.

Magnetic Theory and Characteristics.—The magnetic amplifier can be operated in two ways, as indicated by the diagram of Fig. 3. In one case when the two alternating-current windings are in series, the current in both windings is definite and the flux in the corresponding branches of the core adjusts itself accordingly. In the second case, when the two alternating-current windings are connected in multiple the current in each winding is not immediately obtainable, because a cross-current of a strength not yet defined may flow between the two windings.

The characteristics of the amplifier winding in series and multiple connection as obtained from tests is shown in Fig. 4. These curves show that the multiple connection gives a lower curvature and a lower impedance. For zero direct-current excitation it is evident that the volt-ampere curves for these two connections must be identical. It thus follows that the change of impedance corresponding to a given direct-current excitation is greater with the multiple connection. In this connection there are, however, some other considerations.

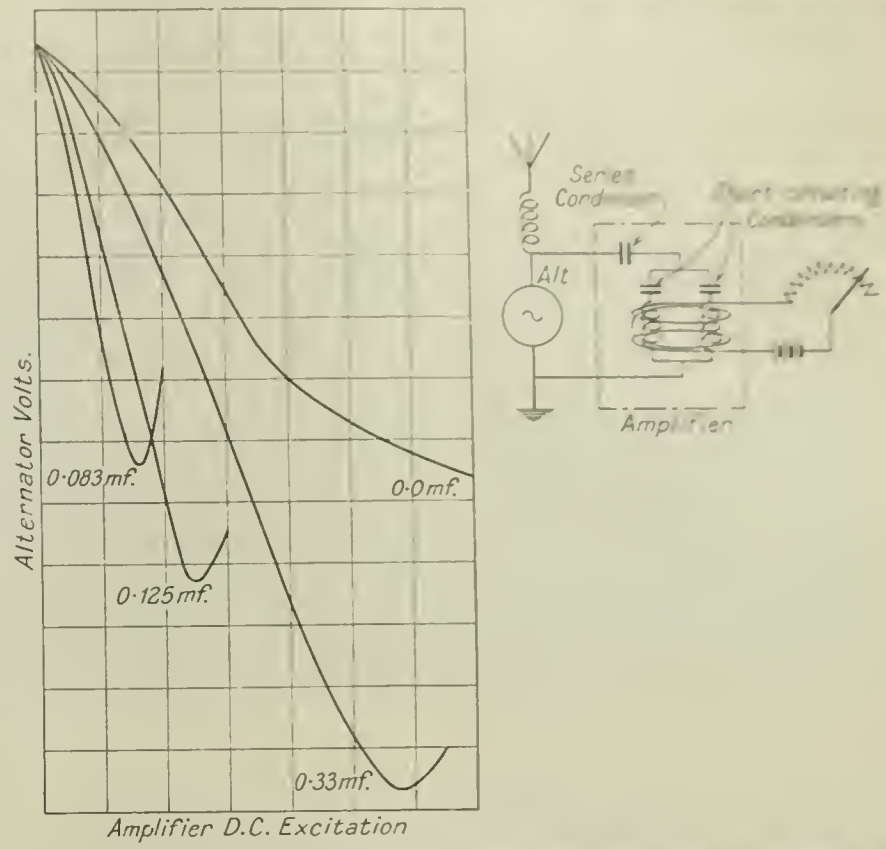


Fig. 5.—Curves Obtained from Test Showing Sensitiveness of Alternator Voltage Control with Different Series Condensers.

Object of Short-circuit Condenser.—In the multiple connection the flux variations are forced as already explained by the short-circuit that is formed between the two multiple coils. The induced current in this short-circuit tends to oppose any changes in the average flux, and thus a telephone current in the controlling winding would simply cause a corresponding short-circuit current between the two alternating-current coils without producing the desired flux variations. Since it operates at radio frequencies it is possible to find a condenser such that it acts as a short-circuit for radio currents and open for telephone currents. The arrangement is shown in Fig. 5.

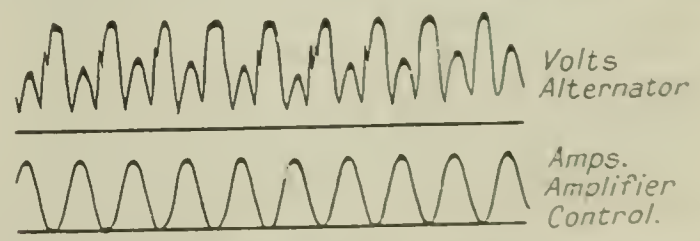


Fig. 6.—Oscillograms Showing the Effect of Departure from Linear Proportionality and Consequent Distortion of Wave Shape.

Combination of Alternator and Amplifier.—In order to demonstrate how the magnetic amplifier can be used for controlling the voltage of an alternator, reference may again be made to the alternator characteristics, as shown in Fig. 2. The volt-ampere characteristics of the amplifier are shown in Fig. 4. A magnetic amplifier may be used as a controlling device for radiotelegraphy. However, in this form, it is not well adapted for telephony because as shown by the curves the relation of volt-amperes and amperes excitation departs too far from the desired linear proportionality. Such proportionality can be obtained by the introduction of a series condenser, as shown in Fig. 5, while at the same time the sensitiveness of the amplifier is greatly increased so that a much smaller control current is needed. If the condenser is chosen so that it exactly neutralises the inductance

of the amplifier winding at some definite value of excitation, the resulting impedance at this excitation becomes a minimum and the impedance at any lower excitation is determined by the difference between the inductive reactance of the amplifier coil and the capacity reactance of the series condenser. The smaller this difference the lower will be the amplifier excitation that gives minimum impedance, and the corresponding minimum of the alternator voltage. This means that the sensitiveness of the amplifier is increased because a smaller excitation is needed to reduce the alternator voltage. Fig. 5 shows from result of test the variations of alternator voltage that can be obtained by different values of series condenser and the corresponding increase of the sensitiveness of the amplifier. The sensitiveness is represented by the steepness of the curves. It can be seen from the shape of these curves that the increased sensitiveness is gained at the expense of range of control or difference between maximum and minimum voltage. However, all the curves show a practically linear proportionality between excitation and voltage over almost the whole range available. The difference in sensitiveness with various series condensers is also illustrated in the Paper by oscillograms. The effect of departure from linear proportionality and the consequent distortion of wave shape is shown in Fig. 6. The ratio of amplification for operation suitable for telephone control ranges from 100:1 to 350:1.

Instability.—The voltage which results from the combination of alternator and amplifier can be determined as has been explained by the intersection of the alternator and amplifier characteristics. If the curves have such a shape that the alternator and amplifier characteristic curves become parallel in some place, the intersection becomes indefinite and the result is instability and generation of self-excited oscillations. This is a condition that must be avoided for telephone control, whereas, it may have useful applications for other purposes.

Shunt Condenser.—A further improvement in sensitiveness can be obtained by using a combination of shunt and series condenser. The shunt condenser is so proportioned as to make the amplifier take leading instead of lagging current at low excitation.

Applications of the Amplifier.—While a specific method of adapting the magnetic amplifier to an alternator as described above has been worked out both theoretically and experimentally in greater detail there are obviously a variety of possibilities for adapting the same devices and theories to other conditions. Outside of telephony the magnetic amplifier will probably be found of value as a non-arcing key for telegraphy and particularly will make possible high-speed telegraphy at the same rate and with the same means as high-speed automatic telegraphy on land lines. Oscillograph records have been taken of telegraphic control from 500 to 1,500 words per minute.

The structure and the mode of operation of the magnetic amplifier which has been described is such that there appears to be no limit to the power that might be controlled in this way if apparatus are designed with suitable dimensions.

THE SHILDON-NEWPORT RAILWAY ELECTRIFICATION.

(*Concluded from p.* 289.)

Locomotives.

The freight locomotives were designed and built at the North Eastern Railway locomotive works at Darlington, the electrical equipment being supplied and fitted by Messrs. Siemens Bros. Dynamo Works (Ltd.), Stafford. They are designed to haul trains weighing 1,400 tons at a speed of not less than 25 miles per hour on the level.

General Construction.—Fig. 22 shows the details and the general appearance of the engines, and below is a detailed description of the same. The work was carried out under the direct supervision of the chief mechanical engineer, Mr. Vincent L. Raven.

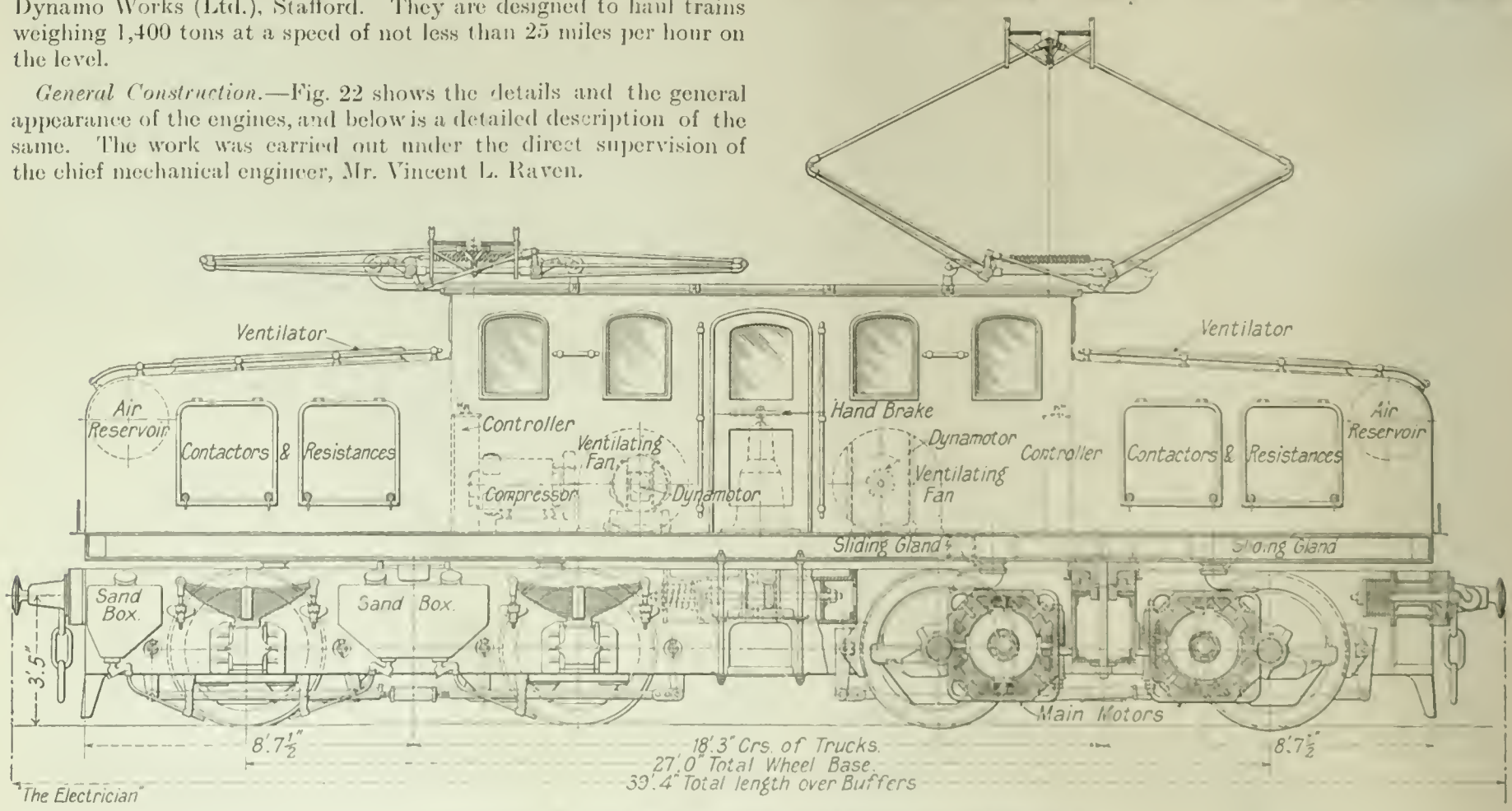


Fig. 22.—Part Sectional Side Elevation of Locomotive.

The engine may be described as an articulated truck locomotive, in which the tractive effort is transmitted through the truck frames. The cab with sloping ends is supported on the centre of each truck by a strong steel casting which embodies the centre pin bearing and side-rubbing surfaces. These castings are securely bolted and rivetted to the cab platform which consists of four beams secured to plates at the top and bottom. The transom between the truck frames at the centre is built up of plates and angles securely rivetted to the side frames of the truck. On the centre of the transom is a steel casting with which the centre bearing mentioned above engages. Rubbing pieces are fitted at each side which bear on the rubbing surfaces mentioned above. The centre pin at No. 1 end is a good working fit in its bearings on the centre of the transom. At No. 2 end provision is made for creeping up of the trucks when passing round curves, but no allowance for movement transversely.

The buffers are carried directly on the truck frames. The trucks are connected by means of a buffer coupling, and arranged for lateral movement with vertical rigidity, the coupling is made with a slotted hole for a draw bar to pass through. The trucks are securely held together by means of this draw bar and a spring, which can be adjusted (the compression of spring being $\frac{3}{8}$ in. per 7 tons load) to act as a connection between the two trucks. This spring cannot be subjected to heavy compression, resulting from buffing action, as the buffer part of the coupling between trucks receives the buffing stresses directly through the truck frames without subjecting the centre pins and platforms to any stresses other than those caused by the weight of the cab apparatus which rests on them.

The sloping ends are partitioned off from the cab and contain the resistances, contactors, motor cutout switches, multiple cutout switches and all high-tension electrical apparatus. Entrance to each sloping end can be obtained through doors which are normally locked.

The bow collectors on the roof of the cab are raised and maintained in connection with the contact wire by compressed air. A cock is fitted on the air system, the removable handle of which forms the key of the doors mentioned. This handle is so arranged that it can only be removed when the cock is in the exhaust position, so that it is impossible to open the doors of the sloping ends while the bows are in contact with the overhead wire

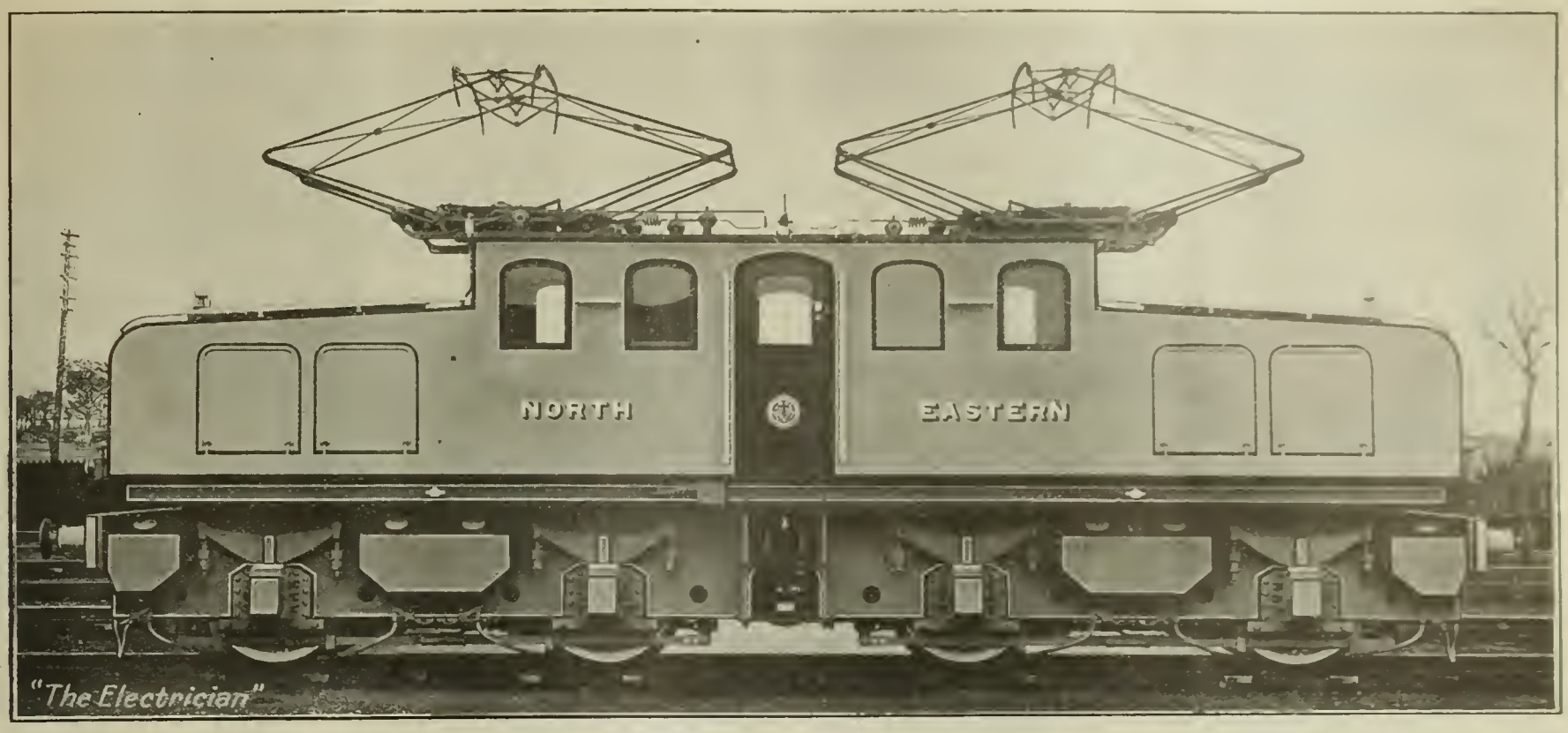


Fig. 23.—Side View of Locomotive.

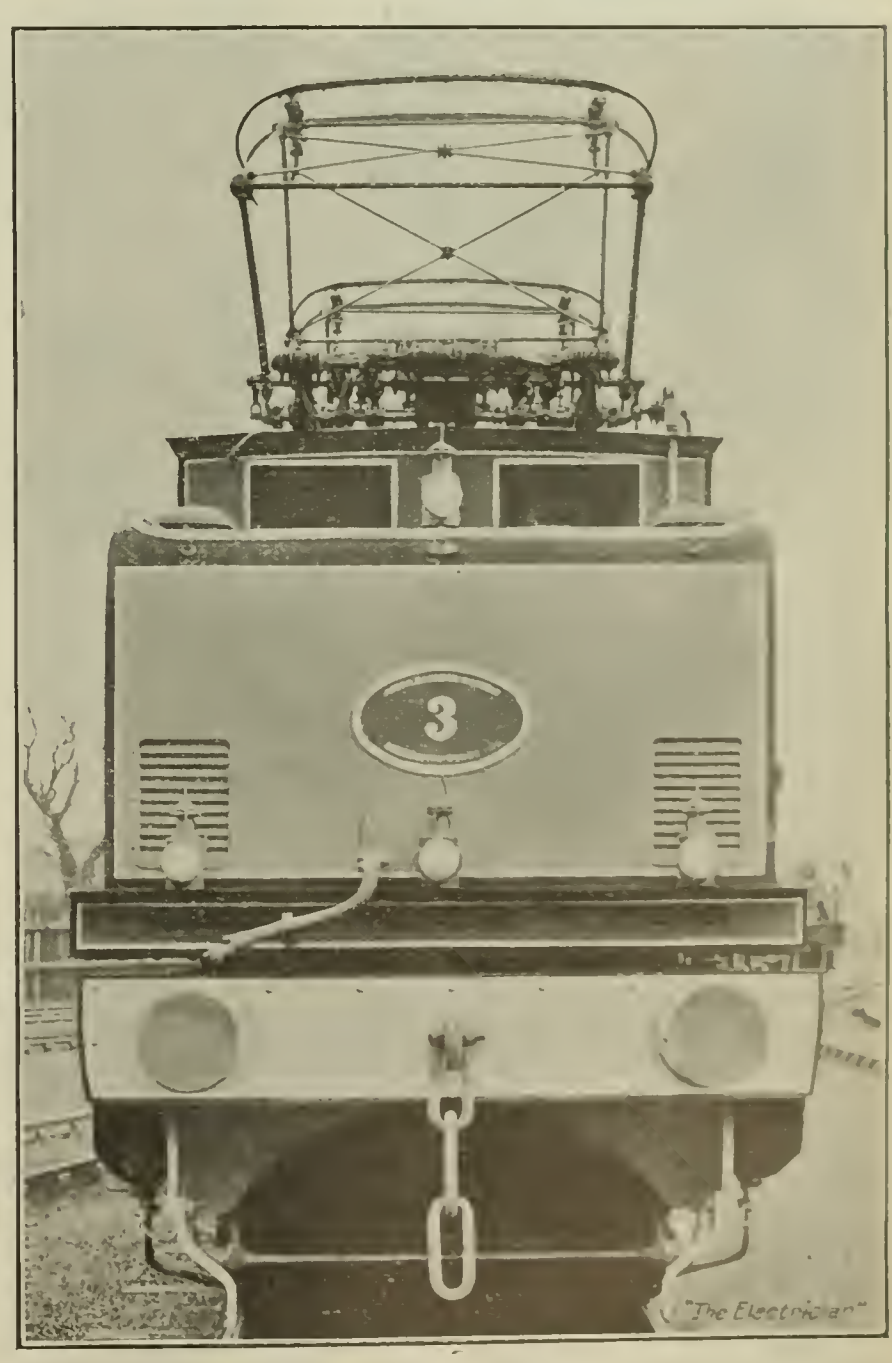


Fig. 24.—End View of Locomotive.

Dimensions and Particulars.

Weight of electrical equipment, inclusive of motors	24 tons 5 cwt.
Ditto, of mechanical parts	50 tons 3 cwt.
Ditto, of motors without gear wheels and gear cases	3 tons 3 cwt.
Ditto, with gear cases and gear wheels	3 tons 13 cwt. 24 lb.
Total weight of mechanical and electrical apparatus	74 tons 8 cwt.
Approximate height of centre of gravity	4 ft. 6 in.
Main dimensions of motors, axial length over windings	$24\frac{13}{16}$ in.
Ditto, over core	$11\frac{11}{16}$ in.
Ditto, diameter of armature	$21\frac{5}{8}$ in.
Ditto, diameter of commutator	$18\frac{7}{64}$ in.
Ditto, length of commutator	$7\frac{3}{8}$ in.
Ditto, number of segments	195
Ditto, air-gap	$\frac{1}{64}$ in.

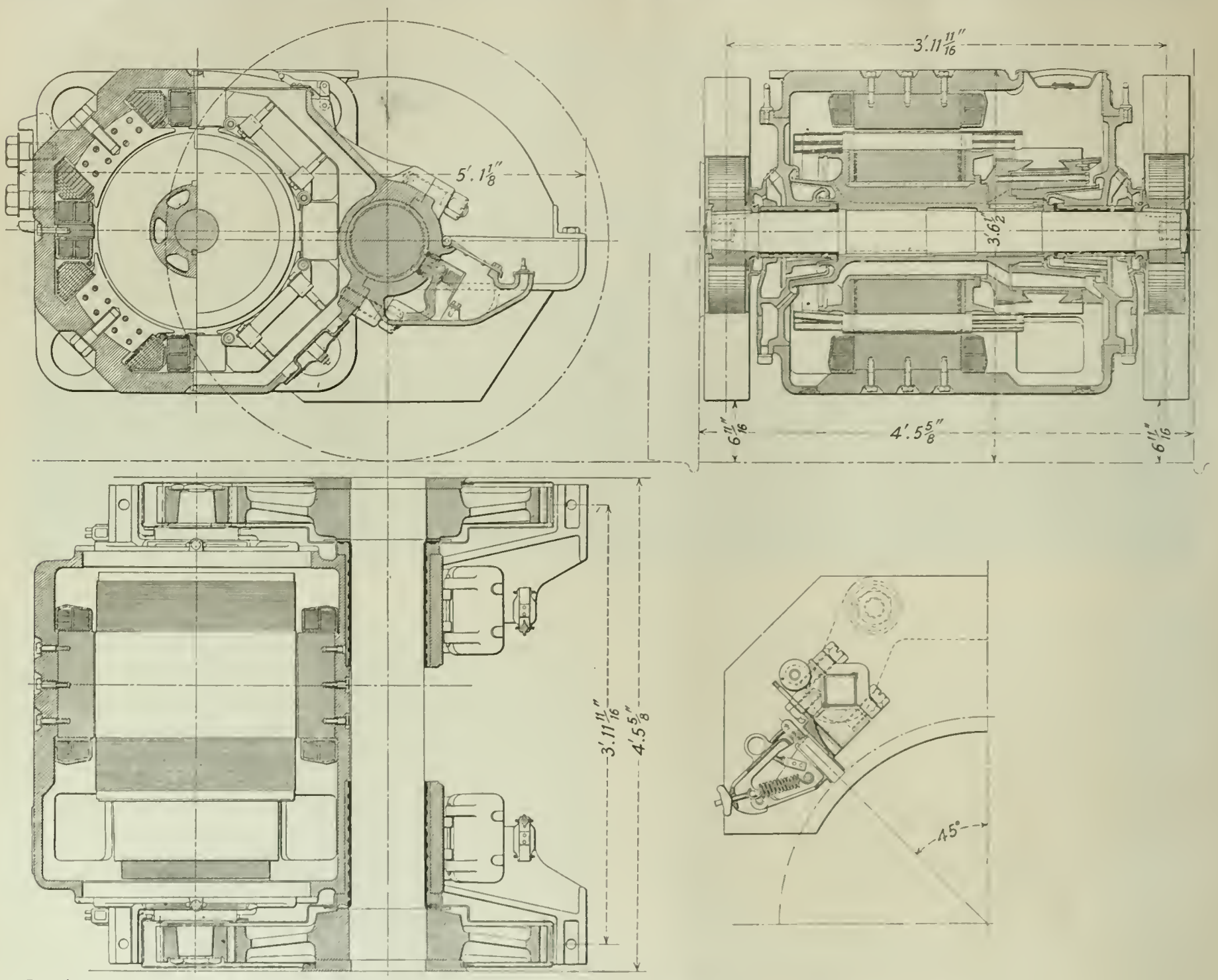
Speed of motors at normal loco. speed of 25 miles per hour—787 revs. per min.

Leading Dimensions of Mechanical Parts.

Length over buffers	39 ft. 4 in.
Height from rail to centre of buffers	3 ft. 5 in.
Height of cab roof from rail	11 ft. $6\frac{1}{4}$ in.
Height of trolley wearing strip from rail when down	13 ft. $1\frac{15}{16}$ in.
Width of trolley wearing strip over horn ends	5 ft. $10\frac{7}{8}$ in.
Width of cab	7 ft. $6\frac{1}{4}$ in.
Width over footplate	8 ft. 4 in.
Total wheel base	27 ft. 0 in.
Wheel base of truck	8 ft. 9 in.
Centres of trucks	18 ft. 3 in.
Diameter of wheels	4 ft. 0 in.
Diameter of wheel seat on axle	$8\frac{1}{2}$ in. $\times 7\frac{5}{8}$ in. long
Diameter of axle for spur wheel seat	$8\frac{5}{16}$ in. $\times 5\frac{1}{2}$ in. long
Diameter of journals	$6\frac{3}{4}$ in. $\times 13$ in.
Motor suspension bearings on axle	$7\frac{7}{8}$ in. $\times 13\frac{13}{16}$ in.
Springs—laminated	3 t. 6 in. span, 18 plates 4 in. $\times \frac{1}{2}$ in.

Cab and sloping ends constructed of steel channels, plates and angles.
Under structure 8 in. $\times$ 6 in. beams, 8 in. $\times 3\frac{1}{2}$ in. channels, and $\frac{1}{2}$ in. plates.
Trucks—articulated.
Truck frames—steel plates $1\frac{1}{4}$ in. thick.
Truck drag plates—flanged plates riveted up securely to frame plates.
Truck transom—built of plates and angles (steel), cast steel centre piece fitted on centre to receive centre pin on under structure, also side bearers.

In the cab two master controllers are fitted, one at each end. The cab also contains all auxiliary switches for controlling the air compressor and the two dynamotors described later, and for lighting and heating. It further contains the control valves for the Westinghouse brake and for air sanding. In the centre of the cab there is a vertical hand wheel for the hand-brake.



"The Electrician."

Fig. 25.—Section Views showing General Arrangement of Main Motor and Gears.

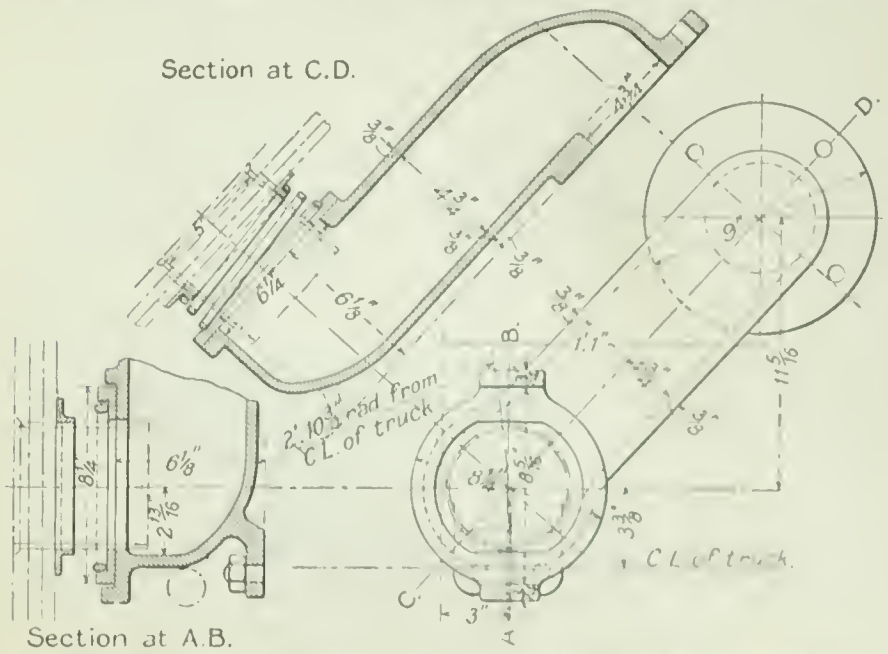


Fig. 26.—Detail of Special Sliding Gland on Ventilating Box.

The dynamotors are securely fixed to the floor, the switches, &c., being fixed on the sides of the cab and weather boards.

Motors.—The motor equipment of each locomotive consists of four totally enclosed motors, each driving an axle through single-reduction twin-gearing. The gears are machine cut with straight teeth of the involute pattern, the face dimensions of the spur wheels and pinion being $3\frac{15}{16}$ in.

A pinion is mounted on each end of the armature shaft, and meshes into a corresponding gear wheel mounted on the running wheel axle, the gear ratio being 1 to 4·5. Fig. 25 shows a section of the motor and gears, the running wheels being shown dotted.

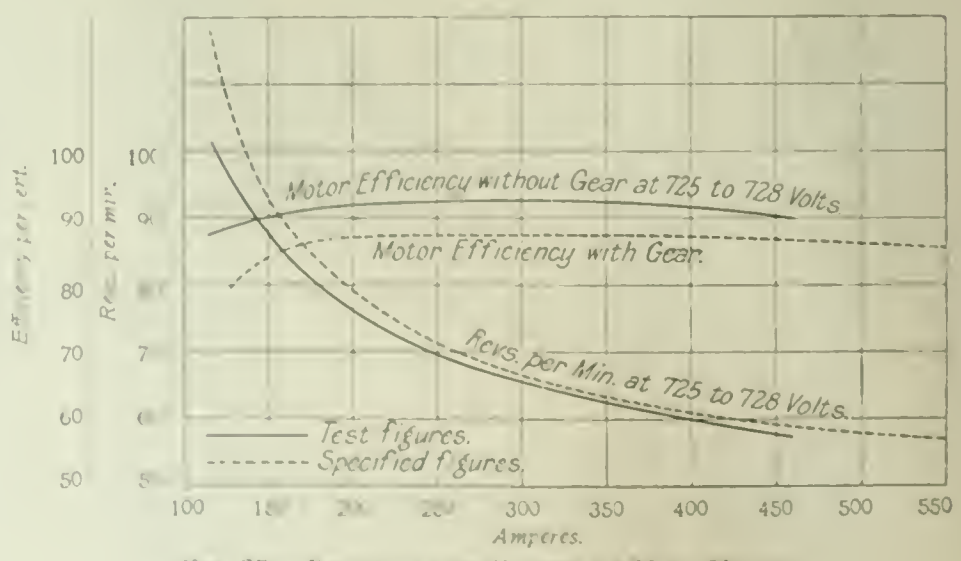


Fig. 27.—Performance Curves of Main Motor.

The motors are suspended by means of a cross-beam suspension bar with bearings and re-action springs. These with the motor suspension bearings on the axle, provide the motors with four points of suspension.

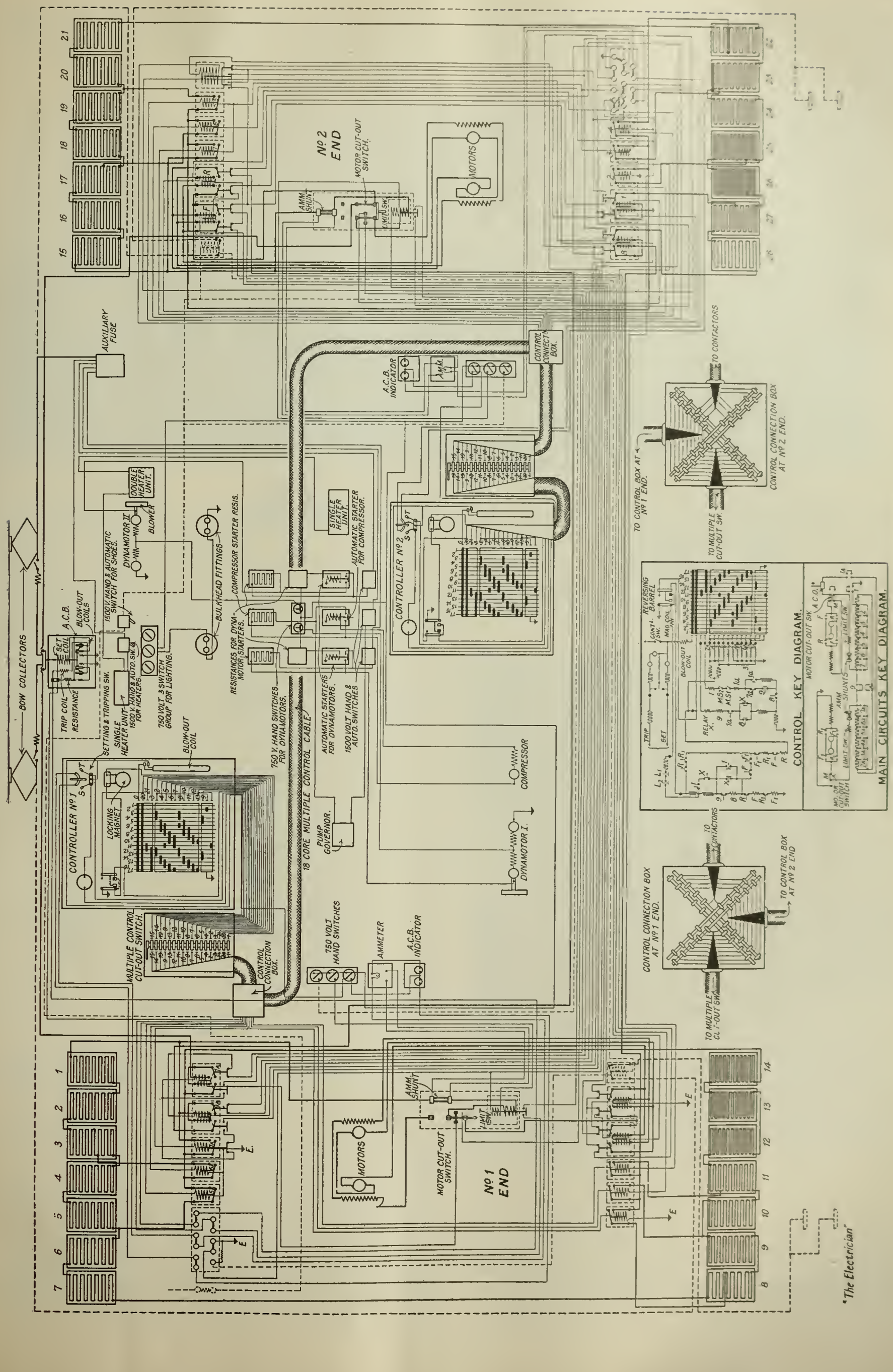


FIG. 28.—DIAGRAM OF CONNECTIONS FOR LOCOMOTIVE.

The gearing is enclosed in a welded sheet-iron case fitted with sight doors, so that the condition of the gears can be regularly examined. A novel feature is the ring lubrication on the armature shaft, shown in Fig. 25. The suspension bearings on the wheel axle have syphon wick lubrication.

The four main motors are fitted two in each bogie, and are each wound for 750 volts, the pair of motors in each bogie being connected permanently in series. The four main motors of each locomotive thus form two units which are controlled on the usual series parallel system.

Each motor is capable of developing 275 B.H.P. at a speed of 20 miles for one hour with forced ventilation. The motor equipment is capable without injury of exerting a torque sufficient to skid the wheels under any conditions of rail, and will exert an average pull of 28,000 lb. at the tread of the wheels when starting under normal conditions of rail. The maximum pull at the tread of the wheels is, of course, considerably greater than this.

gland above mentioned being fitted on this box. The air inlets to the fans are at the ends of the platform, a trough being formed in the cab under structure to convey the air from these inlets. Provision is also made to draw air to the fans from the cab if necessary. The normal quantity of air passed through each motor case is 700 cubic ft. per minute.

Fig. No. 27 gives the performance curves of these motors as ascertained from shop tests.

Control Equipment.—The general arrangement of the control wiring is shown in Fig. 28, to which is also attached a key diagram. Two master controllers are fitted in the cab, one at each end. Notching up can either be carried out by hand or automatically. The automatic arrangement consists of a spring which is wound up by the controller handle, the speed at which the controller drum follows the handle being governed by a step-by-step escapement movement.

The maximum current taken at each step is limited by a limit switch fitted in the sloping ends of the cab, which on the current

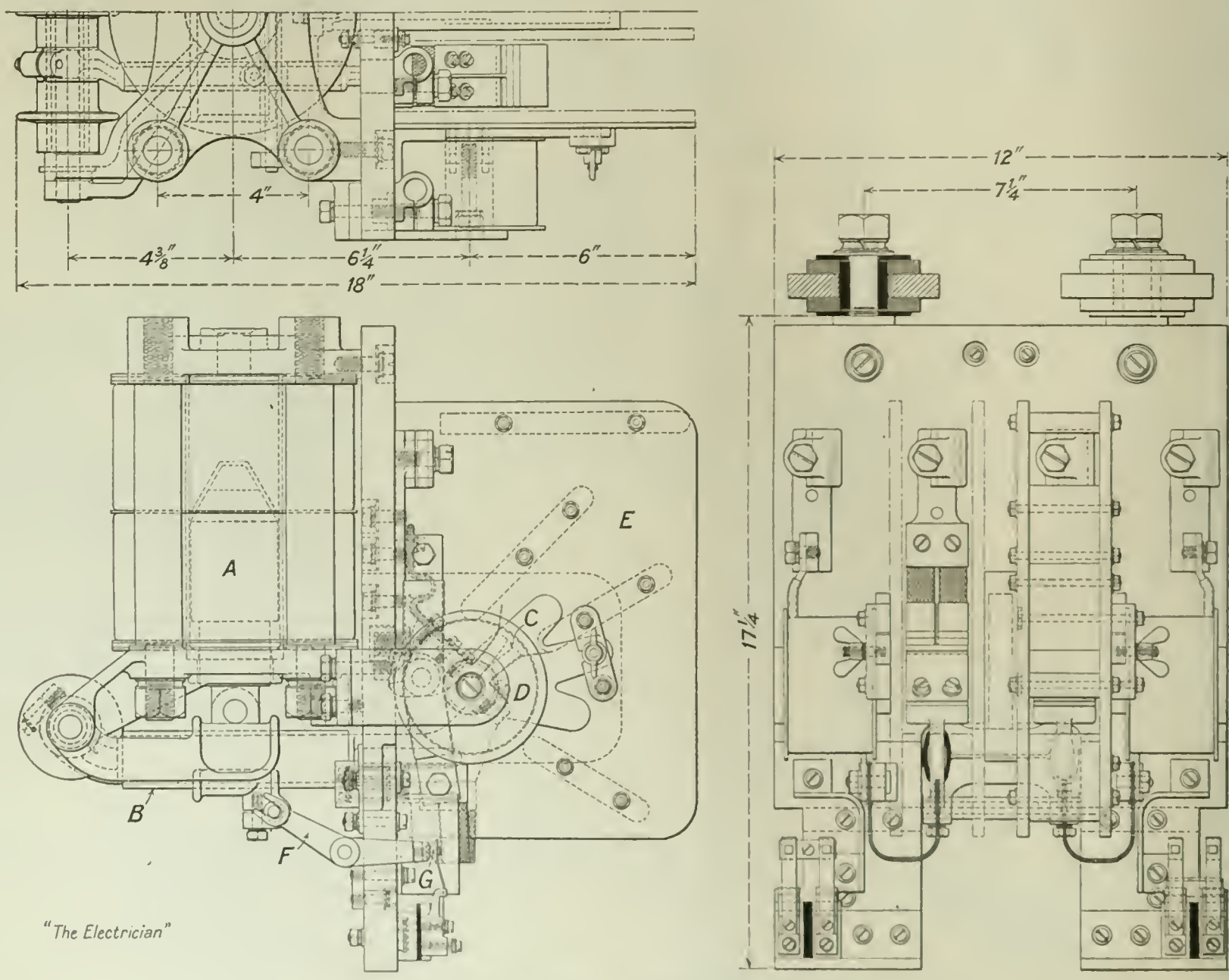


Fig. 29.—General Arrangement of Contactor.

A—Solenoid. B—Contactor lever. C—Main contact. D—Magnetic blow-out coil. E—Arc shield. F—Interlocking contact lever having contact at G to ensure correct sequence of contactors.

The motors and gearing are designed so as to run at a speed of 45 miles per hour without exceeding the limits of safety, but the normal speed on the level when hauling a train of 1,400 tons is 25 miles per hour. The equipment is so designed that each locomotive is capable of performing four round trips in 12 hours, each consisting of a trip from Shildon to Newport with a train of 1,400 tons, followed by a trip from Newport to Shildon with a train of 800 tons, the distance of each trip being about 18 miles. The locomotives are able to start a train of 800 tons from rest on a grade of 1 in 100 and accelerate to normal running speed.

The air supply for ventilating the motors is supplied from fans driven by the dynamotors, which are described later, but a special feature is shown in Fig. 26. In order to avoid the use of a flexible pipe between the fan air duct in the base of the cab structure and the motors a special form of spring sliding gland is employed.

The fans furnish air to the motors at low pressure through pipes to a box fitted between the top and bottom plates of the platform, the

rising beyond a predetermined limit, closes the circuit of a small magnetic interlock, which locks the escapement mentioned, holding the drum of the controller until the current has fallen to the required value.

In addition to the above, by means of a catch inside the controller, which when lifted disconnects the spring and escapement action, the automatic arrangement described can be thrown out of action, and notching performed by hand.

An acceleration switch is also provided, so that in special circumstances the adjustment of the limit switch mentioned can be altered by short-circuiting the turns of an opposing coil, thus allowing of a larger current for accelerating under special conditions.

Each master controller is fitted with the usual reversing barrel, the handle of which can only be removed when in the "off" position. When left in this position the reversing handle locks the main handle. There is also fitted on the master controller a small spring switch by means of which the automatic circuit-breaker on the loco-

motive can be tripped or set. This switch is also locked by the reversing handle in the " off " position.

Current for operating the whole of the control circuits and the lighting and heating in the cab is supplied from either of the dynamotors at a pressure equal to half the line voltage.

An automatic governor is provided for the compressor, and is so arranged that the motor circuit is opened when the air pressure rises to 100 lb. per square inch, and closes again when the pressure falls to 80 lb. per square inch.

Two bow collectors are provided on each locomotive. These can

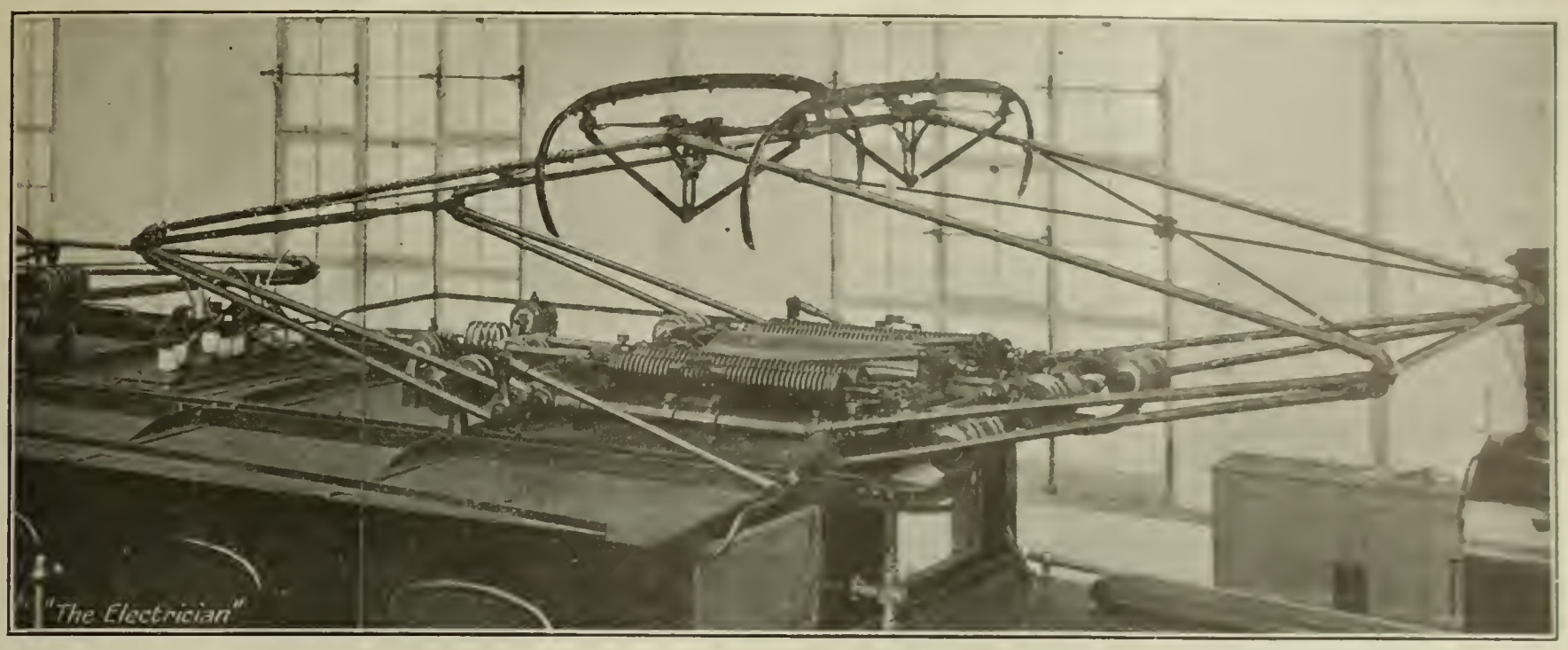


Fig. 30.—Side View of Bows.

Accessory Apparatus.—The contactors shown in detail in Fig. 29 are electrically operated, and are also fitted with auxiliary interlocking contacts to ensure their operating in the correct order.

The resistances, which are of the usual cast-iron grid-type, are fitted in the sloping ends, but are partitioned off from the other apparatus in these compartments.

As can be seen from Fig. 24, louvered openings are fitted at each end of the locomotive providing natural ventilation for the resistances through rainproof air vents on the top of the sloping ends.

The main automatic circuit-breaker is fitted on the roof of the cab, and controls the current to the traction motors. This circuit-breaker is fitted with horned spark gaps, which project through the roof of the cab, as can be seen in Figs. 22 and 23. The circuit-breaker is operated either by means of the set-and-trip switch on the master controllers as mentioned, or by means of a mechanical hand-trip fitted on the circuit-breaker case. The circuit-breaker, however, can only be closed by the set-and-trip switch on the master controller. Red and green lamps are provided to indicate whether the circuit-breaker is set or tripped. An illuminated dial ammeter is provided at each end of the cab in front of the driver.

As mentioned above, two independent dynamotors are fitted in the cab of each locomotive. The armatures of these machines are double wound and fitted with two commutators, the commutators being connected in series across the full line voltage. The control circuit is tapped off between the centre point and earth, so that current is obtained for these circuits at approximately half line voltage. The actual voltage when supplying the control circuits, and about 1 kw. for lighting is about 710 volts. The speed is 1,500 revs. per min.

The shaft of each dynamotor is extended and fitted with a fan, each fan supplying ventilating air to the pair of main motors on one bogie. The rated continuous output with a 50°C. temperature rise is 4·5 kw.

Each dynamotor is controlled by an ironclad circuit-breaker and a no-arc fuse. A starting resistance is in circuit with each machine, the resistance being automatically short-circuited by a relay a few seconds after this circuit-breaker is closed.

A motor-driven air-compressor is fitted in the cab of each locomotive for supplying air for the Westinghouse brake equipment, air sanding, raising the bow collectors and for air whistles. The machine is capable of dealing with 50 cubic ft. of free air per minute and of raising this to 100 lb. pressure per square inch. The machine is run at full line voltage, and is coupled direct in the circuit of the collector bows on the line side of the main circuit-breaker, so that immediately on the bows being raised by the hand pump, as described later, the compressor starts up, pumping the air in the reservoir up to full working pressure. It is controlled by a circuit-breaker similar to those controlling the dynamotor circuits, a starting resistance being provided and short-circuited by an automatic relay in the same manner, but in this case the relay is fitted with a time-limit arrangement to extend the starting time.

be seen in position on the roof of the cab in Figs. 23 and 24. Each collector consists of a hinged pantograph built up of steel tubing, the whole being supported off the cab structure by strong corrugated insulators. Fig. 30 shows a side view of one of the collectors in position, and Fig. 31 shows a general view of the top of the cab, showing both bow collectors in position, one being collapsed, the other raised to the full extent. Each collector has two bows each

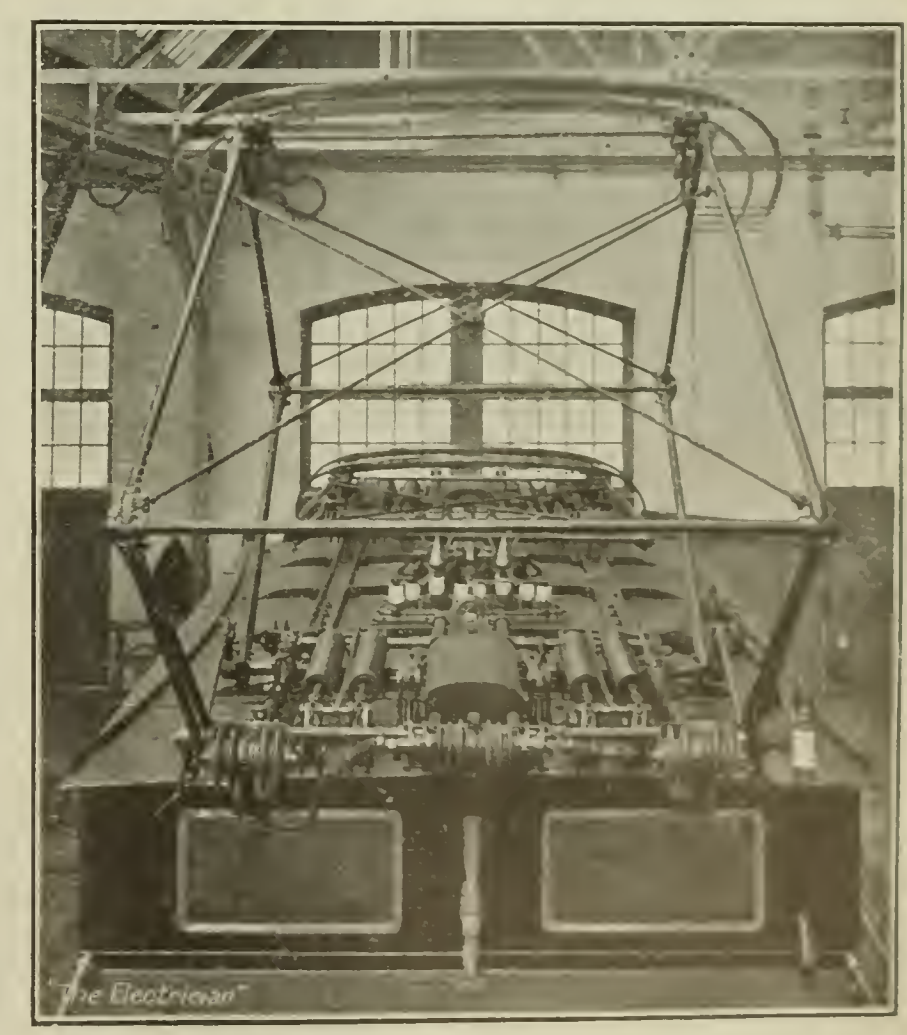


Fig. 31.—End View of Roof of Cab.

fitted with an aluminium rubbing strip making contact with the overhead contact wire. There are thus four rubbing strips per locomotive, which, with the double contact wire, makes eight points of contact. Each of the two collector bows on a pantograph is attached to it by two separate leaf springs, so that they provide for any small

irregularities in the level of the contact wire independently of the vertical movement of the pantograph itself.

A hand pump is provided by means of which the bows are raised at the commencement of the day's working if no pressure is available in the reservoir. By means of the control cocks in the cab, either one or both of the bows can be raised or lowered. Each pantograph is raised and maintained in contact with the overhead wire by means of an air cylinder, so that in the event of a failure of the air pressure the bows are automatically lowered. The air cylinders raise the pantographs through springs which can be seen in the photographs and which maintain an even pressure against the contact wire, notwithstanding variations in its height.

An existing engine shed at Shildon was adapted for the use of these locomotives, a sufficient portion being electrically equipped for the purpose.

An automatic circuit-breaker is provided controlling the whole of the shed equipment, and each engine stall is controlled by an independent isolating and earthing switch, so that work can be safely carried out on the roof of any locomotive without interfering with the operation of locomotives in adjacent stalls.

Tests have been carried out recently with one of the electric locomotives. Several journeys were made between Shildon and Newport, a train of 1,400 tons of laden wagons being taken down from Shildon to Newport and a train of 800 tons, consisting of 92 empty wagons, hauled from Newport up to Shildon with stops on certain of the heaviest grades. The 800-ton train was stopped and started on a grade of 1 in 103. The maximum drawbar pull during the tests reached 16 tons, the average speed on the run up from Newport to Shildon being 18·3 miles per hour, the maximum speed being 26 miles per hour. Up a grade of 1 in 230, which is 4½ miles long, the 800-ton load of empty wagons was hauled at an average speed of 23 miles per hour. The locomotive also proved capable of hauling the 1,400-ton train on the level at 26 miles per hour. The general operation of the locomotive proved satisfactory in all respects throughout the test.

The following is a list of the principal firms responsible for the carrying out of the work :—

Locomotives.—The North-Eastern Railway Co.

Electrical Equipment for Locomotives and the Overhead Track.—Siemens Bros. Dynamo Works (Ltd.), Stafford.

Steelwork and Brickwork for the Sub-station Buildings.—R. Blackett & Son, Darlington.

Cranes in Sub-stations.—Herbert Morris (Ltd.), Loughborough.

The 20,000-volt and 11,000-volt Overhead Transmission Lines and Cables Supplying the Sub-stations.—The British Insulated & Helsby Cables (Ltd.), Prescot.

Sub-station Plant and Switchgear.—The British Thomson-Houston Co. were the main contractors, the low-tension alternating-current and direct-current switchgear, the rotary converters and rotary converter starting gear being of their manufacture. A. Reyrolle & Co. were sub-contractors for the extra-high-tension switchgear, and the British Westinghouse Co. for the static transformers and transformers for the rotary converter.

The architect for the sub-station buildings was Mr. Arthur Pollard, architect to the North-Eastern Railway Co.

NOTES ON DESIGN OF ELECTROMAGNETIC MACHINES.

I. CONTINUOUS-CURRENT MACHINES.

BY STANLEY PARKER SMITH, D.Sc.

(*Continued from page* 282.)

Summary.—In the first part of the article the author deals with the principles underlying the design of continuous current machines, and in the second part he applies these principles to the design of a 350 kw., 500-volt generator running at 200 revs. per min.

4. Armature Windings for Continuous-current Machines.

It has been seen that the armature winding of a continuous-current machine must be distributed uniformly over the armature and closed. A uniformly distributed winding can be closely approximated by filling all the armature slots with a number of identical coils, arranged in two layers like tiles on a roof When coils arranged in this way form systems where the sum of all the pressures of fundamental frequency is always zero, they can be connected in mesh to form closed windings. This is done by joining coils in series, the finish of one coil, say, a, being connected to the start of another coil, say, b, and so on. The joints of the closed windings are then connected to a commutator, which must obviously have as many segments as there are joints or coils in the whole winding

For convenience in counting, it is customary to express the distance y_c between two successive coils a and b in the winding in terms of the number of commutator segments berween the start of the coil a and the start of the coil b. Expressed in this way y_c is called the commutator pitch, and must be a whole number. Two different arrangements of connections are produced according to whether the two successive coils a and b lie under the same pole-pair or under adjacent pole-pairs. In the former case we get the *lap* winding shown in Fig. 4, where y_c can be made any small number—1, 2, 3, &c.—but not zero.

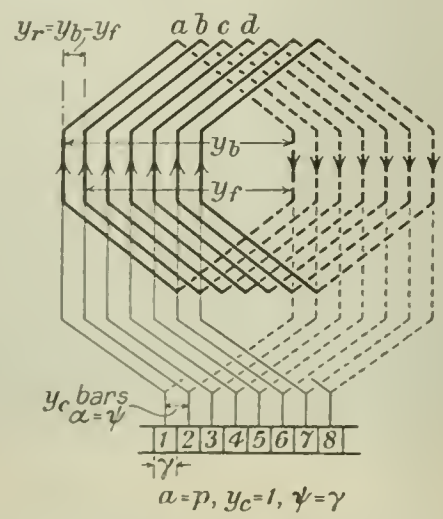


Fig. 4.—Lap Winding.

In the latter case we get the *wave* winding, shown in Fig. 5, where the span y_c must be somewhat greater or less than a double pole-pitch. If α denotes the angle corresponding with y_c, then in a lap winding α must not equal zero ; and in a wave winding α must not equal 2π. The arithmetic rules on which y_c depends are derived from equation (11).

If the double-layer winding is arranged with two coil-sides per slot, and all slots are filled. then the number of slots S will be obviously equal to the number of coils C in the winding. This ideal case, however, is seldom practicable owing to the large number of slots that would be needed. By making the number of coil-sides per slot $u=4$, 6, 8, &c., the number of slots is reduced to one-half, one-third, &c., or, in general, $C=Su/2$, when there are no idle coils. Each coil can have any number of turns T_c, but only one start and one finish.

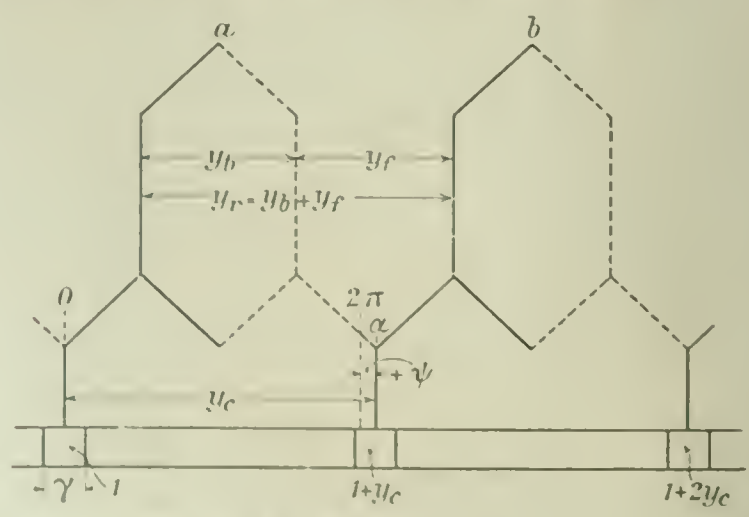


Fig. 5.—Wave Winding.

With closed lap and wave windings, it is possible to get many different numbers of circuits with the same number of poles, but experience has shown that very few of these are of use in practice owing to the stringent conditions imposed by commutation and heating, which necessitates making all parallel circuits identical.

Vector Diagram of Armature Winding.—To understand clearly the circuits in the winding of a continuous-current machine and the conditions for making them identical, it is sufficient to draw the vector diagram for the fundamental of the induced pressure.

For the fundamental in the flux curve B we have :—

$$B_{1x}=\overline{B}_1 \sin \theta_x.$$

Hence, the fundamental of the pressure induced in any coil will be (*see* equation 3) :—

$$e_1=T_c v L 10^{-8} \overline{B}_1(\sin \theta_x - \sin \theta_{x'}).$$

Now, $\theta_{x'}-\theta_x=$coil-span$=\pi \pm \varepsilon$,

where ε=amount in radians by which the coil-span is greater or less than a pole-pitch.

Then $$\sin \theta_{x'}=\sin(\pi+\theta_x \pm \varepsilon),$$
$$=-\sin(\theta_x \pm \varepsilon).$$

By substitution and expansion, we then get

$$\sin \theta_x - \sin \theta_{x'}=f_\epsilon 2 \sin \theta_{x''},$$

where $$\theta_{x''}=\theta_x \pm \varepsilon/2,$$

and $$f_\epsilon=\cos \varepsilon/2=\text{coil-span factor}.$$

Hence, $$e_1=2T_c v L 10^{-8} \overline{B}_1 f_\epsilon \sin \theta_{x''},$$

and the amplitude

$$\bar{e}_1=2T_c v L \overline{B}_1 f_\epsilon 10^{-8} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Let ψ denote the phase angle between the E.M.F.s induced in successive coils, then for a group of m coils the vector diagram for the fundamental will be shown as in Fig. 6A, where the amplitudes

$$\bar{e}_{a_1}=\bar{e}_{b_1}=\bar{e}_{c_1} \ . \ . \ . \ . =\bar{e}_{m_1}.$$

The resultant of the m vectors is shown in Fig. 6B, which is drawn in the same way as the polygon of forces in mechanics.

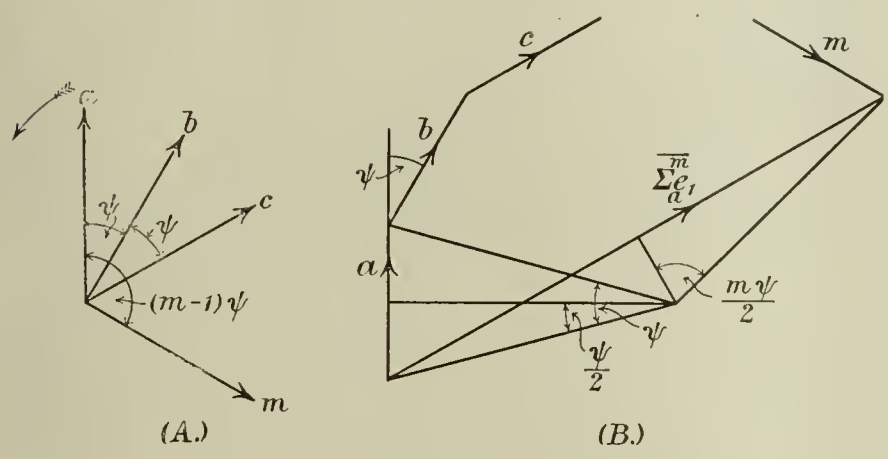


Fig. 6.

(A) Vector diagram of pressures induced in a group of coils.
(B) Resultant of vector diagram.

Such a diagram enables us to see at once the effect of varying the number of coils m, or, in other words, the influence of the distribution of the winding. If we write :—

$\overline{\sum_a^m e_1}=f_m m \bar{e}_1$=amplitude of resultant pressure of fundamental, then from Fig. 6B we see that :—

$$f_m=\frac{\overline{\sum_a^m e_1}}{m\bar{e}_1}=\frac{\sin m\psi/2}{m \sin \psi/2}. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

f_m is called the *distribution factor* of the winding, and its value can be determined once for all for all classes of windings. The distribution factor takes into account the effect of the distribution or spread of the winding. A similar argument applies to the harmonics which have to be considered in connection with the wave-shape of alternating pressures.

Consider, by way of example, a double-layer closed winding having two coil-sides per slot, with 24 coils arranged in 24 slots as a double-layer winding. With two coil-sides per slot, the phase displacement ψ between successive coils in the field is constant. When ψ=30 deg., we get 12 vectors displaced from one another by 30 deg., and each vector represents the E.M.F. induced in two corresponding coils (*see* Fig. 7A). To obtain the resultant of these vectors, we draw the vector polygon in Fig. 7B. Starting from vector 1, the resultant increases until we get to vector 7, that is, until the resultant is equal to the diameter of the polygon, and the vectors subtend an angle $\Sigma\psi=\pi$. This is the largest pressure that can be obtained from the winding. Proceeding, the resultant now decreases until it becomes zero when 12 vectors have been included, or $\Sigma\psi=2\pi$. The same cycle is repeated in passing the remaining 12 vectors, when we ultimately arrive at the starting point again. The distribution factor for the C coils of such a winding is obviously zero, since in equation (9) $\sin m\psi/2=\sin C\psi/2=\sin 2 \cdot 2\pi/2=0$.

If ψ=15 deg. then $C\psi=24\times 15$ deg.$=2\pi$ radians. The resultant of the 24 vectors would then form a single polygon with 24 sides.

Thus, according to the value of ψ, the 24 coils form a single polyphase system with a total phase displacement of 2π radians, or two identical polyphase systems with a total phase displacement of 4π radians.

Closed Windings.—It is well known that the coils of a winding, or of a number of windings, in which the sum of all the pressures is zero at every instant, can be joined in series to form a closed winding. Connections to such a winding take the form of tappings, which may be permanent (slip-rings) or temporary (commutator brushes).

Thus, if the C coils in any double-layer winding are displaced from one another in the field by the angle ψ such that $C\psi=a2\pi$, where a=1, 2, 3, &c., the resultant diagram of the vectors of these C coils will be a closed figure. In such a winding, then, $\Sigma_1^C e=0$ at every instant, and the coils can be joined in mesh to form one or more closed windings.

There is a very simple relation between the value of a in a closed winding and the number of pairs of poles p.

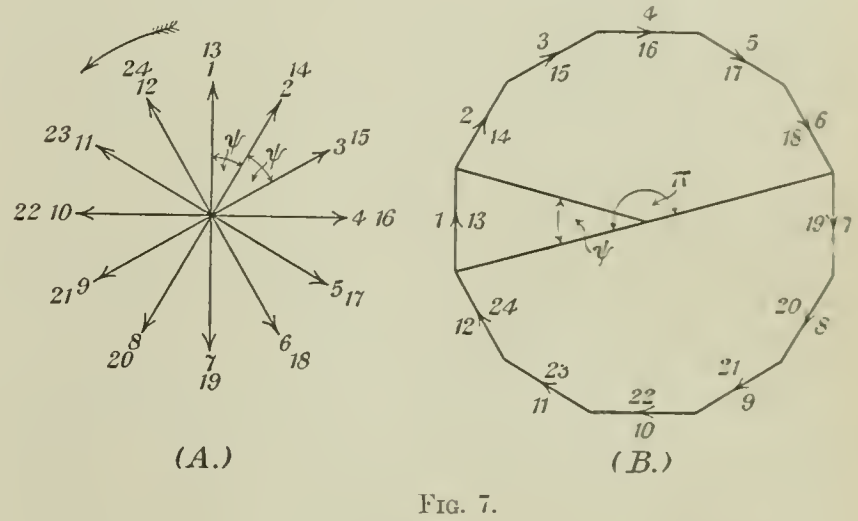


Fig. 7.

(A) Vector diagram of pressures induced in the coils of a closed winding.
(B) Resultant polygon of vector diagram.
C=24 coils ; S=24 slots ; a=2 ; $\psi=a.2\pi/C=4\pi/24=30°$.

We have :— $C\psi=2\pi a$ for a closed winding,
$S\gamma=2p\pi$ where γ=slot-pitch in radians,
$C=S$ with two coil-sides per slot.

From this it follows that :—

$$\psi/\gamma=a/p. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Thus, by choosing the angles ψ and γ suitably, we can vary a with any given number of poles $2p$. According to the displacement in the field ψ between successive coils—*i.e.*, according to the way the coils are joined in mesh—we get the lap or the wave winding. Before dealing with these we can determine the conditions for obtaining indentical circuits in a winding, which are of the greatest importance in commutator machines. These are known as the conditions of symmetry.

Identical Polyphase Systems in a Closed Winding.—Though the vectors representing the pressures induced in C coils, where $C\psi=a.2\pi$, form a closed figure, it does not follow that they will form a identical polygons, or represent a identical polyphase systems. This only happens when C is exactly divisible by a, *i.e.*, when C/a is a whole number. In this case, the a coils represented by any vector can be joined together permanently without fear of producing internal circulating currents and identical circuits are formed by corresponding coils in the a systems. Therefore, when C/a=integer, $C\psi/a=2\pi$ and the C coils form a identical, polyphase systems, each having C/a phases. Thus Fig. 7 represents two identical 12-phase systems.

On the other hand, if C/a is not an integer, there will not be

a identical vector polygons, and we cannot get a identical circuits. For example, if there are 23 coils such that $C\psi=23\psi=4\pi$, the winding can be closed, but we cannot get two identical polyphase systems.

This is an extremely important result, for no matter whether the a systems are united at the slip-rings or by the equalising rings (which are a practical necessity where parallel circuits are concerned), it is clear that unless all the circuits joined in parallel are identical, circulating currents will flow in the winding, and when a collecting ring through commutator brushes places the circuits in parallel series sparking may ensue. One of the conditions of symmetry in a closed winding with $C\psi=a2\pi$, then, is that C/a is a whole number. In this case, there are a equi-potential coils arranged symmetrically over the periphery—*i.e.*, C/a coils or commutator segments apart. $y_p=C/a$ is called the potential pitch, and denotes the number of segments between successive equi-potential points in the winding, and which can, therefore, be joined together permanently when slip-rings or equalising rings are needed.

Up till now we have only considered closed windings with two coil-sides per slot—a condition seldom met with except in turbo-generators. Usually $u=1$, 6, 8, &c., to reduce the number of slots. The above vector diagram no longer applies when $u>2$, because the angle ψ is no longer constant. but so long as $\Sigma_1^u\psi=a\,.\,2\pi$, the C coils can be joined in mesh, since $\Sigma_1^e e=0$. Now the phase of the pressure induced in the coil-sides depends chiefly on the position of the slots in the field rather than on the position of the coil sides in the slot. When there are no idle coils, $C=Su/2$, so that the C vectors can be collected into S groups of $u/2$ each ; thus giving S sides in the closed resultant diagram. If, however, the number of slots is exactly divisible by a, we get a identical polygons each with S/a sides. Hence, with windings having more than two coil-sides per slot, the symmetry of the winding is not upset if S/a is an integer. (For condition for symmetrical phase tappings *see* section on Equi-potential Connectors.)

If S/a is not a whole number, however, the winding will not be symmetrical, for the a polygons will not be alike. For example, let $C=342$ and $a=2$, then $C/a=171$. With six coil-slides per slot, $S=114$, and $S/a=57$. Hence, a vector diagram can be drawn with two identical polygons, each having 57 sides. With four coil-slides per slot, however, $S=171$, so that S/a is fractional, and the vectors of the corresponding coils in the two systems do not occupy identical positions in the diagram because the slots are not in similar positions in the field.

The remaining condition of symmetry refers to the field system. In order that the a corresponding coils have the same pressure induced in them at every instant, they must move in like fields. Now, successive equi-potential coils are $1/a$th of the periphery apart, consequently for these coils to have the same potential, there must be a whole number of pole-pairs between them. In other words, for a coils equi-distant from one another on the armature, to lie in like fields, the number of pole-pairs in the field system must be exactly divisible by a. A further condition of symmetry in a closed winding then, is that p/a must be a whole number.

Hence, to obtain a identical polyphase systems in a closed double-layer winding, p/a, S/a and C/a must all be integers. Windings in which all these conditions are fulfilled are called *symmetrical*.

As far as the author is aware, the conditions of symmetry were first established by Arnold, though by a different method from the above. They are of immense importance in practice, and, in the author's opinion, should be strictly adhered to. These conditions seriously limit the number of lap and wave windings that can be used with parallel circuits as required in commutator machines. Though a certain amount of dissymmetry may be allowable in the windings of small machines, in large machines it is of the highest importance to have all parallel circuits identical because of the equalising action of the brushes and the consequent sparking when the dissymmetry is appreciable. In his treatise on continuous-current machines, "Die Gleichstromtechnik," Arnold shows how to calculate the effects of dissymmetry, and shows what coils it is desirable to connect by means of equalising rings ; but experience has taught firms it is better to avoid dissymmetry altogether. The restrictions imposed by the conditions of symmetry will be discussed when we come to deal with lap and wave windings.

Number of Parallel Circuits in a Closed Winding.—A closed winding is loaded by means of tappings—each load phase tapping a points in the winding. There are thus a circuits in parallel per phase, but these are only identical when the winding is symmetrical. With diametral tappings, each of the a systems is divided into two phases at 180 deg., forming a pair of circuits between which the current divides equally. Thus commutator brushes a pole-pitch apart place $2a$ circuits in parallel, but currents will circulate between them through the brushes unless the a pairs of circuits are identical.

Equi-potential Connectors (equalising rings and phase tappings).—In a symmetrical winding—*i.e.*, a winding with a identical C/a-phase systems—there are always a coils at the same potential, and these can be joined together if desired. If no dissymmetry whatever were present. however, there would be little object in making such connections, unless they were needed as phase tappings to obtain an alternating pressure. Actually there are many causes of dissymmetry in a machine, apart from those due to the arrangement of the winding already mentioned. Thus, the magnetic material may not be uniform, the pole-shoes may not be properly spaced, the gap may not be uniform, and so on. In general, perfect symmetry must be regarded as an unattainable ideal in practice.

Owing to these dissymmetries, the pressure induced in the several armature circuits varies, and causes equalising currents to flow through the brushes. These equalising currents, if of sufficient strength, produce sparking. and, in any case, load the brushes in an undesirable manner. It is interesting to note that, even when no equalising rings are present, the positive and negative collecting rings act as equalisers, and the tendency of these equalising currents is to neutralise the inequalities in the magnetic field to which they are due. (This was recently shown by Lulofs, and later by Hawkins, *see* THE ELECTRICIAN, Vols. LXX. and LXXII.) When equalising rings are present, however, large equalising currents will flow along these and strongly damp out any inequalities in the field, and so reduce the difference of potential between corresponding points in the winding. Consequently the brushes are relieved, and are much better able to perform their proper function of collecting the current.

Of course, equalising rings must not be regarded as in any way essential. and many machines work quite well without them. Nevertheless, they add a certain factor of safety which the manufacturer is glad to purchase at so small a cost, for he is not only surer of his machine passing the test satisfactorily, but also knows that after-effects, like wear of the bearings, cannot give rise to such serious trouble as if equalisers were absent. Consequently, equalising rings are seen on most large machines with lap-wound armatures, or with wave windings with more than two circuits.

At the same time, the author is not of the opinion that equalising rings must have an extremely low resistance. Such practice requires not only an excessive amount of copper, but leads to considerable loss and heating in the winding. All that is really necessary is to provide an alternative path of negligible resistance compared with that of the brushes, and for this purpose it is usually sufficient to make the section of the rings about half that of the conductors.

Regarding the number of equalising rings, much depends on the opinion of the designer. With lap windings, one ring for every 6 to 12 segments is common practice, but this is scarcely feasible when $p>a$, for here $y_p=C/a$ may be fairly large and the number of rings becomes prohibitive. In such cases (wave windings with more than two circuits), one ring for every 15-20 segments may suffice.

There is no need to make the pitch between all the rings the same, but designers generally prefer to split up y_p into a whole

number of parts. In this case the tappings form a symmetrical polyphase system of pressures.

This leads to the question of *phase tappings* from a closed winding. To get a symmetrical N-phase system the pressures of the N phases must be equal and displaced from one another by the angle $\beta=2\pi/N$ radians, or $360/N$ deg. Since the potential pitch $y_p=C/a$ segments corresponds with 2π radians, the phase pitch y_{ph} corresponding with the angle β is obviously $y_{ph}=y_p/N=C/aN$ segments.

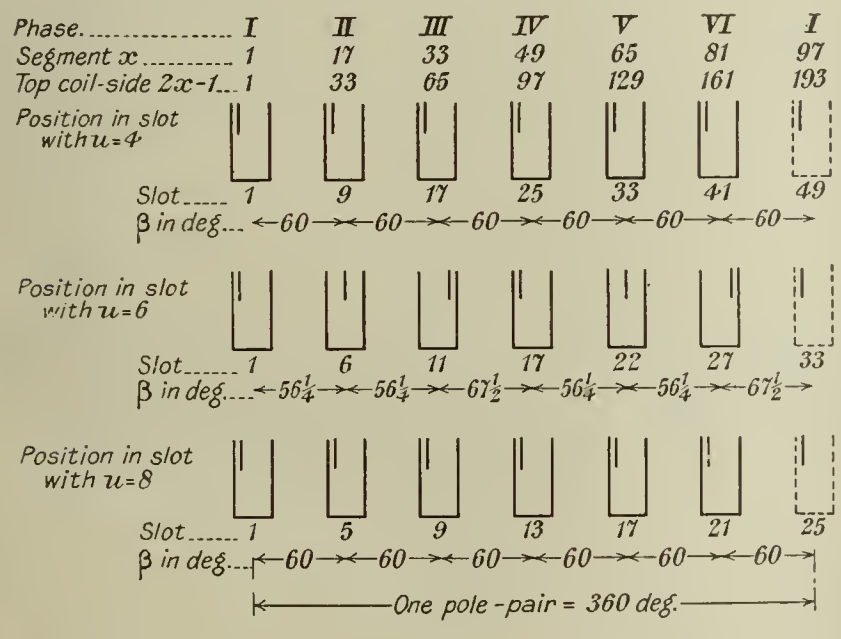
Further, owing to the effect of the slot position on the phase of the pressure, to make the angle β between successive phases constant, the same number of slots must lie between successive tappings. For this purpose S/a must also be exactly divisible by the number of phases N. With two coil-sides per slot, $S=C$, so that this condition is always satisfied when $C/aN=$integer; but with $u>2$ the coils are no longer distributed uniformly over the periphery, and the position in the slots becomes very important.

This can be best illustrated by means of an example. Consider the common case of a rotary converter for 500 volts having 96 coils or segments per pole-pair and a simple lap winding ($a=p$). Then $y_p=C/a=C/p=96$. For a six-phase pressure $N=6$, the phase pitch $y_{ph}=y_p/N=96/6=16$ segments.

Taking, now, $u=$two, four, six and eight coil-sides per slot respectively, we have, since $S=2c/u$,

$u=$	2	4	6	8
$S/p=$	96	48	32	24
$S/Np=$	16	8	5·33	4

Thus, S/Np is only fractional when $u=6$, in the cases considered. If we denote the coil-sides in the top layer by odd numbers, and those in the bottom layer by even numbers, any commutator segment, x, corresponds with the top coil-side $2x-1$; consequently we have for the position of the top coil-sides in the slots (there is no need to duplicate the work by considering the bottom coil-sides) :—



It is seen that with $u=2$, 4 and 8 all phases are displaced from one another by 60 deg., but when $u=6$ this is not so. When $u=6$, the slot-pitch is $360/32=11{\cdot}25$ deg. Assuming the slot position to determine the phase angle, we then get between phases I.-II., II.-III., IV.-V. and V.-VI. $5\times11{\cdot}25=56{\cdot}25$ deg; and between phases III.-IV. and VI.-I., $6\times11{\cdot}25=67{\cdot}5$ deg. The mean value of β is, of course, 60 deg.

If, now, a symmetrical six-phase pressure is applied to the converter, as is usual, it is obvious that the pressures of the converter will not reach their maxima at the same instants as those of the applied pressures, and circulating currents will flow. The problem is now similar to that of cross currents in parallel working of alternators.

This example is enough to show the necessity of making S/aN as well as C/aN an integer to obtain a symmetrical N-phase pressure.

It is not always important, however, to have the N phases identical, as, for example, when the pressures are merely needed for a static balancer to provide the middle wire for a three-wire continuous-current system; though even here too great a dissymmetry is to be avoided owing to the risk of the lights flickering. With some armature windings, especially two-circuit wave windings, it is not possible to get a symmetrical polyphase pressure—*e.g.*, it is not possible to get a symmetrical three-phase pressure from a six-pole wave winding—because the number of commutator segments must not be a multiple of three; similarly, a symmetrical four-phase pressure cannot be obtained from a four-pole wave winding. The method for finding the segments to be tapped is fully described and illustrated in a Paper by the author in Vol. LIII. of the "Proc." I.E.E.

(To be continued.)

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

An invitation having been given by the Right. Hon. Arthur Dyke Acland, chairman of the Executive Committee of the Imperial College of Science, to members of the Circle of Scientific, Technical and Trade Journalists to visit this College last Wednesday, we think a few remarks about the College may be of interest to our readers.

The party was met by several of the professors who, in introducing the members to the College, gave some particulars regarding the growth of the College, and of the work recently done there in connection with the war; in addition, an interesting financial statement was made by the secretary. Mr. Acland, in his remarks, referred to a Memorandum drawn up and signed by the professors of the College, and which had that day been presented to Lord Crewe, and which is dealt with elsewhere in this issue. He dwelt upon the necessity for devising means for sending a larger number of scientifically-trained youths to the universities and colleges. In order to counteract the attraction of these boys going into business, bursaries ought to be provided. Mr. Acland also wished to direct the attention of the visitors to the enormous potentialities of such an institution as the Imperial College as regards trade and manufactures generally. Great stress was laid upon the necessity for *immediate* action in this matter.

It may surprise some of our readers to know that up to the present the value of the land and buildings of this College exceed £1,000,000, and scientific equipment alone cost £69,000, the number of students being nominally 1,000, although at present reduced to about 150. Annual salaries and wages amounting to about £54,000 are made up from a Government grant of £30,000 and a L.C.C. grant of £13,000, and in addition there are fees, &c.

The Professor of Chemistry gave an interesting sketch of what has been done in the chemical department with reference to the war. This comprised work dealing with poisonous gases, water purification and provision of chemicals for hospital purposes, &c., but the fact, which we are sure impressed all the visitors greatly, was that every department directly or indirectly was doing work connected with the war, and much of it would be of a lasting nature as regards trade processes. Some of the typical researches which the various departments have in hand are the following: Substitutes for Jena glass, tin from low-grade ores, treatment of high boiling point oils to give low boiling point petrols, conversion of oleic into stearic acid for soap manufacture, magnetic quality and heat treatment of steels, improvement of petrol motors, flow of steam with reference to turbines, timber diseases with reference to pit props, economic plant physiology, production of refractories for coke ovens, tubes for air craft construction, and critical speeds of turbo-generator shafts. The above are merely a few of the investigations; others included methods of combating disease and destroying flies.

The party was conducted through the chemical laboratory, the largest in the world, viewed the physics department, then through the large electrical engineering laboratories, the metallurgical and the botanical laboratories. They finally arrived at the Students' Union, where tea was served, and where they were received by Mr. Acland.

Mr. Leon Gaster, on behalf of the Circle, in a brief speech, proposed a vote of thanks to Mr. Acland, and the professors, which was duly seconded, and carried by acclamation.

The point to which we have been drawing attention in our leading articles from time to time about the folly of depleting our colleges of students, when, perhaps, the scientific utilisation of their services in other directions, might do much to hasten the end of the war and eventually leave trade uninjured, was amply demonstrated. The College was a "deserted village," with the exception, as we were informed, of a few "crocks," or others whose services were absolutely indispensable. We think such a state of matters is deplorable in many respects, and one for which we shall probably pay dearly in the future.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.
WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.
THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*
THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*
THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.*
PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*
ELECTRIC TRACTION ON RAILWAYS. By Philip Dawson, M.I.C.E., M.I.E.E., &c. Handsomely bound ; fully illustrated. Price 25s. nett, postage 6d. U.K., abroad, 1s. 6d.
SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson, M.I.E.E. 15s. nett.
ELECTRICAL LABORATORY NOTES AND FORMS. Arranged by Dr. J. A. Fleming, M.A., F.R.S. Single copies 4d. nett, or in dozens at 3s. 6d. nett. Complete Sets of 50 Notes and Forms, 12s. 6d. nett, or in strong portfolio, 14s. nett ; or bound in strong cloth, 15s. nett. Spare Copies of Tabular Sheets, 1s. per dozen. Portfolios, 1s. 6d. each. Sectional paper, 1s. per dozen sheets. *Complete Prospectus post free on request.* These Notes and Forms are kept revised as new printings are required.
HANDBOOK OF THE ELECTRICAL LABORATORY & TESTING ROOM. Very fully illustrated. By Dr. J. A. Fleming. *Revised Editions now Ready.* Vol. I., 12s. 6d. nett. Vol. II., 14s. nett.
SECONDARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.
THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.
INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903), Full Report of Proceedings at, 8s. 6d. ; post free, 8s. 9d. ; abroad, 9s.
INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.
BRAKES FOR TRAMWAY CARS. By H. M. Sayers. Price 2s. 6d. nett.
ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.
ELECTRICITY IN HORTICULTURE. By Prof. S. Lemstrom. Illustrated. 3s. 6d. nett.
RADIO-ACTIVITY : AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M.A. Price 4s. nett.
MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by G. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.
PRACTICAL NOTES FOR ELECTRICAL STUDENTS. By A. E. Kennelly & H. D. Wilkinson. Price 4s. 6d.
A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Geipel and H. M. Kilgour. Price 7s. 6d. nett.
THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.
ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.
THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. G. Bond, M.I.E.E. Price 2s. 6d. nett.
CARBON MAKING FOR ALL ELECTRICAL PURPOSES. By Francis Jehl Price 10s. 6d.

ENTIRELY NEW BOOK.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s.** nett. Postage 6d. extra.

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

THE ECONOMY OF TURBO-GENERATORS OF LARGE OUTPUT.

In our last issue, under the heading "The Uneconomical Small Station," figures of a striking character were used to give some idea of the lack of economy in small power stations. Apart from the lack of economy in fuel consumption there is the important question of the misuse of the man-power of the country. The possibility of diverting some 75 per cent. of the labour at present employed in our power stations into other and more productive channels is of itself sufficiently attractive at the present time to warrant close investigation by those who believe in making the most of the material at hand. For this reason we think that the recent letter addressed from the Board of Trade to electric supply authorities on the subject of interconnection and joint working of power stations is opportune ; the more so since the immediate effect of interconnection will be the closing down of many of the small power stations. The steps that are already being taken in Lancashire and Cheshire to prepare an engineering scheme for the interconnecting of the principal power stations of the two counties should go a long way towards securing a much-to-be desired object.

As evidence of the economy of the big turbo-generator we refer the reader to a Paper read last month by Messrs. H. G. STOTT and W. S. FINLEY before the American Society of Mechanical Engineers, and to be found in abstract in another column. In this Paper an account is given of the tests that have been made on the three 30,000-kw. turbo-generator units installed last year by the Interborough Rapid Transit Company. It will be remembered that several comparatively modern 7,000-kw. reciprocating sets were broken up and sold as scrap in order to provide accommodation in the power station for the turbo-generators. The steam consumption of the engines amounted to 17·3 lb. per kilowatt-hour and the guaranteed performance of the turbines at the most efficient load—25,000-kw.—was 11·27 lb. of steam per kilowatt-hour and a Rankine cycle efficiency of 75·76 per cent. The results obtained on test under the most economical load, namely, 26,740-kw., showed a water-rate of 11·258 lb. per kilowatt-hour and a Rankine cycle efficiency of 75·84 per cent. with steam superheated 120°F. at an absolute pressure of 215 lb. per square inch and a vacuum corresponding to 29 in. of mercury. Under the normal operating conditions the annual saving of fuel alone for each turbo unit will amount to £40,000, and the labour charges per kilowatt of output are expected to be about 25 per cent. of those for the reciprocating sets. That these economies are being realised in actual working may be taken for granted in view of the fact that the same company will now install a 70,000-kw. cross-compound unit with three generators, any one of which may be operated independently if so desired.

Striking figures were given by Mr. STOTT in reviewing the evolution of power station design during the past 15 years. Attention was rightly called to the comparison in investments represented by the two types of installations. In the case of the reciprocating sets the cost of engines, generators and condensers amounted to about £8 per kilowatt, while the cost of the new turbo-sets and condensers was

stated to be £1·8 per kilowatt. Not only is the initial cost of the large turbo unit 22·5 per cent. of that of the reciprocating unit per kilowatt, but the former is more economical to the extent of 40 per cent. in coal consumption, and in addition there are the reduced labour charges and the better utilisation of valuable floor space in the engine room as well as in the boiler house.

The Interborough turbo-sets are of unusual interest, not so much on account of their size as on the guaranteed efficiencies over a wide range of loads. These are given in the form of a note at the end of the article so as to enable the reader to compare the actual performance with that guaranteed by the manufacturer. Each unit consists of a high-pressure and a low-pressure element, and the unique feature is that each of these elements drives a separate alternator operating at the most desirable speed of the turbine without being restricted by mechanical limitations. In the case of the high-pressure element this speed is 1,500 revs. per min., while the speed of the low-pressure element is only 750 revs. per min., and the highest stress in the rotating drums at 20 per cent. overspeed is said not to exceed 14,000 lb. per square inch.

Engineers will be grateful to the Interborough Company for allowing such a complete summary of tests at varying loads to be published. Although there are now many large turbo-generators in operation, this is the first time, as far as we are aware, that complete test results have been made public and that discussion has been invited on the tests. Messrs. Stott and Finley draw attention to two peculiarities brought to light by the tests. The first of these is the dip in the curve between 22,000-kw. and 26,000-kw., and is not yet explained. The action of the receiver between the two elements and the velocity of the steam through it might account for the dip, but the tests that were commenced with a view to investigating the matter had to be discontinued before definite results were obtained. The second peculiarity, namely, the turning-up of the efficiency curve between 30,000-kw. and 32,000-kw., is shown by the turbine designer to be a new experience and is accounted for in a satisfactory manner.

THE PREDETERMINATION OF HIGHER HARMONICS IN THE ALTERNATING CURRENT TRANSFORMER WHEN THE IMPRESSED E.M.F. IS A SIMPLE HARMONIC FUNCTION OF THE TIME.

BY GEO. R. DEAN.
(Professor of Mathematics, School of Mines, Rolla, Mo.)

Introduction.

The usual method of determining the form of the curve of the magnetising or no-load current is to assume a sinusoidal flux-density curve in quadrature with the impressed E.M.F. and construct from this curve and the hysteresis loop a new curve whose equivalent sine curve or fundamental harmonic is taken as representing the magnetising current.

There is no warrant for the assumption of a sine curve for the flux density, as no more is known about it, a priori, than about the magnetising current. The proper way would be to deduce the magnetising current from the hysteresis loop and the impressed E.M.F., then the flux-density curve from the magnetising current and the hysteresis loop; but the variable mutual inductance of the coils, due to the variable permeability of the iron, puts mathematical difficulties in the way which prevent a direct solution of the problem.

In the steady performance of most transformers the flux density is kept below the knee of the B–H curve—that is, below 10,000 lines per square centimetre. In such cases a fair approximation may be obtained by substituting a parallelogram for the hysteresis loop, with its vertices at the points of maximum and minimum flux density and the points of remanent flux density. The inductance is then constant along the sides of the parallelogram and is proportional to their slope. When the parallelogram does not follow the hysteresis loop closely enough a polygon of a larger number of sides may be used; but the complexity of the mathematics would be considerable. If hysteresis loops are not available the maximum value of the magnetising current and the remanent magnetism may be computed from the core loss. As the core loss includes both hysteresis and eddy-current loss, the area of the parallelogram will be proportional to the total iron loss. A sufficiently accurate value of the maximum E.M.F. is computed from the given maximum flux density by the formula,

$$E_{\max.}=2\pi f n B_m A,$$

where f is the frequency, n the number of turns in the primary, B_m the maximum flux density and A the section area of core. This assumes that the E.M.F. and the flux are sine curves. The flux is so nearly a sine curve that the error is not serious.

The equation of the magnetising current is found by integrating the equation,

$$L\frac{di_0}{dt}+Ri_0=E\sin(\omega t+\alpha),$$

where L_1 is the inductance of the primary coil, R the resistance and α is the phase displacement of the zero point of the current. This displacement cannot be assumed; it is determined in what follows.

The Magnetising Current.

Let B denote the variable magnetic flux density in the core; H_1 the magnetic intensity; S_1, S_2 leakage inductance of the coils; n_1, n_2 the number of turns; l the length of magnetic circuit in iron in centimetres; i_0 the instantaneous current when secondary is open; i_0' its value from zero point to maximum; i_0'' from maximum to zero point; I_0 the maximum value.

Then $n_1A\left(\frac{dB}{di_0}\right)+S_1$ is the total inductance.

Now $\frac{dB}{di_0}=\frac{dB}{dH}\cdot\frac{dH}{di_0}$, $H=\frac{4\pi n_1 i_0}{10l}$, $\frac{dH}{di_0}=\frac{4\pi n_1}{10l}$.

Therefore, $n_1A\frac{dB}{di_0}=\frac{4\pi n_1^2A}{10l}\cdot\frac{dB}{dH}$

Let B_m denote the maximum flux density, B_r the remanent flux density. Substituting the parallelogram for the hysteresis loop, we have

$$\frac{dB}{dH}=\frac{B_m+B_r}{H_m},\quad \text{from } H=0 \text{ to } H=H_m;$$

$$\frac{dB}{dH}=\frac{B_m-B_r}{H_m},\quad \text{from } H=H_m \text{ to } H=0.$$

Let L_1 and L_1' denote the corresponding inductances. Then

$$L_1=\frac{n_1A}{10^{-8}}\cdot\left(\frac{B_m+B_r}{I_m}\right)+S_1,\text{ and } L_1'=\frac{n_1A}{10^{-8}}\cdot\left(\frac{B_m-B_r}{I_m}\right)+S_1.$$

From $H=0$ to $H=H_m$,

$$L_1\frac{di_0'}{dt}+R_1i_0'=E\sin(\omega t+\alpha). \quad \ldots\ldots (1)$$

and from $H=H_m$ to $H=0$,

$$L_1'\frac{di_0''}{dt}+R_1i_0''=E\sin(\omega t+\alpha). \quad \ldots\ldots (2)$$

Setting $\tan\varphi_1=\frac{\omega L_1}{R_1}$, and $\tan\varphi_2=\frac{\omega L_1'}{R_1}$, where $\omega=2\pi f$, the solution of (1) is

$$i_0'=\frac{E\sin(\omega t+\alpha-\varphi_1)}{\sqrt{(R_1^2+\omega^2L_1^2)}}+Ce^{-\frac{R_1t}{L_1}};$$

or

$$i_0'=\frac{E\cos\varphi_1}{R_1}\cdot\sin(\omega t+\alpha-\varphi_1)+Ce^{-\frac{R_1t}{L_1}}.$$

If we take $i_0'=0$ when $t=0$,

we find $$C=-\frac{E\cos\varphi_1}{R_1}\sin(\alpha-\varphi_1).$$

Then

$$R_1 i_0' = E\cos\varphi_1\{\sin(\omega t+\alpha-\varphi_1)-\sin(\alpha-\varphi_1)e^{-\omega t\cot\phi_1}\} \quad . \quad (3)$$

The solution of (2), taking $i_0''=0$ when $t=\frac{\pi}{\omega}$, is

$$R_1 i_0'' = E\cos\varphi_2\{\sin(\omega t+\alpha-\varphi_2)+\sin(\alpha-\varphi_2)e^{-(\omega t-\pi)\cot\phi_2}\} \quad . \quad (4)$$

Differentiating (3), we see that i_0' is a maximum when

$$\omega\cos(\omega t+\alpha-\varphi_1)+\frac{R_1}{L_1}\sin(\alpha-\varphi_1)e^{-\omega t\cot\phi_1}=0, \quad . \quad (5)$$

that is, when

$$\sin\varphi_1\cos(\omega t+\alpha-\varphi_1)+\cos\varphi_1\sin(\alpha-\varphi_1)e^{-\omega t\cot\phi_1}=0 \quad . \quad (6)$$

Substituting the value of $e^{-\omega t\cot\phi_1}$ from (6) into (3), we have $$R_1 I_m = E\sin(\omega t_m+\alpha) \quad . \quad . \quad . \quad . \quad (7)$$

when t_m denotes the time of maximum current, found by solving (6). Now, $R_1 i_0''$ is equal to $E\sin(\omega t+\alpha)$ when $t=t_m$; therefore

$$\cos\varphi_2\{\sin(\omega t_m+\alpha-\varphi_2)+\sin(\alpha-\varphi_2)e^{-(\omega t-\pi)\cot\phi_2}\} = \sin(\omega t_m+\alpha). \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Equations (6) and (8) constitute a pair of simultaneous equations for determining ωt_m and α. The solution can be effected only by trial. The following approximate forms are more convenient than (6) and (8):

From (6),

$$\mathrm{Tan}\,\alpha=\frac{\sin\varphi_1\cos(\omega t_m-\varphi_1)-\sin\varphi_1\cos\varphi_1 e^{-\omega t\cot\phi_1}}{\sin\varphi_1\sin(\omega t_m-\varphi_1)-\cos^2\varphi_1 e^{-\omega t\cot\varphi_1}} \quad . \quad . \quad (9)$$

From (8). $\mathrm{Tan}\,\alpha=$

$$\frac{-\cos\varphi_2\sin(\omega t_m-\varphi_2)+\sin\varphi_2\cos\varphi_2 e^{(\pi-\omega t)\cot\phi_2}+\sin\omega t_m}{\cos\varphi_2\cos(\omega t_m-\varphi_2)+\cos^2\varphi_2 e^{(\pi-\omega t)}-\cos\omega t_m} \quad (10)$$

In most cases φ_1 and φ_2 are so nearly right angles that we may take

$$\mathrm{Sin}\,\varphi_1=1,\ \cos\varphi_1=\cot\varphi_1,$$

so that

$$\mathrm{Tan}\,\alpha=\frac{\cos(\omega t_m-\varphi_1)-\cot\varphi_1 e^{-\omega t\cot\phi_1}}{\sin(\omega t-\varphi_1)} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$\mathrm{Tan}\,\alpha=\frac{-\sin(\omega t_m-\varphi_2)+e^{(\pi-\omega t)\cot\phi_2}+\tan\varphi_2\sin\omega t_m}{\cos(\omega t_m-\varphi_2)+\cot\varphi_2 e^{(\pi-\omega t_m)\cot\phi_2}-\tan\varphi_2\cos\omega t_m} \quad (12)$$

$$=\frac{\cot\varphi_2\sin(\omega t_m-\varphi_2)+\sin\omega t_m+e^{(\pi-\omega t)\cot\phi_2}\cot\varphi_2}{\cot\varphi_2\cos(\omega t_m-\varphi_2)-\cos\omega t_m+e^{(\pi-\omega t_m)\cot\phi_2}} \quad (12')$$

There is one value of t_m which makes the right-hand members of (11) and (12) equal to each other. The common value is $\tan\alpha$. The values of t_m and α must satisfy the relation

$$\mathrm{Sin}\,(\omega t_m+\alpha)=\frac{R_1 I_m}{E_m}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

An approximate value of α may be found from (3) and (4). Since $\omega t-\alpha-\varphi_1$ is nearly 90 deg. and $e^{-\omega t_m\cot\phi_1}$ is nearly unity, we have from (3)

$$\mathrm{Sin}\,(\varphi_1-\alpha)=\frac{R_1 I_m}{E\cot\varphi_1}=1 \quad . \quad . \quad . \quad . \quad . \quad (15)$$

and from (4)

$$\mathrm{Sin}\,(\varphi_1-\alpha)=\frac{R_1 I_m}{E\cot\varphi_2}. \quad . \quad . \quad . \quad . \quad (16)$$

The average of the two values of α will be suitable for trial in (13) to find ωt_m. Slight corrections will be necessary to make the values of ωt_m and α satisfy (11) and (12). Careful computation is necessary; logarithms and trigonometric functions and quotients must be carried out to five places.

Substituting the numerical values of α, φ_1, φ_2, E and R_1 in (3) and (4) we have equations from which the curve can be plotted.

Numerical Illustrations.

Taking $A=60$ sq. cm., $\omega=2\pi f=377$, $B_m=10{,}000$, $B_1=8{,}000$, $I_m=0{\cdot}50$ amperes, $n_1=1{\cdot}140$, $R_1=2{\cdot}6$ ohms, $S_1=0{\cdot}6$ henrys, we find

$$E_m=3{,}250, \quad L_1=31{\cdot}161, \quad L_1'=3{\cdot}502.$$

$$\mathrm{Sin}\,(\omega t_m+\alpha)=0{\cdot}0001, \qquad \omega t_m+\alpha=179^\circ\ 58'\ 37'',$$

$$\mathrm{Cot}\,\varphi_1=\frac{R_1}{\omega L_1}=0{\cdot}000221, \qquad \cot\varphi_2=\frac{R_1}{\omega L_1'}=0{\cdot}001196,$$

$$\varphi_1=89^\circ\ 59'\ 16'', \qquad \varphi_2=89^\circ\ 53'\ 16'',$$

$$\frac{E\cos\varphi_1}{R_1}=0{\cdot}276, \qquad \frac{E\cos\varphi_2}{R_1}=2{\cdot}450.$$

Equation (15) gives

$$\mathrm{Sin}\,(\alpha-\varphi_1)=-0{\cdot}80. \quad \varphi_1-\alpha=53^\circ\ 0' \text{ nearly},$$
$$\alpha=89^\circ\ 59'\ 16''-53^\circ,\ 36^\circ\ 59'\ 16''.$$
$$\omega t_m=179^\circ\ 58'\ 37''-36^\circ\ 59'\ 16''=142^\circ\ 59'\ 21''.$$

These values when substituted in (11) and (12) will be found to satisfy those equations very closely.

The following equations were used in computing the table below:

$$i_0'=0{\cdot}276\{\sin(\omega t-53^\circ)+\sin 53^\circ \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$i_0''=2{\cdot}450\{\sin(\omega t-52^\circ\ 51')-(\sin 52^\circ\ 51')e^{\frac{\pi-\omega t}{\tan 52^\circ 51'}} \quad . \quad (18)$$

ωt	10°	20°	30°	40°	50°	60°	70°	80°
i_0'	0·322	0·071	0·113	0·159	0·211	0·355	0·303	0·346
ωt	90°	100°	110°	115°	120°	125°	130°	140°	143°
i_0'	0·387	0·423	0·451	0·465	0·475	0·485	0·491	0·496	0·500
ωt	143°	150°	160°	170°	175°	180°			
i_0''	0·500	0·454	0·366	0·211	0·098	0			

The Flux and the Load Currents.

Let Φ' and Φ'' represent the total instantaneous flux corresponding to the two parts of the magnetising current curve. Then

$$n_1\frac{d\Phi'}{dt}(10^{-8})=E\sin(\omega t+\alpha)-R_1 i_0'-S_1\frac{di_0'}{dt} \quad . \quad . \quad . \quad (19)$$

$$n_1\frac{d\Phi''}{dt}(10^{-8})=E\sin(\omega t+\alpha)-R_1 i_0''-S_1\frac{di_0''}{dt} \quad . \quad . \quad . \quad (20)$$

Integrating

$$n_1\Phi'(10^{-8})=-\frac{E}{\omega}\cos(\omega t+\alpha)-S_1 i_0'-R_1\int i_0'dt+C', \quad (21)$$

$$n_1\Phi''(10^{-8})=-\frac{E}{\omega}\cos(\omega t+\alpha)-S_1 i_0''-R_1\int i_0''dt+C. \quad (22)$$

Since

$$\Phi'=\Phi'' \text{ when } \omega t=\omega t_m, \text{ and } i_1'=i_{11}'' \text{ when } t=t_m,$$

we have

$$C'-C''=R_1\left[\int i_0'dt-\int i_0''dt\right]_{t=t_m}.$$

We have also

$$\Phi=0, \text{ when } i_0'=I_0,$$

which is given by the hysteresis loop or parallelogram, and the corresponding value of t by the current curve. Thus C' and C'' are completely determined.

Now let the curves (21) and (22) be plotted and resolved into higher harmonics by any convenient method given in the text-books.

The load currents are found by integrating the equations

$$S_1\frac{di_1}{dt}+R_1 i_1+\frac{\int i_1 dt}{C_1}=-n_1\frac{d\Phi}{dt}(10^{-8}),$$

$$S_2\frac{di_2}{dt}+R_2 i_2+\frac{\int i_2 dt}{C_2}=-n_2\frac{d\Phi}{dt}(10^{-8}).$$

Here S_2, R_2, C_2 include the constants of the load circuit. The numerical work will be given in a later article.

THE MAGNETIC HAND.*

BY PROF. G. KLINGENBERG.

In consequence of the great number of men who are injured in this war in the arms it seems well to endeavour to supply them with artificial mechanism, by means of which they may be able after the war to pursue their ordinary avocations. These avocations may be trades connected with metal or wood working, and some means of grasping and holding tools will be for such men of great importance. The main object of these few lines is to explain simple principles on which the construction of such artificial limbs may be based, and to show how electromagnetic apparatus is adapted for the purpose; and more especially the author wishes to expose these general principles, in order if possible to prevent patents from being taken out which might tend to limit the field otherwise open to all comers.

Taking the case of a man who has lost the lower part of his forearm, a leather appliance might be fastened, as shown in Fig. 1, by

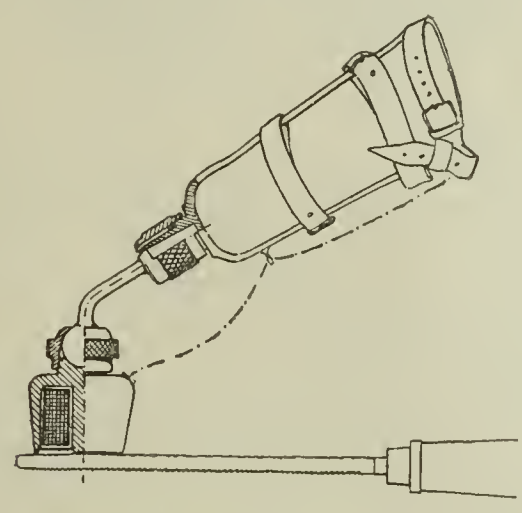


FIG. 1.—ELECTROMAGNETIC APPARATUS FOR FILING.

belts to the remaining stump. At the end of the belted socket a magnet coil, either of the pot or bell type, might be provided, on an arrangement which allows it to move through a flexible coupling of the ball and socket type. In this way the gripping of the magnet can be brought into any desired position. Thus the magnet can either be rigidly fixed, or it can be moved against a slight frictional resistance. The magnet is connected through an ordinary socket to any source of electric supply. This connection can be made by the movement of any part of the worker's body, either with the foot or chin, or with the other arm, or by a definite motion of the injured arm itself. With a magnetic arrangement of this kind any iron object can be seized with a comparatively considerable force, and it can be held as long as is desired, or it can be lifted or moved. This kind of connection between the stump of the arm and the object to be gripped is not rigid but flexible. The method of magnetic grip is, therefore, suitable for all workers in iron, or in any kind of workshop where iron could be used as a gripping surface. Therefore any kind of iron tool could be held by the magnetic hand, and, generally speaking, injured men could work in such workshops without the necessity for any special alterations. Take Fig. 1, which shows the

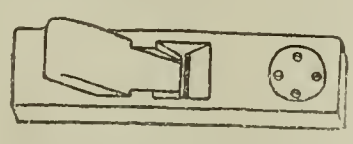


FIG. 2.—SHOWING A PLANE PROVIDED WITH AN IRON GRIPPING PLATE.

method of holding a file. The magnet is placed on the tip of the file, and as soon as the electric connection is made to the supply circuit the worker holds the tool firmly. The movement of filing can now be carried out, because the ball and socket joint allows a certain amount of free movement, exactly similar to that required by the ordinary worker. Fig. 2 shows a plane provided with an iron plate; this allows the tool to be gripped in the usual fashion. A man working at a stamping machine can handle the pieces of iron to be stamped quite conveniently, perhaps even better than a man with a sound hand, seeing that he can grip the iron sheets on their flat surfaces. He can also hold a piece of steel in position on a lathe while he uses the sound hand to adjust the fixing of the steel in the chuck. Tools which are not made of iron can often have an iron plate added, so that it is possible to grip them by magnetic action. Switches can be actuated in the same way, and, if necessary, they can be provided with similar iron plates. A variety of magnetic coils may be provided, so that a suitable gripping force may be obtained in the different cases.

This outline describes all cases which require a simple form of motion; but there are many improvements and extensions of the principle which might advantageously be employed in designing the electromagnetic action of artificial limbs. Thus, it may be desirable at one time to have a certain flexibility in the movement of a joint, such as the ball and socket one above referred to, and at another to have this joint rigid; this can also be effected by the addition of a magnetic coil for the purpose. Figs. 3 and 4 show methods of gripping a forceps or a pair of pincers, both of which

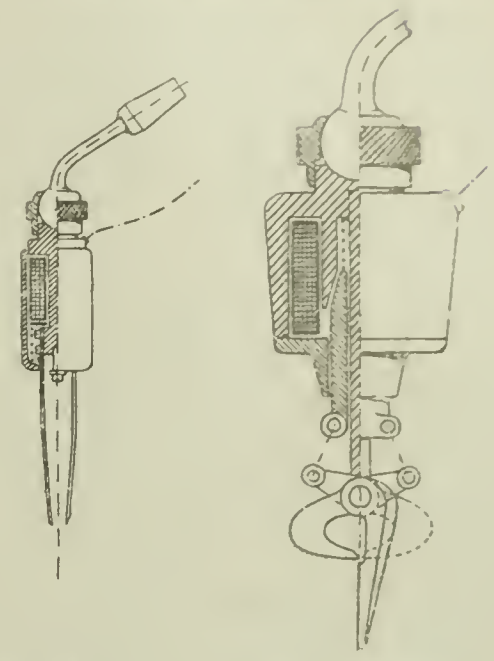


FIG. 3. FIG. 4.

FORCEPS AND PAIR OF PINCERS.

movements can be effected magnetically. It is also not difficult to imitate in the same way any movement similar to that between the lower and upper parts of the human arm, or the movement caused by closing the fingers or the pressure of the thumb. The electric method is to be preferred to the use of compressed air, because it is already provided in many places and because the magnets can be made small and yet relatively powerful: thus no very cumbrous apparatus is required. A man who is provided with such auxiliary apparatus is thus not confined to work in one particular spot; and even when no supply of electric power is conveniently available it is quite easy to get the necessary power from a portable battery of accumulators.

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 50, 1915.

PHYSICAL SOCIETY.

At the meeting held on the 26th ult. at the Imperial College of Science, Prof. C. V. BOYS, F.R.S., President, in the Chair, a Paper, entitled

"The Correction of Chromatic Aberrations When the External Media are Dispersive,"

was read by Mr. T. SMITH.

When one of the external media of a lens system is dispersive it is not possible to ensure the absence of differences in the size and position of images of all objects formed by length of different wavelengths. The degree to which correction can be carried is investigated and formulæ are given by which the power and position of the external surfaces of a system can be found when the type of correction to be adopted is given.

A Paper, entitled

"Note on the Use of the Autocollimating Telescope in the Measurement of Angles,"

was read by Mr. J. GUILD.

The measurement of angles by means of the autocollimator resolves itself into the measurement of the distance between two images produced in the focal plane of a micrometer eyepiece. In most cases the light forming these images passes through portions of the object glass on opposite sides of a diameter. It is shown that when this diameter is perpendicular to the direction of the displacement to be measured, uncertainty and error are introduced on account of any residual spherical aberration of the object glass and the depth of focus of the telescope. One or two particular cases are discussed in which it is shown how this may be obviated.

Dr. R. S. WILLOWS asked why the Abbe type of autocollimating eye-

piece, such as is used on Pulfrich refractometers, &c., was not employed in the arrangement described in the Paper.

The AUTHOR explained that there was a difficulty in adapting this method of illumination to a micrometer eyepiece.

A Paper, entitled

"The Viscosity of Colloidal Solutions,"

was read by Mr. EMIL HATSCHEK.

The author, in reply to some remarks made by Mr. W. B. Hardy in the course of his Guthrie lecture, points out (*a*) that no viscosity formula can cover the stage of gel formation, since the change from a liquid with only slight anomalies to a system having many properties of an elastic solid necessarily precludes this, and (*b*) that the formula given by Einstein and independently by himself for the viscosity of a suspension of rigid spherical particles does not in any event apply to systems such as discussed by Mr. Hardy, which belongs to the class known as emulsoids. In these both phases are quite generally assumed to be liquid, and an expression for the viscosity of such systems was deduced by the author in 1911, from a consideration of the deformation which a homogeneous polyhedral structure must undergo when sheared. The expression contains only the viscosity of the system and the phase ratio, but neither the interfacial tension of the phases nor the viscosity of the disperse phase. It can be tested directly for emulsions of two immiscible liquids; in the case of emulsoids, where only the weight of dispersed substance is known, some assumption has to be made about the relation between the volume of disperse phase formed—*i.e.*, the degree of hydration or solvation—and the weight dissolved. The simplest assumption, that this ratio is constant, has been tested by the author, and by Dr. Harriette Chick, for a number of sols, and is found to hold good over a considerable range. The formula has also been tested by F. Kirchhof in a different way, by comparing the degree of solvation—*i.e.*, the amount of solvent taken up by the disperse phase in different solvents—with the amount of the solvent taken up by the substance (indiarubber) in the swelling which precedes dispersion. Remarkable agreement both in the order and in the absolute amounts in different solvents was observed.

Dr. A. GRIFFITHS said he was in emphatic agreement with the conclusion at the end of paragraph two. He mentioned the case of a gelatine which would not run through a capillary tube, but which could be made to do so when broken up by stirring with a stick. He thought experiments on rigidity as well as viscosity should be made.

The AUTHOR, in reply to a remark by the President, stated that accidental double refraction was sometimes observed in the liquid phase.

CORRESPONDENCE.

"SPEEDING UP" IN ENGINEERING FACTORIES.

TO THE EDITORS OF THE ELECTRICIAN.

The above heading provides a good subject for argument, but I am afraid that the arguments tend rather to develop into expressions of point of view without tangible evidence in support. My views, and the results of their being put into practice, I have fully set out already; but, to illustrate the point, I may refer to Mr. Stuart's letter in your issue of May 12th. His workers lingered for weeks over alterations made in the case of one article, and this, together with the fact that delivery dates were fixed, is given as a reason why it was impossible to use a stop-watch. The fact that I had to work to fixed delivery dates for Government orders was my principal reason for resorting to the stop-watch.

I cannot see anything conflicting in what I have said about the men's not fully understanding the system of payment. If Mr. Brocklehurst has read the original Paper, and my letter in your issue of the 12th ult., and still thinks there is, I am sorry. A little reflection will convince him that his difficulty is only apparent, not real. My remark that the men were given outputs and figures for rates of pay to compare meets his main contention.

Again, my view, backed by experience and results, is still that it is best that workmen should not possess an inner knowledge of the working of a bonus system of payment. I did not notice that Mr. Brocklehurst showed in his last letter that lack of this knowledge led to disaffection among the men. As a matter of fact, the rates of pay under the bonus system I adopted were never considered unsatisfactory as far as I am aware. The term "bonus system," however, proved a convenient peg on which to hang an agitation against speeding-up.

I do not propose to deal in detail with Mr. Carney's long letter. The more he multiplies his quotations the more likely we are to overlook their context. It is easy to pick out, italicise and make a lot of an innocent word like "fairly." It is also easy to say that in one case a "weak" compromise was made; but the Paper makes it clear, I think, that the discretion exercised in this instance did not indicate weakness. Both driving and weakness have now been laid to my charge; I plead guilty to neither.

Although I am certainly interested in cheap production, increasing output was primarily my object in the work I did. I indicated in my Paper that fighting seems to some men more congenial than work. This liking for fighting, be it noted, is in evidence before the men have anything whatever to do with officers. A more likely explanation than Mr. Carney's is probably that fighting appeals much more directly to the "pride of life" than ordinary manual work.

Six minutes' rest per hour may have been too much or too little, as Mr. Carney says: it may also have been a good average figure to adopt. If by the methods adopted speeding-up was rapidly accomplished the methods deserve some credit. I think Mr. Carney's remarks regarding the complexity of the nature and effects of fatigue hardly square with his idea that not one day need have been lost in applying the results of years of work done on this subject.

While I appreciate Mr. Carney's solicitude for my welfare in steering between the Scylla and Charybdis he mentions, I believe I negotiated the course satisfactorily before I knew what his views were, and now that I have read his contributions to this discussion I cannot say that I think they are likely to lead to results as good as those I obtained by my own methods.

London, June 6. R. RANKIN.

BATTERY-ROOM FLOORS.

The construction of battery-room floors has been carefully studied by the New York Edison Company, the accompanying illustrations, Figs. 1 and 2 (from the "Electrical World") showing a floor construction now used. Briefly, the floors are made impervious to acid by a covering and are graded so that they will drain toward one

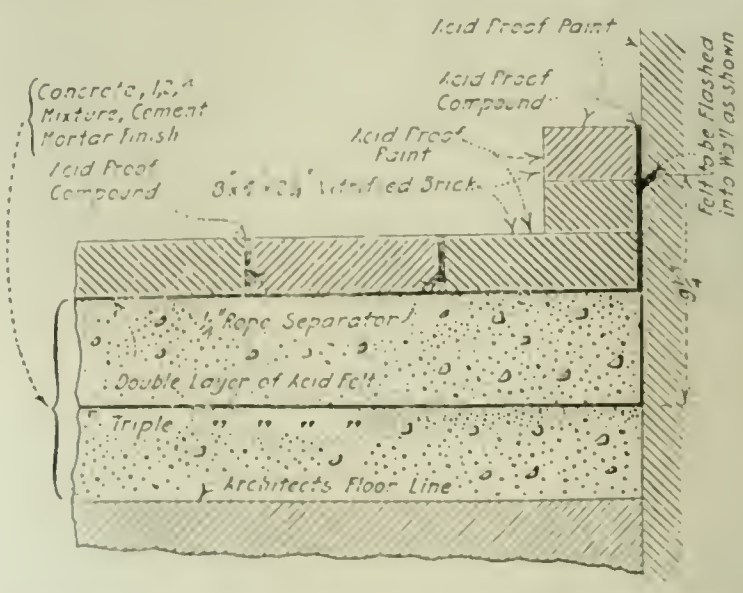


FIG. 1. BATTERY FLOOR CONSTRUCTION NEAR WALL, SHOWING LAYERS OF CONCRETE SEPARATED BY ACID PROOF COVERINGS WITH A BRICK SURFACE.

side where a gutter is provided which empties into a lime box. The latter is employed to neutralise any acidified water which may be collected before it is discharged into the sewer.

The acid-proof coverings are laid on ordinary concrete floors reinforced by steel girders. Over this a 1 : 2 : 4 mixture of concrete with a cement mortar finish is placed. The surface is then painted with hot "Hydrex" compound, and covered with three layers of butt-jointed acid proof Hydrex felt, the strips being run with the flow line of the room. The joints are bonded with hot compound. Around the borders and under the drain box additional layers of felt and compound are employed. A second layer

of 1 : 2 : 4 concrete is placed over all, finished and painted like the first, and covered with two crossed layers of acid-proof felt. Laid on this with their longest dimensions in the direction of the flow line of the room are 8 in. by 4 in. by 2·25 in. vitrified bricks, the spaces between which are filled with 0·25 in. rope separators and hot compound. The thickness of the first layer of concrete is tapered from the gutter to the opposite side of the floor to give the finished floor an 0·8 per cent. grade. The gutter in turn is given a 0·5 per cent. grade. The minimum thickness of the floor is made about $9\frac{1}{8}$ in.

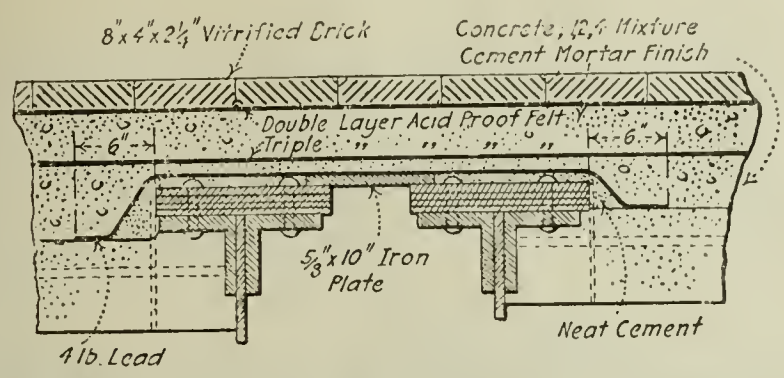


Fig. 2.—Method of Protecting Steel Girders with Cement and Sheet Lead.

Where the acid-proof covering must pass over girders they are first covered with neat cement and a sheet of lead, as shown in the accompanying drawing (Fig. 2). Around the edges of the floors for the battery rooms are built low barriers of vitrified brick coated with acid-proof paint and separated from the walls by Hydrex felt and hot compound.

SCIENCE AND THE STATE.

The following is an abstract of the memorial signed by 21 professors of this College and presented to Lord Crewe on the 31st ult. :—

We, the undersigned, submitted to you in March last a brief memorandum in support of a memorial which had then recently appeared on "The Neglect of Science." We believe that you will welcome a further statement from us as to what, in our opinion, the Government could do in regard to this important subject.

What seems to be primarily needed is that at this critical time in our history, the Government, through some of its leading members, shall speak plainly to the country on the question of national education, and shall guide and instruct the public in a matter where there is still so much lethargy, misconception and ignorance.

A large body of opinion at Oxford and Cambridge and in the country generally, is in favour of altering the conditions of entrance to these universities. It has been clear for a long time that to effect reform in this and other matters, an alteration in the method of their government is required. And yet generation follows generation and nothing is done. Is it not desirable that, at any rate immediately after the war, the legislative changes which are desirable shall be introduced into Parliament by the Government ?

It would appear desirable that the boys with brains should be attracted to the Modern as much as to the Classical sides of the schools, as far as the use of the endowments is concerned. At the present time, however, it is the fact that many of the best boys at the public schools are practically forced to the classical side, and it is often only in exceptional cases, as where a far-seeing parent has intervened, that a clever boy has been allowed seriously to study science.

In the past a considerable proportion of the cleverest boys in these schools and in the preparatory schools which lead to them, have been taught classics from an early age, and because many boys with brains who succeed in after life have been educated in this way, it has been assumed that a classical education is more likely to make a man successful in the public service and in other branches of life than is a modern or scientific education. We believe this assumption to be quite unfounded.

We desire to lay very great stress upon the importance of immediately devising means for sending a larger supply of able young men who have been thoroughly educated in science as part of a well-considered curriculum, to our universities and colleges. This would provide among men of business, or men in public careers, a larger proportion of individuals trained in scientific methods, which is generally recognised as of great importance. In our own experience now that many leaders of industry are realising the value of science, we have found when asked by them to supply the young and promising men that they require, that it has been sometimes impossible to answer their call simply because of a shortage of properly trained men.

There are a large number of boys and young men of real ability to be found in our State-aided secondary schools, our technical schools and classes, and our evening schools. What is needed is that these shall have better opportunities of being well taught, and better chances of coming on to the universities and colleges of university rank. For this purpose we need in these schools, above all, teachers with better pay and better prospects. It is impossible to get the best results as long as many of the teachers in these schools are badly paid, and have not as yet, like so many other teachers, even any prospects of a pension. The whole scale of salaries for teachers of all subjects, especially in the upper part of most of these schools, must be lifted.

In order to bring to the universities the best boys, many of whom now leave the State-aided secondary schools at 16, tempted by offers of salaries into business and industry, an adequate number of bursaries for those from 16 to 18 years of age ought to be provided tenable at these schools. These should be followed by the offer of a large number of Government scholarships, adequate in value, and tenable at the universities and at colleges of university rank. For the above mentioned purposes, probably half a million a year could be wisely spent with results to the nation of the most valuable kind.

As to the universities and colleges themselves, no doubt part of the money for industrial research, which is administered by your Privy Council Committee, will be of real service to them. But much has to be done to put the teaching of science and technology on a proper footing at these institutions. The salaries of the junior staff are often much too low. It is estimated that the State grants to universities in Germany are about a million and a half a year, whilst in England they amount to less than a quarter of a million a year. Another quarter of a million a year could be advantageously expended by Parliament in this direction.

The Government, therefore, can, in our opinion, do great service to national education in ensuring a more adequate position for science : (1) By removing obstacles. (2) By giving information and guidance which may be of service to parents and to the public at large. (3) By recommending to Parliament considerable grants of public money in the directions we have indicated.

We have ventured to lay these considerations before you because we know that, as our chairman, you are interested in these matters. Your position, too, as chairman of the Privy Council Committee on Industrial Research brings you in contact with many of these questions, the high national import of which we feel sure you appreciate.

The Memorial was signed by the following, professors' chairs being given in brackets :—

H. B. Baker, F.R.S.	(Chemistry.)
V. H. Blackman, F.R.S. ...	(Plant Physiology and Pathology.)
W. A. Bone, F.R.S.	(Chemical Technology—Fuel and Refractory Materials.)
H. L. Callendar, F.R.S.	(Physics.)
H. C. H. Carpenter	(Metallurgy.)
C. Gilbert Cullis	(Economic Mineralogy.)
W. E. Dalby, F.R.S.	(Mechanical & Motive Power Engineering.)
S. Dixon	(Civil Engineering.)
J. Bretland Farmer, F.R.S.	(Botany.)
A. R. Forsyth, F.R.S.	(Mathematics.)
A. Fowler, F.R.S.	(Astrophysics.)
W. Frecheville.....	(Mining.)
Percy Groom	(Technology of Woods and Fibres.)
E. W. MacBride, F.R.S. ...	(Zoology.)
T. Mather, F.R.S.	(Electrical Engineering.)
J. C. Philip	(Physical Chemistry.)
H. G. Plimmer, F.R.S.	(Comparative Pathology.)
R. J. Strutt	(Physics.)
Jocelyn Thorpe, F.R.S.	(Organic Chemistry.)
W. W. Watts, F.R.S.	(Geology.)
A. N. Whitehead, F.R.S. . .	(Applied Mathematics.)

PARLIAMENTARY INTELLIGENCE.

TRADE AFTER THE WAR.

In the House of Commons, on the 1st inst., Mr. Pretyman stated, in reply to some remarks made by Sir R. Cooper, that before the close of 1914 a very valuable memorandum dealing with the industrial problems that would naturally arise in this country on the conclusion of the war had been prepared by the Board of Trade. It would not be wise to publish it at this time, but he thought that when it was issued it would be found to contain proposals which would go far towards solving the vital problems which must be expected. The dangers associated with what were known as German methods of peaceful penetration were realised by all in this country now. The tendency of trade prior to the outbreak of the war was in the direction of international undertakings : but while the people of this country regarded that as purely a trade matter and from a national standpoint were entirely unselfish, there was in the action of the Germans a political object as well as a dishonest trade object. The Board of Trade were, as far as possible, getting rid of all the German elements in our trade. One factor that was difficult to deal with was the control which German commercial agents had procured over some particular outputs of a pivotal character, such as certain chemicals. It was not only capital and knowledge that were required if we were to be independent in our supplies at the end of the war. Plant and man power were also needed, and demands of military necessities upon these must come before everything else. At the same time, the Board of Trade

recognised that we must be self-supporting in those vital products when the war was over, for if the gates had to be opened after the war to uncontrolled supplies from abroad of those products because they could not be produced at home it would be difficult to close the gates again. Four Committees had been set up to advise the Board of Trade as to the position of particular groups of trades after the war, with special reference to international competition. The trades concerned were iron and steel, shipbuilding, textile, electrical; and a fifth Committee was now being set up for the coal trade. The mass of the nation was in favour of a national trade policy after the war, and those Committees were uninfluenced by any of the political questions or economic theories which caused controversy before the war.

NEW GAS STANDARD.

A Bill has been introduced into the House of Commons on behalf of the Board of Trade to empower gas undertakings to substitute a standard of calorific power for the present standard of illuminating power. The measure exempts gas companies from penalties to which they are now liable if the illuminating power is deficient. Clause 1 provides that "in considering the expediency of making an order under the Bill, the Government Department shall have special regard to whether the companies have erected and worked, or are prepared to erect and work, suitable crude benzol recovery plant for the production of benzol and toluol."

LEGAL INTELLIGENCE.

A. Weisenberg v. Bodie.

At Birmingham County Court last week plaintiff claimed to recover £50 damages for personal injuries from "Dr." Walford Bodie.

PLAINTIFF said that on June 12, 1915, he went with a friend to the Gaiety, where "Dr." Bodie was appearing. During his performance Bodie placed on the stage an electric battery, and invited people in the audience to hold the handles of the machine, assuring them it would not hurt them. One man in the audience tried it apparently without harm, and plaintiff, placing reliance on Bodie's statement, thought he would like to try it, and caught hold of the handles which defendant swung out to him. Immediately plaintiff touched them he fell on his back. He received a terrible shock and became unconscious for a second or two. His right arm became painful and next morning he went to the Queen's Hospital. His arm became very swollen, and on the following Monday he saw defendant at Smethwick, where he was appearing. Defendant, after looking at his arm, said it did look a bit bad, and gave him a prescription. He said it would be all right, but it might take a week or a fortnight. Plaintiff was unable to work until August 9.

For the defence, Mr. H. HERTON, manager of the Gaiety, said he saw plaintiff take hold of the handles, but never saw him fall, and no complaint was made to witness.

Dr. JONES said from what he had seen "Dr." Bodie generally used high-frequency currents from which it was almost impossible to get any bad results. Witness had not examined plaintiff.

His HONOUR came to the conclusion that plaintiff suffered from an "overdose of current," and his disability was a consequence of that. It seemed to him that where a man had a battery of that kind, and represented to the audience it was safe for them to take hold of the handles, there was a duty upon him to see that a high standard of care was taken to keep the current under control. He did not think that had been done in that case. He gave judgment for plaintiff, and assessed damages at £25.

Stay of execution was granted.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914 SPECIFICATIONS.

17,872 SOC. MARIUS LATOUR ET CIE. Construction of high-frequency alternators. (22/11/12. Divided application on 26,934/13. No. 2.)

1915 SPECIFICATIONS.

2,494 RUSHTON & COVENTRY ELECTRIC CLOCK CO. Electromagnetic driving mechanism. (13/8/15.)

3,760 CANTON. Incandescent electric lamps.

6,296 MAUCLAIRE & BRETON. Apparatus adapted to be used for the production of electric oscillations for wireless telegraphy, wireless telephony and for other purposes.

Consists in the combination in an electric circuit of two conductors one of which is a central rod of carbon or other material and the other is a hollow disc of conducting material surrounding the said rod, the said disc having a central opening at the centre of which the end of the carbon electrode.

6,647 TIGERSTEDT. Sound-directing appliances for use with telephones and microphones. (20/5/14.)

6,674 BEAVER & CLAREMONT. Systems for the protection of electric cables in the event of external damage.

6,818 KING. Automatic switches of electric train lighting systems.

6,930 PHILIP & STEPHENS. Electric measuring instruments.

6,980 TANNER & CLAREMONT. Joint for an electric cable.

7,025 CAUTEAU. Electric time-alarm and call-signals.

7,177 GROB. Switching over systems for electric lighting installations for railway trains and the like.

7,308 WEBB. Electric switches.

7,324 CHADBURN & CHADBURN'S SHIP) TELEGRAPH CO. Ship's stokehold and analogous telegraphic apparatus.

7,355 DAIMLER CO., LANCHESTER & MILLIGAN. Electrical transmission for automoblie vehicles.

7,357 B.T.-H. CO. (G.E. CO.) Wireless signalling systems.

An electron discharge device is employed for producing continuous electrical waves in an antenna. The amplitude of the waves thus produced is controlled by a second electron discharge device operatively connected to the first and having associated therewith a telephone transmitter or other suitable device for varying the potential of a controlling grid in said second electron discharge device. By thus varying the potential of the grid in the second device the amplitude of the waves produced in the antenna may be efficiently varied as desired.

10,762 B.T.-H. CO., & POLLOCK. Dynamo-electric machines.

17,535 ALLEMANNA SVENSKA ELEKTRISKA AKTIEBOLAGET. Time-lag electric switches. (9/11/15.)

17,876 WESTERN ELECTRIC CO. (Western Electric Co.) Keyboard controlling devices, particularly applicable to telephone systems.

339 JACKSON, W. J. MELLERSH. (Arbib, A.) Radiotelegraphy apparatus. (7/1/16, 100,384.)

Comprises radiotelegraphy apparatus having primary and secondary coils movable with respect to each other, in which each coil includes at least two subdivisions, and in which one of the subdivisions is stationary, whereas any one of the other three may be independently moved with respect to each other, and also with respect to the stationary subdivision.

488 KRUPP AKT.-GES., F. Magnetic separators. (9/2/15, 100,063.)

4,338 KRUPP AKT.-GES., F. Magnetic separators. (22/10/15. Divided application on 488/16, 100,379.)

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

May 15, 1916.

6,893 CRAWFORD, PRESTON & SANDERS. Electrical fuse boards.

6,897 CLARK & GIBBINS. Electric alarm.

6,929 & 6,930 HADDON. Mechanical wave transmission of power.

6,945 BAUMGARTNER & PARRIS. Telegraph systems.

May 16, 1916.

6,948 KENYON. Tramway systems.

6,962 DUNGEY & KERSTING. Intercommunication telephones.

6,965 BAESE. Localisation of foreign bodies, and radiotherapic appliances. (17/5/15, Italy.)

6,977 SIEMENS-SCHUCKERTWERKE. Electrical connecting-devices. (22/5/15, Germany.)

6,982 JEFFERSON. Terminal seal for batteries, &c. (21/5/15.)

6,993 SOLOMON. Systems of wireless telephony and telegraphy.

May 17, 1916.

7,009 SHORT. Combined electric lamp holder and lamp lock.

7,014 KOHN. Electric furnaces.

7,023 GINDERS. Joining ends of electrical conductors.

7,026 CLAY. Locking electric lamps in holders.

7,061 DUNGEY & DAVEY. Electrical signalling and telephone systems.

7,062 ROBINSON. Magneto-electric machines, &c.

7,064 NAAMLOOZE VENNOOTSCHAP DE NEDERLANDSCHE THERMO-TELEPHOON MAATSCHAPPIJ, SOAMES & LANGDON-DAVIES. Electrically-controlled clutches.

May 18, 1916.

7,091 BROWN. Electro-magnetic sound receivers and producers.

7,100 AUTOMATIC TELEPHONE MANUFACTURING CO. Automatic telephone systems. (19/7/15, U.S.)

7,074 KNIGHT. Air-inlet attachment for sparking-plugs for internal-combustion engines.

7,088 ROSSO. System of radio-telegraphy for multiple simultaneous transmission. (18/5/15, Italy.)

7,121 STONE & DARKER. Dynamo-electric generators and systems connected therewith.

May 19, 1916.

7,187 BRUNNING & BURNETT. Electric heating devices.

7,156 McLEOD. Electrical signalling or telegraphing systems.

7,178 THAIN, WASHINGTON & ARMSTRONG, WHITWORTH. Electrical rotary switches.

7,186 KLYNE & BAKER. Insulation of electrical machinery, &c.

May 20, 1916.

7,214 ATHERTON. Electric motors with reduction gearing.

7,223 SCHAEFER. Supports for suspended conductors.

7,230 CLAUS. Systems for telegraphic and telephonic communication.

7,235 LOWDEN. Apparatus for laying subterranean electric wires or cables.

7,236 CODD. Electrical condensers.

May 22, 1916.

7,244 DAVENPORT & STOBIE. Electrodes of electric melting and heating furnaces.

7,255 BRITISH INSULATED & HELSBY CABLES & HARRISON. Loading coils.

7,258 WESTERN ELECTRIC CO. Call-distributing telephone systems. (22/5/15, U.S.)

7,275 ERICHSEN. Electric heating apparatus.

7,281 FIRTH. Indicating, recording and cancelling or resetting, &c., apparatus for signalling systems.

7,288 TURQUAND. Mixers, &c., electric lamps.

May 23, 1916.

7,302 SENTER. Use of manufactured material in filling shrapnel shells, bombs, &c.

7,305 FURSE & FURSE. Stands for exhaust tables for electric lamps.

7,314 WICKENS. Adapter for electric miniature lamps.

7,328 CALLENDER'S CABLE & CONSTRUCTION. Multicore electric cables.

7,334 PALMER. Telegraphy. (29/5/15, New Zealand.)

7,335 BYGRAVE & RELAY AUTOMATIC TELEPHONE CO. Telephony.

7,336 RELAY AUTOMATIC TELEPHONE CO. & ROBERTSON. Thermo-electric switches.

7,344 BELL. Vibrating signalling devices for wireless &c.

7,347 LAMB & RUSHTON. Electric-conductor conduits.

May 24, 1916.

7,360 MERCIER. Electric lamps.

7,392 BRITISH, IRISH & COLONIAL BROS & CO. Electric ignition or sparking arrangements.

7,399 & 7,400 MAARSBANT. Railway signalling means.

May 25, 1916.

7,456 FLEW & SMITH. Electro-chemical receivers for wireless telephony and telegraphy, &c.

7,471 PAGE. Electrical locking and operating for railway signal levers.

May 26, 1916.

7,517 LAWSON. Sparking plugs.

7,513 MARCONI. Electrical signalling systems.

7,497 LEMAITRE. Household appliance for telephones.

May 27, 1916.

7,535 FESSIER. Spark plugs.

7,540 HARTLAND & ROBINSON & CO. Transmitting gear of ships' telegraphic, &c., apparatus.

7,552 PETERSEN. Power transmission devices.

7,567 INDIA RUBBER CO. & JACOBS. Substitutes for boundary batteries.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	331	Hotpoint Electric Ranges. Illustrated	66
Imports and Exports of Electrical Manufactures	332	Direct-Current Motor Control Pillars. Illustrated	67
Educational	332	Monometer Tilting Furnaee..	68
Business Notices	332	Rotor Starters. Illustrated..	70
Liquidations, Bankruptcies, &c.	332	High - Angle Searchlights. Illustrated	70
Electricity Supply	332		
Lighting and Power Notes	333		
Traction Notes	333		
Telegraph and Telephone Notes	334	Tenders Invited	336
Empire Notes	334	Tenders Received & Accepted	336
Foreign Notes	335	Municipal Accounts	337
Miscellaneous Notes	335	Companies' Meetings and Reports	338
		New Companies, &c.	339
The Round Table	63	City Notes	340
Window Dressing—New Reflector. Illustrated	64	Electrical Companies' Share List	340

COMMERCIAL TOPICS.

Exclusion of German Influence. In giving orders for the supply of machinery and goods it is now the usual practice to insert a condition providing that the company or person to whom the order is given is not under German influence. We have recently come across a striking instance of this character, and in view of the interest in and importance of this matter at present, we give below the text of the clause in question :—

The Oxcroft Colliery Co. (Ltd.) give the accompanying order (or contract) upon the distinct understanding that the company, firm or individual to whom it is sent is not in any way under the influence or control directly or indirectly of any German, whether naturalised or otherwise, and that none of the payments or profits arising from its execution will pass into the hands of Germans as shareholders, partners or otherwise, By order of the Board, D. Palmer, secretary.

* * * *

Prohibition of Imports. An Order in Council was issued on June 1 prohibiting the importation into the United Kingdom of manufactures of aluminium and manufactures of leather (other than belting), &c.

* * * *

Control of Petrol Supplies. The Petrol Control Committee of the Board of Trade have issued a statement drawing the attention of motorists and other users of motor spirit to the acts and regulations which limit the amount of motor spirit that may be stored without a licence.

The Committee intends to take a census of motor vehicles and of petrol consumption and requirements, and in the meantime a sub-committee (consisting of representatives of the chief distributing organisations) has undertaken to regulate the supply of petrol according to the classification set out below. It is not anticipated that there need be any curtailment at present of reasonable demands in Classes A and B.

Class A includes requirements for or by carriage of munitions of war or materials for munitions of war ; fire brigades and ambulances ; lords lieutenant, high sheriffs, and any services certified by a Government department to be essential, medical practitioners, motor cars used by or under the authority of the Red Cross Society, &c.

Class B includes requirements for or by agricultural machinery, aircraft conveyance of goods, industrial processes, motor cabs plying for hire and used by commercial travellers for business purposes, motor fishing, cargo and passenger boats other than boats running pleasure services, motor omnibuses (except pleasure services), railway companies, stationary engines (including lighting sets).

Class C includes all requirements not covered by Class A or Class B, such as chars-à-bancs and other passenger vehicles running pleasure services, motor boats, &c.

* * * *

Future of the Coal Trade. The President of the Board of Trade has appointed a Committee, consisting of Lord Rhondda (chairman), Mr. A. E. Bowen, Mr. Newton Dunn, Mr. F. J. Jours, Mr. A. Nimmo, Mr. A. F. Pease, Sir Daniel M. Stevenson and Mr. R. Warham, to consider the position of the coal trade after the war, with especial reference to international competition, and to report what measures (if any) are necessary or desirable to safeguard that position. Mr. J. M. Smith, of the Board of Trade, is secretary to the Committee.

* * * *

National Organisation. An important conference of business men was held in Glasgow last week in order to discuss methods of business organisation. Sir Lord Provost Dunlop presided, and referred to the opportunity that presented itself of supplanting the German trader in the Russian market.

Sir Edward Rosling said that organisation was not peculiarly a German quality. They saw that throughout history commercial victory with which military victory was bound up went to the people whose commerce was organised upon national lines. If the industrial power of this country was to survive in face of the fierce competition on national lines which was certain to follow this war we must organise ourselves upon the old lines, which were not German lines, in order to hold our own in the markets of the world. The old and natural organisation of our national commerce was to take each trade as a unit. Then we might have a common organisation like the old Merchant Adventurers to bind together all those organised trades, and to bring pressure upon the Government to assist and support and protect the industrial interest of the country. If we did not do that he could not well see how we were to survive ; if we did that he thought we might hold our own against Germany, the United States or any other power that was going to compete with us. He went into the details of the history of the sugar industry, and he recalled that 100 years ago Great Britain largely controlled the supplies of tea, rubber and sundry other raw articles produced within the Empire, but Continental nations saw the danger to them of that British monopoly. By 1840 beet sugar had become fairly well established on the Continent, and 30 years later it had driven our cane sugar almost out of the world's market. The details of organisation that were suitable for one industry might be quite unsuitable for another. In one it might be necessary to seek the active assistance of the Government, in another it might be the passive assistance that was necessary—in other words, to be left alone ; but in all cases the principle of organisation remained the same—namely, that each enterprise or unit should be one of a number of essential and mutually dependent parts. He did not want to see our industries the sport of politics. Our whole history proved that our industries were built up largely by national support, of which the regulation of customs to protect particular industries played an important part. The first principle of commercial success was and must be the margin of profit, not only to the capitalist, but also to labour, and when they saw that margin disappearing through the action of foreign countries, assisted by their Government, we had every reason to demand that the Government should assist the industries of the Empire to maintain that margin. In the past capital and labour have not always seen eye to eye, and he did not think we could expect it to do so in future, but there was one aim which should be common to both, and which, if we were to maintain our position or strengthen it as producers and manufacturers, must be kept constantly in view by all, and that was efficiency. Unless labour would consent to do its best and not deliberately to reduce its possible output there would be little use in increased scientific research and improved machinery, and, again, if capital was not prepared to ensure for labour the result of its increased output we could hardly expect to see labour view the subject sympathetically. Labour had organised itself chiefly as a protective measure against capital. Was it too much to hope that capital and labour would organise themselves against the common enemy, and was it too much to hope that they would receive not only sympathetic but practical assistance from the Government ? Before the Government could assist they must know what it was that was really wanted.

Capt. Creed said the lack of organisation in this country was not due to inability to organise, but to the independent individualism which was latent and natural in us, and to the fact that before the war we thought we could afford to indulge that trait of our character. The organisation must be on a scale hitherto uncontemplated. The British were the best organisers in the world, and once their consent had been gained they were the easiest people to organise.

Mr. Sam Mavor said the need for organising groups of business was urgent and important, but the foundation upon which the whole structure must be raised was organisation of individual businesses. There was a wide field in which the interest of employers and employed were identical. Why not, therefore, enlist the co-operation of the magnificent organisation which existed in the trade unions, and make it available in so far as the interests of employers and workers were mutual ?

A resolution was ultimately adopted appointing a committee representative of the City Business Club and the Rotary Club, Glasgow, with the following objects : " (1) To suggest changes in industrial organisation necessary to defend the industries of this city and country and Empire against the resumption after the war of aggressive action by enemy countries ; and (2) to suggest the courses of action necessary to be taken at once in order to secure such a commanding position for our trade in this city and country and Empire as to form a defensive barrier against the commercial competition of enemy countries after the war."

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From May 29, 1916, *to* June 3, 1916.

IMPORTS.

GRIMSBY. *Denmark:* Carbon electrodes, 78 pkgs.; electrodes, 10 pkgs.
LIVERPOOL. *U.S.A.:* Elec. carbons, 9 pkgs; insulated wire, 158 pkgs.; unenumerated 433 pkgs.
LONDON.—*U.S.A.:* Elec. machinery, £2,092; elec. lamps, £701; unenumerated, £5,909. *Holland:* Elec. lamps, £3,833; elec. bulbs, 65 pkgs.; elec. lamps and caps, 619 pkgs.; unenumerated, £2,015. *Switzerland:* Elec. machinery, £128; unenumerated, £242. *Italy:* Elec. wire, 122 pkgs. *Japan:* Unenumerated, £376. *France:* Carbon candles, £331; elec. meters, 9 pkgs.; elec. machinery, £310; unenumerated, £247. *Norway:* Elec. machinery, £8. *Sweden:* Elec. machinery, £1,839. *Denmark:* Unenumerated, £97.
SOUTHAMPTON.—*France:* Insulating material, 52 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Wire and cable, £10; unenumerated, £707. *Melbourne:* Wire and cable, £98; unenumerated, £7,465. *Sydney:* Elec. machinery, £7,608; wire and cable, £300; telegraph material, £100; unenumerated, £917. *Wellington:* Elec. machinery, £266; wire and cable, £215; unenumerated, £1,054. *Perth:* Unenumerated £11. *Christchurch:* Elec. machinery, £465; unenumerated, £36. *Lyttelton:* Elec. machinery, £61; unenumerated, £83. *Brisbane:* Unenumerated, £48. *Fremantle:* Unenumerated, £412. *Dunedin:* Wire and cable, £221; unenumerated, £176. *Adelaide:* Unenumerated, £167. *Hobart:* Unenumerated, £141. *Newcastle:* Elec. cable, £80; elec. motors, £318. *Launceston:* Elec. motor, £113.
AFRICA. *Durban:* Wire and cable, £163; elec. machinery, £1,427; unenumerated, £2,896. *Cape Town:* Elec. machinery, £399; unenumerated, £403. *Port Elizabeth:* Elec. machinery, £190. *East London:* Unenumerated, £88. *Beira:* Wire and cable, £39; unenumerated, £225.
EGYPT. *Port Said:* Elec. machinery, £120; unenumerated, £28. *Alexandria:* Elec. machinery, £490; unenumerated, £113.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Elec. machinery, £147; unenumerated, £1,208. *Calcutta:* Elec. machinery, £135; wire and cable, £15; unenumerated, £2,088. *Madras:* Unenumerated, £482. *Singapore:* Elec. machinery, £20; unenumerated, £548. *Ceylon:* Unenumerated, £271.
BURMA.—*Rangoon:* Wire and cable, £32; unenumerated, £63.
SUMATRA.—*Medan:* Elec. motor and parts, £170.
CHINA—*Hong Kong:* Unenumerated, £302. *Shanghai:* Elec. lamps, 15,223 no.; wire and cable, £78. *Penang:* Elec. machinery, £205; wire and cable, £118; unenumerated, £261.
U.S.A. *New York:* Unenumerated, £500.
SOUTH AND CENTRAL AMERICA. *Buenos Ayres:* Wire and cable, £390; unenumerated, £10,319. *Pernambuco:* Unenumerated, £36. *Rio Gallegos:* Osram lamps, £38. *Monte Video:* Elec. machinery, £50. *Rosario:* Elec. cable, £442; unenumerated, £54.
HOLLAND.—*Amsterdam:* Wire and cable, £663; unenumerated, £892. *Rotterdam:* Wire and cable, £1,120; unenumerated, £201.
FRANCE.—*Paris:* Unenumerated, £562. *Dieppe:* Unenumerated, £167. *Calais:* Wire and cable, £174. *Havre:* Telegraph material, £280. *Bordeaux:* Unenumerated, £24.
PORTUGAL.—*Lisbon:* Wire and cable, £313; unenumerated, £119.
RUSSIA. *Petrograd:* Elec. machinery, £178.
CANADA.—*Montreal:* Unenumerated, £551. *Halifax:* Submarine telegraph material, £6,215. *St. John's:* Elec. machinery, £157.
DENMARK.—*Copenhagen:* Wire and cable, £5,843; unenumerated, £269.
MALTA. Unenumerated, £9.
BRITISH GUIANA.—*Demerara:* Unenumerated, £18.
JAVA.—*Batavia:* Wire and cable, £3,484.

FOREIGN GOODS (duty paid and free).

Calcutta: Unenumerated, £51. *Adelaide:* Unenumerated, £424. *Alexandria:* Unenumerated, £75. *Cape Town:* Unenumerated, £26. *Amsterdam:* Unenumerated, £309. *Sydney:* Unenumerated, £68. *Wellington:* Unenumerated, £92. *Auckland:* Unenumerated, £22. *Bombay:* Unenumerated, £68. *Buenos Ayres:* Unenumerated, £67 *Copenhagen:* Unenumerated, £58. *Malta:* Unenumerated, £65. *New York:* Unenumerated, £30. *Penang:* Unenumerated, £60. *Shanghai:* Unenumerated, £829. *Demerara:* Unenumerated, £29. *Lisbon:* Unenumerated, £62. *Petrograd:* Unenumerated, £470.

IN TRANSIT.

Hong Kong: Elec. lamps, £6,400. *New York:* Unenumerated, £80. *Melbourne:* Elec. lamps, £140. *Natal:* Elec. lamps, £110. *Sydney:* Elec. lamps, £720.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

EDUCATIONAL.

Technical College for Middlesbrough.—On Monday at a conference of local ironmasters, employers of labour and education authorities of Durham and the North Riding of Yorkshire, the urgent need of better facilities for technical and scientific instruction to meet the growing competition in trade and industry was emphasised by many speakers, and a scheme was launched for the establishment of a technical college at Middlesbrough. Mr. Joseph Constantine, a local shipowner, gave £40,000 and other local firms promised £15,000.

BUSINESS NOTICES.

THE head offices of Messrs. Berry, Skinner & Co. have been moved to "The Switch House," 86, Newman-street, Oxford-street, London, W. The new telegraphic address will be "Ptolemaist Ox London," and telephone Nos. "Museum 3310 and 3311."

THE London offices of the Manometer Mfg. Co. (Ltd.) have been removed to Imperial House, Kingsway, W.C. Telephone: Gerrard 6326.

CHAS. SEYMOR ENGZELINS and JAS. STROUD NUNN, trading as the Western Electric Lamp Co., 1 & 3, Sun-street, Finsbury, London, E.C., have dissolved partnership. Debts by Mr. Engzelins, who continues the business.

Plant for Sale.—Barnsley Corporation have for sale two 75 kw. d.c. direct-coupled generating sets (Willans engines and Johnson & Phillips dynamos). Tenders, addressed to the Borough Electrical Engineer, by June 17. *See also an advertisement.*

A Belliss steam engine coupled to an E.C.C. dynamo (80/100 kw., 105 volts) and a Roley horizontal cross-compound engine are advertised for sale by the Electric Construction Co., Wolverhampton.

LIQUIDATIONS, BANKRUPTCIES, &c.

Mr. F. S. Culley, Queen-street, Norwich, has been appointed as additional liquidator of Norman & Beard (Ltd.) (in vol. liq.), and claims are to be sent to him by July 15.

The Easton Lift Co. (Ltd.) is being wound up voluntarily and Mr. H. G. Holm is, 23, Paternoster-row, London, E.C., has been appointed liquidator. A meeting of creditors will take place at Express Works, New Cut, London, S.E., on June 15.

Claims against Geo. Edwd. Bonner, electrical agent, Asheroft, 105, Fox-lane, Palmer's Green, Middlesex, are to be sent by June 21 to Mr. E. W. J. Savill, 14, Belford-row, London, W.C.

At Bristol County Court, on the 31st ult., Messrs. Haslam & Stretton applied for an order for the winding up of the Colston Electrical Works (Ltd.), of Bristol.

Mr. HASLAM said he thought the petitioning creditors were entitled to the winding-up order being made. A short time ago the company asked them to agree to the petition being withdrawn and the company wound up voluntarily. On May 23 Mr. Arthur Collins was appointed liquidator by the company. If the company were wound up voluntarily an offer of 12s. 6d. in the £ would be made by outside people. His clients thought it would be to their interest to have the petition withdrawn and the voluntary liquidation carried out. It was a matter for the creditors.

Mr. WEATHERLY (for Simplex Conduits, Ltd.), who had been creditors for £490, and were now for about £90) said it was thought the assets when realised would be more than the liabilities. £797 was the amount of the total liabilities.

Mr. W. S. BROWN said he was no party to what was done at the meeting and had no voice of it.

Mr. TAYLOR (for the Colston Company) said the Simplex Company had claimed about £500, and they obtained judgment and put in an execution. As a matter of fact, they reduced their claim to about £90. When they did that Haslam & Stretton (who were creditors for about £80 or £90) put a petition on the file, which was heard that day. When the petition was presented the idea they had was to protect the estate, and they applied that the official receiver should be made liquidator, and he believed that he had taken possession of the assets. Then there was an informal meeting in Bristol to see if something could be done to keep the company on foot, and the largest creditors were represented. The meeting was held on May 12, creditors for £520 being represented. It was stated that there were persons who would guarantee 12s. 6d. in the £ if no order was made. He asked for an adjournment to consider the matter.

After discussion, his HONOUR said he did not see why he should not make an order for a compulsory winding up.

ELECTRICITY SUPPLY.

EXTENSIONS.

Battersea.—The Electricity Committee reports that in dealing with the supply of energy in the Nine Elms and Church-road districts, it had arranged for the supply of an additional 500 k.v.a. transformer in the New-road sub-station by the British Electrical Transformer Co., and for the supply of switchgear by the British Westinghouse Co.

The Committee recommends the erection of a sub-station adjoining the Nine Elms Baths at a cost of about £1,260. For some time past the Committee has been in negotiation with Babcock & Wilcox with reference to their contract for a boiler and stoker supplied to the generating station. The firm have now undertaken to replace the mechanical stoker with one similar to those already installed, the Council to pay £50 towards two years' maintenance of the stoker to be replaced.

Belfast.—Last week the City Council considered a report on the necessity of carrying out extensions at the electricity supply works, and they were recommended to appoint a deputation to wait upon the L.G. Board to explain the facts and to ask them to authorise the expenditure of £28,391 on extensions.

The proposal was opposed by Ald. Tyrrell, who thought that the sum mentioned would not be sufficient, inasmuch as the estimate was drawn up in January, 1915. He was opposed to the expenditure of such a sum upon a patchwork scheme, as the present works would not admit of extension sufficient to meet the requirements of the city for the next 30 or 50 years. Eventually the amendment was rejected and the Committee's recommendation approved.

Bradford.—On Tuesday the Electricity Committee recommended that, in view of the ever-growing demands upon the department for the supply of electricity, application should be made for sanction to borrow £100,000 for extensions of the generating plant.

Hammersmith.—The L.C.C. has sanctioned the borrowing by the Borough Council of £3,000 for the electricity undertaking.

The order sanctioning the borrowing will, however, not be issued until the Borough Council agrees to limit all expenditure under the sanction, during the war, to the provision of mains, plant and house services necessary to supply energy to consumers doing work directly or indirectly for the Government.

The Electricity Committee has reported upon the letter from the Board of Trade on the increasing difficulties of providing supplies of coal, and calling attention to the considerable saving that can be effected by arranging for inter-connection and joint working of electric supply undertakings. The committee reminds the Council that in June last a scheme for linking-up the generating stations of Battersea, Fulham and Hammersmith was approved in principle, subject to the necessary consents being obtained. H.M. Treasury, however, only sanctioned such capital expenditure on the scheme as was then alleged to be urgently necessary for the effective maintenance of existing supplies, and the London County Council, therefore, decided that loans must at that time be limited to the cost of linking-up the undertakings of Battersea and Fulham. The Borough Council, however, strongly pressed the advisability of carrying out the complete scheme, but the Treasury adhered to their original decision. Accordingly Hammersmith had no alternative but to withdraw from the scheme. Having regard to the terms of the Board's present letter, the Committee has now directed the Town Clerk to re-open negotiations with the Government departments concerned upon the desirability of completing the original scheme of linking-up.

Wolverhampton.—The Corporation have applied for sanction to borrow £17,160 for additional boiler house plant for the electricity works.

GENERAL.

Aberdeen.—The Electricity Committee is in negotiation with a firm for the supply of electrical energy for power to a new shipbuilding yard.

Birmingham.—The accounts of the Electric Supply and Tramways Committees were submitted to and approved by the Council on Wednesday.

Ald. JEPHCOTT, in presenting the report of the Electric Supply Committee, said the output had risen 50 per cent., the principal increase being in l.t. and h.t. power. The cost of generation had also increased, owing to the high price of fuel, and other causes.

Finchley.—The Council has decided to increase the price of current for private lighting by another 10 per cent. in addition to the 10 per cent. previously decided upon.

The price of current for power will also be increased as from the above-mentioned date as follows: (*a*) Consumers with a load factor of 33⅓ per cent. or less, by 10 per cent.; (*b*) exceeding 33⅓ per cent., the increase to be the percentage amount of the excess fuel cost over 0·9d. per unit generated, with a limit of 10 per cent.

It is also proposed to suspend on and after Aug. 1 and during the period of the war the clause of the general conditions of supply relating to free service connections.

Fulham (London).—The Electricity Committee recommend the Council to convey their congratulations to Mr. T. H. Welch (shift engineer) upon the courage and skill he displayed in rescuing a man from drowning.

Last month one of the employés at Townmead Wharf was struck by a crane, and knocked into the river. The man, who was rendered insensible by the blow, would have been drowned but for the promptitude with which Mr. Welch jumped into the river and succeeded in bringing him to the bank. The committee recommend Mr. Welch for the Royal Humane Society's medal or certificate for saving life.

Ilkeston.—For some time negotiations have been going on between the Corporation and the Nottinghamshire and Derbyshire Electric Power Co., as to the purchase by the Company of the Municipal electric tramways and electric supply undertakings.

The company's offer was recently considered by the Tramways and Electricity Committee, when it was decided to recommend the Council to accept the terms offered. In turn, the Council (as a General Purposes Committee) considered the matter, and decided by a large majority to accept the offer, and to sell the undertakings. The resolution was submitted for confirmation to the ordinary meeting of the Council on Tuesday.

The electric tramways were opened on May 16, 1903, and during the whole of the time they have involved an annual loss varying from £2,000 to £3,000, equal to a rate of from 6d. to 9d. in the pound. Considerable expenditure is now needed to put the track in better order, and new cars are also required.

The proposed sale was approved by the Council.

Liverpool.—The Corporation is recommended by the Finance Committee not to approve the resolution of the Tramways, Electric Power and Lighting Committee to increase the pay of certain of their employés by ¼d. per hour, but that a war bonus of 1s. 6d. per week should be given to all men in the Corporation employ of 18 years of age and upwards who are in receipt of a weekly wage, and who have been in the service of the Corporation for at least 12 months, with a proviso that no man shall receive by reason of such bonus a sum in excess of £3 per week.

Maidstone.—The Council have adopted a new scale of charges for the supply of electrical energy. The revised scale will come into force on July 1, and represents an increase of 25 per cent. over pre-war rates.

Salford.—The Electricity Committee recommends the Council to agree to a reduction of 2½ per cent. in the contract charges for the supply of electrical energy to the works of R. Haworth & Co.

LIGHTING & POWER NOTES.

Electricity in Mining.—At the recent meeting of the Waihi Gold Mining Co. (Ltd.) it was stated that several items of expense would have been very much larger than they are if it had not been for the Hora Hora hydro-electric plant, which was exercising a most beneficial influence on their costs in every way. Last year they were not able to estimate the advantage it was proving to the company, though they knew it was considerable, but this year a careful comparison had been made between the costs for 1915 and the costs for 1913, when the electric installation was not at work. So far as it could be estimated, it was effecting a saving of between £20,000 and £25,000.

In the annual report of the Western Dominion Collieries (Ltd.) it is stated that the company requires a new shaft and tipple on another part of the company's property, or very extensive underground electrical haulage equipment to extend the present workings, the expense of which will in either case be considerable.

The water trouble at the Saltwood colliery of the Denby Iron & Coal Co. has now been overcome. An electrically-driven pumping plant has been erected, which will deal with all the water, but as a stand-by the steam pumps are being re-built.

Leyton.—The Highways Committee has agreed to the electric lighting department's proposal to make a charge of £10 per lamp per annum for lighting arc lamps converted into incandescent. The department is making no charge for carrying out the conversion, the cost of which is estimated at £100.

Plymouth.—The Electricity & Street Lighting Committee has decided to suppress public lighting altogether until further orders.

The electrical engineer (Mr. E. G. Okell) reports that for the quarter ended March the Prince Rock station sold 1,084,427 units, producing estimated receipts of £11,340, compared with 910,589 units sold and £9,745 received in the corresponding quarter of 1915. In the year ended March 31 the units sold were 3,553,878, and the receipts £35,586, compared with 3,155,233 units sold and 31,901 received in the previous year. The Newport-street section sold 866,651 units last quarter, the receipts being £7,797, compared with 742,070 units sold and £6,640 received in the corresponding period of last year. In the 12 months ended March 31, 2,834,734 units were sold and £24,989 received in the Newport-street section, against 2,520,720 units sold and £21,790 received in 1915. The number of consumers in the Prince Rock section was 2,061 (against 1,908) and in the Newport-street section 1,013, against 908.

Reigate.—At last week's meeting of the Council the chairman of the Electricity Committee (Mr. Priest) said that their heating and power supply had increased 36·25 per cent. up to March last.

TRACTION NOTES.

Aberdeen.—The Aberdeen Suburban Tramway Co. has established on the Deeside route an international time recorder, which gives an absolutely accurate automatic record of the time a car passes a given point.

The conductor of each car is provided with a key bearing the distinctive number of his car. He presses this key into a recess in the front of the recorder, and this unlocks a shutter permitting him to insert the key into the proper keyhole to record the time and number of the car. A printed record of the time a car passes a given point is in this way obtained, and can be compared with the scheduled times and irregularity noted.

Accrington.—The insurance of the tramway depot will be undertaken by the Corporation's own fire insurance fund.

Belfast.—The Electricity Committee recently received 42 applications for the position of tramways manager, and these have been reduced to the following six:—

Mr. J. S. D. Moffett, manager West Ham tramways; Mr. William J. M'Combe, manager Hull tramways; Mr. R. S. Pilcher, manager Aberdeen tramways; Mr. J. F. Simpson, manager Preston tramways; Mr. J. W. Dugdale, manager Oldham tramways; and Mr. R. H. Wilkinson, manager Huddersfield tramways. A sub-committee has been appointed to visit the systems with which the selected applicants are connected and to report.

Bolton.—Owing to the difficulty in obtaining suitable male labour for car cleaning in the night time, women are to be employed for the work.

154 employés of the department are serving with the colours, and 18 more are to go. 40 women conductors are now employed.

A deputation from the Association of Tramway Workers met the Tramways Committee last week in reference to an application for an advance of ½d. per hour for motormen, conductors, overhaulers, cleaners and day labourers. A special war bonus of ½d. per hour to Corporation workmen whose wages do not exceed 40s. a week was agreed to, and this will be submitted to the men's union.

Bradford.—The Tramways Committee has adopted a report by the general manager of the tramways (Mr. C. J. Spencer) on the question of extending the tramway stages.

In his report, Mr. Spencer reminds the Committee of his report on the same subject made in 1915 and states that there is very little that he can add to it. Owing to the war conditions are still very far from normal and circumstances are not favourable to a cheapening of tramway fares. The question is not merely one of lengthening the Great Horton or any particular stage. If the Great Horton stage were lengthened, then other stages with equally good claims must be dealt with at the same time. On the face of the accounts the results for the past year are similar to those of normal years. The net profit is approximately the same, but a close examination of the accounts, however, reveals the fact very plainly that the tramways have been working during the year under very abnormal conditions, and that the effect of those conditions has had a marked influence upon the accounts. The total cost of operation per car-mile (including interest and sinking fund) for the year just closed, amounted to 11·905d. Taking the five years ended March 31, 1914, the receipts per car-mile averaged 11·439d., or 0·466d. per car-mile less than the expenses for the year just closed. It followed, therefore, that had the receipts of war time been the same per car-mile as the average of the previous five years in peace time there would have been a loss of nearly ½d. per car-mile, or a total of £12,900. Receipts per car-mile had been exceedingly good during the war, due to the extraordinary volume of traffic consequent on good trade and war work, and to the restriction of the service owing to insufficiency of staff and cars, and the consequent reduction of car-miles run. The unpleasant accompaniment of the latter factor has been the overcrowding of cars. The extension of the 1d. fare stages under present conditions would result in a considerable loss of revenue, unless it were possible to put on additional cars to meet the extra traffic which would be attracted by the cheaper rides. Under present conditions it would be impossible to provide cars to meet the demand of the extra traffic, so that two things would inevitably happen, viz., (1) a reduction in receipts, and (2) a still further overcrowding of cars. At the present moment it was very inadvisable to cheapen tramway fares, though he quite agreed that under normal circumstances the proposition was in the right direction. He had made inquiries from 78 towns as to alterations in fare stages since the beginning of the war, and in 12 towns (including Birmingham) fares had been increased since the war started. In 66 towns no alteration had been made, and only in one case had any decrease in fares taken place.

Glasgow.—For the year ended May 31 the traffic receipts of the tramways department were £1,148,513, against £1,070,351 in 1914-15, an increase of £78,189.

Gloucester.—It was announced to the Council last week that the manager made a special report on the financial position of the light railways.

It appeared from the report that all practical economies had been adopted, and that the only way of avoiding the present deficit on the working of the undertaking would be to increase the fares. The simplest and best way would be to adhere to the existing stages as far as practicable, but to charge 1d. for two instead of three stages, which in most cases would give a little over a mile for 1d. Instead of abolishing transfer tickets they should be issued as at present at 1½d. instead of 1d. The report and suggestions were adopted.

London County Council.—On Tuesday the Highways Committee submitted revised estimates of capital expenditure on tramways for year ending March 31, 1917, and half-year ending Sept. 30, 1917.

The first item was £134,805 and the second £10,130. A sum of £81,780 for machinery and plant and buildings at Greenwich generating station is included.

Doubling of Tramways.—An estimate of £2,750 for the further doubling of tramways in Woolwich was approved.

Manchester-Bury Electric Railway.—The number of trains on the L. & Y. Railway from Victoria station, Manchester, to Prestwich and Bury has been increased.

The time occupied by an electric tram between Manchester and Prestwich is 12 minutes, or six minutes less than a steam tram. On Sundays a half-hourly service will be run each way from 7·50 a.m. till 10:30 p.m.

North London Railway Electrification.—Trial runs have been made on the portion of the line between Broad street and Richmond, which has been equipped for electric traction, and it is hoped that the electric service will be inaugurated in September.

Plymouth.—The Tramways Committee has again had under consideration the report by the manager (Mr. C. R. Everson) on the adoption of universal penny fares.

Mr. Everson, in his report, said there were as many systems of fares as tramway systems. Generally speaking, the system of fare stages had not given satisfaction. Where tramways were owned and worked by a Corporation agitations were repeatedly taking place for universal penny fares—fares of one penny for any distance. The arguments in favour of universal penny fares were: Simplicity for conductors in collecting fares and for inspectors in checking them, less opportunity for pilfering, greater inducement for people to ride, better facilities for the riding public, less checking and clerical work in book-keeping in the office, no need for transfer tickets, no need for workmen's fares, and less cost of tickets and way-bills. In Plymouth the number of ordinary passengers carried was 10,395,028, and workmen 973,338, total 11,368,366. The average receipt per ordinary passenger was 1·03d., average receipt per workman 0·50d. The total cost of carrying 11,368,366 passengers was £40,318. 10s., an average cost per passenger of 0·851d. The average cost per workman was 0·85d., or a total of £3,451. 5s. 10d., and the loss per annum was £1,423. 10s. 1d. With an average of 10,395,028 ordinary passengers at 1d. per passenger the receipts would be £43,312. 12s. 4d., or a decrease of £1,681. 5s. 4½d. The additional number of 1d. passengers required to make up that loss would be 403,504, or 1·09 passenger each single journey. There would be no need to carry any additional passengers if workmen were to pay 1d. fare, as the receipts from that source would amount to £4,055. 11s. 6d., an increase of £2,027. 15s. 9d. The number of single journeys per annum was 440 960, and the average number of passengers carried each single journey 25·73. In the Devonport area the passenger receipts for the six months from Oct. 2 to March 31 last were £17,884. 18s. 9d., the total number of passengers being 406,051, and the average receipts per passenger being 1·056d. With an average of 406,051 passengers at 1d. per passenger, the receipts would amount to £16,921. 0s. 11d., or a loss of £963. 17s. 10d. The additional number of passengers required to make up this loss would be 231,334. It would, therefore, be seen that if no additional passengers were carried on the whole of the system, the loss, based on last year's figures, would only amount to £617, provided workmen paid a penny fare.

The Committee decided to re-submit their proposal for the adoption of universal penny fares on all the sections of the Corporation system.

It was reported that the Board of Trade had sanctioned the junction of the tramways at Peverell Park-road and Tavistock road, Devonport, and also the construction of the proposed new terminus at Catherine-street, Plymouth.

The Treasury wrote that they were unable to sanction the raising by the Corporation, by the issue of stock bonds or bills, of £111,706 for the purchase of the Devonport & District Tramway Co.'s undertaking. Under the terms of the agreement for the purchase of the undertaking the Corporation must pay interest at the rate of 5 per cent. on whatever amount might be awarded by the arbitrator until the Board of Trade sanction to borrow was obtained.

TELEGRAPH & TELEPHONE NOTES.

Radio-Telegraphy.—The Government have published a Decree ordering the service regulations annexed to the International Radio-telegraph Convention to be put in force in the Portuguese colonies.

Trunk Telephone Service.—Arrangements have been made for improving the trunk telephone service between Manchester and Ashton-under-Lyne telephone areas.

The interval between the time at which a call is passed to the trunk exchange and the time at which it is effected will be reduced, and a call between the two areas will be completed on demand as far as possible, as in the case of an ordinary junction call. The charges will not be affected.

EMPIRE NOTES.

Australasia.—"Tenders" (Melbourne and Sydney) says the question of a lighting scheme for Morwell (Victoria) was discussed at a public meeting recently, but it was decided to postpone action until after the war.

North Illawarra (N.S.W.) Council, which had under consideration for three years a project for electric lighting, but dropped it, has now received an offer from the contractor for electrical plant for the adjoining Shire of Bulli. The offer is for 158 lamps, 60 c.p. and 40 c.p., charge £3 per lamp per annum, the Council to have the right to purchase the installation at any time at cost price, plus 10 per cent.; the contractors to have the right to supply private consumers at 6d. per unit, or 12s. 6d. per year per 16 c.p. light. It is being considered by a Committee.

Sydney (N.S.W.) Electric Supply Committee recently recommended that in view of a report (dated March 20, 1916) on tenders received for the supply of induction regulators no tender be accepted, but that quotations be obtained for the supply of the apparatus required; that in accordance with a report, dated March 14, 1916, by the City Electrical Engineer, the increase of 10 per cent. in prices for motors supplied by the Australian General Electric Co. under contract (specification No. 382), from Jan. 12, 1916, be approved, subject to the company's satisfying the

Town Clerk and the manager of the department that the increase is fair and reasonable; that authority be obtained from the Governor-in-Council for borrowing, by sale of debentures, £500,000 for extensions of the electric light undertaking; and that authority be given for an expenditure of £1,050 for 13 steam flow meters on 13 boilers at the power house, and that the General Electric Co. of America be asked to quote for same.

FOREIGN NOTES.

Argentina.—The "Review of the River Plate" says the Government of the Province of Cordoba have authorised Messrs. Trelsi & Riesco to introduce electricity supply at Villa Huidobro (Department of General Roca).

Official trade returns show that imports into Argentina in 1915 were valued at £45,378,000 (a decrease of £8,985,000 compared with 1914), and exports were £111,656 000 (increase £41,805,000). The United Kingdom took nearly 30 per cent. of the exports and supplied nearly 30 per cent. of the imports. The U.S.A. the second largest supplier, sent 24·8 per cent. of the imports, and took 16 per cent. of the exports. More than £1,000,000 worth of goods were received from Germany. The total imports included electrical goods £751,000 (against £1,405,000 in 1914), manufactures of iron and steel £3,729,000 (against £7,031,000), and vehicles, including locomotives, railway and tramway rolling-stock, material, &c., £1,360,000 (against £4,591,000).

In their report for the year ended Dec. 31, 1915, the directors of the Compañía Industrial de Eléctricidad del Rio de La Plata say the profits are the highest since the foundation of the company. This is due to the entire output of the carbon factory having been placed, to a more profitable utilisation of the workshops and to economies. Net profit, after adding the balance brought forward, was $186,576 in gold. The following distribution is proposed: Amortisation $130,000, prevision fund $20,000, leaving legal reserve fund $1,828, directors and syndic $3,657, shareholders $31,090, being $5 gold per share; carry forward $1,090.

The Air Electric Generator Co. of La Plata inaugurated its first installation, on a private estate near La Plata, on April 13. The company claims that its apparatus for the generation of electricity by wind power is the last word in simplicity and economy.

The electric power station and the public water supply of the town of 25 de Mayo (province of Buenos Ayres) have been acquired by the Compañía Americana de Luz y Traccion of Buenos Ayres.

Messrs. Agar, Cross & Co. recently sued Buenos Ayres municipality to recover $9,958 m/n. and interest thereon for fire prevention installations made by plaintiffs in the municipal building. Plaintiffs asked that an embargo in their favour should be placed upon the 6 per cent. tax payable by the Cia Alemana Transatlantica de Electricidad, but the Court declined to authorise such an embargo.

Automatic Telephones for Buenos Ayres.—The "Review of the River Plate," says Senor Alejandro Schwimer, representing a North American syndicate, has applied to the municipality of Buenos Ayres for permission to install and operate a system of automatic telephones in the capital. The application states that the system is in operation in more than 500 cities in the United States, with a million and a-half instruments installed.

Chili.—The Government has granted permission to Don H. U. Gundian to establish works for supplying electricity for light and power in the towns of Illapel, Salamanca and Vieuna.

Copenhagen.—The Municipal Council have decided to light fewer street lamps, and in future electric and gas power will not be supplied by the municipal works for illuminated advertising signs.

Persia.—It is announced from Petrograd that a Russo-Belgian company, consisting of Russian and Belgian financiers, has secured from the Persian Government a concession for the construction of a network of electric tramways and light railways in Teheran and the neighbourhood.

Peru.—The "Engineer" states that the once-powerful position held by Germans in South America, especially with regard to engineering contracts, has been very seriously imperilled by the war.

A few weeks ago a party of engineers, mostly North American, but some few of British nationality, arrived at Lima en route to Chuquicamata and Braden—and later to Tocopilla—to undertake extensive alterations to the power plant there installed. Practically the whole of that plant had been supplied by the Siemens-Schuckertwerke, but owing to the war the owners of the power plant (the Chile Exploration Co.) had found it impossible to secure extra parts from Germany, and no other manufacturer could or would supply them. It has now been decided that it would be more economical to replace the whole of the German units and to install either American or British machinery. In all probability this will be obtained from the United States. Originally the orders were placed with the Siemens-Schuckertwerke owing to the cheaper prices quoted. A large number of other orders placed with German firms for certain kinds of machinery, especially brewery, refrigerating and agricultural, have been cancelled owing to the impossibility of the manufacturers securing shipping facilities. On the other hand, British interests have been more fortunate, while North American shipments have been subjected to even less delay.

Portugal.—A bill is being promoted to authorise the municipal authorities of Guimaraes to borrow [illegible] (about £70,000) for public works, including the construction of electric tramways between Braga and Guimaraes, the erection of a new municipal building, &c.

Uruguay.—The electrical department of the Government has started a free school for electricians at Montevideo, which will grant certificates to students qualifying in mechanics, electrotechnics, &c.

The "Review of the River Plate" says the Government are creating a commission of engineers to report upon the proposed utilisation of the fall of the river Queguay in the generation of electrical energy.

The owners of a property near Burgueño quarries have asked the National Department of Geology to carry out investigations on their ground, where evidences of abundant copper deposits have been found. They propose that the Government should participate in the profits in return for their co-operation.

The "Review of the River Plate" says a contract has been entered into for the supply of 180,000 units of electrical energy monthly by the State Electrical Department to La Transatlantica Tramway Co.

MISCELLANEOUS NOTES.

Defence of the Realm Regulations.—The Minister of Munitions, on June 5, specified copper, zinc, tin and any alloy of any of these metals, with or without the admixture of other metals, to be metals required for the production of war material, and therefore subject to the provisions of Regulation No. 30c of the Defence of the Realm (Consolidation) Regulations, 1914.

On May 31 the Minister of Munitions ordered that platinum, metal and ores, residues and bars containing the same are included in the Order made on Dec. 31, 1915, under Regulation 30A of the Defence of the Realm (Consolidation) Regulations, 1914. Applications for permits in connection with this Order should be made to the Director of Materials, Ministry of Munitions, Armament-buildings, Whitehall, London, S.W.

Enemy Firms Wound Up.—The Board of Trade have ordered up to date the winding up of 183 firms controlled by alien enemies.

The latest lists include Krupka & Jaroby (Ltd.), 26-36, Chapter-street, Westminster, S.W. (Controller: Thos. Wise, Bassishaw House, Basinghall-street, London, E.C.); Walter Sthamer, St. Dunstan's-buildings, London, E.C., dealer in chemicals, &c. (Controller: Jas. Fraser, 31, Copthall-avenue, E.C.); Westendarp & Co., Dunster House, Mincing-lane, London, E.C. (Controller: T. A. Fox, 79, Mark-lane, E.C.)

Claims against Isaria (Ltd.) are to be sent to Mr. G. S. Pitt, 140, Leadenhall-street, London, E.C. by July 1.

Exports to China.—The following have been added to the list of firms, &c., to whom goods may be consigned from the United Kingdom:—

British Municipal Council, Hankow; Liverpool, London & Globe Insurance Co.; Peking Electric Co. (Ltd.), Peking.

Alteration.—The Chinese Electric Light & Power Co. *should read* Peking Chinese Electric Light & Power Co., Peking.

Inquest.—An inquest was recently held at Fencehouses on John Henry Allison, a coal-cutter in the Lambton Colliery.

Allison was found lying dead, with his foot under the frame of the machine. The electrician in charge (Arthur Dowlen) stated that he had tested the machine in April and found it in perfect order. After the accident he (in conjunction with Mr. Fisher) examined the machine. Mr. Fisher tested the resistance of the earthing system and found it very high, which was an indication that there was a fault in the wire. Witness examined the actual cable, but found nothing wrong there. Later he tested the cable without the plugs, and still found the earth wire faulty. A thimble in the machine end plug had also been unseated, owing to the excessive heating of the solder. Witness thought that the excessive heat would be due to slack connection between the plug and the socket. He had examined the earth wire since, and found that a solder joint in it had been broken by the moving of the cable from time to time. The fault was about 15 yds. from the machine itself. The machine would be "alive," and anyone coming in contact with it would receive a severe shock. In his opinion a solder joint in a flexible earth wire was bad practice. He had now received instructions to examine every cable and get rid of all solder joints.

The jury returned a verdict of "Accidental death."

Miners' Safety Lamps.—On May 15 the Home Secretary made an order approving the following lamps for coal mines:—

Best's Excelsior lamp No. 3, Best's Canzeless lamps Nos. 1 and 1A, Rothwell & Co.'s A3, B3, C3, D3 and E3 lamps, Teale's Muesler or Thornburry Nos. 6 and 6A lamps, and Teale's No. 1 miners' electric safety lamp. A complete list of approved safety lamps is appended to the Order.

Trading With the Enemy.—The "London Gazette" of June 2 contains further lists of persons and firms with whom trading by persons or firms in the United Kingdom is prohibited. The names include:—

Argentina.—Otto Francke & Co. (C. Bolivar 161, Buenos Ayres), Koerting Bros. (292, C. Bolivar, Buenos Ayres), Sociedad Tubos Man-

nesmann, Ltda. (C. Defensa 383, Buenos Ayres), R. Van Wentzky (C. Corrientes, 685, Buenos Ayres).

Brazil.—N. Guimaraes & Co. (rua Luis de Camoes 16, Rio de Janeiro).

All Countries in Central and South America.—Sociedad Tubos Mannesman, Ltda.

Denmark.—General Import & Export Co. (Frederiksholm Kanal 4, Copenhagen).

Norway.—Kristianssands Elektrochemiske A S (Fiskaa, near Kristianssands).

Peru.—Sociedad Tubos Mannesman, Ltda. (Lima).

Under Trading with the Enemy Proclamations of June 25 and Nov. 10, 1915, all Proclamations relating to trading with the enemy applies to all persons or bodies of persons of enemy nationality in Persia, Morocco or Portuguese East Africa, and it is an offence to trade with such persons or bodies of persons in such countries even if such persons or bodies of persons are not included by name in the statutory lists.

All branches of any enemy firm mentioned in the list are to be held to be included, even if only one address of such firm is specifically mentioned.

Information can be obtained from the British Consular officers in the several countries concerned as to names on the list, and names of substitutes for firms on the list can be obtained from the Foreign Trade Department.

Tribunal Cases.—Conditional exemption was granted by St. Anne's Tribunal on May 31 to the chief electrician of the local tramway company and two engine drivers at the electricity works.

At Blackpool on June 1 a local hydro company was granted conditional exemption for their engineer and electrician, aged 32.

Last week at Warwick Rural District Tribunal Lord Leigh applied for the exemption of his electrical engineer, aged 37 and married.

He was the only man conversant with the electric lighting plant for his establishments and for the power used for the agricultural work. He was also in charge of the two steam fire engines and apparatus on the Stoneleigh estate, and was responsible for the maintenance of the private telephone apparatus.

Exemption was granted until Jan. 1.

TENDERS INVITED.

Telegraph and Telephone Material.

Tenders are also invited up to July 19 for the supply to the Australian Commonwealth Postmaster-General's Dept. (State of Western Australia) of Insulators (schedule 510). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

Tenders are invited up to Aug. 16 for the supply to the Australian Commonwealth Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502). (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, Perth (W. Australia), requires tenders by 3 p.m. June 21 for 10,000 Flat g.i. Combiners, 100 Lead Earth Plates, 12,000 Screw Plugs and 10,000 Crossarm Straps (schedule 505 W.A.), until 3 p.m. June 28 for Paper-insulated Lead-covered Cable (schedule 489 W.A.), and until 3 p.m. July 19 for 96 Terminal Blocks (schedule 495 W.A.). Specifications from the Deputy Postmaster-General, Perth, W.A.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the Australian Commonwealth Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

The Deputy Paymaster-General, Perth (W. Australia), also requires tenders by 3 p.m. July 12 for supply of 3,000 Dry Cells for the Australian Commonwealth Postmaster-General's Dept. Specification, &c., from the Deputy-Postmaster-General.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the Australian Commonwealth Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

The Deputy Postmaster-General, Melbourne (Victoria), requires tenders by 3 p.m. June 27 for 18,551 Stalloy Telephone Receiver Diaphragms (schedule 1303). Specification, &c., from the Deputy Postmaster-General.

Street Lighting, Generating Plant, Gas Engines, Dynamos, &c.

Oamaru (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1. 1s. for each contract.

Pahiatua (N.Z.) Borough Council requires tenders by noon July 10 for (contract No. 1) Overhead Wires, Poles and Street Lamps; (No. 2) Gas engines, Producers, Dynamos and Auxiliary Apparatus; (No. 3) Accumulators. Specifications and plans from the Town Clerk, Pahiatua.

Electric Lorry.

Sydney (N.S.W.) Council require tenders by 3 p.m. June 20 for the supply of a 2-ton Electric Lorry. Specification, &c., from the City Surveyor.

Electrical and General Stores, Wiring, &c.

London County Council Asylums Committee require tenders by 11 a.m. June 19 for supply of Electric Lamps. Forms of tender, &c., from the Clerk, 2, Savoy-hill, London, W.C.

West Ham Guardians require tenders by 10 a.m. June 22 for three months' supply of Electrical Fittings, Oils, &c. Forms of tender from the Clerk, Union-road, Leytonstone, N.E.

Tenders will be received until June 10 by Mr. J. N. Clarkson, clerk to War Hospital Building Extension Committee, 40, North-street, Keighley, for Electric Wiring and Fitting in the temporary war hospital buildings at Morton Banks.

Tenders are required for the electric lighting of "Landrends," Launceston. Specification from the Manager, Electricity Works, Launceston.

Signal Lighting Transformers.

The Victorian Railway Commissioners want tenders by 11 a.m. July 26 for 400 Signal Lighting Transformers (contract No. 29,997). Specifications from the Commissioners' Offices, Spencer-street, Melbourne, Victoria.

TENDERS RECEIVED AND ACCEPTED.

Hammersmith (London).—Ten tenders were received for the supply of the panels required in connection with the proposal to fix new switchboards at Shepherd's Bush sub-station, and the lowest, that of the Park Royal Engineering Co. (at £18) has been accepted. The amount of the highest tender was £40. 15s.

St. Austell.—The Urban Council has accepted the local electric light company's tender for public lighting for three years at an increased price of £36 per annum.

Battersea (London).—The Electricity Committee has accepted the following quotations:—

British Electrical Transformer Co., 500 k.v.a. transformer, £370. 10s.; British Westinghouse Co., switchgear, £190.

Salford.—The Electricity Committee has accepted the following tenders for the annual supply of materials:—

W. T. Glover & Co., unarmoured cable, schedule of prices; Key Engineering Co., fibre pipes, approximate amount of contract, £100; Doulton & Co., stoneware pipes, spigot and socket joint stoneware troughs, with stoneware covers, £500; Albion Clay Co., stoneware conduits, £200.

The following tenders have also been accepted: United Electric Car Co., permanent way wagon body, £159; British Westinghouse Co., auxiliary steam turbine, £740; G. & J. Weir (Ltd.), two roto-feed pumps, £560; Wm. Gornall, erection of Blackfriars-road sub-station, &c., £3,280; British Westinghouse Co., three-phase extra-high-pressure switchboard, £1,203; Bertram Thomas, continuous-current switchboard, £2,215. 10s. Stewarts & Lloyds, mild steel pipes and separator, £159; Stanton Ironworks Co., cast-iron pipes and valves, £772.

Leyton.—The Council is entering into contracts with the Electrical Apparatus Co., the Reason Mfg. Co. and Chamberlain &

Hookham for the supply of ordinary electricity meters for 12 months, also with the British Insulated and Helsby Cables for the supply of slot meters during a similar period.

In addition to the five tenders received, the British Thomson-Houston Co. wrote stating that under present conditions they were unable to enter into a contract, as their meter factory was engaged exclusively on Government work.

SCHOOL LIGHTING.—The London Education Committee received five tenders for wiring Southampton-street School (Camberwell), and the lowest (that of H. J. Cash & Co., at £145. 11s.) was accepted. The highest tender was £526.

For wiring the Haverstock-hill School, St. Pancras, five tenders were also received, and the lowest (that of H. J. Cash & Co., at £291. 10s.) was accepted. The amount of the highest tender was £410.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Barrow-in-Furness.—The accounts of the electricity department for the year ended March 31, adopted by the Council on Monday, show total capital expenditure £177,355 (increase £12,868), of which £165,595 was borrowed and £57,132 has been repaid.

Total revenue was £59,208 (compared with £26,584 in previous year), and working expenses were £34,808 (£13,867), leaving gross profit £24,399 £12,717). Interest required £4,610 (£3,658 and sinking fund £6,985 (£5,896), the net result being a surplus of £12,803 (£3,162). Average price obtained per unit was 1·020d. (1·742d.). Coal, &c., cost 0·405d. (0·408d.) per unit, total works costs were 0·527d. (0·691d.), and total working costs 0·605d. (0·925d.). Units sold were 13,806,254 (3,597,410). Maximum combined load was 3,905 kw. (2,285 kw.) and combined load-factor 40·36 (17·97) per cent. Total connections are equivalent to 253,714 (190,647) 30 watt lamps.

In his report Mr. H. R. Burnett, borough electrical engineer, says during the year No. 8 water-tube boiler has been put into commission, a steel chimney has been erected, with a Davidson induced draught fan, an additional cooling tower has been erected by Premier Cooler Co. (150,000 gallons per hour), pipework for same by Aitan & Co., and ash-handling plant by Herbert Morris (Ltd.), and the siding accommodation at the works has been increased by the Furness Railway Co. 86 houses at Vickerstown, hitherto supplied through the Walney Estates Co., have been taken over as direct consumers of the Corporation. The new connections during the year almost equal the number made during the first 10 years' working of the undertaking. 927 pieces of apparatus are out on hire, and many consumers have purchased apparatus for domestic use, the employment of which has been greatly facilitated by the demand system of charging introduced four years ago. The average consumption of a large number of domestic consumers is three times as great as it was four years ago, and it will further increase as soon as the demand for apparatus can be fully met. Motors connected are 382(=2,780 E.H.P.), and the apparatus connected includes radiators 152, flat irons 500, kettles 38, ovens 47, hot plates, grills, &c., 93. The output increased 283 per cent. for the year, and was larger than that of any undertaking in a town of equal size. The reduction of cost per unit sold was 0·320d., or 34·6 per cent. Average price of coal was 18s. 2d. (increase 3s. 10d.). The large increase of output was only rendered possible by the c.h.t. scheme carried out three years ago, and its effect on the total cost of production is shown by the fact that the capital charges are 0·20d. per unit, against 0·94d. three years ago. Nearly 95 per cent. of the output was generated by the two large turbo-alternators, which have proved very reliable, though frequently overloaded. Twelve men from the department had joined H.M. Forces, and one has been killed and one is a prisoner in Turkey.

Blackburn.—The net profit on the electricity department for the year ended March 31 was £3,132 (compared with £2,348 for the previous year).

Revenue was £51,110 (against £48,100), working and general expenses were £26,650 (£24,887), leaving gross profit £24,460 (£23,213), out of which £21,328 (£20,865) was required for interest and sinking fund.

The engineer and manager (Mr. P. P. Wheelwright) says in his report the supply of coal during the 12 months caused anxiety, especially during the heavy winter lighting loads, when considerable difficulty was experienced in obtaining full contract quantities, but the department was in a position to overcome the shortage, due to the anticipation of this eventuality. The situation for all large coal users is, without doubt, an anxious one, and Mr. Wheelwright fears there is not much prospect of material relief whilst the war lasts. The full effect of the lighting restrictions have not yet been fully realised, and as further reductions and economies are under consideration the output for the coming year is likely to be adversely affected. The acceptance of the Daylight Saving Bill will no doubt considerably reduce consumption from residential lighting. The abnormal conditions resulting from the increase on cost of all materials and shortage of labour make any kind of comparison with previous years' figures of little value. The augmented amount required to meet working expenditure, which compelled the department to make an increase in the rates of charges last October, makes it impossible to forecast how far the greater revenue will compensate during the coming year, with its probable higher expenditure. Of the 34 men who have joined the Colours since the outbreak of war, two were killed in action, whilst another has been wounded. The electricity department now comes under the category of a public utility service, and war service badges have been issued to a number of the staff and the skilled and experienced men required to maintain and carry on the undertaking. At the same time every endeavour has been made to help the Recruiting Committee by releasing for active service every dispensable man. It is imperative to conserve all the resources of the undertaking in view of the continuance of the war and the delay imposed upon the scheme for the proposed new generating station. Units generated for lighting, power, traction and heating were 7,829,477 (an increase of 336,454, or 4·5 per cent.). Private lighting output increased by 1,804 units, and power by 426,148 (or 12 per cent.), but traction supply decreased 60,300 units, or 3 per cent. The demand for power increased, but not to the same extent as in past years. Motors aggregating 357 B.H.P. have been connected. The total connections for motors, heating and lighting in equivalent 30-watt lamps now aggregate 369,307 (increase 6·4 per cent.). Consumers connected on March 25, 1915, totalled 3,756. This has been increased to 4,054. During the year a free supply of electricity to the extent of £100 has been granted to various hospitals, refugee homes, barracks, &c., in the town. Revenue from street lighting decreased about 33 per cent.. Increase in cost of coal was £2,359, or 33 per cent., whilst for other material the increase was 20 per cent. The department recently inaugurated a system of maintenance of motors.

Bury.—The accounts of the Corporation tramways department for the year ended March 31, show total capital expenditure £297,921 (apart from the expenditure on lines leased and worked by the Corporation), an increase of £4,683. £62,011 has been placed to sinking fund, and reserve or renewal funds amount to £37,209.

Revenue was £69,792, working expenses were £37,312, interest required £8,882, and sinking fund £5,875, and the net profit was £7,314, after deducting £1,645 for war allowances (compared with £8,472, after deducting £897), to which is added £401 net surplus from the Radcliffe tramways, making a total of £7,715, out of which £5,000 has been contributed to Borough rates, £1,314 placed to reserve and depreciation fund, and £1,000 to insurance fund against third-party claims, and £769 refunded to rates on account of previous loss on Radcliffe tramways. Passengers carried were 15,810,869, and car-miles run 1,549,366. Total revenue per car-mile was 10·81d., and working expenses, including power, were 6·152d. (against 5·696d.) Average fare charged per mile was 0·77d.

The General Manager (Mr. Wm. Clough) states in his report that £1,837 was spent on repairs and maintenance of permanent way. At least £500 more ought to have been spent on materials, but it has been impossible to obtain the requisite supplies. The price paid for electricity, both to Bury and Radcliffe, has been increased by 10 per cent.

Grimsby.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £136,390 (increase £1,299), of which £42,000 has been redeemed, and £14,452 contributed out of revenue and reserve.

Revenue was £22,144, compared with £24,202 in previous year, and after paying working expenses, the gross profit was £9,805 (£10,738). Capital charges were £7,944 (£7,926), leaving net profit £1,851 (£2,812), out of which £877 has been paid to employees who have enlisted, and £640 has been carried to reserve. Units generated were 3,645,213 (3,985,162) and sold 2,641,496 (2,787,298). There are 2,062 (1,993) consumers with the equivalent of 179,612 (164,280) 8 c.p. lamps connected. Average price obtained per unit was 1·88d. (1·89d.); total working costs were 1·104d. (1·083d.).

In his report Mr. A. S. Channon (deputy electrical engineer) states that there was a decrease in revenue from public and private lighting (£1,787 and £1,186 respectively), while the cost of coal increased, but this has been met to some extent by an increase in the price of current. Motors in use are 426=2,591 H.P. (against 375=2,213 H.P.), and power units sold were 1,075,313 (908,616). The decrease in public lighting amounted to 170,000 units. In addition to the usual revenue contributions to capital outlay, £877 was paid out of revenue to employés who have enlisted. Plant capacity (exclusive of turbine plant) is 1,860 kw., and the maximum load was 1,647 kw. Mr. Channon says the load, when normal conditions prevail, may be well over 2,000 kw., so that additional plant must be installed, or restrictions on use of energy imposed.

Huddersfield.—The capital expenditure of the electricity department at Dec. 31 was £292,272 (increase £24,865), of which £108,285 has been repaid or placed to redemption fund.

Revenue was £63,945 (compared with £52,518) and working and general expenses (including £5,306 for capital items) were £42,326 (£32,422),

leaving gross surplus £21,618 (£20,095). Interest required £9,193 (£7,952) and redemption fund and loan repayments £8,984 (£8,118), the net surplus being £3,441 (£4,025). £1,291 (£1,925) has been carried to depreciation and contingencies account and £2,150 (£2,100) to relief of rates. The number of consumers connected is 6,461 (6,014) with the equivalent of 687,704 (564,166) 8 c.p. lamps. Units sold during the year were 10,536,374 (8,073,220).

Stafford. The accounts of the electric lighting department for the year ended March 31, which were received and adopted by the Council at its last meeting, show total capital expenditure £35,334, of which £15,252 is outstanding.

Revenue was £9,067 and working expenses were £6,391 (including £1,000 for depreciation), leaving £2,676 gross profit. Interest required £600, repayment of loans £1,546 and income tax £316, leaving net profit £212.

Units generated were 1,657,906 (compared with 1,287,074 in previous year) and sold 1,360,831 (1,021,633). Total maximum supply demanded was 680 kw. (600 kw.). Revenue was 1·598d. and working expenses (without depreciation) were 0·950d. per unit sold.

In proposing the adoption of the accounts, Ald. Westhead said sales increased 32 per cent., but the profit was very little more than the previous year, as coal cost increased nearly 73 per cent.

COMPANIES' MEETINGS AND REPORTS.

BRITISH EVER READY CO. (LTD.) At the meeting last week the chairman (Mr. Fredk. Gus) stated that the directors had decided to take over a new additional factory at Clissold Park for extending their battery manufacturing facilities. Their home trade was steadily increasing, and they had a large number of orders and contracts in hand. In addition, their export trade, which was principally carried on within the British Empire, was steadily growing. The amount written off for depreciation of plant had been more liberal than for the previous year owing to a good deal of unskilled labour having been used. Principally from that and to a smaller extent from longer working hours, additional wear and tear had been thrown on the plant. The final profit after writing everything off and also taking in the amount from last year, was £59,218, compared with £29,958. The directors recommended a final dividend of 10 per cent. for the year on the preference shares and a dividend of 10 per cent. for the year, plus a bonus of 10 per cent., on the ordinary shares.

BRUNNER, MOND & CO. (LTD.) The net profit for the year ended March 31 was £1,011,590, and £107,658 was brought forward. Dividends amounting to 27½ per cent. are proposed on the ordinary shares, adding £150,000 to suspense account, writing £2,500 off patents, and carrying forward £123,547, subject to directors' fees. The board have written off investments account £128,460, being the purchase value of the ordinary shares of the Ammonia Soda Co. acquired in January last.

CASTNER-KELLNER ALKALI CO. (LTD.)—The Right Hon. G. W. Balfour presided at an extraordinary general meeting of the company last week, when the resolutions embodying an increase of capital and the agreement for mutual co-operation in technical and commercial matters, with Messrs. Brunner, Mond & Co., were submitted for approval. The company would allot to Brunner, Mond & Co. 250,000 shares of £1 each, and Brunner, Mond & Co. would allot to the company 200,000 shares of £1 each. This proportion of 200,000 to 250,000 corresponded as near as might be to the Stock Exchange values of the shares respectively. As regards dividends, the directors anticipated that their company would receive from the 200,000 shares they would own in Brunner, Mond & Co. just about what they would have to pay on the 250,000 Castner Kellner shares that would be owned by them. The shares were to carry no voting power. Under the agreement Brunner, Mond & Co. would own one fourth of the entire capital of the Castner-Kellner Company, whereas the Castner-Kellner Company would own less than one-twentieth of the capital of Brunner, Mond & Co. The object of the agreement was not to raise prices, but to avoid wasteful competition, wasteful expenditure of capital, and to improve the earning power of both companies by effecting economies in working and distribution. The war had taught them many lessons. It had brought home to their minds the danger of allowing articles of prime national importance to become the monopoly of a foreign, and, as it had now turned out, an enemy country. He hoped that state of affairs would be acquiesced in no longer. After the war was over we might expect the Germans to fight for all they were worth to regain their position both in the British and in the foreign market. We must meet organisation with organisation, and we must be prepared to be able not only to hold what we already possessed against all attacks, but also to strike out in new directions. The resolutions were agreed to.

DOULTON & CO. (LTD.) The report states that, after providing for debenture interest, and including balance brought forward, there remains at the credit of revenue account £86,699. The directors have already paid out of this amount the preference share dividend for the year to Dec. 31, 1913, and now propose to make a similar payment for 1914, absorbing in all £35,000, and leaving £51,690 to be carried forward.

GENERAL ELECTRIC CO. (U.S.A.)—The report states that the value of orders received for electrical apparatus and devices in the past year was $98,385,891, an increase of $14,637,370. The increase was largely due to the general revival of business in the latter part of the year. The figures are exclusive of orders for special war munitions, valued at $33,980,000, which have been so restricted as to interfere as little as possible with the regular product of the company. The percentage of profit from these orders will probably be less than that of the average of the company's output. The amount of sales billed was $85,522,070, a decrease of $4,945,621. The net result from sales billed was a profit of $8,623,887, to which was added income from other sources ($3,684,108), giving a total net income of $12,307,995; less interest on bonds ($570,085), and dividends on stock ($8,129,918), leaving a surplus of $3,607,991. The sale of several small factories substantially offsets the manufacturing floor space added in 1915; and plant expenditures, amounting to $4,485,068, were chiefly for improvements in existing construction and equipment and the purchase of special tools and machinery which are subject to a high rate of depreciation. Because of the nature of this expenditure, and on account of the liquidation of the book value of the factories sold, the reduction in plant account was $5,985,068. Quarterly dividends at rate of 8 per cent. per annum have been paid during the year.

MARCONI INTERNATIONAL MARINE COMMUNICATION CO. (LTD.)—The net profit for 1915 amounts to £63,630 (after deducting £29,281 for depreciation and debenture interest), compared with £55,668 for 1914. Notwithstanding the considerable decrease in passenger traffic and the necessary restrictions in respect of private messages at sea, the revenue from ships' telegrams, subsidies, &c., amounted to £208,900, against £175,021. The increase is mainly due to the greater number of ships installed with wireless apparatus. The number of telegraph stations owned and worked by the company as public telegraph stations on the high seas increased from 875 to 1,008 at the end of 1915. The organisation of the company, together with that of its associated companies, with a total of some 2,300 mercantile vessels fitted with Marconi telegraph stations, has continued to render inestimable service. The available balance is £75,602, including £11,972 brought forward. The directors recommend a final dividend of 7½ per cent., making 12½ per cent. for the year. The losses sustained in consequence of attacks upon our mercantile fleet during the latter part of 1914, and those incurred during 1915, have been debited to profit and loss account. The £10,000 which was placed last year to credit of a special reserve account to meet any losses arising from this cause remains intact, and it is now proposed to transfer this sum, together with the share premium account, to a general reserve account, which will then stand at £27,640. The continuous growth of the business, and the large number of additional telegraph stations on board ships which are being installed year by year without the issue of additional capital renders it prudent to carry forward £33,841 after providing £3,500 for the redemption of debentures. There has been a net increase of 133 stations, representing a substantial capital outlay for which it would have been impossible to provide without raising additional capital had it not been for the policy of prudently husbanding the cash resources. The balance carried forward will also serve to meet the excess profits duty, which must exceed £8,095, the amount payable under this head for 1914. The Amalgamated Wireless (Australasia), Ltd., in which the company is interested, has paid a dividend of 6 per cent. in respect of the year ended June 30, 1915.

METALLIC SEAMLESS TUBE CO. (LTD.)—The net profit for the past six months was £5,593. A dividend of 20 per cent. on the ordinary shares is recommended, and £2,320 has been placed to reserve for excess profits' duty, and £1,825 carried forward. In future the accounts will be made up from Jan. 1 to Dec. 31 in each year.

At the meeting on Friday last Mr. A. E. Beck said they congratulated themselves not only upon the past success of the business, but upon the provision they were able to make for the future. They might look forward with confidence to a continuation of prosperity during the war, and they were quite prepared to enter into competition with other firms with prospects of success.

NEW GENERAL TRACTION CO. (LTD.)—For the year ended March 31 the revenue amounted to £20,288, 18s. General expenses, including directors' fees and legal charges, amounted to £1,491, 18s., and debenture interest (less tax) to £6,595, 6s. 8d. The profit for the period was £11,299, 19s. 6d., to which is added £7,080, 19s. 9d. brought forward, making £18,380, 19s. 3d. available for distribution. The directors recommend that £10,480 should be appropriated to the payment of a 4 per cent. dividend (less tax), and the balance of £7,900, 19s. 3d. carried forward. The Norwich Electric Tramways Co. paid a dividend of 3 per cent. for the year ended June 30, 1915, being the same rate as for the previous year. The Douglas Southern electric tramways system has been closed down on account of the war. All expenses have been reduced to the minimum necessary for the safeguarding and upkeep of the undertaking. The income received from the Philadelphia undertaking (the Darby, Media & Chester Street Railway Co.) for the year ended Dec. 31, 1915, amounted to £14,237, 14s. 9d.

RANGOON ELECTRIC TRAMWAYS & SUPPLY CO. (LTD.)—The gross profits for 1915 amounted to £61,651, against £63,621 in 1914, and the net profit, including £2,766 brought forward, to £23,094, against £23,076, including £1,055 brought in. A dividend on the ordinary shares of 3 per cent. for the year, tax free, has been declared, the amount carried forward being £2,781.

UNITED ELECTRIC TRAMWAYS OF MONTEVIDEO (LTD.) The gross receipts for the year ended Oct. 31 were $1,553,824 (decrease $145,061); operating expenses, $988,791 (decrease $15,151); net receipts, $565,033 (decrease $99,910); at exchange of $4·7 to the £, £120,220, decrease £21,257. The amount receivable from La Sociedad Commercial de Montevideo in respect of revenue was £111,413. After providing for administration expenses and charging £48,937 for debenture interest, the credit balance was £51,692, making, with £12,973 brought forward, £64,665. The following amounts have been set aside: For redemption of debenture stock, £3,562; for redemption of preference and ordinary share capital, £2,500; for renewals and contingencies, £20,000. A final

dividend on the preference shares at rate of 6 per cent. per annum (less tax) in respect of the half-year to March 31 is recommended, carrying forward £13,103. The directors regret that in the circumstances they are unable to recommend the payment of any dividend on the ordinary shares.

WESTERN UNION TELEGRAPH CO.—The report for 1915 states that gross operating revenues were $51,171,795.47, and operating expenses, including repairs, reserve for depreciation, rent of plants, &c., were $40,972,541.42, leaving $10,199,254.05. Income from loans and investments was $1,303,925.77, making $11,503,179.82. Interest on bonds required $1,335,588.19, and the balance transferred to surplus account was $10,167,591.63. The surplus at Dec. 31, 1914, was $13,531,921.16, and balance from income account for year ended Dec. 31, 1915 ($10,167,591.63), and adjustment of surplus (net) ($169,819.99) made a total of $23,869,332.78. Dividends paid and declared absorbed $4,986,364.25, leaving surplus at Dec. 31, 1915, $18,882,968.53. Total book value of property account is $144,889,324, a decrease of $2,026,159. The company had 209,854 miles of pole line, 933,603 miles of iron wire, 649,990 miles of copper wire and 2,965 miles of land line cables. There are 25,142 offices under operation (decrease 642). Small offices have been changed to agencies, which are not classed as Western Union operated offices. Over $550,000 was expended in increasing efficiency of cable transmission. A new cable ship, the "Lord Kelvin," to take the place of the "Minia," will shortly be ready for use. Investments of $240,002 were made in shares of telegraph, cable and other allied companies operated under leases, but whose plants are not merged in the Western Union property account. Capital liabilities were reduced by $691,030. Shares of telegraph, cable and other allied companies not leased were acquired at a cost of $136,004, returning 7·6 per cent. annually on investment on the basis of present dividends. The unexpended balances of reserves for maintenance of cables and depreciation of land lines amount to $9,912,515. The reserve for employés' benefit fund stands at $1,000,000. Gross operating revenues increased $4,907,019. The transmission of the increased volume of business with a comparatively small increase in expense is generally to be attributed to refinements in organisation, improvements in plant and methods, reductions in fixed charges, &c. Net income before paying dividends shows an increase of $4,796,197, or 89·3 per cent. The multiplex automatic printing telegraph system was installed on a number of the principal trunk line routes, and further installations are in progress. Wherever installed this system operates satisfactorily, its capacity for the accurate handling of messages over long distances being greater than that of any other known system. Notwithstanding depression in business at the beginning of 1915, the work of improving and strengthening the plant, particularly the trunk lines and the important operating offices, was diligently continued. In the larger cities and towns the work of providing more permanent plant in the form of underground or aerial cable in place of open wire construction has been continued. The surplus at Dec. 31, 1915, was $18,882,969 (increase $9,799,145), and the total improvement in company's financial position in the last five years is $18,985,748, consisting of increase in surplus $9,799,145, and increases in unexpended balances of reserves for maintenance of cables, &c., $9,186,603.

WORCESTER ELECTRIC TRACTION CO. (LTD.)—Including £293 brought forward, the accounts for 1915 show an available sum of £4,042. The directors recommend a dividend of 3 per cent., after transferring £1,000 to reserve, leaving £180 to be carried forward.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

BRITISH ELECTROLYTIC ZINC CO. (ISHERWOOD PROCESS) (LTD.) (143,918.)—Reg. May 24, capital £62,500 in £1 shares, to adopt an agreement with the Venture Trust (Ltd.), to carry on the business of refiners, reducers, crushers, purifiers, and separators of and dealers in zinc and other ores, base bullion, slag, metals, &c., metallurgists, assayers, metal workers, dealers in metals, &c. Private company. The Refractory Zinc Ore Treatment Co. have the right so long as they hold 15,000 shares, to appoint two directors.

BRITISH GRAPHITE & TRADING CO. (LTD.) (9,597.)—Reg. in Edinburgh May 13, capital £12,000 in 8,000 participating preference shares of £1 each, and 80,000 ordinary shares of 1s. each, to carry on the business indicated by the title. Private company. First directors are J. Logan and J. J. Fisken. Reg. office, 53, Bothwell-street, Glasgow.

ELECTRICAL ACCESSORIES ASSOCIATION (LTD.) (143,940.) Reg. May 26 as a company limited by guarantee, with not more than 500 members, each liable for £10 in the event of winding up, to afford pecuniary, legal and other assistance to members, to co-operate with kindred associations, to promote and assist the home, colonial and foreign trade in and the manufacture of electrical accessories, to examine any patent, trade mark, concession or charter which in the opinion of the association, may tend towards the creation of an unjustifiable, oppressive or unreasonable monopoly in electrical accessories, or which the association may deem otherwise objectionable, and to bring or defend any proceedings in relation thereto, to support and promote the status and interest of the electrical accessories trade generally, to diffuse information amongst members, to carry on the business of a mutual trade protection association, to assist members in collecting debts, &c. The income of the association is to be applied solely towards the promotion of its objects. Any person or firm engaged in the electrical accessories trade or allied trade whose place of business is situated in the United Kingdom, the Channel Islands or the Isle of Man is eligible for membership. The council is to have absolute discretion as to the admission or rejection of any candidate. The entrance fee is 5 guineas, and the annual subscription 2 guineas. The management is vested in a council, the provisional members of which are the subscribers to the memorandum of association, viz.: C. S. Giddins, solicitor; L. N. H. Speer, factor of electrical accessories; F. Watkinson (of J. & W. B. Smith), general lighting merchants; F. Stanley Smith, buyer; C. G. L. Hulme, electrical accessories factor; B. R. Agazar, of A. & A. Electrical Co., Ltd.; W. A. Bradshaw, manager; F. Summers, merchant; W. G. Hellyer, merchant.

ENGINEERING EQUIPMENT CO. (SWANSEA) (LTD.) (143,681.) Reg. April 20, capital £500 in £1 shares, to carry on the business of makers and sellers of silicate, cotton or slag wool, and other non-conducting coverings for steam boilers and steam pipes, contractors for fireproofing and soundproofing buildings, dealers in steam packings, beltings, &c. Private company. First directors are T. W. Ellis and J. C. Hastie. Reg. office, Salubrious-chambers, Salubrious-passage (Wind-street), Swansea.

GALLOWAY ENGINEERING CO. (LTD.) (9,604)—Reg. in Edinburgh on May 26, capital £40,000 in £1 shares, to carry on the business of engineers, electricians, chemists, &c. Private company. First directors are Major H. R. Alexander and R. H. Ballantine. Reg. office: Shakespeare-street, Dumfries.

HADDOW & CO. (LTD.) (9,579)—Reg. in Edinburgh on April 28 capital £3,000 in £1 shares (500 preference), to take over the business of electrical contractors carried on by Haddow & Co. and by A. Wylie & Co., Glasgow. Private company. First directors are A. F. Wylie and J. S. Hutchison.

LYNDIN PARTNERS (LTD.) (143,768)—Reg. May 4, capital £1,000 in £1 shares, to carry on the business of ironfounders, mechanical and electrical engineers, manufacturers of machinery and tools, metal workers, &c. Private company. First directors are D. L. Honeyman, A. B. Burbridge and J. F. Wakelin.

QUEAD (LTD.) (143,850).—Reg. May 15, capital £7,000 in £1 shares, to take over the business of vendors and manufacturers of gas and electric stoves, heaters, lamps and apparatus and appliances relating thereto carried on by F. Eads and R. J. Quainton as Eads & Quainton. First directors are F. Eads (permanent), F. L. Wright and R. J. Quainton. Secretary: H. Middleton. Reg. Office: 47, Marylebone-lane, W.

F. J. SHENTON & CO. (LTD.) (143,861).—Reg. May 17, capital £3,500 in £1 shares (3,000 ordinary and 500 "B"), to carry on the business of munition makers, electrical, telephone, telegraph, mechanical and general engineers and merchants, electricians, millwrights, founders, stampers, &c. Private company. First directors are F. J. Shenton (managing) and E. H. Smith (chairman). Reg. Office: 284, Queen's-road, Peckham, S.E.

STOREY MACHINE TOOL CO. (LTD.) (143,827).—Reg. May 12, capital £10,000 in £1 shares, to take over the business carried on as the Storey Machine Tool Co., and to carry on the business of engineers, tool makers, machinists, &c. Private company. First directors are W. Storey, A. P. Highett (and secretary) and J. H. W. Storey. Reg. office: 43A, Pomeroy-street, New Cross, S.E.

THOS. J. LOCK (LTD.) (143,697).—Reg. April 25, capital £5,000 in £1 shares, to take over the business of a general and experimental engineer carried on by T. J. Lock, and to carry on same and the business of scientific and electrical instrument makers, opticians, machinists, tube-makers, &c. Private company. First directors are T. J. Lock (man. director and secretary), G. C. Sprenger and W. H. Halsey. Reg. office: 35, Whetstone Park, High Holborn, W.C.

WM. HILL & SON & NORMAN & BEARD (LTD.) (143,960)—Reg. May 27, capital £40,000 in £10 shares (1,500 6 per cent. cumulative preference), to take over (1) the business carried on as Wm. Hill & Son, and Norman & Beard (Ltd.), to adopt an agreement with A. G. Hill, H. P. Gould, L. Simon, G. A. W. Beard, J. P. A. Kirkland and A. J. S. Morris, and to carry on the business of builders and manufacturers of organs and other musical instruments of all kinds, electricians and manufacturers of and dealers in apparatus and things used in the manufacture or erection of or in the application of electric or other action to or in the maintenance, improvement or repair of organs or other musical instruments. Private company. First directors are A. G. Hill and G. A. W. Beard (managing directors), J. Penderell, A. Kirkland and A. J. S. Morris. Reg. office: Organ Works, York-road, Islington, N.

MORTGAGES AND CHARGES.

BAXENDALE BROS. (LTD.)—Particulars of £2,000 debentures, created May 11, 1916, have been filed, whole amount being now issued. Property charged: Company's undertaking and property, present and future. No trustees.

ELECTRO-GALVANISERS (LTD.)—Particulars of £4,000 debentures created May 9, 1916, have been filed, whole amount being now issued. Property charged: Company's undertaking and property, present and future. No trustees.

LAMPLOUGH & SON (LTD.)—Mortgage, created by receiver, dated May 16, 1916, to secure £1,200 charged on company's undertaking and property, including uncalled capital. Holder: H. E. Taylor.

NEW ERA SIGNS (LTD.)—Particulars of £2,000 debentures, created May 1, 1916, have been filed, amount of present issue being £1,300. Property charged, company's property, present and future. No trustees.

RECEIVERSHIP.

CUNNINGHAM (LTD.)—E. H. Hawkins, 4, Charterhouse-square, E.C., ceased to act as receiver or manager on April 8, 1916.

GALVO-BOX CO. (LTD.)—Notice of appointment of H. A. Pepper, 14, Temple-street, Birmingham, as receiver and manager on May 23, 1916, under powers contained in debenture dated Oct. 1, 1915, has been filed.

CITY NOTES.

MEMORANDA (June 7).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 58. Consols Pay Day, July 5. Stocks and Shares Ticket Days, June 14 and 28. Pay Days, June 15 and 29. Price of silver, 31 13/16d.

CANADIAN GENERAL ELECTRIC CO.—A quarterly dividend of 1¾ per cent. has been declared for the quarter ended June 30.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and register of holders of the 5 per cent. first and 4½ per cent. second debenture stocks of this company will be closed from 16th to 30th inst., inclusive.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.)—The directors have declared a 10 months' dividend at rate of 6 per cent. per annum (less tax) on the preference shares, thereby making the cumulative dividend paid up to Dec. 31, 1915.

WESTERN TELEGRAPH CO. (LTD.)—The directors have declared the third quarterly interim dividend of 3s. per share (tax free) for the year ending June 30, 1916, being at rate of 6 per cent. per annum. The transfer books will be closed from the 16th to the 23rd inst. inclusive, and the dividend will be payable on the 24th inst.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date June 6, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	18d.
Solid Drawn Copper Tubes	20½d.
Brazed Copper Tubes	20½d.
Brazed Brass Tubes	20d.
Brass Wire	17½d.
Copper Wire	20½d.
Rolled Brass	17½d.
Brass Sheets	18½d.

	per ton.
Copper Sheets	£168 0 0
Spelter	£80 0 0

	per ton.
English Lead	£33 0 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£105 0 0
Clean Brass Scrap	£65 0 0
Braziery Copper Scrap	£95 0 0
Old Lead	£27 0 0
Old Zinc	£50 0 0
Hollow Pewter	£115 0 0
Black Pewter	£75 0 0
Gun Metal	£83 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date June 6, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£68 0 0
Clean Copper	£102 0 0
Braziery Copper	£88 0 0
Gun Metal	£80 0 0

	per ton.
Old Lead	£23 0 0
Tea Lead	£26 0 0
Old Zinc	£52 0 0
Hollow Pewter	£135 0 0
Shaped Black Pewter	£95 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £90; Commercial Tinman's Solder, £115; Blowpipe Solder, £125.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, June 6. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., June 6.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅝	6 10 2	Mar, Sept
10	4¼%	Do. 4¼% Cum. Pref.	7⅞	5 13 5	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	10⅛	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅞	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. C. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 8	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	7 3 3	..
5	5%	Do. Ord.	3⅞	7 1 7	Aug, Feb
5	4½%	Do. City Pref.	2¼	8 9 5	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅛	6 5 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	1	6 13 4	Feb, Aug
10	6/0	Do. 6% Pref.	10⅛	5 16 4	Mar, July
St.	5%	Do. 5% Deb. St.	98	5 2 0	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	1⅜	6 13 4	Mar, Sept
10	6%	Do. 6% Pref.	10¼	5 16 4	Feb, Aug
St.	4½%	Do. 1st Deb.	86½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	97	4 12 9	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	7[illegible]	[illegible] 10	July
5	7%	Kensington and Knightsbridge Ord.	5	7 [illegible] 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	[illegible] 1 0	Jan, July
5	6/	London Elec. Supp. 6% Pref.	4[illegible]	[illegible] 12 5	..
St.	4%	Do. 4% Mort. Debs.	8[illegible]	[illegible] 1 1 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅛	5 [illegible] 9	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 9	Mar, Sept
[illegible]	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4[illegible]	5%	South London E.S. Ord	2[illegible]	7 [illegible]	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., June 6.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5[illegible]	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5[illegible]	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	71½	6 5 10	Aol, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1[illegible]	6 18 5	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5½	6 7 3	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4[illegible]	5 10 9	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	80	6 5 0	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	75	8 0 0	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	69⅜	5 14 11	..
St.	4%	Do. do. Assented Def. Ord.	65⅛	6 1 8	..
St.	4½%	Do. 4½% Pref.	80½	5 11 10	Jan, July
St.	4%	Do. 4% Deb. St.	76½	5 4 7	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	70¾	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2¼	5 17 9	Jan, July
St.	4%	Do. 4% Pref.	65½	6 2 2	Mar, Sept
St.	4%	Do. 4% Debs.	74	5 8 1	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25	4 0 0	Feb, Aug
St.	3½%	Do. 3½% Pref.	63¾	5 9 6	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	60	5 16 8	Feb, Aug
St.	3½%	Do. 3½% A Debs.	65	5 7 8	Jan, July
St.	3½%	Do. 3½% Debs.	67⅞	5 3 4	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19⅜	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 0	May, Nov
St.	4½%	Do. 4½% First Pref.	69	6 10 5	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	106½	5 12 8	Jan, July
St.	4%	Do. 4% Debs.	73½	5 8 10	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	68⅜	5 17 0	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2[illegible]	5 10 2	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1[illegible]	4 19 7	Mar
100	5%	Do. Prior Lien Debs.	93[illegible]	5 6 11	Jan, July
1	6%	Do. 6% Pref.	[illegible]	6 12 5	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10[illegible]	7 2 0	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5[illegible]	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref.	[illegible]	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2[illegible]	6 13 4	April
100	6%	Do. 6% Prior Lien Debs.	100[illegible]	5 19 1	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	68	5 17 8	Jan, July
5	20%	Callender's Cable, &c., Co. Ord. x d & bonus	12[illegible]	8 0 0	Jan, July
5	5%	Do. 5% Pref.	4[illegible]	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	[illegible]	7 7 8	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	[illegible]	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	[illegible]	8 17 9	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	71[illegible]	5 11 6	Jan, July
10	10%	General Electric Ord.	11	9 1 10	July
10	6%	Do. 6% Pref.	9[illegible]	6 3 6	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15	6 13 4	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4[illegible]	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	11[illegible]	8 17 9	Feb, Aug
10	5%	Do. Pref.	8[illegible]	6 2 2	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	38[illegible]	6 5 1	Mar, July
100	4%	Do. 4% Debs.	95[illegible]	4 6 0	Jan, July
1	7½%	Vickers Ord.	1[illegible]	4 2 9	May, Aug
1	6d.	Do. 5% Pref.	[illegible]	5 14 3	May, Aug
St.	4%	Do. 1st Debs.	78[illegible]	5 0 11	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99[illegible]†	4 10 5	Jan, Dec
St.	4½%	Willans & Robinson B.Cm Pref. x d & bonu	40[illegible]	10 2 6	..
St.	4%	Do. 1st Mt. Deb. St.	56†	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	102[illegible]	5 18 10	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	22[illegible]	6 18 2	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69[illegible]	5 14 6	Ja.Ap,Jly,O
10	5%	Cuba Submarine Ord.	7[illegible]	6 13 4	May, Nov
10	10%	Do. 10% Pref.	13[illegible]	7 7 10	..
5	5/0	Direct Spanish 10% Pref.	7[illegible]	6 13 4	..
10	4%	Direct United States	6[illegible]	6 11 3	Ja,Ap,Jly,O
St.	[illegible]%	Eastern Tel. Co. Ord. x d & [illegible]	14[illegible]†	5 12 6	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	64[illegible]†	5 8 4	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	77[illegible]	5 3 7	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	77[illegible]	5 3 3	Feb, Aug
10	8%	Do. Ord. x d & [illegible]	14[illegible]†	5 13 9	Ja, Ap, Jly,O
10	22½%	Gt. Northern Tel. Co. with Coup. 10	3[illegible]	5 19 4	Ja, My, Jly
25	13%	Indo-European	43[illegible]	6 14 9	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2[illegible]	4 3 1	April
1	7%	Do. 7% Pref.	1[illegible]	3 12 3	July
10	1%	West India & Panama Ord.	[illegible]	10 2 8	May, Nov
10	6%	Do. 1st Pref.	7[illegible]†	8 1 4	May, Nov
10	8%	Western Telegh. Co.	14[illegible]	5 9 10	Mr, Jly, O, Dec
St.	4%	Do. 4% Deb. St.	77[illegible]	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	97	4 10 11	May, Nov.
		Telephones.			
1	7½d.	Mutual Video Telephn. Ord	[illegible]	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	1[illegible]	5 4 11	Apl, Oct
St.	4%	Do. Db. St.	79[illegible]	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83†	5 8 5	Jan, July
5	8%	United River Plate Ord.	6[illegible]	6 7 4	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4[illegible]	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	8[illegible]	5 5 7	Jan, July
		Financial and Investment.			
10	6%	Globe Telegn. & Trust	12[illegible]	4 15 1	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10[illegible]	5 14 3	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	84[illegible]†	5 18 [illegible]	Ja,Apl,Jly,O
..	4%	Do. $100 Pref	83†	5 17 8	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4[illegible]	6 5 2	Mar, Sept
St.	5%	Do. 5% Debs.	95[illegible]	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10[illegible]	5 14 3	..
St.	4½%	Do. 4½% Debs.	85	5 5 11	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6[illegible]	7 6 11	May, Nov
5	5%	Do. 5% Pref	4[illegible]	5 14 3	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,987. [Vol. LXXVII. No. 11.] FRIDAY, JUNE 16, 1916. PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1/r., or 90 pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 341	Association of Consulting Engineers (Incorporated) 355
Arrangements for the Week .. 344	Electric Furnace Melting of Ferro-Alloys. By R. S. Wile 356
An Automatic Generating Station. Illustrated 345	THE SMALL GENERATING STATION 358
Turbine-Driven Alternators. Illustrated 346	Obituary 359
The Problem of the Small Generating Station. By Geo. Wilkinson. Illustrated 348	Notes on Design of Electromagnetic Machines. By Stanley Parker Smith, D.Sc.—*Continued* 360
A New Frequency Meter. By Prof. W. Peukert. Illustrated 350	Interesting Mains Laying Operation at Glasgow. Illustrated 362
The "Garrett" Superheated Steam Semi-Stationary Engine. Illustrated 352	Arsem Vacuum Furnace. Illus. 363
The Electric Lighting of Small Towns. By H. N. Munro. 353	LEGAL INTELLIGENCE 364
	The "Electrician" Commercial and Industrial Section .. 365-374

NOTES.

Mobilise the Engineers.

KNOWLEDGE that something will be done, sooner or later, to mobilise the engineering strength of the country encourages us to lend our columns, and to use such influence as we possess, in an endeavour to keep the subject before the notice of our readers. It is interesting to note that the importance of the subject is being recognised by an influential section of the daily press. Thus, Mr. F. W. WILE, the late Berlin correspondent of the "Daily Mail," writing under the heading "Great War-after-the-War Alliance," in the "Mail" of the 8th inst., states that :—

> By far the most significant manœuvre in Germany's scheme for the War-after-the-War is the amalgamation of the Empire's "engineering brains" in one centralised body called the "German League of Engineering and Economic Associations." It comprises the following six leading institutions :—
>
> Society of German Engineers.
> Society of German Architects, Designers and Builders.
> Society of German Blast Furnacemen.
> Society of German Chemists.
> Society of Electrical Engineers.
> Society of Shipbuilding Engineers.
>
> The combination will represent a membership of 60,000, and can justly claim to incorporate all the scientific and engineering talents of Germany. The first presidency of the new league—a fact worthy of more than passing note—has been given to Privy Councillor Prof. Dr. Busley, managing director of the Schichau warship building plant at Danzig. Dr. Busley, an intimate friend of the Kaiser and Herr Ballin, is a distinguished marine engineer, who has been as conspicuously identified with the purely constructional side of the German Navy and merchant marine as Tirpitz and Ballin respectively have been with their general development. It is openly acknowledged in Germany that the league of all the talents has been organised "to confront the great new tasks which the present era conjures up."

THE need for mobilising the engineers in this country still remains, and we again urge the authorities to mobilise the engineering talent of the Empire for reasons that have already been given in these columns. We ask: "How much longer are we going to employ our technical engineers in the mere inspection of shells and such like, when work which such engineers alone can perform is waiting to be done." One of these days we hope to make the following announcement: "By far the most significant manœuvre in Britain's scheme for the 'war-after-the-war' is the amalgamation of the Empire's 'engineering brains' in one centralised body called the 'British Engineering Economic League.' In addition to the eight leading engineering institutions it comprises the Amalgamated Society of Engineers and kindred societies, as well as the several Engineering Employers' Federations. The combination will represent a membership of close upon 250,000, and can, without fear of contradiction, claim to incorporate all the engineering talents and interests. Among the objects of the League three may be mentioned. These are: (i.) To meet the whole of the engineering needs of the Empire in the workshops of the Empire; (ii.) to enable our engineers to be as well informed as their competitors on the immediate and prospective requirements of foreign buyers, and (iii.) to secure for everyone engaged in the engineering industries a share of the profits derived from such industries." On that day we shall be proud of our connection with the profession.

Contracts for Public Lighting.

THE Government restrictions have very naturally led to difficulties in regard to contracts for public lighting, and there has been a disposition on the part of some local authorities to avoid the payment of sums due under such contracts, on the ground that the light was not supplied. The case of Leiston has actually been before the Courts, the gas company suing the Urban District Council for a sum due under the contract. As was reported in our columns some time ago, Mr. Justice Low held that the contract was still valid, and found in favour of the gas company. This judgment, however, did not satisfy the Council, and they, therefore, carried the matter further: but in the Court of Appeal last week the judgment of Mr. Justice Low was confirmed. It seems to us unfortunate that public money should be wasted in this way at such a time. In such matters it is surely better to compromise and to be satisfied with some small reduction. It seems to be forgotten by municipal bodies that the charge for electricity or gas in street lighting is only one of the charges when a contract is entered into for the supply of light and maintenance of lamps. A certain amount of plant at the station must be kept available for the supply of the light, and the lamps, cables, &c., must be maintained in proper condition. It is, therefore, a common-sense view, as expressed by the LORD CHIEF JUSTICE, that, although part of the performance of the contract had become unlawful, another part of the contract, which cannot be regarded as trivial, is lawful and can be performed. The opinion was also expressed that the agreement as to the supply of gas should be regarded as an independent agreement. The same question

in another form arises in connection with charges made to domestic consumers for light. We notice a letter in the daily Press complaining that, although the Summer Time Act might reduce the consumption of electricity for lighting, nevertheless a minimum charge has to be paid which may be considerably higher than the sum equivalent to the amount of electricity used. Here again, of course, merely the energy supplied is not all that has to be considered. Moreover, it must be remembered that the Summer Time Bill was not introduced merely with a view to relieving the consumer of expense, but also to relieve the generating stations from the necessity to some extent of having to use quite so much coal. We hope that the judgment given by the LORD CHIEF JUSTICE will enable the public generally to realise the position rather more clearly.

Effect of the Power Load.

IN glancing through the annual reports of municipal electricity undertakings which are now coming to hand it is noticeable that such undertakings may be put into three classes, according to the influences of present conditions upon them. The first includes small undertakings which merely serve residential areas, and which have been seriously affected by the lighting restrictions. In such cases an increase in price has been almost inevitable. We may, perhaps, take Birkenhead as an example, where we notice that the Summer Time Act has led to an increase of 5 per cent. in the tariff. The second class includes those undertakings which have, on the whole, made more or less normal progress. Loss of revenue in one direction has been more than made up by an increase in the power load. Among such undertakings we may include Manchester and Leeds. In the case of Manchester the maximum demand has increased from 50,160 kw. to 52,976 kw., and the number of units sold has increased by over 18 millions. Notwithstanding an almost stationary gross profit, and the fact that expenditure includes a sum of £11,110 for war service allowances, and £11,308 additional income tax, the financial result is satisfactory, and the rates have benefited to the extent of £30,000, as in the previous year. At Leeds the power supply has, for the first time, been the largest source of income. Domestic electricity supply has made considerable progress, and the net profit was a good deal larger than the previous year.

LASTLY we come to the third class of undertaking, in which the progress has been very marked owing to a large increase in the demand for power. As examples we may take Barrow and Lincoln. In the case of Barrow the output has increased from 3·6 million units to 13·8 millions, or an increase of 283 per cent. The gross profit has risen from £12,717 to £21,399, and the load factor has made the extraordinary advance from 17·97 to 40·36. In the case of Lincoln the output has not increased so largely, but there has been an increase of 38 per cent. The engineer, Mr. STANLEY CLEGG, has gone to the trouble of analysing the accounts, so as to demonstrate that a power load really is worth having, and can be supplied remuneratively at a very much lower figure than a lighting load. There must be very few engineers who do not now realise the importance of the power load, but there are others who are concerned with electricity supply on whom it is well to impress this fact, and such persons will, no doubt, do well to read the reasons advanced by Mr. CLEGG that it is possible and reasonable to sell electricity used continuously for power, as opposed to electricity used only intermittently, at a very considerably lower rate than for lighting, and yet carry on a profitable business.

Electric Undertakings in Japan.

WE have received an informative statistical report showing the condition of existing electric undertakings in Japan at the end of 1914. Not the least interesting part of the report is the section in which is briefly told the story of the electrical development in the country of our progressive Ally. Beginning less than 30 years ago with a "home-made" 75-lamp dynamo installed at Nihonbashi, in little more than a year the aggregate capacity of all the generating stations in Japan had become about 500 kw. Twenty years later—in 1907 to be precise—a 15,000 kw. 55,000-volt hydro-electric station was constructed and the power was transmitted to Tokyo, 50 miles distant from the power station. At the end of 1914 another hydro-electric station was set to work. In this case the output is 14,000 kw., and the power is transmitted 140 miles at a pressure of 115,000 volts. According to the report, of which we hope to give an abstract in an early issue, at the end of 1914 the total capacity of the generating stations in operation amounted to 609,000 kw. in round numbers. It is evident that our friends have followed orthodox lines in so far as there are no less than 578 generating stations owned by nearly the same number of companies. Of the latter, over 90 per cent. are joint-stock companies. The report shows that there is the usual high percentage of small stations generating all sorts and conditions of current. No information is given as to the steps that are being taken to reduce this chaos (which reminds one of the present state of power supply at home) to engineering order, so as to minimise waste. The most recent estimate of the available hydraulic power in Japan is 2,300,000 H.P., and the utilisation of this power is likely to go a long way towards promoting uniformity. From the development recorded in the report it is evident that there should be a good market in Japan for all classes of electrical machinery and apparatus.

Forced Ventilation.—Mr. W. M. Hoen, in a discussion on "Modern Electric Mine Locomotives," at San Francisco, after referring to the high temperatures sometimes attained in motor armatures, states: "The addition of a blower giving forced ventilation increases the radiating capacity of the motors, giving much lower temperatures for the same service." The increased capacity greatly overbalances the disadvantages, especially on the larger engines.

Asymmetrical Rotors.—In a Paper read before the Institute of Radio Engineers, by Mr. B. Liebowitz, on "The Pupin Theory of Asymmetrical Rotors in Unidirectional Fields," special reference is made to the Goldschmidt alternator. The case of a simple circuit with periodically varying inductance is first examined, then follow cases in which the circuits have inductance, resistance and variable mutual inductance. The solutions are worked out to the fourth harmonic in each case, the general solutions being in the form of a Fourier series in which each amplitude is an infinite series. According to this theory all the currents in low resistance stators and rotors, when tuned, tend towards infinity, but in practice this is prevented by the variable permeability of the iron which upsets the tuning and the iron losses which limit the current.

Organisation of British Engineering Industry.—The following resolutions were carried at the general meeting of the Council for the Organisation of the British Engineering Industry (Manufacturing Engineering Concerns Section), on June 6, 1916:

1. That this meeting approves the steps taken to organise British Engineering Industry by the Council appointed on Dec. 6, 1915.

2. That this meeting approves the formation of an Association on the lines advocated in the memorandum circulated, with power to negotiate, and if advisable to amalgamate or combine with existing or projected Associations; and this meeting pledges itself to support such an organisation.

3. That those firms who by signing the card have promised their adhesion and support to the organisation be asked to subscribe to the funds of the new Association and to make forthwith a minimum payment of £5 on account of their first year's subscription towards preliminary expenses.

4. That the existing Committee be empowered to give effect to the resolutions passed at this meeting.

Hydrogen by Electrolysis. According to "Metallurgical and Chemical Engineering" one of the first commercial plants for decomposing water into hydrogen and oxygen was that at Waverley, Newark, N.J. The electrolyte used is an aqueous solution of caustic potash or soda. Each cell produces per kilowatt-hour 8 cubic ft. of hydrogen and 4 cubic ft. of oxygen. The watts per cell is 800. The purity of the electrolytic hydrogen and oxygen is 99·8 and 99·6 per cent. respectively. The cost of hydrogen by this process is 0·0625d. per cubic foot at a cost per kilowatt of 0·5d.

Electrical Treatment of Timber.—The "Builder" refers to methods of treating timber electrically. When current is passed through freshly-cut timber a chemical change is stated to occur, which renders it more able to withstand attacks of fungi. By using the "Nodon" process it is claimed that the effect in a few hours is equivalent to months of ordinary drying in free air. Since moisture assists the flow of electric current the process is best applied just after the tree is felled. In this way the transit weight is reduced. The electric power required is 3 kw. to 6 kw. per cubic meter.

Electric Gas Detector.—The "Colliery Guardian" refers to an electric gas detector for use in mines devised by Mr. C. M. Means, of the Randolph-Means Co., Pittsburg, U.S.A. It consists of two glowers placed vertically side by side, and enclosed with gauze and glass. To use it a button is pressed and electric current from a primary or storage cell heats the glowers to a dull red. In air both glowers are of equal luminosity, but in inflammable gases one of them gets brighter, and the other duller. It is intended to indicate the presence of 2 per cent. of gas, and it is stated it can be used for as small percentages as 0·5.

Long-distance Telephony.—A demonstration of long-distance telephony was given at the recent dinner of the National Geographical Society at Washington. Details of the demonstration indicate how all long-distance obstacles have been overcome by the engineering department of the American Telephone & Telegraph Co. Connections were made between the banqueting hall at Washington and the points mentioned below, in the sequence given: Seattle, Ottawa, El Paso, Jacksonville and San Francisco. Circuits were built up to the same points, which brought the total up to 19,600 miles. Mr. J. J. Carty, chief engineer of the American Telephone & Telegraph Co., first said a few words to someone at the distant point, and then called the roll of the important test stations along the line, someone at each of these intermediate points answering him.

Illumination From a Radiating Disc.—Mr. P. D. Foote, in the "Bulletin" of the Bureau of Standards, refers to a recent discussion of the Illuminating Engineering Society, and states that the integral proposed to calculate the illumination from a radiating disc is incorrect, and the approximation method given in detail is not warranted, since the correct solution is easily obtained. He then writes out the integral and calculates the illumination at any point in space on a surface parallel to the disc, as well as considering the cases of illumination at a point on a line perpendicular to the disc from a point on the circumference. Another case considered is the illumination on a line perpendicular to the disc at the centre. Three curves are given illustrating the results of calculation. In making the calculation diffuse radiation and the validity of Lambert's law is assumed as well as the inverse square law for infinitesimal points.

Composition and Density of Copper Sulphate Solutions.—A publication of the Bureau of Standards, entitled "Relation Between Composition and Density of Aqueous Solutions of Copper Sulphate and Sulphuric Acid," has recently been issued. In connection with a study of copper electrotyping baths, which usually contain only copper sulphate and sulphuric acid, it was found desirable to devise a simple method for determining their composition. Since the composition of such a solution is fixed, if the acidity and density at a given temperature are known, all that is required to determine the content of copper sulphate is a table showing the densities of solutions of known composition. The densities of such solutions varying in concentration from 0 to 20 per cent. each of copper sulphate and sulphuric acid were determined at 25° C. and 10°C., and were found to be consistent and almost independent of their proportion. Those interested in the subject may obtain a copy free by addressing a request to the Bureau of Standards.

Our Earth a Magnet. The "Journal" of the Franklin Institute contains an instructive article dealing with the earth's magnetism by Dr. L. A. Bauer, of the Department of Terrestrial Magnetism, Washington. Starting off with the appropriate quotation of Dryden that:

> "Gilbert shall live till lodestone cease to draw
> Or British fleets the boundless ocean awe."

the early magnetic discoveries are referred to. The science of terrestrial magnetism is sketched, and it is mentioned that compared with steel, the earth is but a feeble magnet (only about 1/10,000th that of highly magnetised steel). The variation of the compass is then discussed, and the definition of a magnet as "a body capable of exerting magnetic force," and magnetic force, as "the force exerted" by a magnet, leads naturally to an inquiry. The voyage of the non-magnetic vessel "Carnegie," and particulars of some results, are illustrated by photographs and diagrams, and the article ends with a quotation of C. R. Clarke's lines on the compass:—

> "By many long enduring links,
> I clasp the Northern Star."

It is altogether a most interesting and readable article.

Wave-lengths in the Iron Spectrum.—We have received a copy of a new publication of the Bureau of Standards entitled "Interference Measurements of Wave-length in the Iron Spectrum." The bureau undertook this investigation in order to establish for spectroscopists a satisfactory system of standard wave-lengths and to study some characteristics of the emission lines in the spectrum of the iron arc. For successful spectroscopic analysis the wave-lengths and other characteristics still exist, and to remove the ambiguity it is of primary importance to have a good system of standard wave-lengths. The wave-lengths of about 400 iron lines were measured throughout the spectrum from the visible red (6,750 A) into the ultra-violet (3,233 A). As far as possible, sharp lines of different intensities were chosen at regular intervals in this region. The accuracy of the measurements is one part in several millions. The wave-lengths of other spectra photographed together with these standards can be accurately obtained and the corresponding chemical elements identified. The Bureau has applied this to the analysis of alloy steels and various ores. The sharpness of over 600 lines in the iron-arc spectrum was carefully examined and the relation of this property to intensity and change in wave-length by pressure or other causes was sought. The results are given in the Paper.

The Proposed Development of the Walchensee Waterfall in Bavaria.—Mr. Oskar von Miller has presented a report to the Bavarian Home Office, in which he gives estimates of the results which might be expected to follow from the proposed hydro-electric station for the utilisation of the water of the Walchensee. This water-power is estimated at a maximum of 40,000 kw., with a total annual output of 120,000,000 kw.-hours. The report suggests that it would be better not to endeavour to distribute the power locally or in any one particular district, but to distribute it throughout the whole of Bavaria, in conjunction with already existing sources of supply. With this object in view, the central station and transmission schemes, which are at present in operation, should be unified under one management, and the whole should be developed as one undertaking under the name of the Bavarian Central Works. It is considered that in this way it will be possible to shut down a number of steam stations, which are supplying very inefficiently. It may be necessary to have a few steam stations as a stand-by, and the sites for these will have to be carefully chosen; but the net result will be a considerable cheapening of the cost of supply. The report contains figures relating to the financial estimates. According to these, it should be possible to lower the prime cost of supply by 20 per cent.

OBITUARY.

Lieut. Wilkinson.—We regret to record the death of Lieut. J. R. Wilkinson, B.Sc., elder son of Mr. Geo. Wilkinson, borough electrical engineer of Harrogate. The deceased, who was 26 years of age, belonged to the 2nd Lancashire Fusiliers.

He went to the Front in the early part of August, 1914, and on Aug. 26, in the fighting at Cambrai during the retreat from Mons, a shell burst near him, and he sustained 10 shell wounds. He was found by three Red Cross Germans, and was taken in a cart to Cattenieres, where he was overhauled by German doctors. From there he was taken to Cambrai and then on to Hessen, and later to the fortress at Mainz, and subsequently to Neisse and Cnadenfrei. Six of his wounds soon healed, and in time the other four got well. Letters were regularly received from Lieut. Wilkinson, and he lightened the monotony of his life by studying languages, in several of which, notably German, French and Russian, he became quite proficient. Lieut. Wilkinson was interested in meteorological matters, and he appears to have pursued his studies in Germany. He was in the habit of going on to the roof to make his observations, and on one of these occasions, for some cause unknown, he fell off the roof and was instantly killed. The deep sympathies of a wide circle of friends will go out to the family in their great sorrow.

Killed in Action.—The death is announced of Engineer Sub-Lieut. Charles P. Tanner. He was educated at Oakham School, whence he proceeded to Rowan's Engineering Works, Glasgow, and studied at the university, where he took his B.Sc. degree in March. He won many scholarships, and was Lloyd's and Whitworth exhibitioner. He received a commission in the Royal Navy in April, and joined H.M.S. "Indefatigable" on May 8.

Capt. Thos. Wilkes Lonsdale (Duke of Cornwall's Light Infantry) died in France on June 5 of wounds received on May 24. He was born in June, 1894. Capt. Lonsdale, who was recently awarded the Military Cross for conspicuous gallantry, was studying at the Battersea Polytechnic for an Engineering Degree until the outbreak of the war.

PERSONAL.

Correction.—With regard to the first paragraph in our Personal column of our issue of June 2nd, this should have referred to Mr. L. P. Marshall, chief engineer to Rangoon Municipality, and not to Mr. J. L. Holmes, who is chairman and resident engineer of the Rangoon Port Trust (and who sits on the Board of the Municipality and advises them in an honorary capacity). Mr. Marshall is at present in England, and letters addressed to him, care of Messrs. Ogilvy, Gillanders & Co., 67, Cornhill, London, E.C., will be forwarded to him. The letters already sent to that address for Mr. Holmes, as the result of the publication of our previous note on the subject, will also be dealt with by Mr. Marshall.

Mr. J. H. Butters, chief engineer and general manager of the Hydro-Electric Department, Tasmania, has been appointed a member of the advisory council constituted by the Federal Government in connection with the initiation of a Scientific Research Bureau for the collection and dissemination of industrial scientific information.

Royal Engineers (T.F.)—The following appointments have been made:—

London Electrical Engineers: The following announcement is substituted for that in the "London Gazette" of May 5: Sec.-Lt. (temp. Capt.) A. R. Z. Porter, from Lond. R., to be Second Lieutenant; Sec.-Lt. A. R. Z. Porter to be temp. Lieutenant (May 6).

Tyne Electrical Engineers: Sergt.-Maj. F. T. Hamilton to be Second-Lieutenant (on probation).

APPOINTMENTS VACANT AND FILLED.

The Governing Body of the Manchester Municipal School of Technology invites applications for the appointment of vice-principal. Salary £500 a year. Conditions from the Registrar, to whom applications by June 19.

Mr. W. G. Crossle, of the engineering staff of Messrs. Fyvie & Stewart, of Melbourne, has relinquished his position to take charge of the Commonwealth Government's wireless station at Woodlark Island.

Mr. E. C. Barlow, assistant manager and engineer, Siemens Bros. Dynamo Works (Ltd.), Melbourne, has joined the staff of Noyes Bros. Pty. (Ltd.), Melbourne.

Mr. W. O. Strangward, secretary of the Prahran and Malvern Tramway Trust, has been appointed secretary of the Melbourne Tramway Trust.

Mr. Eric Halliwell, of Koroit (Victoria), has been appointed electrical engineer to Bulla Shire Council.

INSTITUTIONS AND SOCIETIES.

Institution of Mining Electrical Engineers.—In the discussion of Mr. Kivlen's Paper at Glasgow on the "Standardisation of Switchgear," Mr. J. Gibson remarked that if they took a fairly extensive colliery they would find 50 motors and not two of them alike. They ought to be standardised as well as switches, as it required about 20 spare armatures being kept, which was serious. As a rule, collieries were not stopped through failure of 100 H.P. motors, but through the breakdown of some small motor driving an auxiliary haulage or fan. It was pointed out that many of the American starters were fitted with American screws, making repairs difficult, although in some cases this was partially remedied. The Branch President stated that although electrical engineers had been trying to standardise for years they were no nearer getting over the obstacles to-day than 10 years ago. He referred to the improvements made in motors, and asked where we would be if these had been standardised. The manufacture of standard cables and the failure of getting them taken up in mines was dealt with. Mr. Anderson referred to the induction motor as a beautiful piece of apparatus, but which left something to be desired in mechanical details. Mr. J. P. C. Kivlen, in his reply, stated that all he suggested was standardisation in small parts, or details, such, for instance, as trailing cable plugs. He did not consider it good practice with a "cab-tyre" cable to have two different plugs fitted to it. Makers should also standardise the actual locking pin of the plug. He considered it most unfair of colliery people purchasing American goods at present when our manufacturers were busy with munitions.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, June 17th.

Association of Teachers in Technical Institutions.

2.30 p.m. Day Training College, Southampton Row, London, W.C. 1916 conference and address by Dr. Wm. Garnett.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

Thursday, June 22nd.

10 a.m. Annual Convention at the Institution of Electrical Engineers, Victoria Embankment, London, W.C. Presidential Address by Mr. Alex. C. Cramb, borough electrical engineer of Croydon. Paper on "Boiler House Design," by Mr. W. W. Lackie.

2.30 p.m. Papers on "Area of Supply from an Economic Standpoint," by Mr. H. S. Ellis, and on "The Application of Electric Power to Agriculture," by Mr. W. T. Kerr.

Friday, June 23rd.

10 a.m. Council meeting.

10.30 a.m. Annual general meeting. To receive the Council's annual report to date and auditors' report and statement of accounts for year ended March 31, 1916, &c.

3 p.m. To reassemble if necessary to complete any adjourned business.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding Lieut.-Col. C. B. Clay, V.D.

Orders for the Week.

Officer for the Week.—Platoon Commander N. E. Brown.

Next for Duty.—Platoon Commander C. H. C. Bond.

Resignation.—Platoon Commander E. L. Sanderson resigns his appointment (June 5).

Monday, June 19.—Technical for Platoon No. 9, 46, Regency-street, S.W. Squad and Platoon Drill, Platoon No. 10. Signalling Class and Recruits.

Tuesday, June 20.—School of Arms, 6 to 7. Recruits, 7.15 to 8.15. Lecture, 7.15, "Sketching and Reconnaissance," Mr. R. J. Finch.

Wednesday, June 21.—Platoon Drill, No. 3 Platoon.

Thursday, June 22.—Platoon Drill, No. 7 Platoon. Shooting for No. 10 Platoon. Miniature Range. Recruits, 5.45 to 7.45. Instructional Class, 5.45.

Friday, June 23.—Technical for No. 10 Platoon, 46, Regency-street, S.W. Squad and Platoon Drill, No. 9 Platoon.

Sunday, June 25.—Entrenching at Otford, parade Victoria (S.E. & C. Railway Booking Office), 8.35 a.m. Uniform, haversacks, water bottles. Midday rations to be carried. Railway vouchers will be provided.

Otford Camp.—On and after Saturday, June 3, there will be a standing camp at Otford, see monthly orders.

Musketry.—For Nos. 1 and 2 Companies, see Notice and Tables A and B at Headquarters.

Note.—Unless otherwise indicated, all drills, &c., will take place at Chester House.

AN AUTOMATIC GENERATING STATION.*

When designing the generating station at Thompson, Iowa, to furnish its 431 inhabitants with 24-hour service, special considerations were given to arrangements that would reduce operating details in the handling of the plant load. As now operated, one man acts as plant engineer, meter reader, new-business solicitor, wireman and repair man for the entire system. His duties in the station consist only of keeping the fuel oil and the lubricating oil tanks filled and taking an occasional reading from the switchboard instruments.

The station equipment consists of two double-cylinder 28 H.P. oil engines directly connected to two 17 kw., 220/110-volt, three-wire, direct-current generators operated in conjunction with a storage battery of 116 cells. A combined balancer and booster set is also installed, and the equipment controlled by an automatic system so arranged that the very light loads on the plant are carried by the storage battery. When the load increases beyond a predetermined value one of the two 17 kw. units is started. Should the load increase beyond the rating of the one engine the second unit is automatically started. The battery is charged automatically while the engines are operating. Whenever the load decreases beyond the predetermined limits the engines automatically stop and the battery takes the load.

All current passing to or from the storage battery must also pass through a special ampere-hour meter connected in series with the battery. The needle or hand of this meter is provided with a platinum point which engages other platinum points at different positions around the dial of the meter. When current is being discharged from the battery the meter hand travels in the discharge direction until it makes contact with a platinum point located on the 50 per cent. discharge division of the meter scale. When this contact is closed, the switching mechanism is operated so that one engine and generator is started with the generator acting as a motor. As the battery is charged the hand on the meter travels back toward the full-charge position, and when it reaches the full-charge point makes another contact, stopping the engine and generator.

A mercury-type reverse-current time relay is placed in series with the generator. Whenever the engine and the generator are started, the current which is being used to operate the generator as a motor will cause the hand on this reverse current relay to travel slowly over its scale and close a contact after a certain interval of time has elapsed. When this contact is closed, the switches which control the generator are opened. In this manner the machine is prevented from taking excessive current from the battery in attempting to start the engine. The time limit of this reverse-current relay is set so that ample time is provided for the engine to start firing. If it does begin firing the action of the generator causes the hand on the reverse-current relay to return to its original position so that it will be in readiness to start the engine. Should the hand on the ampere-hour meter come to the half-discharge position for starting the engine and generator, and the engine fail to fire, the hand on the ampere-hour meter then travels in the discharge direction. At the 70-per cent. discharge point it would make contact again, operating the shunt trip breaker to cut off the battery. This action prevents over-discharging of the battery.

The reverse-current relay is so arranged that when the engine is cut off by its action a signal circuit operates bells or other warning devices.

The generator, when it is operating, runs as a compound machine, supplying current directly to the line and also to the battery through the battery booster. The battery booster is provided with a shunt field winding as well as with series field windings. When the generator is running, a relay closes the circuit to the shunt winding on the booster, causing the battery to be charged. When the engine stops, the circuit to the shunt field winding is opened, and the battery discharges through the booster armature to the line. At times when the battery is called upon to supply current to the line and also to start the engine, a special series field winding is brought into action to cause the booster to raise the battery voltage sufficiently to compensate for the resistance drop. The circuit to the shunt field is always held open until the engine starts firing and driving the generator. Current passing to the line also flows through the series fields on booster, so that when the engine and generator are running

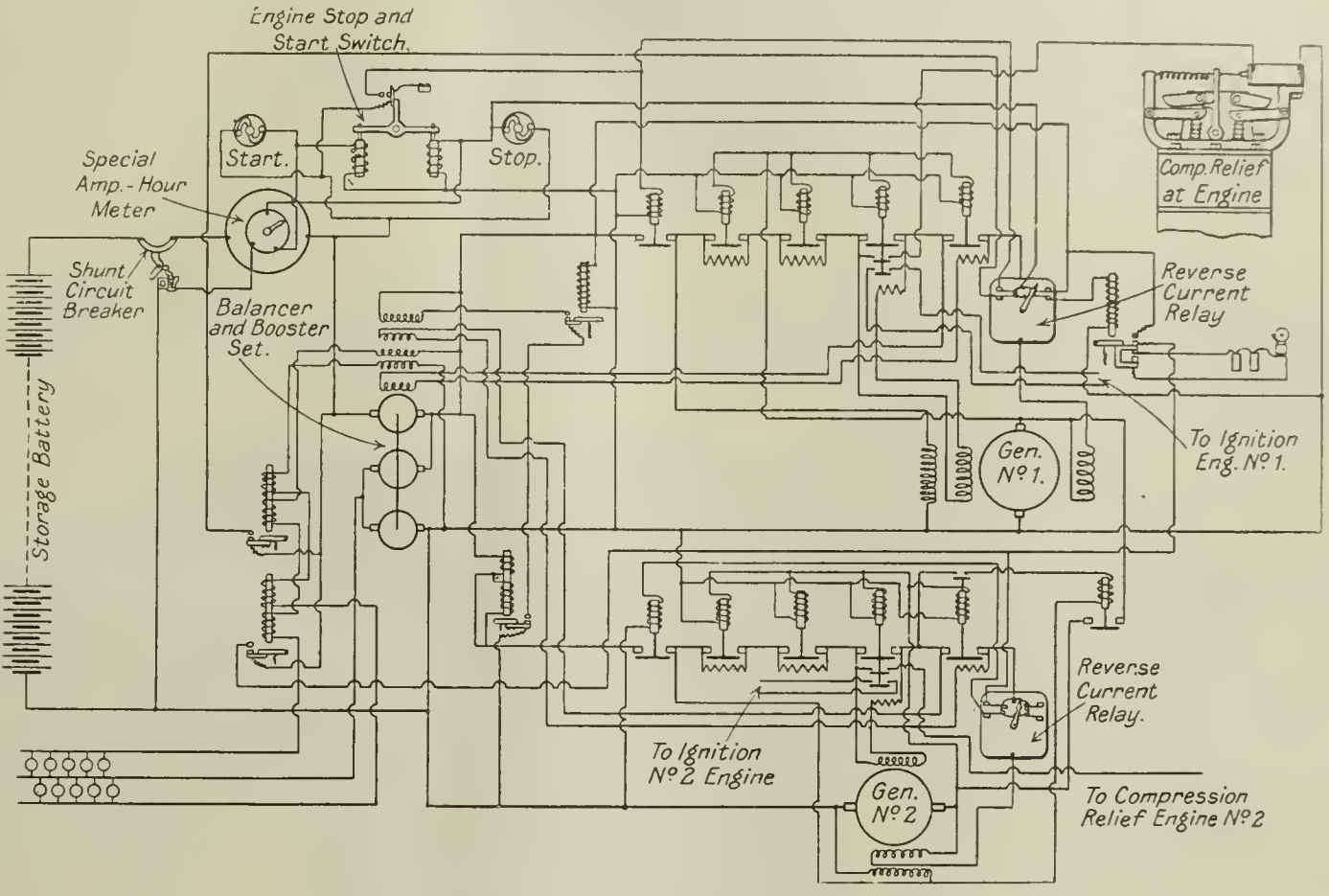


Fig. 1.—Station Wiring Diagram, showing Method of Controlling Engine Operation.

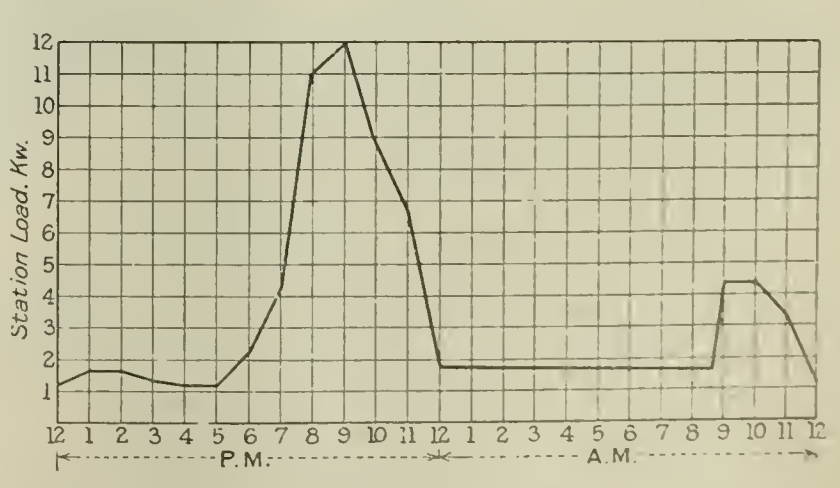


Fig. 2.—Average Load Curve at Thompson (Iowa) Station.

* From the "Electrical World," slightly abbreviated.

the action of the line current in the series field is to buck that of the shunt field winding and to reduce the charging rate of the battery. Whenever the engine and generator are not operating, and the battery is supplying current to the line, these series field windings compensate for the resistance drop of the battery, maintaining practically a constant line voltage between full charge and half discharge of the battery.

The engines of the equipment are provided with an automatic compression relief, so that at starting no extraordinary load will be thrown on the battery. The compression relief valve is operated by a solenoid, which is energised during the starting operation by action of the switching mechanism. When the engine attains practically full speed the relief valve is closed. The flow of current to the generator when it is cranking the engine is controlled by a series of solenoid switches, which in turn short-circuit consecutive portions of the starting resistance, as the engine is brought up to speed. As a further protection, the starting equipment at Thompson is arranged so that if engine No. 1, which is started first as a load comes on, fails to fire it is cut out and unit No. 2 is started. The failure of unit No. 1 to start operates the alarm circuit to indicate that the services of the engineer are required. Fig. 1 shows the electrical connections of the system.

The total cost of the electric lighting system at Thompson, including the power station and its equipment, pole lines and meters, slightly exceeded $13,000.

Income and Operating Costs.

For the month ending April 10, 1916, the plant output was 1,545 kw.-hour and the gross income was $207.21 (£41). The lighting rates for energy are 15 cents for the first 20 kw.-hour, 13 cents for the next 20 kw.-hour, and 11 cents for all over 40 kw.-hour. The power rate is 10 cents per kilowatt-hour. A minimum charge of $1 per month is made. The operating expenses for the month ending April 10 were $136.10 (£27) as follows :—

Fuel oil—760 gall. at 8·5 cents.....	$64.60
Lubricating oil.....	7.50
Operator's salary.....	65.00
Total.....	$136.10

A lower fuel cost than 4·18 cents per kilowatt-hour, according to the above figures, has been shown on short runs. During the month of March experiments with fuel mixtures were conducted; these account for this high fuel consumption as compared with the operating costs for the month ending March 10, which showed fuel cost to be 2·7 cents per kilowatt-hour. The average load for the station thus far is shown by Fig. 2.

TURBINE-DRIVEN ALTERNATORS.

As an example of modern turbine-driven alternators, we give some particulars of the British Thomson-Houston alternators, which are standardised in sizes from 1,000 kw. to 20,000 kw., for 50 and 60 cycles, and designed to carry continuously their full rated load at any power factor between unity and 80 per cent.

Stator.

The stationary armature, or stator as it is termed, consists of a box-type cast-iron frame supporting a laminated iron core in which the stator windings are embedded. The frame is of hollow section, well ribbed, the space between the outer and inner shells serving as a passage by which the air, after ventilating the machine, is conducted to the exit openings. The frame is also provided with detachable panels to facilitate inspection of the machine.

The thin iron punchings of which the core is composed are specially selected and insulated before assembly, so as to reduce the core loss to a minimum. They are held firmly in position in the frame by means of steel keys on their outer circumference, while their inner circumference is slotted to receive the stator windings. Air ducts are provided at frequent intervals along the core, by means of which efficient cooling of the stator iron and the embedded portion of the windings is ensured.

The slots carrying the windings are either of the semi-enclosed or open type, their selection depending upon various circumstances as well as the type of windings employed.

The stator frame is cast in one piece; but in some cases of the larger machines, especially where crane and railway facilities may be inadequate, it can be built in two halves, split horizontally. This arrangement of a split stator is not recommended, as there may be some difficulty with the winding, which has to be completed after the machine is erected. When a split stator alternator is asked for, the reason, in nearly all cases, is because the crane equipment of the station is not large enough to deal with the weight of the parts of an unsplit stator machine. If due consideration were but given to the matter it would be found that less trouble and expense would be caused by installing a new and more powerful crane rather than by putting in a split-stator alternator. The erection and dismantling of a machine with a split stator involves a great deal of extra labour and expense, especially with regard to connecting and disconnecting the stator windings. As a consequence, alternators with unsplit stators should invariably be adopted, except in cases of very large machines, where it is quite impracticable to ship them complete.

In such case the stators of the alternators are split vertically and assembled on site. This form of division provides for uninterrupted ventilation, and leaves the machine with the same unbroken exterior as presented by an alternator with an unsplit stator.

Stator Winding.

Bar windings (Fig. 1) are preferably provided in the stator, the lattice work arrangement of their ends providing ideal cooling surface, while by means of heavy insulated supporting rings the windings are rigidly supported against any displacement in the event of accidental short-circuit. For machines of unusually high voltage, coil windings are employed with a suitably modified form of support.

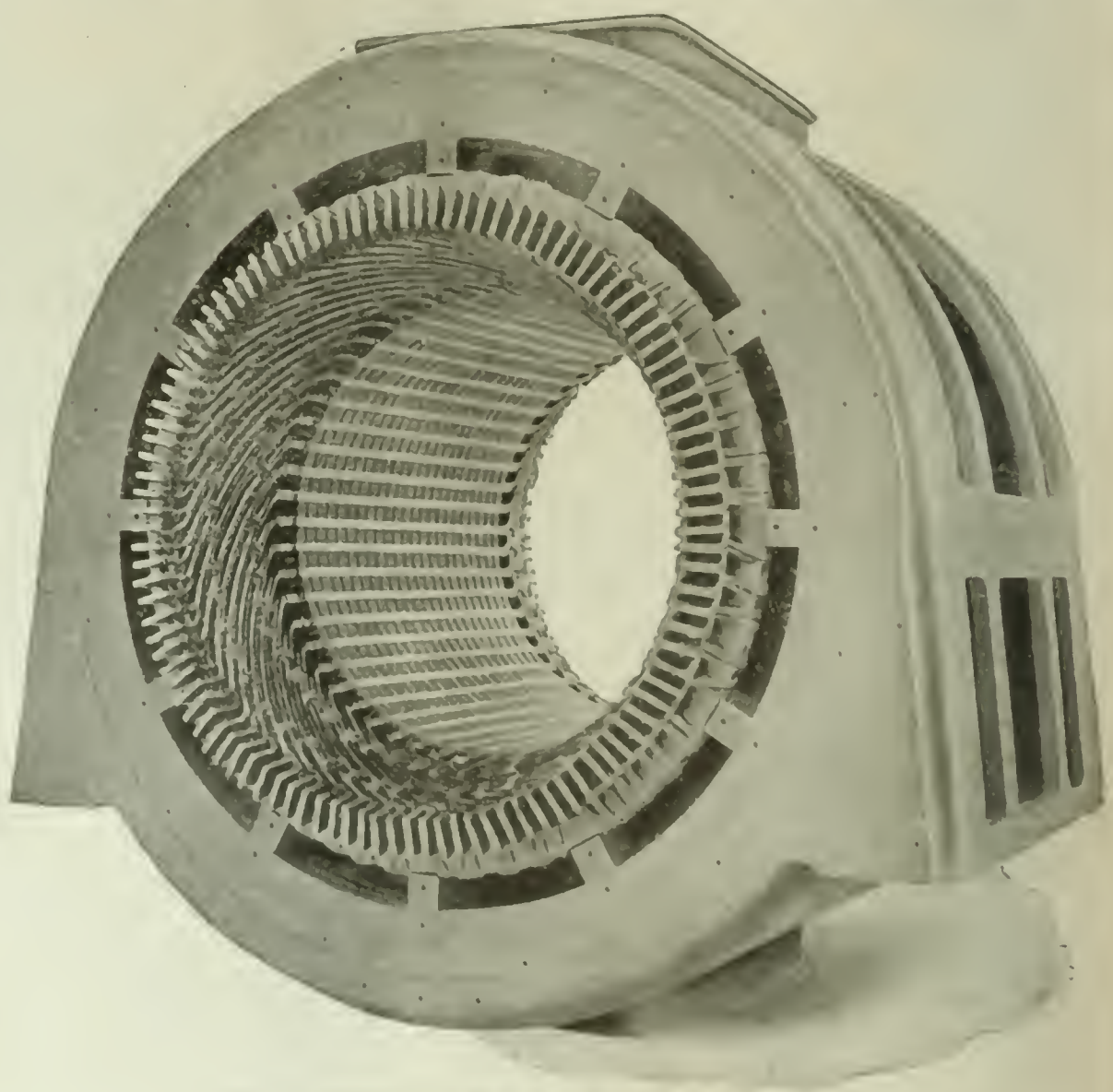


Fig. 1.—Stator Completely Wound. Bar Winding.

Special attention is devoted to the methods of insulation. In the case of bar windings, each bar has several tapings of varnished cloth and mica. Coil windings may either be of the "pulled-through" type, or may consist of previously insulated former-wound coils inserted in the slots. In the "pulled-through" type the conductors consist of flexible pressed strand cable, with a specially-treated insulated covering, and are pulled through heavy insulating slot tubes contained in the semi-closed slots of the stator. In the other case, each coil is first wound complete on a former, solidified as a whole with impregnating compound under alternate vacuum and

pressure, so as to eliminate all air spaces, then pressed to slot dimensions in steel clamps, and finally covered with the necessary thickness of insulating jacket built up in a manner similar to that adopted in the case of bar conductors.

In both forms of coil windings substantial supports are provided for the end portions of the coils, to prevent displacement in the event of a short-circuit. Ample room is also provided for free circulation of air between the coils.

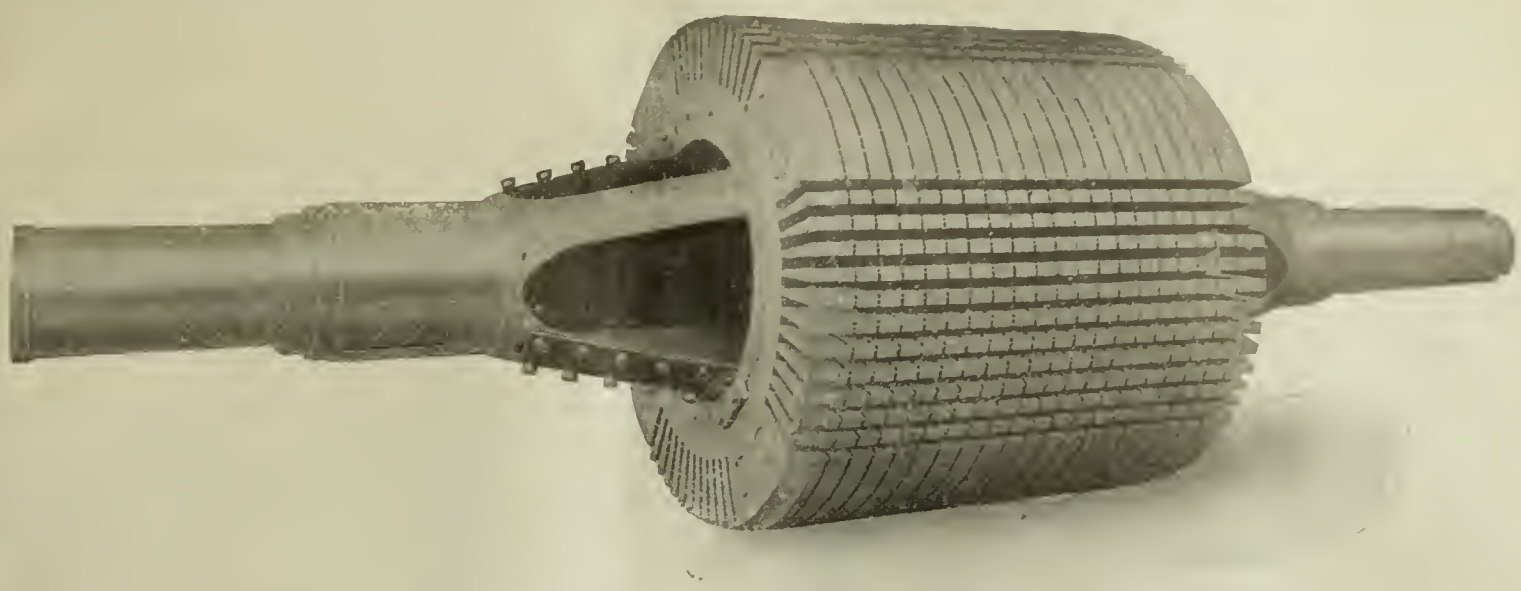


Fig. 2.—Four-pole Rotor Unwound, 7,500 k.v.a., 1,500 revs. per min., 50 Cycle.

The different applications of the various types of winding are roughly indicated above, but it is not possible to formulate the type of winding for each machine of the standard range, as this depends on the circumstances connected with each case. Both the form of slot and type of winding are chosen with due regard to the capacity and voltage of the alternator, and so as to ensure the realisation of the best possible design.

The leads from the stator windings, in the case of low-voltage machines are often brought out in the form of insulated strip, suitable for screw connections. In other cases, however, and in all high-voltage machines, the leads consist of heavily insulated flexible cables terminating in cable couplings. The latter consist of brass screw couplings, each covered with a screwed insulation sleeve. This arrangement of terminals presents the simplest and safest means of connecting the machine to the external circuit.

Rotor.

The revolving field or rotor is of the drum type without salient poles, and consists of a core built up of high-tensile steel disc stampings mounted and keyed to the shaft or spider, and so proportioned that a large factor of safety is provided to resist the various stresses to which the rotor may be subjected when running.

An arrangement of ventilating ducts allows a thorough circulation of cold air to all parts of the rotor. In Fig. 2, illustrating the mechanical construction of a four-pole rotor, it will be seen that the spider is formed out of the solid shaft, which provides large clear passages for the free entrance of the air to the body of the rotor. The shaft is of high quality forged carbon steel carefully annealed to eliminate any shrinkage stresses.

The punchings are held between heavy flanges of similar shape, while the whole is firmly bound by bolts extending from end to end of the rotor core, and secured in the end plates. The shaft is of generous dimensions, the enlarged portion which carries the punchings being designed so as to provide numerous air passages by means of which the thorough ventilation of the rotor is ensured. The exciting windings consist of coils carried in slots provided in the periphery of the rotor. The coils are supported throughout their entire length, thereby preventing any tendency to displacement through the action of centrifugal force.

In the small sizes of machines the coils consist of stranded cables threaded through closed slots. In the larger machines the winding is formed of copper strip bent to shape and carried in open slots.

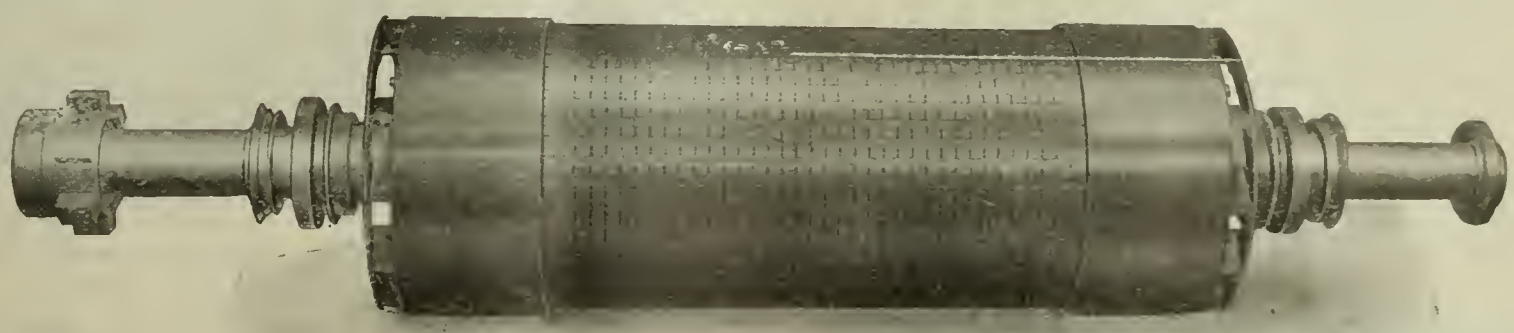


Fig. 3.—Two-pole Rotor Complete, 3,750 k.v.a., 3,000 revs. per min., 50 Cycle.

The rotor is shown complete in Fig. 3, with slip-rings and half-coupling in position. The fan wheels for circulating the air to the stator may also be seen in this figure at each end of the rotor.

The winding is subdivided into comparatively small slots, so that

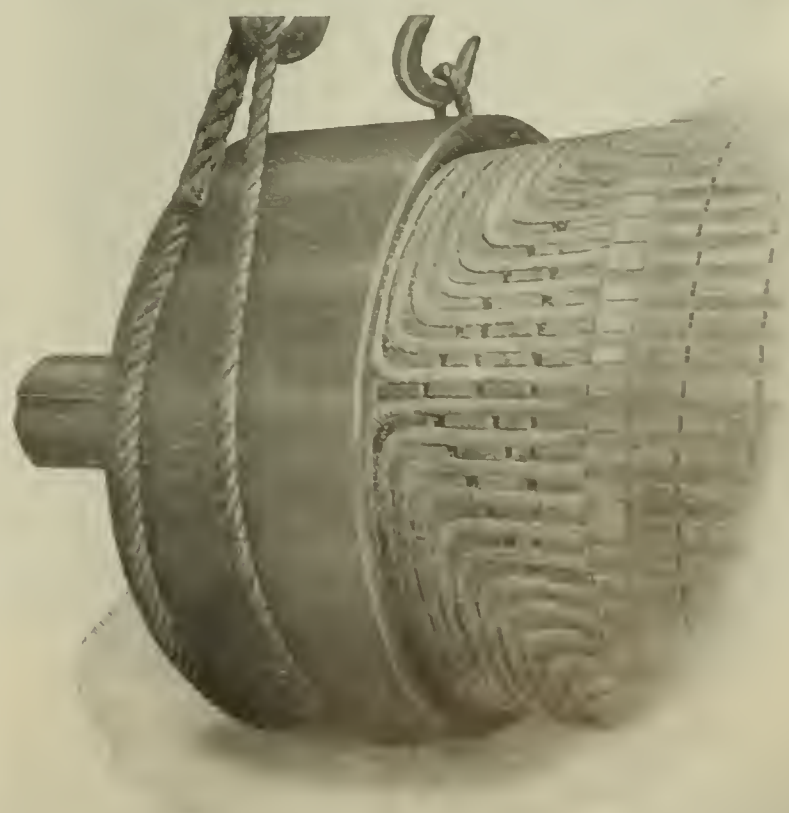


Fig. 4.—End Winding of a Two-pole Rotor. Placing a Retaining Ring in Position. 7,500 k.v.a., 1,500 revs. per min., 25 Cycle.

every conductor in that portion of the coil which is in the slot is close to the cool iron of the rotor, and consequently local heating cannot take place. With regard to the end portions, the winding on one side is in contact with a supporting ring, which has particularly good heat-conducting qualities (Fig. 4), and on the other side the winding is freely exposed to the incoming ventilating air. The supporting rings are of heavy steel insulated by stout mica insulation, and of ample strength to resist the action of centrifugal force.

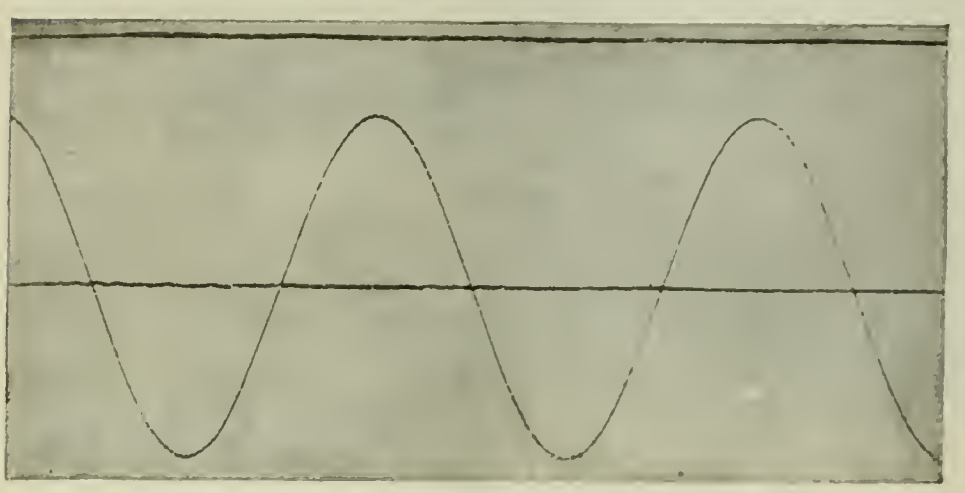


Fig. 5.—Wave-form of B.T.-H. Turbine-driven Alternator, taken by Duddell Oscillograph.

The insulation of the rotor consists of mica reinforced by means of tape or other fibrous material to give mechanical strength. When the winding is completed the whole rotor is finally dipped in a bath of insulating varnish, so that it is thoroughly impregnated.

The form of rotor described has many advantages, and, in conjunction with the type of stator used, results in the generation of a smooth potential wave very closely resembling a sine wave at all loads and free from ripples which, in the case of longfeeders, may cause an abnormal rise in potential. The smooth and symmetrical wave-form generated by these alternators is shown in Fig. 5, which

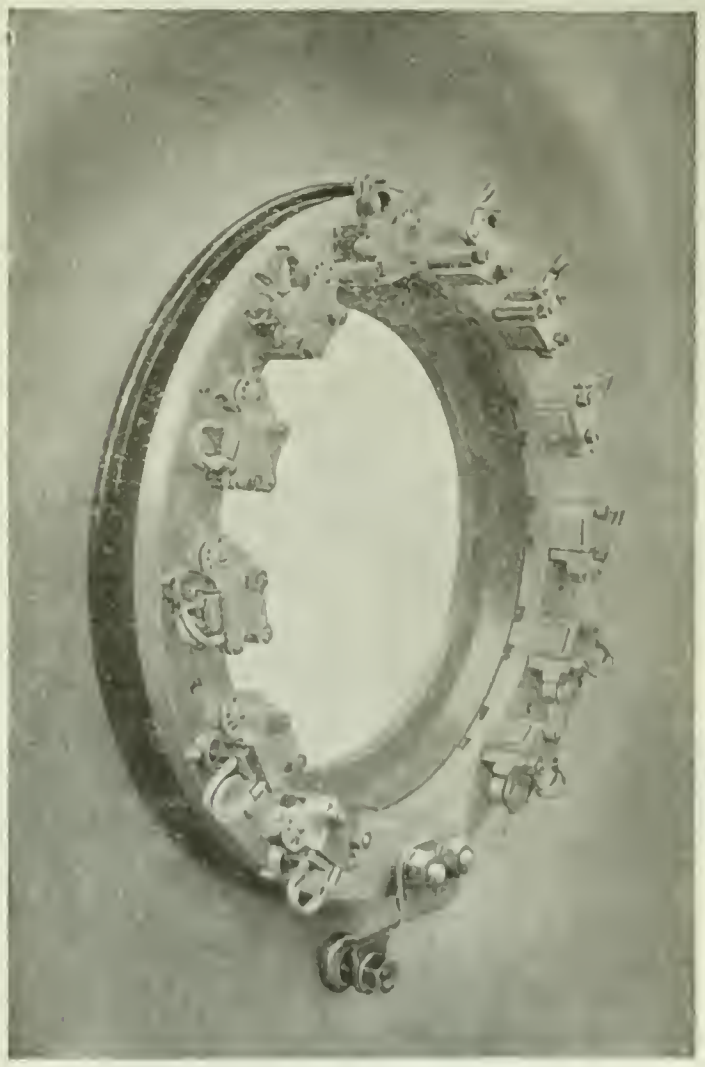


Fig. 6.—Arrangement of Alternator Brush holders.

is reproduced from an untouched oscillogram taken by a Duddell oscillograph. This result is of very great importance in modern machines, where a large proportion of the energy is used for power loads, as motors and rotary converters will only work at their highest efficiency when supplied with sinusoidal currents.

Single-phase alternators are provided with a compensating winding consisting of bare copper bars uniformly distributed round the rotor, and connected at their ends by means of heavy bronze short-circuiting plates. The cross section of the bars and plates is ample for the current which the bars carry, and the whole short-circuiting structure is arranged so that expansion can take place freely without straining the joints. Thus the contact remains good under all conditions of operation.

Collector Rings and Brushes.—The rotor slip-rings are of heavy forged steel, mounted with a shrink fit on mica-insulated sleeves, one at each end of the rotor. Graphite brushes are used mounted in holders distributed all round the rings. This arrangement ensures that at least one brush must always be in contact with the ring should it wear slightly eccentric. The brush boxes are bolted to substantial bronze rings, as shown in Fig. 6, where they are readily accessible, and can be adjusted and replaced whilst the machine is running.

Alternators which run normally at 1,500 revs. per min., for example, and in general all large slow-speed machines, have a normal running speed of about 20 to 50 per cent. below the critical speed. But to do this for machines with speeds of about 3,000 revs. per min. seriously handicaps the designers in most cases, as the shaft becomes abnormal in size and the ventilation of the rotor windings is rendered very difficult. The shaft, therefore, is so designed that the normal speed is about twice the critical speed. When running up to speed, all tendency for violent vibration to occur at the critical speed is avoided in the machines by the use of a slip bearing, in which the bearing sleeve is allowed to have a small amount of play between friction collars. The small amount of movement thus allowed completely destroys any tendency to cumulative gyration, and ensures that the critical speed is passed through with perfect safety.

THE PROBLEM OF THE SMALL GENERATING STATION.

BY GEO. WILKINSON.

It is generally admitted that there are many urban and rural districts that can be supplied with electricity in bulk on advantageous terms by a power supply company. Also some small electrical undertakings equipped with somewhat ancient and wasteful plant could—apart from local prejudice—be scrapped in favour of a bulk supply, with advantage both to the local community and to the nation at large

It is equally true, however, that there are many manufacturing and residential districts located in inconvenient positions so far as bulk supply is concerned; also there are localities—and many of them—in which the character of the demand and the local conditions warrant on economic grounds the building of a small local power house for the purpose of electricity supply, notwithstanding that there may be a power supply station in the same district.

In other words, while a good case can be made out for the establishment of large power companies as a means for securing cheap electrical service with an economical use of coal, an equally good case on precisely the same grounds can in numerous instances be made for the small local generating station.

Inasmuch, then, as small generating works will continue to be called for, the question may well be raised as to what constitutes the most serviceable and economical equipment for such a works and what type of building is best fitted for housing the generating plant.

The districts to be served are generally fairly compact areas, containing populations of from, say, 3,000 to 20,000 inhabitants, with a local demand chiefly for residential supply, and a secondary but not unimportant demand for industrial purposes which develops at a slower rate.

Almost without exception in such cases, the load factor will be good, but the total revenue, even when the business is largely developed, will be of such dimensions as to call for the greatest economy in capital expenditure, running costs, and especially in supervision and labour, if satisfactory commercial results are to be realised on the undertaking, be it controlled by the local authority or by a limited liability company.

During the last two years the problem of the economical use of our coal supplies has become one of first importance, and

while considerable progress in this direction has been and is continuing to be made in the big generating station, a corresponding improvement in the case of small equipments is not generally demonstrated. Since, however, the future will see the erection of many small electric generating stations, the question of their economical equipment is one well worth close attention.



Fig. 1.—View of Ilkley Generating Station.

We frequently have demonstrated the power of fashion in determining the character, shape and cut of our garb, especially so far as it concerns the female part of the community. Careful observation, however, will prove that fashion is a powerful factor even amongst engineers. If, say, water-tube boilers, steam-driven condenser sets, or coal conveyors are introduced into a large works, the engineer of the little works is apt to imagine that like developments are desirable in his works, and thus capital is frequently expended in directions neither wise nor profitable.

Until recent days, the popular idea for small stations in the engineering world was largely concentrated upon the introduction of Diesel engines as the prime movers, seeing that they call for no boiler plant or boiler house, and are supposed to be in a position to take the load at any time at short notice.

In a few instances gas engines with producer plant have been used, but the writer is not aware of any continued success having been made with this class of plant, and has frequently heard loud complaints of their unreliability in operation with the rapidly varying loads met with in electric generating stations.

A third equipment hitherto used has consisted of steam plant, the "lay-out" being upon the general lines followed in big power houses. The engine room is equipped with vertical high-speed compound engines supplied through a range of steam piping of generous length and dimensions from a separate boiler house, greatly to the disadvantage of the coal heap, due to large radiation losses. Again, due to the propensity to copy large works, the boiler houses are frequently equipped with water-tube boilers of small size, instead of with the cheaper, more easily managed and safer shell boiler of the Lancashire type.

None of the equipments named will compare favourably in capital cost, ease and reliability of operation, smallness and cheapness of buildings required, or in economy of fuel and labour, with a steam plant of the "locomobile" type. Plant of this type, supplying direct current at from 460 to 500 volts on the outers with accumulators, are capable in many cases of generating and supplying current to a distribution network at a cost per unit which would leave little, if any, margin of profit to a power company giving a bulk supply. This is demonstrated by the figures appearing later, which were obtained in an electricity works so equipped and under the daily running conditions.

Plant of this type is made by several first-class British firms, who turn out plant greatly superior to the German firms who advertised so extensively in this country prior to the war.

Experience has shown that the expected advantages from the small station equipped with Diesel plant have not been fully realised, due to the necessity for employing specially skilled labour to run and repair the plant, to the expensive repairs and to the liability to sudden breakdown.

The writer, who put to work the first Diesel engine employed by a public authority in Great Britain, opines that the frequent mechanical troubles met with in the Diesel engine fully justify the existence of and continued activity of the Diesel Engine Users' Association. Within the last few days he has seen the photographs of a fractured crank web taken from an engine of the most modern manufacture, made by probably the first firm on the Continent; the repair involves the provision of a new crank shaft at a cost of not less than £1,000. Finally, the immense rise in the price of crude fuel oil, which has all to be imported, seems to have given the final *coup de grace* to this class of plant for general use in small electric power houses, at any rate, until more favourable developments take place.

Steam equipments in small-powered units with separate boilers are too wasteful of fuel and heavy in labour charges for successful operation at tariff rates attractive to customers. Some of the wasteful factors are found in long steam pipe ranges, which are expensive in radiation losses and upkeep, while the banked boilers account for a substantial percentage

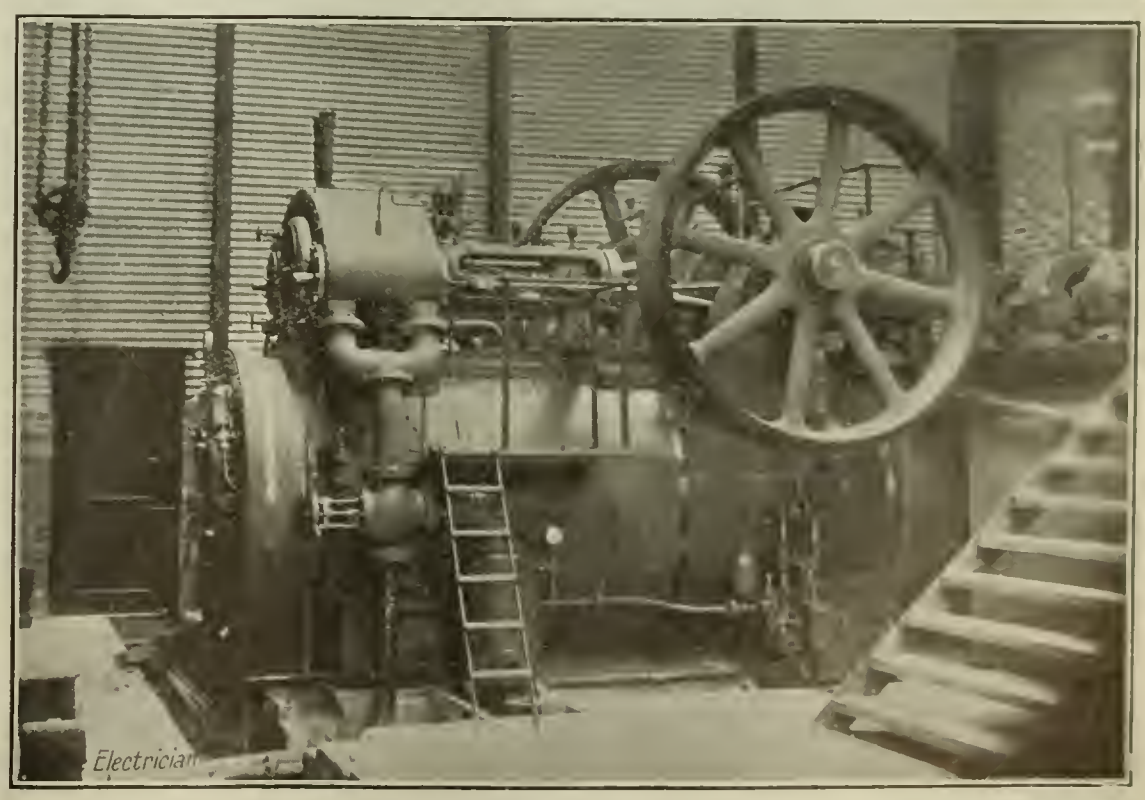


Fig. 2.—View of One of the Steam Plants.

of the fuel bill. In many cases, also, water cannot be obtained in sufficient quantity to condense the exhaust from engines, which more often than not show a healthy appetite for steam. Thus, another factor operates to swell the fuel bill and cost of production.

An equipment consisting of superheated steam semi-

stationary compound condensing engines driving direct-current generators, direct coupled or driven by means of steel belts, while being more economical in fuel, labour and running cost, also compares favourably in capital cost when compared with any of the alternative equipments above named. Water for condensing purposes can be obtained at little cost, even when water is scarce, by the provision of a small pond furnished with a double row of cooling jets, through which the heated water from the condensers is forced by a centrifugal pump driven from the engine shaft. Due to the efficiency of the plant and its small demand for steam, the necessary water-cooling plant is surprisingly small and cheap.

Again, in point of capital expenditure in buildings, such an equipment easily takes first place, as no separate boiler house is required, the engines are economical of floor space, and no expensive foundations are required.

Due to the compactness of the plant—all in one room—one man with a youth on the switchboard is ample for dealing with the heaviest loads, so the weekly wage bill is kept within reasonable limits. The plants are always run at an economical load, the hours of light demand being supplemented by charging the accumulators. As each power unit is complete and self-contained, trouble might be apprehended due to a breakdown of a running plant and the reserve plant having no steam in its boiler or fire in the furnace. This has been successfully met by connecting the boilers together by small steam pipes in such a manner that the steam from any active boiler can be passed into the water of any reserve plant boiler through a silent water heater; thus a ready means is provided for transferring heat from the active boiler into the cold water of another, which quickly raises the temperature to boiling point; also the furnace of the reserve plant is furnished with a well laid fire ready to be lighted at any moment. The fire on being lighted can be forced quickly, as the steam from the active boiler passing through the silent water heater within the reserve boiler heats up the boiler plates and produces rapid circulation, thus all undue strain on the boiler plates is avoided. In this way full steam pressure can be raised in the spare plant in the space of from 15 to 20 minutes. Meantime the working plant can be kept running, or, at the worst, the battery will supply the demand during the few minutes necessary to get the spare plant on the load. Thus a banked boiler, with the continuous waste of fuel thereby entailed, is entirely avoided, also the heavy loss of fuel due to steam traps and continuous radiation of heat from a range of steam pipes is saved, as no steam range exists: moreover, the cylinders are jacketed with superheated steam, and have perfect drainage by gravity direct into the boiler. These are some of the features that account for the pre-eminence of such plant in point of fuel consumption, labour and cheapness in upkeep.

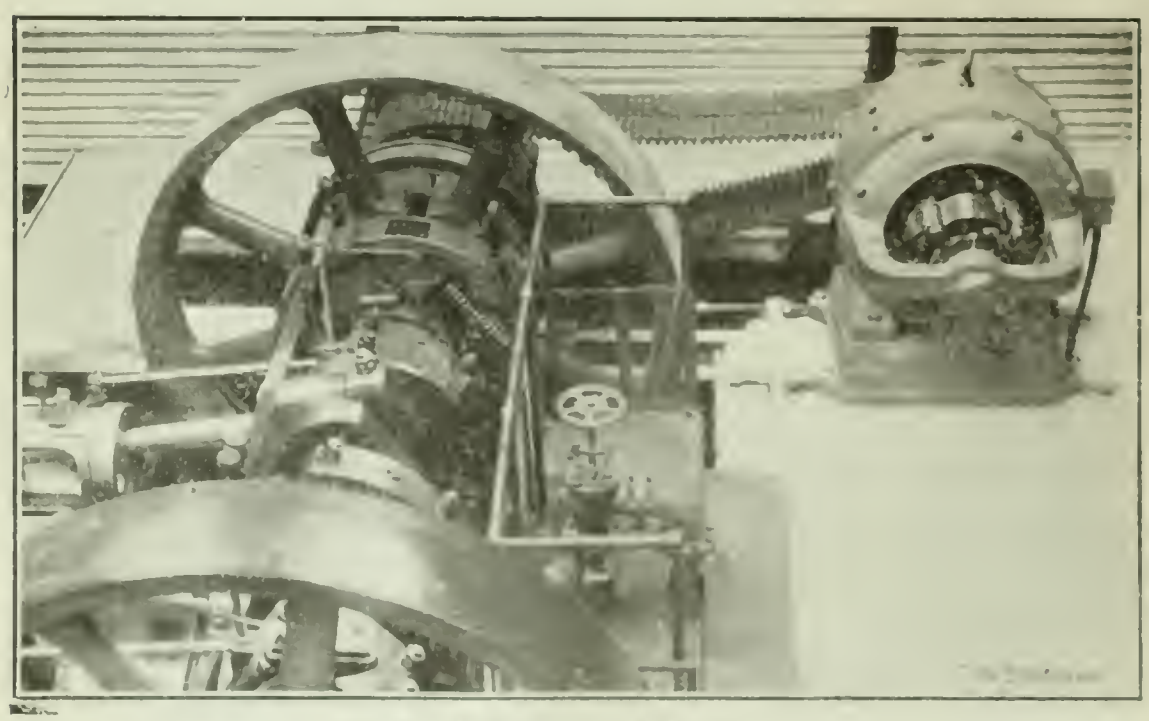


Fig. 3.—View of Chain Drive.

An example of a generating station built and equipped by the author on the lines advocated is in operation at Ilkley, of which a general view of the buildings is shown in Fig. 1; Fig. 2 shows one of the 180 B.H.P. steam plants by Messrs. R. Garrett & Sons, of Leiston; and Fig. 3 is a closer view of the chain drive. The latter is not according to the original design, which called for thin steel belts; but it was found that these were made in Germany only, and the war having broken out meanwhile recourse was had to Hans Renold's driving chains, as shown, which, however, are furnished with steel protecting cases and run in oil.

It is to be regretted that these works have had to be inaugurated under the adverse conditions due to the war, which has both increased the capital cost and greatly reduced the number of immediate customers. The demonstration of economy in running and the successful financial results which would undoubtedly have quickly resulted in normal times are thus postponed until more normal times return.

Several months after the works were opened for public supply—viz., in January last—official tests were made which gave the following results:—

	Cost with coal at 21s. per ton.
At 25 per cent. overload, 2·9 lb. of coal per kilowatt-hour	Per unit gen. =0·324d.
On full load of 130 kw., 2·24 lb. of coal per kilowatt-hour	=0·25d.
*On half load, 2·61 lb. of coal per kilowatt-hour	=0·291d.

A NEW FREQUENCY METER.†

BY PROF. W. PEUKERT.

The so-called skin effect is well known, and consists in the increase in the resistance of a conductor, owing to the passage of an alternate current through it. When such a current flows, it does not distribute itself uniformly over the section of the conductor: in the outer layers the current-density is greater than in the inner layers, owing to effects due to mutual induction. This irregularity in the distribution of the current causes an increase in the resistance. The skin-effect depends on the size of the conductor, on the periodicity, and on the magnetic permeability: it is, of course, much greater with iron conductors than with conductors of non-magnetic material. The energy-consumption in an alternate-current circuit is greater than in a similar direct-current one: the difference depends on the size of the conductor and the periodicity. The alternate-current resistance of a conductor is therefore always greater than the true ohmic resistance. Formulæ have been repeatedly proposed to express the relation between the effective alternate-current resistance and the dimensions of the cable and the periodicity; these formulæ are, of course, approximations; among them may be mentioned those due to Stefan, Mie, Dolezalek, Zenneck, &c. With copper conductors, the effective resistance depends only on the dimensions and the periodicity; with iron conductors the effective resistance changes in consequence of hysteresis with the current, so that with a given iron wire and a given periodicity, the resistance depends on the current. It is proposed to give the result of tests on iron wires, carrying alternate currents; these were carried out with stretched wires and with coils. The results were the ground work, on which the frequency meter was constructed. The tests were carried out with stretched iron wires of 1 mm. and 1·5 mm. diameter; in this way the relation between the effective resistance and the frequency and the current was determined. The effective resistance was found from the watts, measured on the wattmeter, and the current. In order to exclude the effects of temperature, the direct current resistance was determined indirectly: the iron wire was loaded with a direct current of the same amount, and the ohmic resistance was determined from the voltage-difference and the current. The current-density during the tests was kept low, so that there was a negligible temperature-rise owing to the current.

* Arrived at by calculation from engine tests.

† Abstract of an article in the "Elektrotechnische Zeitschrift," Heft. 1, 1916.

It is well known that for a given current the temperature depends on whether the current is alternating or direct. The periodicity could be raised to 500. The first series of tests was conducted with a constant alternating current and a variable periodicity. The results

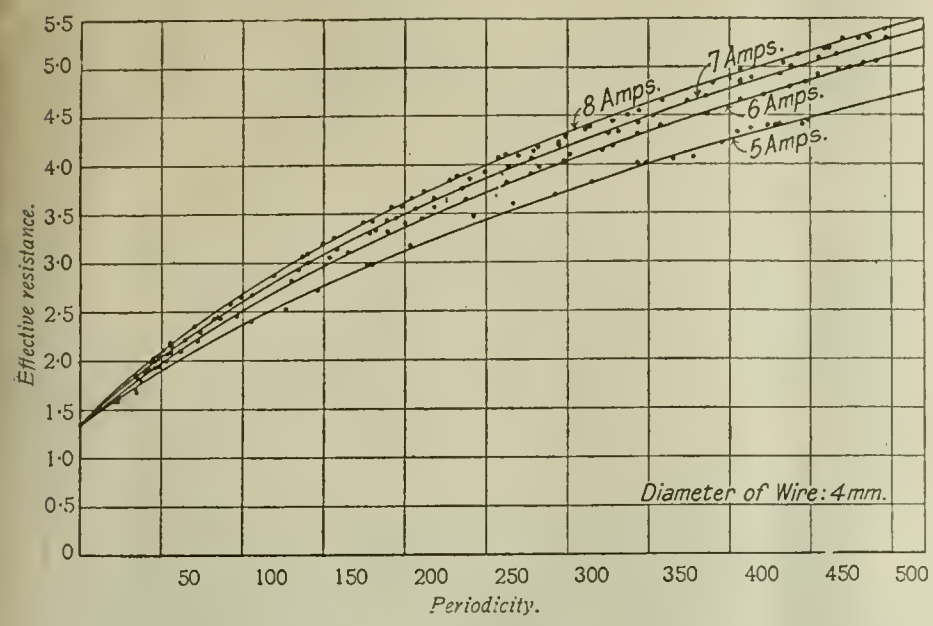


Fig. 1.—Curves showing the relation between the Effective Alternate-Current Resistance and the Periodicity.

are given in Fig. 1 ; these curves show that the effective resistance of an iron wire, carrying a constant current, is a function of the periodicity. Thus a frequency-meter could be constructed on this

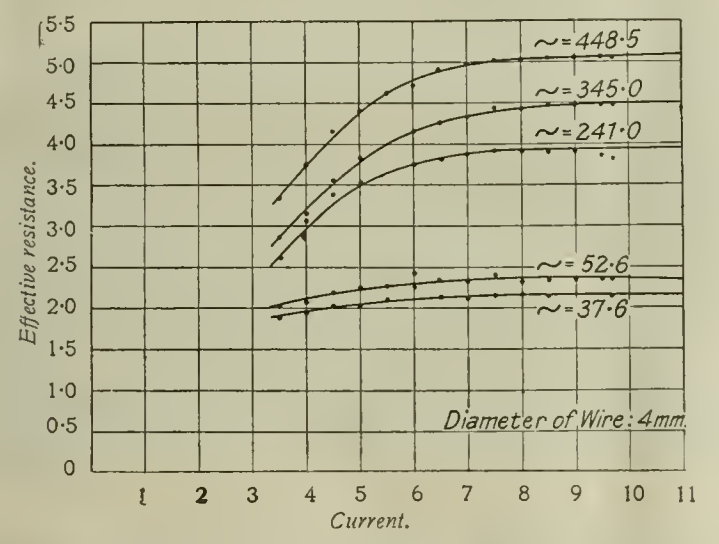


Fig. 2.—Curves showing relation between the Effective Resistance and Current for Different Periodicities.

principle. A little calculation shows that there is a direct relation between the periodicity and the reading of the wattmeter. The wattmeter can be provided with a scale from which the periodicity

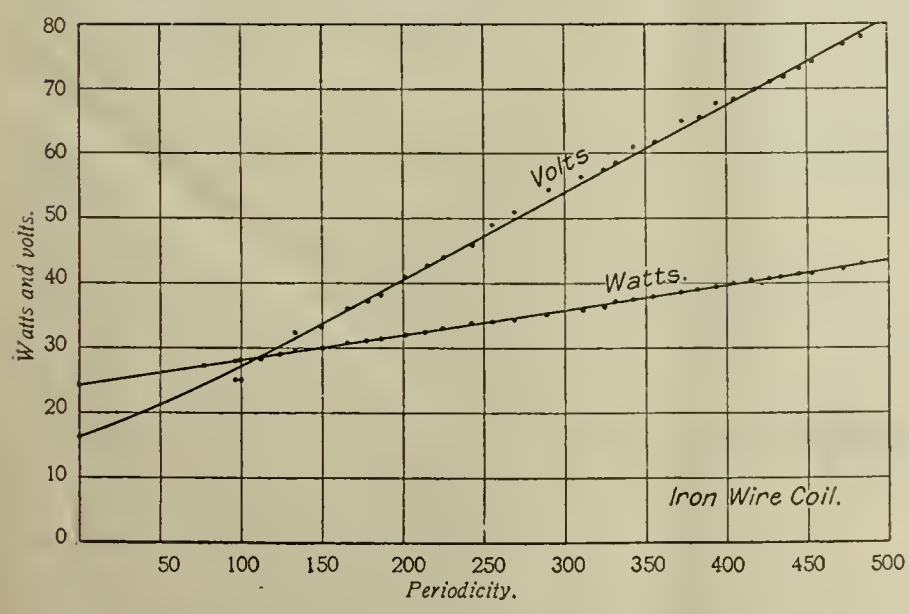


Fig. 3.—Curves connecting Voltage and Periodicity and Watt-Consumption and Periodicity in a Coil of Iron Wire.

can be read directly ; in this way we have a direct-reading frequency meter. If such an instrument is used, it is necessary to keep the current constant, even if the voltage varies, and it will be shown that

Table I.
Current = 1·5 amperes.

∼	Watts.	Volts.	Resistance.	∼	Watts.	Volts.	Resistance.
100	27·8	25·0	12·35	324	36·2	57·5	16·1
112	28·0	28·0	12·45	331	36·8	58·8	16·35
124	28·8	29·0	12·8	343	37·3	60·8	16·59
150	29·9	33·0	13·29	355	37·9	61·8	16·83
166	30·5	36·0	13·55	373	38·5	65·0	17·12
176	30·9	37·0	13·73	383	38·9	65·8	17·3
187	31·1	38·0	13·82	394	39·2	67·5	17·42
201	31·8	41·0	14·14	405	39·9	68·5	17·73
214	32·1	42·5	14·25	416	40·1	69·8	17·85
225	32·8	44·0	14·59	426	40·5	71·8	18·0
242	33·5	46·0	14·89	434	40·8	72·0	18·15
256	33·9	49·0	15·08	445	41·1	73·2	18·28
269	34·2	50·8	15·2	453	41·5	74·5	18·45
290	35·0	53·2	15·55	472	42·1	76·8	18·71
311	35·8	56·5	15·92	484	42·8	78·0	19·05

this is easily done. Stefan's formula states that the ratio of the alternate-current resistance to the direct-current resistance is

$$\left(\pi \cdot r\sqrt{(\infty\mu/\rho)}+\frac{1}{4}\right),$$

where r is the radius of the wire, and ρ is the specific resistance. The results given by this formula agree quite satisfactorily with the figures given by measurements.

But in order to determine the relation between the effective resistance and the current, a second set of tests was carried out, with constant periodicity. These are given in Fig. 2. Further tests were made with a coil of iron wire, which had 800 turns of wire, 1·5 mm. in diameter. The watts and voltage were first determined with constant current and variable periodicity ; these results are given in Table I. and Fig. 3. In Fig. 4, the results are given in which the current was kept constant over the separate tests, in each of which, however, a different value was taken. These tests show that the frequency can be determined from the voltage across the coil, if the current is kept constant. This effect can be produced by putting

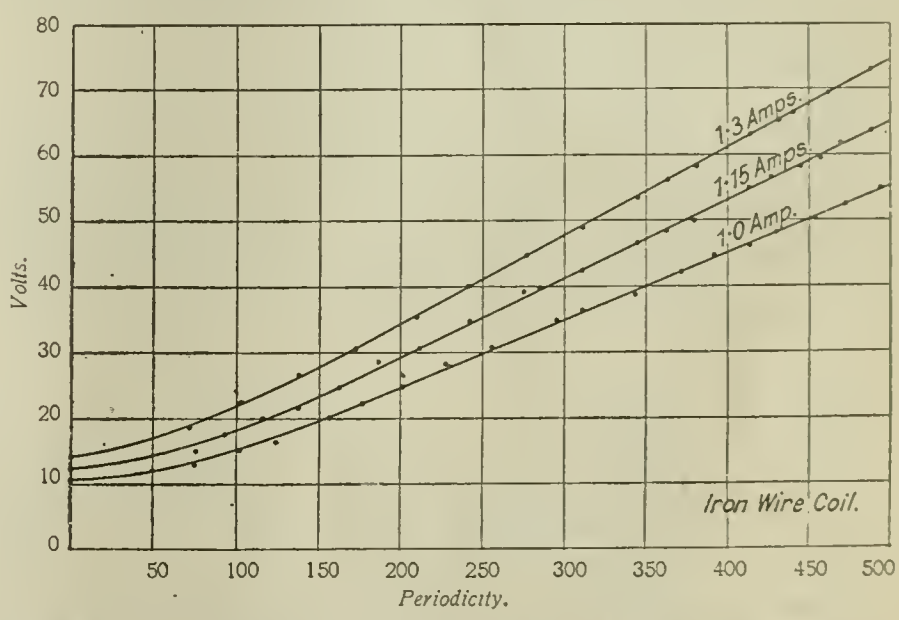


Fig. 4.—Curves showing relation between Volts and Periodicity with Different Currents.

a compensating resistance in series with the coil, so that the current remains constant although the machine-voltage varies. The most suitable form of compensating resistance is the so-called Nernst type, consisting of very thin iron wires which are run in an atmosphere of hydrogen. The size of the wire is so chosen that it is suitable for all probable variations of voltage, and for keeping the current constant under these conditions by the variation in its resistance.

The following experiment shows this to be possible. A Nernst resistance was put in series with the coil of iron wire, the voltage of the machine was varied within wide limits by altering the excitation ; the current through the coil was measured. Curves and figures are given which show that, over a considerable range, the current is constant ; in the case cited, the current remained constant while the voltage was varied from 50 to 77, and even beyond these limits the variation is for practical purposes very small. This gives an idea of the possible range. It is therefore possible by a proper choice of the Nernst resistance to keep the current absolutely constant, even though the voltage varies by 50 per cent. ; thus the reading of the

Table II.

Overall voltage.	~	Amperes.	Voltage on coil.	Overall voltage.	~	Amperes.	Voltage on coil.
70·8	283	1·04	34·4	99·8	410	1·09	51·0
73·2	294	1·05	36·2	101·0	417	1·10	52·2
78·5	317	1·07	39·5	104·0	431	1·10	54·3
85·8	345	1·07	43·2	105·6	438	1·12	56·0
90·2	365	1·07	45·4	107·5	448	1·125	57·4
94·5	384	1·07	48·0	109·0	455	1·14	59·0
96·0	393	1·075	48·9	114·0	479	1·16	64·2

voltmeter is a direct measurement of the frequency. Table II. gives the results obtained in a special case, in which the instrument was intended to be used with periodicities varying between 300 and 400. In this way a very simple form of frequency meter is obtained, which can be used over a considerable range. During the tests it was only possible to obtain frequencies up to 500, but much higher frequencies can actually be measured in the same way. The meter is extremely simple, and has a very large range; by mere measurement of a voltage we obtain the frequency. The meter need not be placed in the immediate neighbourhood of the machine, but can be put in any position; it is therefore suitable for readings which require to be obtained at a distance from the generator. In essence it is only a voltmeter with a suitable scale, calibrated so as to give direct readings in frequencies; it may, if desired, be of the electrostatic type; there are no cumbrous or costly auxiliaries needed, and it can therefore be mounted both cheaply and easily. It is made and supplied by the firm of Siemens & Halske.

THE "GARRETT" SUPERHEATED STEAM SEMI-STATIONARY ENGINE.

In the article by Mr. George Wilkinson on the problem of the "Small Generating Station" in this issue, the "Garrett" superheated steam semi-stationary engine is referred to, and some indication given of its design and economical performance. It will be of interest, therefore, to consider the design and construction more in detail. The accompanying drawing (Fig. 1) shows clearly the arrangement of the principal parts of one of these engines which are manufactured by Messrs. Richard Garrett & Sons (Ltd.), of Leiston, Suffolk.

It would be more correct to describe this "engine" as a semi-stationary steam "plant," as any one unit consists of a complete set of all the parts which go together to form a complete steam plant—viz., boiler, superheater, engine, condenser, air pump and feed pump. These various organs are disposed in such a manner that the result is a very compact self-contained plant, which, however, is entirely accessible for inspection and overhauling.

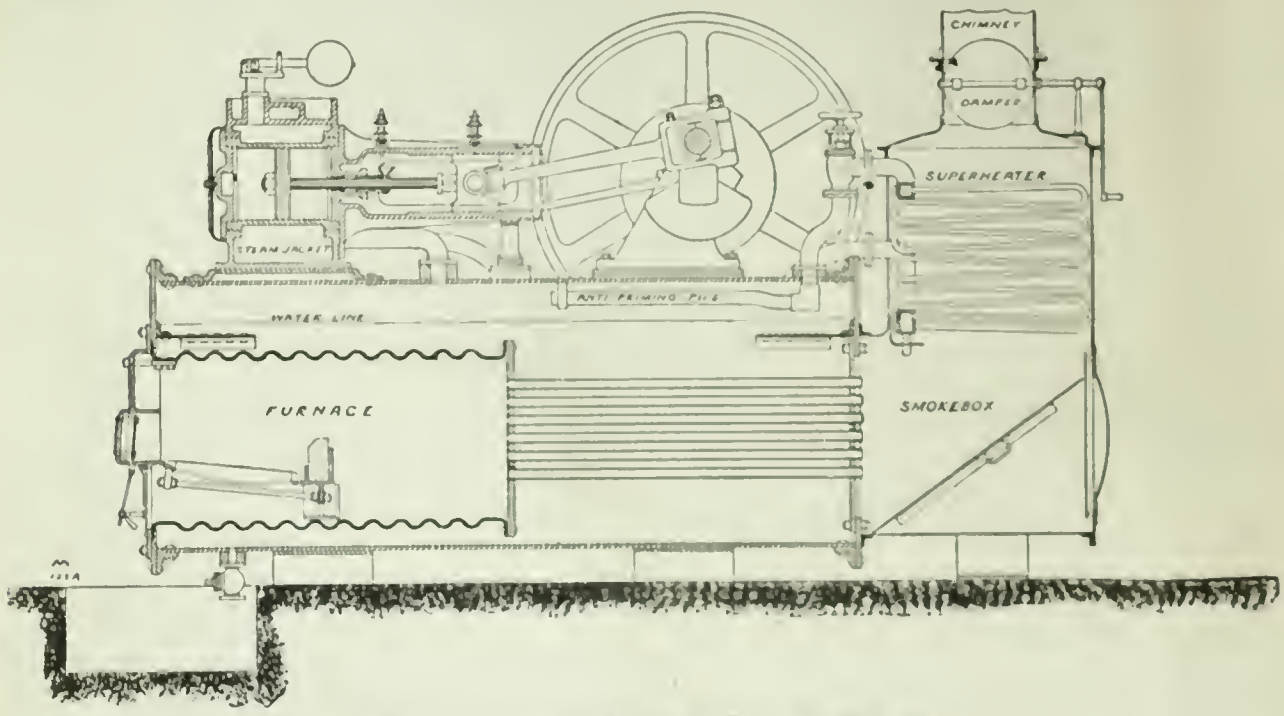


Fig. 1.—Longitudinal Section of Garrett Engine.

Referring to Fig. 1, it will be seen that the boiler is of the cylindrical single-flue multitubular type. This type of boiler gives the advantages of the loco-type boiler in respect of high evaporative efficiency, without the disadvantages of a rectangular fire box and confined water spaces round it, which are readily choked up with sediment.

The furnace and tube system are so designed that they can be readily disconnected and withdrawn from the boiler. Fig. 2 shows this operation partially carried out. The great advantage of being able to do this is obvious, as when the furnace and tube system are withdrawn all the heating surfaces and the inside of the boiler can be thoroughly cleaned and inspected with the greatest of ease. In cases where more than one unit of the same size are installed, a complete spare flue and tube system can be kept, so that no time may be lost when it is necessary to clean one of the boilers. This arrangement entirely removes the objection to using a boiler of the tubular type.

Heavy pressed steel facings are riveted to the top of the boiler to receive the cylinders and main bearings of the engine, and, as the boiler is designed specially for this purpose, a very rigid frame for the engine is thus provided.

The engine is of the side-by-side compound type with piston valves, both cylinders being entirely surrounded by a steam jacket directly connected to the boiler, forming an extension of the steam space of the boiler. By this means the advantages of a steam jacket are obtained without any loss due to jacket drains, all water condensed in the jacket being returned direct to the boiler at the temperature of the

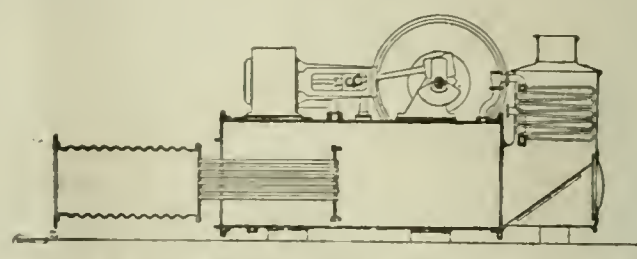


Fig. 2.—Diagram showing Furnace and Tube-system Withdrawn.

steam. Governing is effected by varying the cut-off in the high-pressure cylinder by means of a crankshaft governor, giving very close regulation of speed.

The superheater, consisting of solid-drawn steel tubes arranged in zig-zag coils connected at each end to cast-steel headers, is placed in an extension of the smoke box. The superheat is obtained from the heat in the gases after they have finished with the heating surface of the boiler, and consequently are at a comparatively low temperature. There is, therefore, no possibility of the superheater burning out or the degree of superheat becoming too high at any load.

The smoke box can be arranged either as a downtake to conduct the waste gases to a flue below ground level, and thence to a chimney, or, as shown in Fig. 1, as an uptake to which a steel chimney is bolted.

The condenser is of the jet or surface type, according to the requirements of the local conditions. The air pump is of the Edwards type, and is driven by an eccentric on the crankshaft. To the air pump crosshead is also connected the boiler feed pump.

The engines are provided with two flywheels, either of which is capable of transmitting the whole power of the engine by means of belt, ropes, or, as in the case of the Ilkley generating station described previously, by means of silent chains. Frequently engines are installed direct coupled to generators or main shafts by means of a flexible coupling.

Fig. 1 shows a boiler fitted with the standard grate for reasonably good steam coal. It is possible, however, to arrange the grate to burn any type of fuel available. For instance, many of these engines are at work in wood-working factories, burning nothing but the refuse from wood-working machinery. Others use rice husks, peat, lignite, wood logs, &c.

With this type of steam plant the fuel consumption is so low that fuel costs are obtained which compare favourably with those of suction gas or oil engines. A steam plant has certain characteristics which are not shared by an internal combustion engine plant, or, at any rate, not to the same degree. Amongst these we may mention flexibility, reliability, overload capacity, economy at light loads, and capacity for running for long periods at light or heavy loads. All these are very desirable in public electricity generating stations, for which this type of engine appears to be eminently suited.

The various organs are designed and constructed in accordance with the best practice, and it is only in their arrangement and pro-

portions one to the other that this plant differs from the ordinary steam plant.

Lubrication is carried out so as to require the minimum amount of attention, and the coal consumption is so small that one man can easily look after several units.

A number of electric light stations abroad employing native labour have been equipped with these engines, many of them in out of the way places where facilities for engineering repairs are very limited. This is indicative of the high degree of reliability possessed by this type of steam plant.

Further advantages are that the space occupied is small, the foundations required are inexpensive, and the complete plant can be erected and put to work in very short time.

It is of interest to note that a test on one of these engines rated at 50 B.H.P., of the compound condensing type, on a seven hours' full load run, gave the astonishingly low fuel consumption of 1·21 lb. per brake-horse-power per hour, on coal having a calorific value of 14,000 B.Th.U. per lb. This test was carried out at the makers' works by an independent engineer, and is a remarkable result for an engine of such small output.

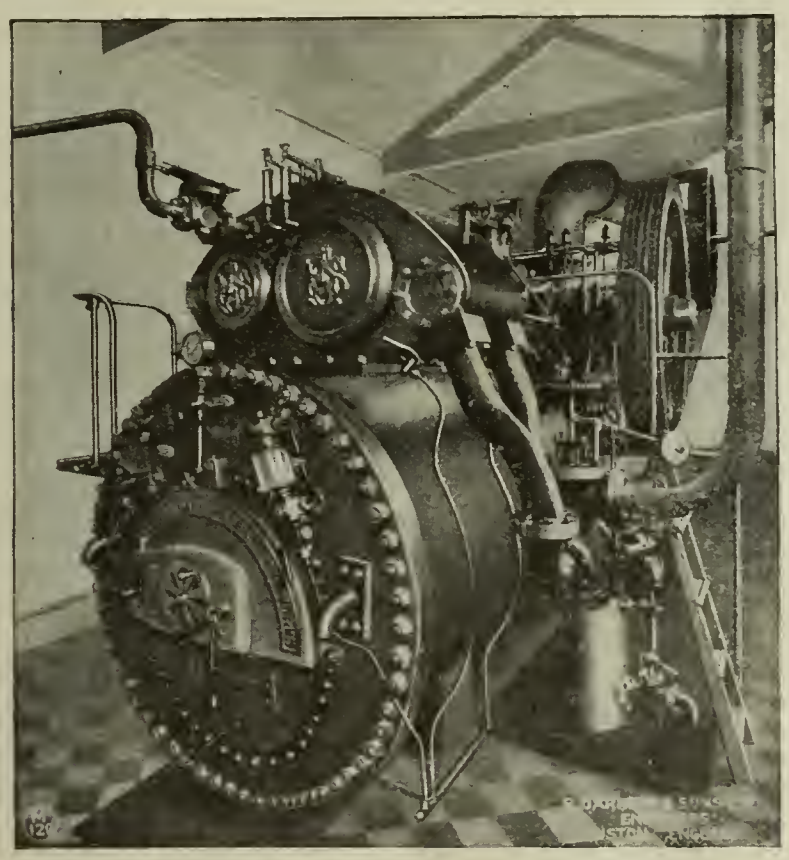


FIG. 3.—VIEW OF A 65 B.H.P. GARRETT ENGINE.

Messrs. Richard Garrett & Sons (Ltd.) have installed a large number of these engines in central power stations, for camp lighting, and also in munition factories during the last year. Fig. 3 shows a typical installation of a "Garrett" engine in a small factory.

THE ELECTRIC LIGHTING OF SMALL TOWNS.*

BY H. N. MUNRO.

Summary.—The requirements of a small town of 5,000 inhabitants are considered. The selection of suitable plant is discussed, and the results of working are estimated.

Introductory.—In presenting this Paper the Author has endeavoured to include in as small a compass as possible information on a branch of electrical engineering which does not receive the attention it merits. The technical aspect of this subject calls for some practical experience, involving matters not usually met with in high-tension power transmissions. The subject is one which should be of interest to both engineer and layman, and for this reason the Author has confined these remarks to its general aspect.

The Author refers particularly to the putting down of plant in places with less than 10,000 inhabitants. The metallic filament lamp has helped in this direction greatly. Obtaining a Provisional Order is referred to as a "lengthy and expensive matter," and the precautions to be taken regarding wayleaves are dealt with.

For a small town of, say, 5,000 inhabitants, a sum in the neighbourhood of £4,500 is necessary to provide plant and mains to supply energy. The following details are average costs which are sufficiently correct for determining what the expenditure on a scheme is likely to be. The capital will be required on account of: (1) Plant and buildings. (2) Mains. (3) Legal and other preliminary expenses.

Plant and Building.—A good average figure for load per 1,000 of population is about 12 kw., and the town under consideration will therefore require plant able to generate some 60 kw. of supply, which, at an average figure of £35 per kilowatt, gives a sum of £2,100 necessary for plant alone. This includes dynamos, engine, battery, booster, switchboard, and all station connections. In addition to this, an outlay will be necessary for the erection of a building where it is not possible to purchase an old building cheaply or to rent an existing structure suitable for the work, and where circumstances may render this undesirable. It is of great importance that all plant should be adequately protected from the effects of weather, malicious interference, &c., so that it is perhaps advisable to allow for a substantial brick and galvanised iron structure. Such a building may cost in the neighbourhood of £400. This, added to the plant, gives a total of £2,500 for plant and building.

Mains.—In such a town as is here discussed there would not be an extensive route of mains, nor would there be any outlying houses, &c., which might necessitate a separate feeder of any great length. A mains length of 4 miles is a fair figure to take. This, carried on wood poles with bare copper conductors at 230 volts on the direct-current two-wire system, would cost approximately £400 per mile, making a total of £1,600 for mains. This would include services, protective apparatus, and house meters.

Legal.—A sum of £50 should be sufficient to cover this item.

Capital.—Summarising the foregoing figures, it will be seen that a sum of £4,150 will be required to erect plant and mains, made up as follows: (1) Plant and building, £2,500. (2) Mains, £1,600. (3) Legal, &c., £50.

It is possible that alterations and extensions may be found necessary during construction, necessitating a still further expenditure. The odd amount of £350 should well cover such a contingency, thus bringing the capital, in round figures, to £4,500. Full powers should be obtained when the company is formed to increase the declared capital, if necessary, by a sum of, say, £1,500 to cover the cost of future extensions, &c.

For the purpose of illustration, it will be assumed that the company has a declared capital of £4,500, consisting of 1,500 £1 Five per cent. debenture or preference shares and 3,000 ordinary shares.

OVERHEAD MAINS.

In the majority of cases the only practical means of distributing electrical energy is by overhead mains, principally on account of the prohibitive cost of underground mains. The system of distribution to be adopted should be at once the cheapest, simplest, most efficient, and safest; and such requirements are met by a direct-current two-wire system at about 230 volts. This has the advantage of being simple to erect and maintain, and the voltage is a convenient one for lamps, motors, &c.

An average number of 20-watt lamps per house or shop being assumed, the estimated possible load can be arrived at. It can be safely assumed also that the plant will never be called upon to supply this. For residential districts 60 per cent. of the estimated possible load may be taken as the maximum load on the feeders, while for shopping areas a percentage of 80 will give the maximum load figure. Having thus obtained the "load" for the whole area, the next step is to divide this up into districts, each served by a feeder. The load on all feeders should be as nearly as possible equal, so that it does not necessarily follow that the districts will be of equal size. Having now split up the area into districts for obtaining the number of feeders, it now remains to decide on the feeder termination point. This should be as near to the power station as possible.

The distributors, on the same principle, should be as few as possible, and each one should take in as many consumers as is practicable. Each feeder and distributor, at its termination, should be adequately fused, the fuse being in a cast-iron box, as this enables faults to be localised.

To the engineer engaged in this work the use of ordnance maps is strongly recommended. On these maps pole positions can be marked, and the feeder and distributor routes shown in different coloured inks.

Sometimes a Post Office telegraph or telephone line is encountered along the mains route. It is best to avoid these if possible, but often no alternative offers itself, and guarding has to be resorted to in order to protect the Post Office lines from the power circuit. For protection of the line itself from the effects of lightning discharges a length of iron wire is run from the top of each pole and coiled round the butt of the pole in the ground, and to this is connected all arms, brackets, &c., and at intervals earth plates, which are buried in such a way as to ensure a good earth. At the station end of each feeder is a lightning arrester. This, in its simplest form, consists of a short air gap

* Abstract of a Paper read before the Junior Institution of Engineers.

between the conductor and the earth, and to protect the dynamos and plant in the station "choking coils," consisting of a number of turns of heavy copper wire, are placed in circuit between the switchboard and the arresters.

Conductors.—Now that aluminium has come into use as a conductor, the question of choice between this metal and copper has to be decided. Copper conductors have been used for nearly all work of this description, although aluminium lines are in operation in many parts of the country on large schemes. This material has up to the present chiefly been used for long-distance high-tension transmission lines, particularly in America and on the Continent. In the small town scheme at Balderton, Yorks, bare stranded aluminium cable is used throughout. The mains are 7/0·148 section, while cable of 7/0·103 section is used for the main streets, and 3/16 S.W.G. for the side streets. In all, about 12,000 yds. of aluminium cable is employed, the necessary joints being of the torsion type, with special twisted joints for tappings. For the same conductivity an aluminium overhead line weighs one-half of a copper line, but the sectional area is greater. This would increase the allowable tensile strength, and a longer span would be possible. Aluminium is also a better resistant to corrosion than copper, especially in places where ozone (as on the coast) and sulphur, &c., are met with. Copper presents less difficulties in the way of jointing, and is considered by some engineers to be easier to handle. It would, however, be good policy to consider both metals when contemplating the erection of an overhead line, as local circumstances may have some bearing on the decision.

Poles.—While most of the overhead work of this nature is carried out with wood poles such as are used by the Post Office for telegraph lines, steel poles are occasionally used, most of these presenting a better appearance. They are, however, about three to five times as costly as wood poles, and are more difficult to erect, although longer spans are made possible by their use. They also cost more for maintenance than wood poles, continual repainting being necessary; and as this costs somewhere about 8s. or 9s. per pole, this item is a fairly heavy one for a small undertaking.

The poles commonly used are of fir, felled in the winter, and trimmed and creosoted with 10 lb. to 12 lb. per cubic ft. by one process, and with 4 lb. to 9 lb. by another called the Rüping process. The poles vary in size, according to the size of the line conductors, position along the route, &c. Light poles used for carrying very small conductors along a straight route are from 22 ft. to 30 ft. long, and about 6 in. diameter at top and 9 in. diameter at the bottom. For medium conductors medium poles are used—about 25 ft. to 35 ft. long, and 8 in. at top and about 10 in. at the butt. Stout poles of about the same length, but an inch or two larger in diameter, are used for heavy conductors and for corner or terminal positions where heavy strain is encountered.

Arms.—As a means of supporting the line either wood or iron arms are used, or malleabe cast-iron brackets may be employed. The first named are usually made of well-seasoned oak thoroughly impregnated with a preservative solution, and are usually 24 in. to 30 in. long, and about 2½ in. by 2½ in. section. These arms are drilled at each end to receive the insulator stalk or spindle, and are bolted through the centre to the pole by means of a ⅝ in. or ½ in. bolt. The iron arms are usually of channel section of about 2½ in. by 2½ in., and about the same length as the wood arms. While costing much more, they are more rigid and last longer than oak arms.

The malleable bracket presents a very neat and unobtrusive appearance. The bracket has a curved back, and is fixed to the pole by means of two or three coach screws, and projects about 4 in. to 5 in. The brackets can be mounted on opposite sides of the pole to give the conductors a spacing in the horizontal plane of about 14 in. to 18 in., or they can be arranged one above the other on either side of the pole to give almost any spacing in the vertical plane.

Insulators and Spindles.—The insulators used are similar to those adopted by the Post Office on telegraph lines. They are made of porcelain, and can be either white, brown, or of a neutral tint. Each insulator is screwed or cemented on to a steel stalk, which is bolted on to the arm or bracket.

Plant.

There is one great difference between the plant for a small town scheme and that for a power supply in a large city. The latter has, in the first place, to be supremely efficient: cost is, to a certain extent, a secondary consideration. The small plants with which this Paper is concerned are dependent, to a great extent, on initial cost. Superlative efficiency is not, however, required, but the plant must be reliable, strong, and simple to work, as skilled drivers and attendants are not readily obtainable in small places.

Gas plants are very popular in places where coal is not so cheap and water is not abundant. The same remarks apply to oil engines; with these latter, however, the cost of the oil is an appreciable item. A brief summary of the claims put forward on behalf of the different classes of plant mentioned may help to render a decision easier.

Steam Plant.—A suitable steam plant for these small schemes may be obtained for about £9 to £10 per brake horse-power (B.H.P.), and, provided that coal is cheap and plenty of water is available, highly economical results are obtainable. The steam engine of modern design is a fairly simple plant to understand, and can be run without the attention of a skilled mechanic. The lubrication and repairs are perhaps not so costly as the gas or oil engine, and at the same time more economy is given on light load and at overload. The stand-by losses are, however, greater. The average space of a steam plant for a small town station is about 7 sq. ft. or 8 sq. ft. of floor space per brake horse-power, about the same as an oil engine of the same rating. The fuel consumption of such engines ranges around 4 lb. to 5½ lb. of coal per unit of electricity generated.

Gas Engines.—The gas engine is either of the "town-gas" or of the "suction-gas" type. In the former, the gas is taken direct from the local gas mains to the engine, and in the latter the gas is generated in a "producer," and led from there to the engine. Town gas is more expensive to use, and is open to obvious disadvantages. The gas engine and producer is a popular plant, and can be run very economically. Stand-by losses are not very great; cheap fuel can be utilised, while an abundant water supply is not necessary as in the case of a steam plant. Running at normal load is more efficient, and thermal efficiency of the gas engine is greater than that of the steam engine.

On the other hand, the cost of repairs and lubrication is higher, and on light loads the gas plant will not run so economically, nor will it respond so readily to overloads as will the steam plant. Producers are now constructed so that very cheap fuel may be utilised, but it must be remembered that stand-by plant is not always available, and therefore cleaning is not so easily accomplished. For this reason it pays to use a fairly good anthracite coal in the form of peas. This ensures a clean gas being generated comparatively free from tar.

The vertical high-speed gas engine has become prominent of late, and has the advantage in saving of space, lower running costs, and a higher speed. It is, however, a more costly plant to install than the horizontal engine, and is not to be recommended for sizes under 80 B.H.P. An efficient horizontal gas plant consumes about 2 lb. to 2¼ lb. of anthracite per unit of electricity generated, and the cost, including producer plant, averages £8 to £9 per brake horse-power.

A point to be remembered is that to run efficiently at full load continuously, the brake horse-power of the engine should be 15 per cent. above the maker's rated load.

Oil Engines.—Oil engines are an extremely satisfactory plant to deal with, provided they are well chosen and attended to carefully. The three types in general use are the crude oil engine, the Diesel, and the Semi-Diesel engines.

The Diesel engine is rather expensive to install, its cost running to about £12 to £14 per brake horse-power. It is very efficient, and only consumes about one-half the quantity of fuel used in the crude-oil engine. Against this, however only refined oil can be used, and the high cost of this offsets any saving made by the lesser quantity of fuel used. The plant has also the disadvantage that it requires very careful attention by an attendant thoroughly conversant with its working. The Semi-Diesel engine, while requiring a little less attention and being less costly—about £9 to £11 per brake horse-power—is subject to the same restrictions as the Diesel engine.

The crude-oil engine is most frequently met with in small power stations for this work. This plant costs in the neighbourhood of £8 per brake horse-power, and consumes about 1½ pints of crude oil or paraffin per unit of electricity generated. The space occupied is about the same as that of a steam plant of the same rating—about 7 sq. ft. per brake horse-power. As regards load, the oil engine is subject to the same limitations as the gas engine, but stand-by losses are much less, while the attention required is about the same.

Generator.—The choice of a generator is principally a matter of taste in design and manufacture. Shunt-wound generators are used, and, when controlled by a shunt regulator, with properly designed steps, these machines give a constant pressure at all loads. In addition to its supplying energy direct to the feeder 'bus bars, it is also used for charging the battery, if one is installed, direct from the dynamo 'bus bars. The nature of the drive—belt or direct—will depend on the circumstances of space, &c., and upon the prime mover. With low-speed engines a belt drive is usual, while direct coupling is resorted to in case of high-speed engines.

The arrangement of battery and switchboard are next dealt with, after which foundations, installation wiring and fittings are discussed, as well as methods of charging and metering.

Financial Results.

In order to give a brief summary of the working costs and revenue, an example is taken of the case of a town already assumed to have a population of 5,000.

The revenue from such a place would be obtainable from two sources—private lighting and public, with perhaps, in addition, a small power demand. This latter, however, will be neglected, as it is found that power load will follow in two or three years, when it can be adequately provided for. The lighting supply is what is first required, and all efforts should be concentrated on this. Of course, the matter assumes a different complexion when the load in the locality is principally a power one. In a town of 5,000 inhabitants a reasonable installation to expect is in the neighbourhood of an equivalent of 1,000 lamps of 20 c.p. each for the first year's working. In a well-managed place this should easily be about doubled during the second year, making an equivalent connection of 1,800 to 2,000 20 c.p. lamps. In a great number of these small places gas or oil is the only illuminant, the gas being sometimes as high as 6s. to 7s. per 1,000 cubic ft. Electrical energy may be supplied up to 8d. per unit, 6d. being a good average to take, which compares favourably with gas at 3s. 6d. per 1,000 cubic ft.—a very low rate for a small town.

As regards public lighting, it is usually possible to enter into a contract with the local authorities for the electric lighting of the whole or part of the main streets, a price per annum being taken as the basis of charge. A reasonable figure for this is about £3 per lamp per annum.

It may be assumed that the whole of the street lighting is undertaken, and that 100 street lamps, each consisting of 3/40-watt lamps, are in service, each lamp burning for an average of 3,000 hours per annum.

While in many cases a dividend is yielded as the result of a first year's running, it would be unfair to base one's estimate of working on this year. In the second year the scheme has had a good chance to develop, and may be reasonably expected to be running normally. In the following details only figures representing the second year's working will be considered—the private lighting of, say, 1,800 20-watt lamps, and the street lighting of 100 3/40-watt lamps.

The revenue from the private lighting is as follows :—

$$\frac{1{,}800 \text{ lamps} \times 20 \text{ watts} \times 800 \text{ hours}}{1{,}000} = 28{,}800 \text{ units,}$$

which, at 6d. per unit, produces a sum of £720. To this must be added meter rent—say, 150 meters at 5s. per annum, producing £37. 10s.

The revenue from street lighting will be 100 lamps at £3 per lamp per annum, producing a sum of £300.

The total revenue from all sources is :—

Private lighting	£720	0	0
Meter rents	37	10	0
Street lighting	300	0	0
	£1,057	10	0

For supplying this load the number of units generated would require to be :—

$$\text{Private lighting, } \frac{1{,}800 \times 20 \times 800}{1{,}000} = 28{,}800 \text{ units.}$$

$$\text{Street lighting, } \frac{100 \times 3 \times 40 \times 3{,}000}{1{,}000} = 36{,}000 \text{ units,}$$

making 64,800 units. To this it would be advisable to add, say, 5 per cent. to cover losses in mains, &c. This would give a total of about 68,040 units generated.

Fuel, oil, waste and stores, engine repairs and maintenance should be in the neighbourhood of ¾d. per unit ; but, in order well to cover all contingencies, 1d. per unit should be allowed. This figure does not include management expenses, &c., which are detailed below separately. The cost per unit may be analysed in the following manner :—

Fuel	0·75d. per unit.
Oil waste and stores	0·10d. ,,
Repairs and maintenance	0·15d. ,,
	1·00d. ,,

The management expenses may be reduced to a cost per unit if desired, or may be taken as a yearly sum as below. When working under statutory powers these figures must be reduced to a cost per unit, and allocated in the accounts as such.

The profit is therefore £250. Of this amount the debenture or preference shares will absorb their dividend of 5 per cent., totalling £75. The balance of £175 remains to satisfy the ordinary shareholders and any reserve or other fund which is contemplated. A dividend of 5 per cent. can be paid on ordinary shares, leaving the sum of £25 to be placed to the reserve or other fund.

Manager and Secretary	£150	per annum.
Driver and Fitter at 35s. per week Lad at 10s. per week	117	,,
Stationery, postage, &c.	10	,,
Insurance and rates	25	,,
Legal and audit	10	,,
Directors' fees	100	,,
Unforeseen	15	,,
Battery maintenance	30	,,
Street-lamp maintenance—300 lamps at 3s. 6d. each per annum	53	,,
General establishment charges	15	,,
Total management costs	£525	per annum.

Summary—

Expenditure—68,040 units at 1d.	£283	10	0
Management expenses	525	0	0
Total expenditure	£808	10	0
Revenue—			
Private lighting—28,800 units at 6d. per unit	£720	0	0
Street lighting—100 lamps at £3 each per annum	300	0	0
150 meter rents at 5s. each per annum	38	0	0
	£1,058	0	0

The foregoing figures are, of course, only approximate, and do not represent the working of any particular undertaking. They are, however, representative of what may be met with in actual practice. No notice has been taken in this Paper of power loads or requirements or of any profit which may accrue from the sale of fittings, lamps, &c., which, after a few years' working, may amount to a substantial sum.

An average dividend of 5 per cent. has been deduced from the statistics of 10 companies with populations varying from 2,500 to 10,500, which shows that not only do such undertakings provide an efficient lighting and power supply, but are paying concerns.

Conclusion.—It will be apparent from the foregoing remarks that an undertaking of this kind needs a great expenditure of personal energy in order to maintain a live interest on the part of consumers and non-consumers alike ; the personal effort is absolutely essential if the scheme is going to be a success.

A canvass of all shops likely to need electric supply might be undertaken with advantage, followed up by a visit to the residential quarter, where, no doubt, many consumers will be obtained as a result of a little tactful dealing.

ASSOCIATION OF CONSULTING ENGINEERS (INCORPORATED).

The annual general meeting of the Association took place on Wednesday, May 31, Mr. G. Midgley Taylor, M.Inst.C.E., presiding.

The Hon. Secretary (Mr. A. H. Dykes, M.Inst.C.E., M.I.E.E.) having read the notice convening the meeting and the minutes of the previous general meeting, and announced that letters of regret at inability to attend had been received from Sir John Snell, Mr. Blizard, Mr. E. L. Mansergh and Mr. Walter Emmott,

The Chairman said it fell to his lot to present the report of the Committee which had been circulated. The year, as the report stated, had been one of depression for the consulting engineering profession, and the Committee, therefore, had had a year of patient watchfulness, and nothing of very startling importance had occurred.

One of the most important things they had done was to decide that the Committee should issue quarterly to every member a statement showing the more important matters that had come before the Committee, and the manner in which they had been dealt with. The Committee had long felt that members must experience some difficulty in keeping in touch with what the Association was doing. The country members must feel this more than those in practice in London, who could at least get into touch with London members of the Committee. In future each quarter the Committee would issue a confidential document showing the more important matters that may have been dealt with.

Practically with a stroke of the pen, the Government, by refusing municipal borrowings, took away a large portion of the consulting engineers' practice, and though no loyal member of the Association wished to grumble, because where the interests of the country were at stake and the best means of carrying on the war had to be considered, their private interests must stand aside ; still, it had had a great effect on the profession generally, and hence the Committee

had not had the amount of work which they might have had if the profession had been in a prosperous condition.

There was a matter which he thought might with advantage receive the further consideration of those in authority.

All engineering work passing at present through the shops of controlled firms was under the Defence of the Realm Regulations placed either in Class A, B or C, A being reserved for munitions of war; B for work in connection with the production of munitions; and C for all other work. It followed from this that plant for export, which would be the means of bringing money into this country, had no preference over orders for material required for ordinary purposes at home, which, very rightly, was given no preference.

It certainly appeared to him that there was need for a third class between B and C into which could be placed all work which, whilst not directly connected with the supply of munitions, was of such a nature that it was in the interests of the Nation that it should receive attention immediately after that work.

Of course, if such a class was instituted, facilities would have to be accorded as regards railway transport and shipment.

While the first consideration was the production of all materials necessary for the successful prosecution of the war, surely the next thing was to carry on our export trade and to attract into the country money from outside sources.

As it was at present, there were a number of foreign contracts in a half-finished state, for the completion of which the payment of large sums of money from foreign sources was held up.

One matter mentioned in the report was the employment of municipal officers outside their own districts. He did not suggest for one moment that these engineers were not perfectly competent to advise on outside engineering questions, but it seemed to him that their time should be fully occupied in carrying out their own special work.

The case that was quoted in extenso was taken up by the Association, although the engineer who brought the facts before them was not a member. They thought it was a case where the Association could reasonably suggest that there could be found amongst consulting engineers one acquainted with the local conditions and circumstances of the water supply referred to.

In the report, the Committee recorded appreciation of his (the Chairman's) services. He wished to thank them for having appointed him to the position, which he left with great reluctance. He had had great support from every member of the Committee, and he thought they parted as friends. He thought it was an excellent idea upon which they started, that they should not have a President, but that they should have a Committee who were all equal, and then the Committee could choose a chairman to preside at the meetings. The Association was not founded for any purpose of self-aggrandisement, but to protect the interests of Consulting Engineers generally. Under the rules a certain section of the Committee retired every year, and this year he went off the Committee. He thanked the members of the Committee and all those who had been on the Committee in the past for the courtesy and kindness they had shown him. He now propose the adoption of the report.

Mr. H. J. Rofe seconded the resolution and it was carried unanimously.

The Hon. Treasurer (Mr. S. R. Lowcock), in moving the adoption of the accounts, which he thought the members would agree were very satisfactory, said each year the Association increased a little the credit balance, and at the end of the year they had rather over £200 in hand. This meant that they had £128 to the good, because the Accountants treated a proportion of the subscriptions as being paid in advance. He suggested that they might buy £100 worth of Exchequer Bonds, or something of that sort.

Mr. F. W. Hodson seconded the motion for the adoption of the accounts and it was carried unanimously.

It was agreed that £100 be invested as suggested.

Mr. M. G. Weekes (Mr. Mansergh's co scrutineer of the ballot for membership of the Committee) announced that the new members of Committee elected were:—

Mr. A. A. Campbell Swinton Mr. Frank Gill Mr. Wm. Vaux Graham Mr. E. P. Hill	London members.
Mr Arthur Hindle Mr. Charles D. Lomax	Country members

The Chairman said the Committee welcomed the return of Mr. Campbell Swinton and Mr. Gill, who had given them material assistance in the past. Mr. Lomax he was also pleased to see re-elected. With regard to the new members, Mr. E. Hill, Mr. Wm. Vaux Graham and Mr. Arthur Hindle, he was sure they would add materially to the ability of the Committee.

Mr. F. W. Hodson proposed and Mr. A. M. Sillar seconded the reappointment of the honorary auditors, Messrs. Cash, Stone & Co., the mover remarking that they were much indebted to the firm for the work they had done for the Association free of charge.

The resolution was adopted.

The Chairman said the next business was the re-election of the honorary solicitor, Mr. F. E. Wright, who had done a great deal of work for them when they were getting the Articles of Association in order.

Mr. E. Brough Taylor proposed and Mr. W. J. E. Binnie seconded that Mr. Wright be re-elected hon. solicitor, and that the thanks of the Association be accorded him for the assistance he had afforded them. This was carried unanimously.

Mr. H. H. Rofe proposed a hearty vote of thanks to Mr. G. Midgley Taylor for his services as Chairman, and said his sound knowledge had been of great value to the Committee and the Association. He (Mr. Rofe) did not know where a chairman was to be found adequately to replace him, and he hoped that before long he would be back again in the position of Chairman.

Mr. A. A. Campbell Swinton said he had great pleasure in seconding the motion. He endorsed all the last speaker had said; the Chairman's services were invaluable.

The motion was carried unanimously.

The Chairman, in acknowledging the vote of thanks, said it had been a great pleasure to him to act as Chairman, but he wished to remind members that when they found a chairman acting with undue energy they must know that there was a gentleman behind him keeping him up to the mark. He referred to the hon. secretary, Mr. Dykes, who would not let the Chairman go to sleep on any subject. The Association owed an immense debt of gratitude to Mr. Dykes, who practically started the Association and *con amore* had run it excellently ever since. Unless the future Chairman was a live man he would not get on well with the hon. secretary. He also wished to express their indebtedness to their hon. treasurer, Mr. S. R. Lowcock.

The meeting then terminated.

The annual report of the Committee deals first with some of the points raised by the chairman at the meeting. In accordance with a resolution passed at the last annual general meeting, a deputation was received by the Board of Trade to point out the serious effect on consulting engineers' practice of the Treasury Minute restricting the borrowing powers of local authorities in connection with new schemes, and to suggest certain ways in which this could be mitigated.

In March of the present year the attention of the Committee was drawn to the fact that the Admiralty had employed as their expert adviser in connection with the water supply of Admiralty works in Yorkshire an official of the Metropolitan Water Board. It was, therefore, decided to send a letter on the subject to the First Lord of the Admiralty, and to enclose copies of this letter to the Prime Minister and to the heads of each of the Government departments. The letter pointed out that it was preferable for Government departments requiring engineering advice to apply to individual consulting engineers or to the engineering department of the Local Government Board, which from the nature of its work is fully acquainted with and well able to select those best fitted to advise on any particular branch of engineering.

While in normal times there are strong objections to local authorities allowing their permanent officials to undertake consulting work outside their own areas, these objections are greatly intensified at the present time, and the Committee, therefore, felt it desirable to address a communication to the Electric Light Committee of Manchester when a paragraph appeared in the technical press stating that their city electrical engineer had been given permission to advise the boroughs of Rochdale, Chesterfield and Stafford with regard to proposed extensions of their electricity undertakings. A copy of the communication was sent to each of the boroughs and also to the Local Government Board. Similar action was taken when the Committee learnt that the city engineer of Liverpool had been permitted by his Committee to advise the borough of Wigan. On the other hand, the Committee wrote to the Corporation of Aberdeen expressing their gratification on seeing that that body had refused permission for their water engineer to advise an outside authority.

The Committee feel that it is only by persistent action of this kind that public authorities can be educated up to the desirability of employing independent experts rather than officials from other towns.

ELECTRIC FURNACE MELTING OF FERRO-ALLOYS.*

BY R. S. WILE.

Summary.—The author describes the working and gives the results of the saving effected by using electric furnaces.

This country (U.S.A.) has never given much attention to the manufacture of special steels, most of these having come from abroad: but now that the supply has stopped more attention is being given it here, but it finds us largely unprepared. Very few mills are so equipped that they could add 3,000 lb. of ferro-chromium to a 50-ton heat of steel.

* Abstract of a Paper read before the American Electrochemical Society.

I will give a brief description of the furnace I have used before going into results, in order that its operation may be clearly understood. The furnace is of the three-phase type, one bottom and two top electrodes. The spacing of the electrodes is such that they compose, as nearly as possible, an equilateral triangle. To start, the two top electrodes are lowered to the floor of the furnace, some granular graphite or plumbago is sprinkled in, and when this glows the slag-making materials are added. These vary with the material, but window glass is used for most purposes, as it is neutral to most of the metals to be melted. As this melts, the electrodes are raised until the proper height is reached, and the alloy is then charged into the furnace and is melted beneath the slag from the heat of the bath, and not from the direct heat, as in the case of the arc furnace. No auxiliary mechanism is used, the current coming direct from the transformer to the furnace, the heat being regulated by the depth of the electrodes in the slag. When the metal is melted it is either poured into an auxiliary ladle and thence into the steel ladle, or the entire electric furnace is picked up by the auxiliary hoist of the crane and the furnace poured as if it were a ladle. The slag stays in the furnace to be ready for the next heat. It retains its molten condition for a considerable length of time, which enables the power to be quickly picked up again. If the furnace is used as a ladle it is set down by the auxiliary before the big ladle is poured, and is either picked up by another crane and put into place or kept where it is until the ladle is poured and then replaced.

It may be questioned by many as to the advantages derived from introducing the alloy in a molten condition, other than those of distribution, &c. I mean the saving of metal effected. The percentage of saving varies with the amount of manganese added to the steel. As is well known, a great part of the manganese added to both open-hearth and particularly Bessemer steel is lost in freeing the steel of oxides, and the amount of manganese oxidised is less with a high carbon than with a low carbon steel—it decreases with the amount added. Thus, if 1 per cent. manganese be added to the bath, 0·60 will be found in the steel (loss 0·40); if 0·60 per cent. be added the steel will retain 0·40 (loss 0·20). The loss in one case is 40 per cent. and the other 30, and there is no assurance that all parts of the steel will show 0·60 per cent. or 0·40, as the case may be.

The following extracts from an article by Felix Schröder, of Livet, France, giving the results of melting over 1,000 tons of ferro-manganese are interesting and give some idea of the cost in an arc furnace. The costs of doing this in the resistance furnace are somewhat less, as later figures will show.

The results obtained with one furnace of the Keller system at the Burbacherhütte, in Saarbrücken, are described. It was adopted there after previous tests at the works of Keller-Leleux Company, in Livet, had shown the possibility of melting 80 per cent. ferro-manganese in the electric furnace without any losses of manganese.

The continuous operation of the converter plant during the six week days required an uninterrupted running of the electric furnace in order to have hot ferro-manganese ready whenever needed. On Sunday the metal usually remained in the furnace and was maintained fluid by the electric current, the consumption of electric current for this purpose being "very low." When no electric power was available the furnace was emptied, and re-started on Sunday night. During the week the furnace was never emptied. Small repairs were done on Sunday, the hot metal meanwhile being poured into a ladle.

The longest period during which the furnace was fused for melting ferro-manganese was three months. During this time the roof of acid brick, which had already been used before during a period of steel refining, was neither repaired nor renewed. The dolomite lining was not renewed, and only a few small repairs were made from time to time. After these three months of ferro-manganese melting the furnace was started to run on steel again, and the lining was still in fair condition. The roof and lining of the furnace when used for melting ferro-manganese, therefore, last at least three months, and the author claims that a lining of magnesite would stand from six to nine months in continuous operation. The inclined lower lining between door and hearth, and also the lining of the hearth itself, were not changed for nine months, requiring only a few repairs.

From the results obtained at the Burbacherhütte the following conclusions may be drawn: (1) The re-melting of ferro-manganese in the furnace occurs without any losses of manganese by volatilisation.

For example, 10 average samples of solid ferro-manganese had the following analysis: 80·29 per cent. Mn.

Thirty-seven successive samples of molten ferro-manganese taken from the electric furnace had the following analysis: 80·22 per cent. Mn. The re-melting, therefore, causes practically no loss of manganese. There is no smoke nuisance at the furnace.

2. The net saving due to the use of molten ferro-manganese amounts to 35 per cent. of the amount of solid ferro-manganese which would be necessary for the production of steel of the same quality and under the same conditions of operation.

In this comparison it is assumed that the same amount of manganese shall be in the finished steel as in usual practice. As a matter of fact, however, it is possible, if the addition of ferro-manganese is made in molten form to reduce slightly the manganese content in the finished steel without affecting the rolling quality.

3. Costs of melting based upon a price of ½d. per kilowatt-hour were approximately £1 per ton of ferro-manganese, including electric power consumption, electrode consumption, wages, linings and repairs. These are not the costs of special experiments, but a monthly average, and therefore include costs of heating and starting the furnace, delays, interruptions due to electrode changes, Sunday work, &c., or, briefly, all the expenses of using the process in a commercial basic-converter plant.

Assuming that the melting cost per ton of ferro-manganese is £1, the price of 1 ton of ferro-manganese £8 only (abroad), and that 5 kg. of ferro-manganese are to be used per ton of steel, we obtain results as follows: In 100,000 tons of steel per annum 500 tons of ferro-manganese are re-melted, the melting costs are £500, and the saving of ferro-manganese 100 tons (if 1 kg. is saved per ton of steel), or £800.

It may be said that, on account of the smaller ferro-manganese consumption, the weight of steel produced is also smaller. The slag is also less. The useful phosphorus in the slag increases, and there is no reduction of phosphorus back into the metal. All these facts have a very small influence on the final results.

Besides this, the use of ferro-manganese offers many other advantages which should not be overlooked. The desired quality of the steel is far more easily obtained than is possible with the use of solid ferro-manganese. All of the molten alloy is completely absorbed by the hot metal. With some experience in estimating the manganese contained in a sample of converter metal taken after the blow, it becomes easy to determine accurately the amount of ferro-manganese to be added. This is of great value for high carbon steels.

Using solid ferro-manganese on cold heats in the converter, one always runs the risk of it not being absorbed in the bath; but, using molten additions, the distribution of molten ferro-manganese in the ladle is uniform, the deoxidation quick and more effective, and rephosphorisation impossible.

There is no reason why this process should not be successfully employed in open-hearth practice.

The average power consumption is nearly 800 kw.-hour per ton; the carbon electrode consumption is never over 12 lb. per ton, and rarely that; the lining cost is between 5d. and 6½d. per ton, depending upon the rapidity of melting. This means that the cost, with power at ½d. per kilowatt-hour and carbon electrodes at 2d. per lb., will be between 18s. and 19s. per ton, exclusive of labour, which is incidental to the plant anyhow. This will add to the cost of the average steel between 1½d. and 5d. per ton—a very small amount, which is easily compensated by the reduced handling.

Most of these remarks have been confined to ferro-manganese, but the saving in ferro-chromium is easily greater, as this alloy is now charged into the steel while in the open hearth, where the loss is greatly increased. Without an electric furnace it is necessary to do this owing to the high melting point of the alloy and the impossibility of its becoming melted by the time of pouring the ladle. It is truly wonderful to contemplate the saving possible by pre-melting this alloy.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Theoretical Elements of Electrical Engineering." By C. P. Steinmetz, A.M. (London: Hill Publishing Co.) Pp. xiii+368. 4th edition. 12s. 6d.

"The Principles of Apprentice Training, with Special Reference to the Engineering Industry." By A. P. M. Fleming, M.I.E.E., and J. G. Pearce, B.Sc. (Eng.). (London: Longmans, Green & Co.) Pp. xiii.+202. 3s. 6d. net.

"The Year Book of Wireless Telegraphy and Telephony." 1916. (London: The Wireless Press) 3s. 6d. net.

"Engineering" Directory, No. 62, April, 1916. (London: "Engineering," Ltd.)

"Leçons sur le Fonctionnement des Groupes Electrogènes en Régime Troublé." By L. Barbillion. (Paris: Gauthier-Villars et Cie.) Pp. 306. 11 fr.

"Engineering as a Career." By P. and A. W. Marshall. (London: Percival Marshall & Co.) Pp. 51. 6d. net.

"Proceedings" of the Institute of Radio Engineers. Edited by A. N. Goldsmith. (New York: The Institute of Radio Engineers.) Pp. 92 $1.10.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed* "*Coutts & Co.*"
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s 6d. nett, by post 13s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.*

"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Down, Wh.Ex. M.I.Mech.E. Price 2s. 6d. nett.

ELECTRIC LIFTS AND HOISTS. By Gilbert Rowe, M.I.E.E., &c. *In preparation.*

THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C.E., M.I.M.E., &c. Price 5s. nett.

INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 8d. nett.

INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.

ELECTRICITY METERS : THEIR CONSTRUCTION AND MANAGEMENT. By C. H. W. Gerhardt. Profusely Illustrated. Price 9s. nett. [Price 10s. 6d.

MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.

SIGNALLING ACROSS SPACE WITHOUT WIRES : THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.

BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By G. M. Baines. Price 7s. 6d. nett.

THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol. I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.

THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. *New Edition.* Bound cloth, 2s. 6d. nett, post free 2s. 9d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone 9s. nett, post free 9s. 4d.

STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett

ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S. Heather, M.I.E.E. 9s. nett.

AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM) : A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d. each, post free. Hanging Cards : 8d. each post free. Pocket Books, complete in envelope, 2s. 6d., post free.

A RELIABLE WORK OF REFERENCE.

THE LOCALIZATION OF FAULTS IN ELECTRIC LIGHT AND POWER MAINS.
By F. C. RAPHAEL.

THIRD EDITION : Price **9s. 6d.** nett, post free.

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

THE SMALL GENERATING STATION.

On the Continent the small generating station has been a recognised feature for many years, and it has flourished largely, for the reason that consumers were willing to be quite modest in their requirements. Not only were overhead wires accepted as a matter of course, but a supply of light in the day-time was looked upon as an unnecessary luxury. This made the beginning of such an undertaking particularly easy, and it was a simple matter to run on more ambitious lines when the power-load showed signs of developing.

During the last few years the small station has shown marked signs of development in this country also. A glance through the Table of Electricity Supply Undertakings, which we issued at the beginning of this year, shows that there are some 85 stations in towns having less than 5,000 inhabitants, and we do not doubt that there are still a certain number which have not yet found their way into our Tables. Since these stations are mostly put down by private capital it is clear that electricity supply in these small towns is commercially feasible.

The ideal arrangement would no doubt be to have all such places linked to the mains of a power company, but there are many districts where such mains are not yet to be found, and where consequently generating plant must be laid down. The character of the plant that should be used is one of considerable importance if satisfactory results are to be obtained. Not only should the plant be economical, but it should, as far as possible, be of a simple character, so that it can be run without very special knowledge and with freedom from breakdown. In a few fortunate cases it may be that water power is available. Generally speaking, however, it is a question between gas, oil and steam. We shall not attempt any comparison between these various types of plant, each of which has certain advantages and must be considered on its merits in each particular case ; but we may here draw the attention of our readers to an article in our present issue by Mr. GEORGE WILKINSON, in which a strong case is made out for the locomobile type of steam engine. There is no doubt that for the average mechanic the steam engine has less mystery about it than the gas engine or the oil engine, and this particular type of steam plant is capable of wonderfully high efficiency even in small sizes.

In quite small stations the items of labour and management are of considerable importance, and for this reason attempts have been made to produce a plant which is entirely automatic. Elsewhere we give an account of a plant of this kind which at present is supplying the village of Thompson, Iowa, in the United States, having the small population of 431 inhabitants. In this case the plant is quite automatic, and consequently one man is able to fill the very varied rôle of plant engineer, meter reader, canvasser, wireman and repair man. In reading the description one feels some fear of the numerous operations that are carried out automatically, but having regard to the fact that automatic telephone exchanges, which, we imagine, present a still more difficult problem, have been working for some years, it may well be that the automatic generating station will come into use. It certainly speaks well for the ingenuity of the designer that one of two oil engines should start up when the load becomes too much for the battery,

that this engine should be automatically cut out if it refuses to fire, that the second engine should then be brought in, that the engine should be shut down when the load becomes smaller, and that the battery should be charged as required without any attention from a superintendent.

Of course, the real difficulty with the small station is to make it financially successful, and details from this point of view are given in a Paper by Mr. H. N. MUNRO, which we reproduce in abstract in another column. Perhaps the weakest point in the scheme given by Mr. MUNRO is the fact that the Manager and Secretary receives a salary of only £150 per annum. On the other hand, directors' fees amount to £100 on a gross revenue of only £1,058. For a salary of £150 we cannot, or, at least, we ought not to, expect very much, whereas a good deal of sound knowledge is necessary for both technical and financial success to be secured. For this reason we think it will be allowed that success is more readily achieved in the direction of the small central station by combining several of them under one highly qualified management, as is, indeed, done to a considerable extent in this country. The cost of local management can then be cut down to a minimum, and, on the other hand, highly qualified men can be employed, as their cost can be distributed over a number of stations.

Lastly, although we cannot hope to have these small towns and villages supplied in many cases from the mains of power companies at the present time, we think that the design of such generating stations should be carried out with a view to their being eventually converted into sub-stations, for assuredly the mains of power companies will extend, and the most efficient results will finally be obtained by having sub-stations rather than generating stations for these small places.

OBITUARY.

SILVANUS PHILLIPS THOMPSON.

It is with deep regret that we record the death of Prof. Silvanus Thompson, at his residence in London, after an illness of only two days. Born at York in 1851, Prof. Thompson has passed away at the age of nearly 65, at a time when all who knew him looked forward to many more years of his activity, for there were no signs of failing health.

Prof. Thompson was educated at the Friends' School at York, subsequently studying at the Founders' College, and in 1869 he took his B.A. at London University. Having, however, a preference for science rather than literature, he studied to qualify himself for the post of science master in his former school at York. This post he abandoned for the sake of further study of chemistry and physics, and pursued courses in these subjects at the Royal School of Mines, supplemented by visits to the University of Heidelberg and other foreign institutions. In 1875 he graduated as Bachelor of Science of the University of London, being bracketed first in Honours; and in 1878 he took the further degree of Doctor of Science, selecting experimental physics as his subject for examination. Meantime he had been acting as Lecturer in Physics in the then newly established University College at Bristol, and had also begun to lecture under the Gilchrist Educational Trust. In 1878 he was appointed Professor of Experimental Physics in Bristol University College. From the time that he entered on his duties at Bristol Prof. Thompson made important contributions to contemporary science. His investigations ranged from the chromatic aberration of the eye to the form of coils in the tangent galvanometer. The curious optical illusion, "strobic circles," was his discovery, as was also the illusion of "the three great statesmen." Prof. Thompson also applied Clerk Maxwell's electromagnetic theory of light to the explanation of the behaviour of tourmaline crystals in their action upon polarised light, in which he brought out a new proof of the fact—then regarded by some physicists as not quite settled—that the displacements in a wave of light are perpendicular to the so-called plane of polarisation. He also discovered the circumstance that the heavy metals, such as uranium and osmium, are better emitters of Röntgen rays than those of lighter atomic weight. But Prof. Thompson is better known by his work on the applications of physics. His studies upon dynamo-electric machines are known to all electricians, and have received the recognition of the Society of Arts by the award of two silver medals. His Cantor Lectures on the latter subject, delivered in the autumn of 1883, at once established his reputation of being among the foremost in the special study of the construction, theory, and mode of working of dynamo-electric machines. The success of Prof. Thompson's "Elementary Lessons in Electricity and Magnetism" has been remarkable, 100,000 copies having been printed in the English language, besides French, German, Italian, Japanese and Polish editions. It has been thrice re-written and enlarged. He also published a biographical notice of Philip Reis—whose invention in the years 1860 to 1863 of the telephone that bears his name had been almost lost sight of in the fame of later



SILVANUS P. THOMPSON.

improvements—a study of Apprenticeship Schools in France, and several pamphlets on Technical and Scientific Education. In 1884 Prof. Thompson published his treatise on "Dynamo-Electric Machinery," which has run to seven editions, and has been translated into French and German. In 1885 Prof. Thompson was elected to fill the Chair of Physics at the City and Guilds Technical College, Finsbury, where at the time of his death he was also Principal. In 1887 he communicated to the Institution of Electrical Engineers a Paper on his Telephonic Investigations, and in 1888 another on the Influence Machine. In 1898 he read a Paper on Rotatory Converters. To the "Proceedings" of the Physical Society he has contributed a number of Papers on Physical Optics and Geometrical Optics, on Harmonic Analysis and other subjects. To the Society of Arts he has given several bibliographical Papers; one on the Development of the Mercurial Air Pump and another on the Mechanism of Arc Lamps. For the same society early in 1890 he delivered a series of Cantor Lectures on the Electromagnet, the outcome of six or seven years of work. His address on Electromagnetic Mechanisms, delivered as President of the Junior Engineering Society, is a continuation

of the same topic. His book, "The Electromagnet," which has been translated into French, German, and Russian, is a greatly enlarged reprint of these lectures. His Cantor Lectures of 1895 were on "The Arc Light," and dealt mainly with the physics and optics of the arc. His Howard lectures on "High-Speed Electric Machinery," in 1905, had special reference to steam turbines and turbo-alternators. He published in 1896 a work on "Polyphase Electric Currents and Motors," which has also been translated into German and French. His Royal Institution lectures on "Light, Visible and Invisible," were published in the autumn of 1897. Prof. Thompson took the leading part in the Gilbert Club, and worked actively on the translation of "De Magnete." In pursuance of these objects, he has repeatedly lectured on the life and work of Dr. Gilbert. In 1898 he contributed to Cassell's series a book entitled "Michael Faraday: His Life and Work."

He was a Fellow of the Royal Society, of the Royal Astronomical Society, a member of the Royal Academy of Sciences at Stockholm, of the Academy of Sciences of Bologna, and of the American Philosophical Society, Honorary LL.D. of Birmingham, Honorary D.Sc. of Bristol, honorary member of the American Institute of Electrical Engineers, a past-president of the Institution of Electrical Engineers, of the Physical Society, of the Institution of Junior Engineers, of the Röntgen Society, of the Optical Society, and of the Illuminating Engineering Society: he was a Senator in the University of London, and took a prominent part in the reorganisation of that body; he was one of the honorary vice-presidents of the Electrical Exhibition at Frankfort in 1891, and one of the British delegates to the Electrical Congress of Chicago in 1893, where he read a Paper on "Ocean Telephony," in which he propounded the idea of accelerating the speed of signalling in cables by the use of inductive shunts at intervals along the cable. He was one of the delegates to the Italian Congress of Electricians in 1899 at Como, when he read a Paper on "Magnetic Images and their Application in the Theory of the Rotatory Field Motor." In January, 1901, he lectured on "Faraday" at the Urania Society in Berlin; and at Oxford, in June, 1901, he delivered the Boyle lecture on "Magnetism in Growth." In 1908 he gave the first Kelvin lecture at the Institution of Electrical Engineers. His "Life of Lord Kelvin" appeared in January, 1910. His most recently published Papers were on "Hysteresis Loops and Lissajous Figures," on "The Physiological Action of an Alternating Magnetic Field," and on the "Magnetism of Permanent Magnets." He gave the Christmas lectures on Sound at the Royal Institution in 1910-11. In 1911 he delivered three lectures on Historic Magnetism, as professor of applied physics in the University of London. He was an honorary vice-president of the Electrotechnical Congress at Turin in 1911; and president of the Optical Conference in London, 1912.

Our portrait, which, unfortunately, is not a recent one, shows Prof. Thompson as he was some ten years ago.

During the last few years Prof. Thompson took an active part in the work of the Illuminating Engineering Society, of which he was the first president, but he also found time to take part in the proceedings of other societies, more particularly the Institution of Electrical Engineers, where his contributions to discussions were always welcome. He was a man of unusually all-round attainments. He was an excellent linguist and was able to address an audience equally in French, German or Italian. He was one of our most fluent speakers. Clearness of thought was not confined to his written Papers, for he was admirably lucid as a lecturer, and his lectures were delivered with a certain charm of manner. Moreover, he was an adept in lecture experiments, which made his lectures particularly attractive. Only a few weeks ago we had the pleasure of attending his discourse on "Electric Discharges" at the Royal Institution, in which, although the experiments were not novel, they were so pleasingly reproduced as to make the discourse well worthy of attendance. But Prof. Thompson's tastes were not limited to mathematics, optics or electrotechnics. He was one of the few scientific writers who might be said to possess literary style, a gift which stood him in good stead in writing the lives of Faraday and Kelvin. Historical matters had a keen attraction for him, as shown not merely by these biographies, but in his accurate treatment of the historical introductions to the various works which he published. The same taste was shown in his unique collection of old books on magnetic subjects. He was also no mean artist, his water-colour sketches having been hung at the Royal Academy.

The death of Prof. Thompson comes as a shock to all who knew him, and his loss will be felt keenly in both science and industry. The initials "S.P.T." were so familiar to us all, and his genial kindness was so welcome at any gathering. He was always ready to give a helping hand, and no one who knew him could fail to admire his generous appreciation of the work of other people. His death will be felt as a keen personal loss by those who knew him, and as a loss not much less than personal by many who had not that privilege.

The funeral takes place to-day, and his friends are invited to a service which will be held (after the cremation) at the Friends' Meeting House, 52, St. Martin's-lane, at 3 p.m.

NOTES ON DESIGN OF ELECTROMAGNETIC MACHINES.

I. CONTINUOUS-CURRENT MACHINES.

BY STANLEY PARKER SMITH, D.Sc.

(*Continued from page* 323.)

Summary.—In the first part of the article the author deals with the principles underlying the design of continuous-current machines, and in the second part he applies these principles to the design of a 350 kw., 500-volt generator running at 200 revs. per min.

Number of Windings on an Armature.—According to the relation between the commutator pitch y_c and the number of commutator segments C it is possible to have one or more independent windings on an armature. This is made clear from the following simple consideration. In connecting coil a to coil b we pass y_c segments; hence, in connecting up all C coils, we pass $y_c C$ segments. In other words, in connecting up the whole winding we go round the commutator y_c times. Similarly, to connect up $1/h$th of the winding or C/h coils we go round the commutator y_c/h times. To do this, of course, it must be possible to divide the C coils into h equal parts—*i.e.*, C/h must be a whole number.

Suppose, now, that y_c is also exactly divisible by h, then y_c/h represents a complete number of tours round the commutator—that is to say, after joining up C/h coils we come back to the starting point, and the winding therefore closes. So on for each of the h sets of coils. Hence it follows that if C and y_c have a common factor, h, there will be h separate windings on the armature. To ensure having only one winding on the armature, therefore, C and y_c must be so chosen that their H.C.F. is unity.

In all, the C coils produce a pairs of circuits, so that in each of the h windings the number of pairs of circuits will be a/h. Thus, a/h is a whole number: *i.e.*, $a = h$, or is a multiple of h.

Whether the h independent windings are identical or not depends on whether the symmetry conditions just developed (C/a, S/a and p/a = integers) are satisfied.

The question arises whether it is better to have one or more than one winding on an armature. In reply it can be said that experience seems to show that it is better to have a single winding than a number of separate windings. It is not easy to explain satisfactorily why this should be so, especially when the several windings are connected by means of equalisers. Nevertheless, it is permissible to doubt whether the distribution of the current in the several windings is as uniform, even when equalisers are used, as it is in a single winding. By choosing C and y_c suitably, it is nearly always possible to obtain a single winding, and experience shows it is best to adhere to this rule.

Lap and Wave Windings.—We must now see how to join up C coils displaced from one another by the angle γ, such that

$\Sigma_1^c\psi = a \cdot 2\pi$ to form one or more closed windings. In cases where $a>2$, it is possible to increase the number of slots $a/2$ times without affecting the connections to the commutator in any way, so that to find the commutator pitch y_c it is only needful to consider a winding with two coil-sides per slot and the angle ψ constant. In this case, $\Sigma_1^c\psi = C\psi = a \cdot 2\pi$, and the relation between the number of pairs of circuits and the number of pairs of poles is given by the simple formula (equation 10) $a/p = \psi/\gamma$, where ψ is the phase displacement between two successive coils y_c segments apart, and γ is the angular pitch of the commutator segments, or of the slots when $u=2$.

Now, the angle on the commutator between the start of one coil and the start of the next is obviously $y_c\gamma$. Let $y_c\gamma = a$; then we can re-write equation 10 as follows :—

$$y_c = \frac{a}{p}\frac{a}{\psi} \quad \ldots\ldots\ldots \quad (11)$$

This is merely the condition for obtaining a pairs of parallel circuits in a closed winding; but they will only be identical if the conditions of symmetry are fulfilled.

(i.) *Lap Windings.* To produce a lap winding, the finish of one coil is joined to the start of another—usually the next—under the same pole-pair, so that the angle between two successive coils in the winding is equal to the displacement between these coils in the field (*see* Fig. 4). Hence, in a lap winding, $a=\psi$. Substituting this in equation 11, we have

$$y_c = \frac{a}{p}\frac{a}{\psi} = \frac{a}{p},$$

Hence $a = y_c \cdot p$.

Now we can make $y_c = 1, 2, 3,$ &c.,

whence $a = p, 2p, 3p,$ &c.

Thus, in a closed lap winding the number of parallel circuits can only be a multiple of the number of poles.

We now apply the rules of symmetry, which seriously reduce the number of practicable lap windings. The condition that p/a must be a whole number is only satisfied when $y_c = a/p = 1$; consequently the only lap winding that can be symmetrical is where $a=p$; *i.e.*, where the number of circuits is equal to the number of poles. This is an unfortunate restriction, for large current at low pressures could be easiest obtained from windings with $a>p$. It is true that such machines have been built, but in many cases have had to be altered, due to the trouble caused by connecting unlike circuits in parallel. Thus, the only practicable lap winding is the one where the number of circuits is equal to the number of poles. The $a=p$ pairs of circuits, however, are only identical when $S/a = S/p$ is a whole number. This condition is usually satisfied in large machines and rotary converters, but it is common practice with some firms to fit equalising rings so long as $C/a = C/p$ is a whole number. With standard four-pole motors it is often irksome to make C/p and S/p whole numbers, because C and S are usually made odd to make the armature suitable for a two-circuit wave winding. Owing to the comparatively high resistance of the armature winding in small machines, however, the equalising currents may not be harmful, and some makers go so far as to fit equalising rings or phase tappings to such windings.

Since $y_c=1$ when $a=p$, it follows that in lap windings the H.C.F. of C and y_c will always be unity, so that there is only a single winding on lap-wound armatures.

(ii.) *Wave Windings.*—Here the finish of one coil is joined to the start of another coil under the next pole-pair, the angle between them being $a = 2\pi \pm \psi$ (*see* Fig. 5).

Substituting in equation 11, we get for the connecting rule

$$y_c = \frac{a}{p}\frac{a}{\psi} = \frac{a}{p}\left(\frac{2\pi \pm \psi}{\psi}\right)$$

$$= \frac{2\pi}{\gamma} \pm \frac{a}{p}, \qquad \text{since } \frac{a}{p} = \frac{\psi}{\gamma}$$

$$= \frac{C}{p} \pm \frac{a}{p}, \qquad \text{since } C\gamma = 2p\pi$$

$$= \frac{C \pm a}{p}$$

or $a = \pm(py_c - C)$.

Thus, in a wave winding, $a \gtrless p$, but the value of C is restricted by the choice of a and p.

When $a=1$, $y_c = (C \pm 1)/p$, and we have the common two-circuit wave winding. In this case the symmetry conditions are satisfied when $S = 2C/u$. The resultant of the vector diagram then consists of a single polygon and the winding is a symmetrical polyphase system. Further, it is only possible to make a single winding of the C coils when $a=1$.

Nevertheless, it is not always possible to obtain a symmetrical N-phase pressure from a two-circuit wave winding with the common values of N—namely, 3, 4 and 6—due to the fact that it is not always possible to make S/N a whole number. This may not be serious in some cases—*e.g.*, when a wave winding is used on the rotor of an induction motor, or when tappings are needed for a static balancer; but dissymmetry in the angular phase pitch is usually inadmissible in rotary converters or alternators.

(iii.) *Wave Windings with More than Two Circuits (Series-parallel Windings).*—The closing rule, $y_c = (C \pm a)/p$, shows that by choosing C suitably it is possible to obtain a closed winding with any desired number of circuits with a given number of poles. Such a range of possibilities would be invaluable to the designer if he could avail himself of them; but, unfortunately, the symmetry conditions impose restrictions on wave windings only less stringent than those on lap windings, where it was seen that, in order to obtain identical parallel circuits, the number of circuits must be made equal to the number of poles, thus leaving us with only one practicable lap winding.

With wave windings the symmetry conditions are, fortunately, not quite so restrictive, in consequence of which the designer obtains one or two very useful windings which often enable him to improve his design and to reduce the cost of his machine very materially. The necessity of making p/a a whole number at once rules out all windings with more circuits than poles, thus leaving us with windings with $a \leqslant p$. The case of the wave winding with $a=p$, however, can be rejected at once, since the lap winding is used almost invariably for this case. It is true that certain single-phase commutator motors have been found to work well with wave windings where $a=p$, but in general only lap windings are used here. This means that we have only to consider wave windings where $a<p$. It will be simplest to take each number of poles separately, and see what symmetrical windings are possible.

For a two-pole machine either a two-circuit lap or wave winding can be used.

For a four-pole machine we shall use either a two-circuit wave or a four-circuit lap winding.

For a six-pole machine we are limited to the two-circuit wave and six-circuit lap windings, since the four-circuit wave winding ($a=2$, $p=3$) is unsymmetrical. This is probably the most objectionable restriction of all, because so many cases arise where the designer wants four circuits in a six-pole machine.

For an eight-pole machine we can have wave windings with two or four circuits and an eight-circuit lap winding. This is the first instance of a symmetrical wave winding with $a>1<p$, and can be used with great advantage in many cases, as will be seen in the design to follow. (*See also* the cases referred to by Miles Walker in his book on "Specification and Design of Dynamo-Electric Machinery.")

For a 10-pole machine there are again only two symmetrical windings—the two-circuit wave and 10-circuit lap windings.

For a 12-pole machine the possibilities are much greater, for we can have wave windings with two, four or six circuits and a lap winding with 12 circuits.

The list can be continued further, if desired, but it is plainly seen that certain very important advantages are open to the designer by making use of wave windings with more than two circuits in 8, 12 and 16-pole machines.

It is necessary, however, to observe the other conditions of symmetry, namely, S/a must be a whole number and idle coils must be avoided. This often means that some alteration to existing standards is needed, but it will generally be found that

the extra cost of tools, &c., is slight compared with the saving which results through using these windings, which is all that one has a right to expect from a commercial standpoint. In every case, however, the designer should ensure that all the conditions of symmetry are strictly observed.

The advocacy of wave windings with more than two circuits (or series-parallel windings, as they are often called) will doubtless meet with serious objection from many manufacturers, especially from those who can only look back on the bitter experience of bygone days. It must be remembered, however, that in the early days when these windings were used too little attention was paid to symmetry, in consequence of which it was not possible to prevent sparking and excessive heating. As a result, many firms to this day refuse to build commutator machines with any other windings than the lap winding with as many circuits as there are poles, or the wave winding with two circuits.

A great improvement in the working of wave windings with more than two circuits resulted from the use of equalising rings. Arnold, one of the foremost pioneers on armature windings, obtained a British patent for these in 1901 (British Patent, 1901, No. 11,857), but did not restrict their application to symmetrical windings. It is now general practice to employ equalisers on wave windings with more than two circuits, just as they are generally used with lap windings, but the author is not able to say why they are any more necessary with symmetrical wave windings than with lap windings, and has designed machines that have worked splendidly without them. Most of the machines having wave windings with more than two circuits have been built on the Continent, and in order to find out whether experience has proved that the conditions of symmetry ought to be adhered to and whether equalising rings (equi-potential connectors) ought to be used, the author circulated the following eight questions some time ago among the designers of six large Continental firms. All six firms replied, and only one stated that, in consequence of bitter experience, which led to the re-construction of several large machines, wave windings with more than two circuits were avoided on principle.

Question 1.—Should wave windings with more than two circuits be avoided as much as possible ?

Three firms find no reason whatever to avoid these windings and employ them whenever a saving can be obtained by their use.

Question 2.—Should wave windings with more than two circuits always be symmetrical ; *i.e.*, should p/a and S/a be whole numbers and idle coils avoided ?

Four firms insist on the windings being quite symmetrical, whilst a fifth says it is chiefly needful to make S/a a whole number and avoid idle coils.

Question 3.—Is it permissible to use a four-circuit winding on a six-pole machine ? (This is unsymmetrical, since p/a is a fraction.)

Three firms avoid building machines with p/a fractional entirely. A fourth knows of machines with $a=2$ and $p=3$ working satisfactorily, whilst a fifth makes a practice of building such machines where really desirable, but makes the dissymmetry a minimum, and obtains good results.

Question 4.—Is it better to use a lap or a wave winding when the number of circuits is equal to the number of poles ?

All prefer the lap winding, but some point out that the mechanical dissymmetry is less in the wave winding, and so find it better for single-phase commutator motors.

Question 5.—Is it better to have a single winding or a number of independent windings. (To obtain a single winding, the highest common factor of the commutator pitch and the number of commutator segments must be unity.)

Three firms use only single windings, whilst two firms find it is immaterial whether one or two windings are used in the case of a four-circuit winding.

Question 6.—Are equi-potential (equalising) connectors necessary in wave windings with more than two circuits ?

Three firms find them an absolute necessity, a fourth uses them in large machines, and a fifth finds them desirable.

Question 7.—Does the use of commutating poles render equi-potential connectors unnecessary with wave windings, having more than two circuits ?

Three firms find that equi-potential connectors are necessary—one, more than ever so—when interpoles are used.

Question 8.—Is any particular brush-width advisable or necessary with wave windings having more than two circuits ?

All the replies show that the practice here is not materially different from that with ordinary lap and wave windings, where the number of brush spindles is the same as the number of poles.

The replies to the above questions are very instructive, and may be summarised by saying that experience has proved that there is no objection whatever to the use of wave windings with more than two circuits, provided they are made symmetrical and equalisers are used.

In the above method of treating commutator windings it will be observed that practical considerations alone have been kept in view, and all purely academic considerations, such as a tabulation of all the possible closed windings, have been rigorously pruned by the application of the stern conditions of symmetry. Thus instead of innumerable x-plex, y-re-entrant possibilities, we have merely the lap winding with as many circuits as there are poles, the two-circuit wave winding and the symmetrical wave windings with more than two circuits. This arises from the fact that the ordinary rules for connecting up coils to form a closed lap or wave winding derived from equation (11) are simply general arithmetic relations, having no direct bearing whatever to the working of the machine. It is only when the restrictions imposed by the conditions of symmetry are observed, that the several pairs of parallel circuits are identical. In a similar way, it is only when each of the identical polyphase systems can be divided into N equal parts that a symmetrical N-phase pressure can be tapped off the winding. It is hoped that the emphasis which has been laid on the conditions of symmetry in closed windings will show the great importance of this matter for both lap and wave-wound armatures ; also that some of the present nervousness against wave windings with more than two circuits will be dispelled.

(To be continued.)

INTERESTING MAINS LAYING OPERATION AT GLASGOW.

The Glasgow Corporation electricity department mains staff carried out an interesting operation on Sunday, June 4th in the minimum of time. Two 20,000-volt 0·2 sq. in. split conductor cables were laid



Fig. 1.—Ready to Start from South Side.

across the bed of the River Clyde at Whiteinch. Two telephone cables, each 12 pair 1·18 S.W.G. paper-insulated and lead covered were laid at the same time. The overall diameter of the cable was 3⅞ in. and each drum containing 200 yds. weighed 7 tons. The

cables were three-core, paper-insulated, lead covered, with double wire armouring consisting of two layers of steel wire each 0·128 in. diameter.

A channel 12 ft. broad and 5 ft. deep had been dredged, and the cables in position would be 30 ft. below low water level. Suitable trenches were opened on the banks of the river on either side. Three barges or punts each 30 ft. by 15 ft. were used. The cable drums



Fig. 2.—In Mid Stream.



Fig. 3.—Arrival at North Side.

were loaded on these barges by a steam crane and the barges were towed down to the place where the cables were to be laid and moored at one side. The cables were then paid out over timber sheaves fixed to the ends of the barges away from the bank, brought in under the barges, and up into the trench as far as necessary. Suitable rope stoppers were in position at these sheaves which were to be used should the cables tend to run off too quickly. The stoppers were never required.

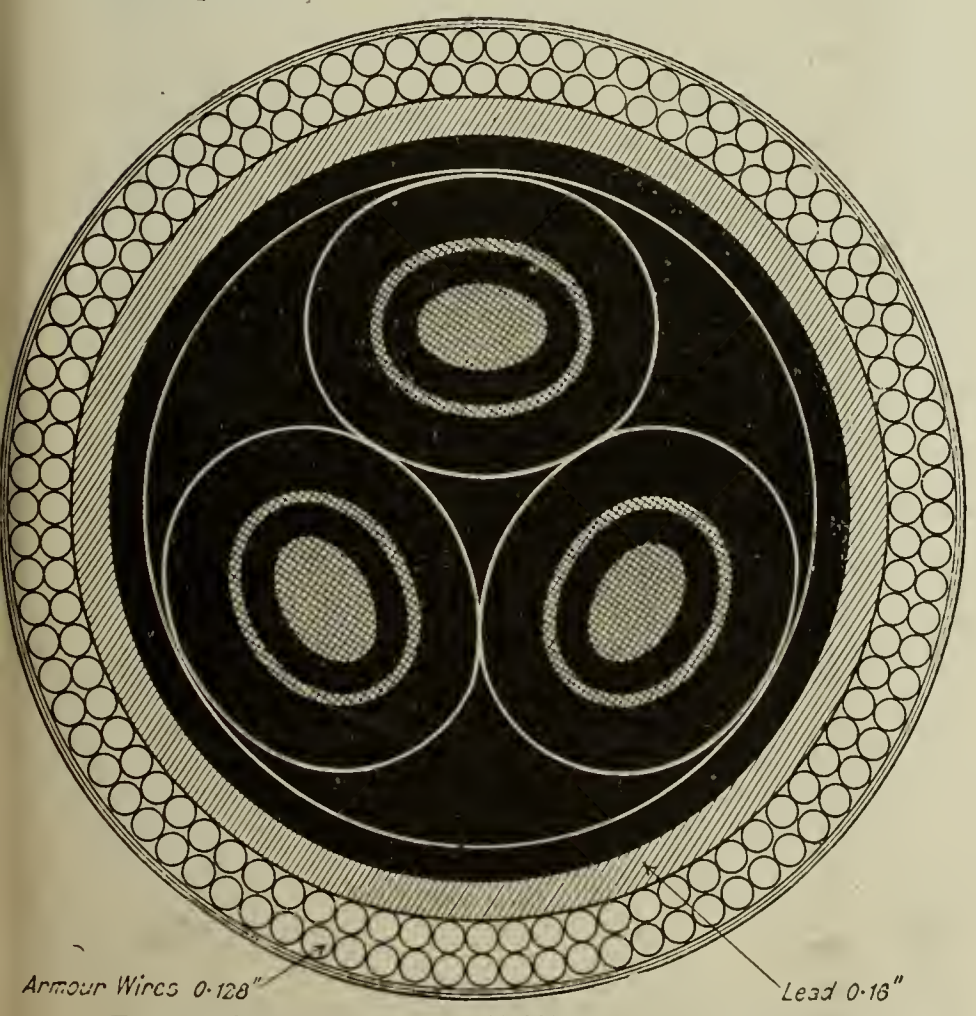


Fig. 4.—Cross-section of 20,000-volt Three-core Split Conductor Lead-sheathed Double-wire Armoured Cable, 0·2 sq. in. (Full Size.)

The barges were towed by a steam winch slowly across the river, the cable being paid out at a suitable speed. Anchors had been laid out at some distance from the barges and during the crossing the ropes attached to the anchors were used to keep the barges in the proper position over the trench. When the farther bank was reached the remainder of the cable was unwound from the drums and pulled up the bank and into the trench.

The whole operation took about 10 hours, the greater part of the time being occupied with the work on the banks. The actual time taken to lay the cable in the river bed was 45 minutes, and during that time the river was blocked at this point. The crossing was effected at dead low water. Some little delay was caused at the start by the winch used for pulling the cable up the bank not being quite heavy enough for the work, but the whole of the preparatory work was completed in time for the crossing to be carried out at low water. The accompanying illustrations (Figs. 1-3) show the operation in progress, and Fig. 4 shows the three-core cable in cross section.

ARSEM VACUUM FURNACE.

The furnace described below was used by Prof. T. D. Yensen in his researches on vacuum irons, full accounts of which have been given from time to time in these columns.* The furnace was modelled after the vacuum furnace developed by Mr. W. C. Arsem, who presented a Paper descriptive of this type of furnace before the American Electrochemical Society in 1906. The furnace constructed by Prof. Yensen is shown in the accompanying illustration. The vacuum tank was made from a 12 in. (30 cm.) wrought-iron pipe, with a $\frac{1}{4}$ in. (0·64 cm.) steel plate welded on at one end. A steel ring was shrunk around the top, and the joint made airtight by means of a groove filled with molten lead. The cover was made from a $\frac{3}{4}$ in. (1·9 cm.) steel plate and the dome from a 4 in. (10 cm.) wrought-iron pipe provided with a flange at each end. A mica window was placed in the top of the dome for the inspection of the charge during operation. As the furnace is submerged in water, all the joints were made airtight by means of rubber gaskets.

The heating element was cut from a solid $4\frac{3}{4}$ in. (12 cm.) carbon electrode by first cutting a helical groove of the desired pitch and depth and then cutting out the core by means of a pipe provided with teeth on one end. Care had to be exercised to obtain a perfectly uniform cross-section. The radiation screen surrounding the helix was made from an 8 in. (20 cm.) carbon electrode, and filled with crushed graphite. Both the helix and the screen are supported at the lower end by a carbon base which in turn is supported by a water-cooled copper tubing. This tubing is connected to the base by means of a cast-iron clamp, and it serves both as support for the heating part of the furnace and as a conductor for the current. It is clamped in place by two airtight insulating bushings in the cover. The upper end of the helix is similarly supported by another water-cooled copper tubing connected to the helix through a cast-iron clamp. An ordinary mercury manometer was used to measure the pressure, as it was deemed unnecessary to reduce the pressure below 0·5 cm.

At first the furnace was submerged in ordinary water, but as continuous-current was used it was found that under these conditions the bushings were very badly attacked by electrolysis. Consequently, the furnace was placed in a tank filled with distilled water, and this was kept cool by circulating water in the outside tank, and also by means of cooling coils placed on the top of the cover. With this arrangement the temperature of the distilled water seldom rose above 60°C.

The furnace was exhausted down to a pressure of 2 cm. to 3 cm. by

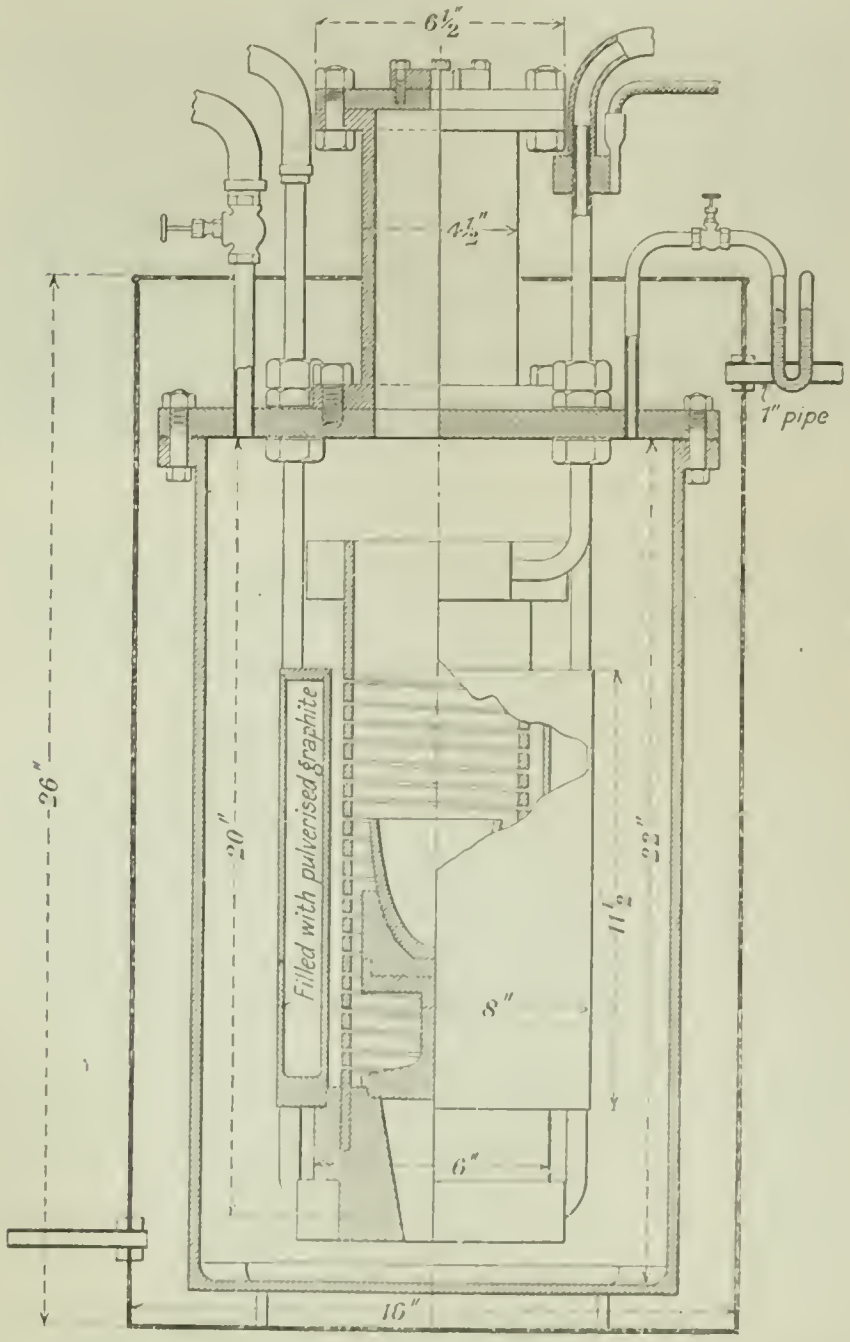
* The Electrician, Vol. LXXV., p. 119, 1915.

means of a water aspirator. The Geryck pump was then started, and this reduced the pressure to 0·5 cm. or below.

With an input of 15 kw. the temperature in the crucible was raised to 1,600°C. in half an hour, and could be maintained at that temperature with 12 kw. No instrument was used for measuring the temperature, as the melting of the iron could be observed through the window in the top of the dome.

The life of the helix heating element has been about 50 melts, each melt lasting approximately one hour with a temperature of 1,500°C. to 1,600°C. in the crucible. The temperature of the helix itself was, of course, much higher, possibly 2,000°C.

It was found that the helix gradually sagged and after a certain length of time the lower turns came close enough together to allow an



arc to form. This arc increased the current so as to raise the drop between the next two turns sufficiently to cause an arc, and so on. As after this length of time the helix had become partly disintegrated, any attempt to increase the distance between the turns resulted in a broken helix, and a new one had to be substituted. For this reason a different shaped heating element might be preferable, although the helix can be made quite cheaply for this size furnace. For larger sizes the helix form would probably be out of the question.

Electrostriction in Condensers.—A recent issue of the "Physical Review" includes a "Note on the End Effect in the Electrostriction of Cylindrical Condensers," by Mr. E. C. Kemble. A longitudinal traction is exerted by the electric field in the neighbourhood of the ends of the coatings of a cylindrical condenser. If a is the internal radius, d the thickness of cylinder, H the average electric force, δ_2 a constant depending on the change of dielectric inductivity by strain, then $P = \frac{1}{4}ad\delta H^2$, and there is a force $P_1 = \frac{1}{4}adKH^2$ (where K is the inductivity of the dielectric) on the edge of the coating. By using these formulæ discrepancies that have been previously noticed disappear.

LEGAL INTELLIGENCE.

Leiston Gas Co. (Ltd.) v. Leiston-cum-Sizewell Urban Council.

On Friday the Court of Appeal (the Lord Chief Justice, Lord Justice Warrington and Mr. Justice Scrutton) heard this appeal by defendants from a decision of Mr. Justice Low. Plaintiffs claimed £157. 15s. 9d. for services rendered to the defendants under a lighting contract of June 2, 1911. Under the contract plaintiffs were to provide gas standards with lanterns and burners complete at their own expense; to supply gas to the standards; and to keep the whole installation in repair; and defendants undertook to pay for gas at a certain rate per lamp per annum for five years from August, 1911. Plaintiffs supplied gas until the end of 1914. Subsequently the military authorities, acting under the Defence of the Realm Acts, 1914 and 1915, and the regulations thereunder, forbade the lighting of any lamps whatever within defendants' area, and the lamps had accordingly remained unlighted since Jan. 26, 1915. The company sought to recover the price of gas for the period during which the order of the military authorities was in operation. Mr. Justice Low held that the exercise by the authorities of their powers under the defence of the Realm Acts did not render the contract either unlawful or impossible of performance, and he gave judgment for plaintiffs for the amount claimed, with costs.

Mr. Hawke, K.C., and Mr. A. H. Poyser appeared for appellants; and Mr. J. B. Matthews, K.C., and Mr. Rayner Goddard for respondents.

Mr. Hawke submitted that the contract was one for public lighting, which plaintiffs had not provided, and they could not, therefore, recover on their contract. By the action of the military authorities illumination had become illegal, and the supervening illegality suspended the contract.

Mr. Matthews, K.C., submitted that the doctrine of frustration of commercial venture did not apply in this case. That doctrine only applied to cases of commercial ventures strictly so called, and they formed a class by themselves. The restriction of the Army authorities might have been removed at any time. Could it be said that respondents were not bound to keep their plant in readiness for that event? Plaintiffs were always ready and willing to do all that was necessary under the contract, except in so far as they were prevented by the Executive.

In giving judgment, the Lord Chief Justice said there was no doubt that when a party contracted to perform an act, lawful at the time of the making of the contract, which thereafter became impossible of performance by reason of a change in the law, he was discharged from the obligation under the contract. Again, the law was well settled that where the performance of the contract became impossible by the cessation of the existence of the thing which was the subject-matter of the contract, the contract was to be construed as "subject to an implied condition that the parties shall be excused in case, before breach, performance becomes impossible from the perishing of the thing without default of the contractor." This principle was not confined to the cessation of the existence of the subject-matter of the contract, but applied equally to the cases where the event which rendered the contract incapable of performance was the cessation or non-existence of an express condition or state of things going to the root of the contract. The decision in the present case must depend on the true effect of the contract. Under the agreement plaintiffs undertook to perform various services for defendants in return for an agreed rate of payment to be made quarterly by defendants for every quarter in the five years' duration of the contract. Plaintiffs had performed the various services under the contract for nearly three years and a half before the event under discussion happened. The column lamps remained their property under the contract, and defendants had had the advantage of them throughout the three years and a half. They had used them even in the three quarters of 1915, not, indeed, to the full extent, as the lamps were not lighted except for the 26 days of the first quarter, but to the extent that they remained there connected with the main and would be lighted immediately the prohibition by the military authority was relaxed or withdrawn. On those facts he could not hold that the performance of the contract had become unlawful, or that the venture was frustrated by the act of the Executive in forbidding the lighting of the lamps. Part of the performance of the contract had become unlawful, but another part of the contract, which could not be regarded as a trivial part, was lawful and could be performed. In those circumstances defendants were not justified in treating the contract as at an end, or in refusing to make the payments as agreed by them. It was not intended that the supply of gas should be a condition precedent to the right to recover the quarterly payments. Under the agreement there was an inclusive payment for all the services and the consideration could not be apportioned. He held that the agreement by plaintiffs to supply the gas was to be regarded as an independent agreement and not as a condition precedent. Defendants had received part of the consideration, and if plaintiffs had been in default defendants would have recovered compensation for the failure to supply the gas and light the lamps. Plaintiffs were not in default, and, therefore, defendants could not recover on a cross claim for damages, but as the supply of gas by plaintiffs was not a condition precedent to the right to recover, defendants could not justify their refusal to make the quarterly payments under the contract. He came to the conclusion that the appeal should be dismissed.

Lord Justice Warrington and Mr. Justice Scrutton delivered written judgments to the same effect, and the appeal was, therefore, dismissed with costs.

Re Browett, Lindley & Co. (Ltd.)—On June 6, Mr. Justice Sargant confirmed the reduction of the capital of this company by £12,500, being capital lost or unrepresented by available assets.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	365	Ediswan Fans. Illustrated	73
Imports and Exports of Electrical Manufactures	366	Ajax Gear and Fluvent Fuses. Illustrated	74
Business Notices	366	"L.P.S." Accessories. Illus.	74
Liquidations, Bankruptcies, &c.	366	B.T.-H. Isolating Switches. Illustrated	76
Electricity Supply	366		
Lighting and Power Notes	367	Tenders Invited	370
Traction Notes	367	Tenders Received & Accepted	370
Empire Notes	368	Municipal Accounts	371
Foreign Notes	368	Companies' Meetings and Reports	372
Miscellaneous Notes	369	New Companies	373
The Round Table	71	City Notes	373
Artistic Theatre Lighting. Illustrated	72	Electrical Companies' Share List	374

COMMERCIAL TOPICS.

Zinc Smelting. On Friday last the Prime Minister of the Commonwealth of Australia (Mr. Hughes) introduced a deputation of zinc-producers in Australia to the Secretary for the Colonies (Mr. Bonar Law) to lay definite proposals involving a wide avenue of employment before the Government.

Mr. Hughes explained that the members of the deputation owned and controlled all zinc ores produced in Australia. The proposal he desired to lay before the Minister was imperial in its scope and objects, and at the same time rested on sound business lines. It covered a proposal for the erection of smelting works in Great Britain, and involved the exclusion of German spelter after the war. The scheme as ready for adoption provided for preferential treatment of the Empire's products, but also allotted a fair share of raw materials to France and Belgium. Though details of the scheme are lacking, it is stated that the proposals submitted are on the same general lines as those submitted to the Government a year ago. They cover a proposal to erect smelting works in this country to treat about 60 per cent. of the Australian output. British capitalists are willing to put up the works if the Government will protect the new industry from German dumping after the war. Up to the present the producers have not been able to obtain any guarantees from the Government on this subject. The producers are not wedded to any particular scheme, and they would be prepared, if the Government desired to avoid controversial fiscal questions in war-time, to entertain a proposal that the State shall erect works of its own and make a contract for the supply of concentrates with the producers over a period of years.

* * * *

Chambers of Commerce and Engineering. At the recent meeting of the Liverpool Chamber of Commerce it was decided to form an exporters' sub-section of the Coal Trade Section of the Chamber. A member urged the necessity of an engineering section also being formed, and the secretary (Mr. A. H. Milne) said he was in communication with certain people to see what could be done in that direction.

Personally, we are rather surprised to learn that the Chamber of Commerce of such an important commercial and industrial district as Liverpool has not yet got a section to represent the most important trade of this country. We would go further and urge the members to form an electrical section. At London, Newcastle-on-Tyne and other places there are separate sections for the important electrical and allied trades, and we believe it is time the chambers in the leading industrial areas of the country followed suit. Organisation is now the order of the day, and in view of the rapidly increasing use of electrical energy for power and industrial purposes, and the continued expansion of the applications of electricity, the electrical members of Chambers of Commerce would do well to organise themselves on modern lines, and keep in touch with all movements affecting the welfare of their industry.

* * * *

Prohibited Exports. An Order in Council has been issued amending the list of prohibited exports so as to include the following articles :—

Electric lamps, except carbon filament lamps and arc lamps for street lighting.

Emery corundum, natural or artificial (such as alundum), carborundum and crystolon and manufactures thereof.

Tale, varnishes containing tale.

Manufacturers and Organisation. At the recent meeting of the Metropolitan Carriage, Wagon & Finance Co. the chairman (Mr. F. D. Docker, C.B.) referred to the proposed scheme for organising the manufacturers of this country.

Already, he said, companies and firms with an aggregate capital of between £80,000,000 and £90,000,000 had joined the movement, and it was hoped to found a society which would be strong enough to influence the Government in all matters affecting trade. It was not to be an organisation in opposition to labour claims; on the contrary, it was hoped that it would be the means of bringing capital and labour into a sort of partnership. Naturally, its principles were somewhat nebulous at present, but that would not be the case when all the interests concerned had had an opportunity of stating their wants. He hoped those who joined would discard their old prejudices and old theories, in order to formulate a policy which recognised that the war had created a new industrial world. They hoped that all existing and kindred associations, great and small, would be connected with them in more or less intimate relationship. Already three had amalgamated and negotiations were proceeding satisfactorily with others.

* * * *

Electric Enterprise in the Far East. At the recent meeting of the Shanghai Electric Construction Co., the chairman of the board of directors (Sir Alfred Dent, K.C.M.G.) stated that they were looking forward to opportunities for expanding the railless form of traction, which had been proved to be so well suited to the narrow streets of the Shanghai settlement and to the requirements of the population. They also hoped when the war was over and the disturbances in China had ceased, that there would be inquiries as to the construction of electric tramways in other townships in the interior, and this might lead to their company being invited to take an interest in such schemes. China, with its extensive territory and its vast natural resources in minerals, &c., should undoubtedly prove a fruitful field for exploitation by electrical engineers, and every possible step should be taken by manufacturers and exporters to cultivate it.

* * * *

Trade After the War. Several matters relating to trade during and after the war were considered at last week's conference which was convened by the British Imperial Council of Commerce. Delegates were present from India and many British colonies and dependencies.

Mr. S. Machin (London) opened a discussion on the reciprocal trading relations between various parts of the Empire, which he considered depended on imposition of a tariff. A tariff must be the foundation of their future policy and through that tariff he hoped they would be able to build up a system which would enable them to weld the Empire in one great whole, and preference would enable them to give sympathetic treatment to our Allies, and at the same time deal with benevolent neutrals in a fair and reasonable way; but, above all, it would keep unscrupulous and vicious enemies for ever in their proper place. The Government must be called on to abolish the system whereby Germany had made this country the dumping-ground of the civilised world.

Mr. C. King (Melbourne) said if the conference could evolve a scheme which would be fair to all, and put no pressure on any country, they would have laid the foundation of an Empire such as the world had never dreamt.

Mr. A. H. Sytner (Port Elizabeth) stated that the feeling in South Africa was in favour of preference, and he had been asked by his Chamber to press for a distinct policy to be formulated.

Sir A. Firth moved a resolution urging that arrangements should be made at the earliest possible moment to provide :—

(*a*) For preferential reciprocal relations between all parts of the British Empire;
(*b*) For reciprocal trading between all parts of the British Empire and the Allied countries;
(*c*) For the favourable treatment of neutral countries; and
(*d*) For restricting by tariffs and otherwise trade relations with all enemy countries so as to render dumping or a return to pre-war conditions impossible.

Mr. J. W. Woods (Canadian Trade Commission) seconded the motion. Experience in Canada had shown them that preference would have the desired effect, and that a surtax would also be successful.

Mr. J. C. Pillman (London) said that while it was very desirable to encourage trade between the Dominions, he did not think it could be done by subjecting their manufactured products to a tax. It would be better to impose a tariff on neutral countries for revenue purposes and levy a tax on enemy countries.

Mr. B. Pardoe Thomas (Newport) took exception to a hard-and-fast resolution which would tie the hands of the Dominions, and asked the conference not to bind themselves with a tariff.

Mr. Pennefather, M.P., hoped that that conference, and the conference that was going to be held in Paris, would result in a policy which would be honourable to the Allies and beneficial to the Empire.

Mr. R. B. Stoker (President of Manchester Chamber of Commerce)

said that of late the complexion of the Manchester Chamber had altered very much, and it now supported the resolutions which were adopted by the Associated Chambers in February.

Ultimately, the motion was put and carried, only three voting against it.

On the motion of Sir A. FIRTH, seconded by Mr. C. KING (Melbourne), the following resolution was also passed :—

That legislation should be enacted by the different Governments within the British Empire under which each Government shall have the power to insist that any individual, firms, or companies producing, manufacturing or trading within the British Empire shall be British controlled both as regards management and ownership; and in the event of enemy companies or firms being permitted to re-open or commence trading in any part of the British Empire they shall be subject to such control and inspection as shall make it impossible for them to be used as political agencies under the guise of commercial establishments.

The question of the reform of the law relating to patents, designs and trade marks was referred to the Executive Committee.

The following resolutions were also passed :—

That an early agreement should be arrived at between the Home Government and the Dominions to adopt a single income tax on incomes within the Empire wherever earned or produced.

That the Council should make every effort to bring about the adoption throughout the Empire of a uniform decimal system of weights, measures and currency.

That larger funds should be provided throughout the Empire by the respectiv Governments in order that the fullest facilities might be given for the promotion of scientific research and training.

* * * *

Telephone Revenue.

In the first report of the Committee of Public Accounts for 1914-15 it is stated that there is a deficiency of £111,018 on the net revenue account for telephones for 1914-15, compared with a profit balance of £239,111 in the previous year.

The deficiency is stated to be largely owing to causes resulting from the war, but it is also due to an increase of £142,358 in the charge for depreciation of plant and an increase of £36,749 for pension liability. The charge for depreciation must inevitably increase, as very large capital expenditure remains to be incurred out of funds sanctioned under the Telegraph Money Act, 1913, whilst the wages of the employees show continuous growth, with the result that even under normal conditions the telephone accounts will, unless special measures are devised, probably show a net loss in the near future, instead of giving a reasonable return for the outlay incurred.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From June 5, 1916, *to* June 10, 1916.

IMPORTS.

LIVERPOOL.—*U.S.A.:* Insulating tape, 20 pkgs. *Rangoon:* Elec. fan motors, 19 pkgs.

LONDON.—*U.S.A.:* Elec. machinery, £3,054; elec. lamps, £684; carbon candles £505; wire and cable, £517; unenumerated, £3,185 355 pkgs.; *Holland:* Elec. lamps £2,782 509 pkgs.; elec. machinery, £218; wire and cable, £750; unenumerated, £103. *Switzerland:* Elec. lamps, £105; unenumerated, £1,954. *Italy:* Unenumerated, £4,634. *Japan:* Unenumerated, £144. *France:* Carbon candles, £511; unenumerated, £410. *Norway:* Unenumerated, £1,205. *Denmark:* Unenumerated, £147. *China:* Unenumerated, £317. *Canada:* Unenumerated, 266 pkgs.

SOUTHAMPTON. *France:* Unenumerated, 47 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Unenumerated, £373. *Melbourne:* Wire and cable, £79; unenumerated, £695. *Sydney:* Elec. machinery, £675; wire and cable, £1,551; elec. lamps, £481; unenumerated, £402. *Wellington:* Elec. pocket lamps, 1,053 no.; unenumerated, £422. *Perth:* Unenumerated, £296. *Christchurch:* Wire and cable, £159; unenumerated, £31. *Lyttelton:* Unenumerated, £162. *Brisbane:* Unenumerated, £1,588. *Fremantle:* Elec. machinery, £212; wire and cable, £1,101. *Dunedin:* Wire and cable, £495; unenumerated, £54. *Adelaide:* Unenumerated, £283. *Gisborne:* Wire and cable, £140.

AFRICA.—*Durban:* Wire and cable, £99; elec machinery, £179. *Cape Town:* Wire and cable, £63; unenumerated, £789. *Port Elizabeth:* Unenumerated, £417. *Sierra Leone:* Elec. machinery, £20; unenumerated, £14. *Seconde:* Elec. machinery, £86, unenumerated, £114.

EGYPT.—*Alexandria:* Unenumerated, £229. *Suez:* Elec. machinery, £23; unenumerated, £23.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Elec machinery, £473; wire and cable, £4,321; telegraph material, £85, unenumerated, £250. *Penang:* Telegraph material, £56; unenumerated, £32. *Calcutta* Wire and cable, £2,223; unenumerated, £980. *Madras:* Wire and cable, £1,600; unenumerated, £143 *Ceylon:* Elec. machinery, £33; telegraph material, £208; unenumerated, £2,072. *Karachi:* Unenumerated, £67. *Bankok:* Unenumerated, £309 *Port Swettenham* Unenumerated, £37.

CHINA.—*Shanghai:* Elec. material, £50, wire and cable, £10, unenumerated, £53.

U.S.A.—*New York:* Unenumerated, £870.

SOUTH AND CENTRAL AMERICA.—*Monte Video:* Unenumerated, £31 *Rio de Janeiro* Unenumerated, £1,501. *Pernambuco:* Wire and cable, £1,260, unenumerated, £53.

HOLLAND.—*Amsterdam:* Unenumerated, £634 *Rotterdam* Elec. machinery, £250; unenumerated, £35.

FRANCE.—*Paris:* Unenumerated, £58. *Dieppe* Unenumerated, £275. *Havre:* Unenumerated, £48.

JAPAN.—*Yokohama:* Unenumerated, £14.

RUSSIA.—*Vladivostock:* Elec. machinery, £336.

SWEDEN.—*Gothenburg:* Elec. machinery, £89.

CANADA. *Montreal:* Elec. machinery, £300; unenumerated, £132

ITALY.—*Genoa:* Wire and cable, £132; unenumerated, £281

DENMARK. *Copenhagen:* Elec. machinery, £37, wire and cable, £2,204; telegraph material, £199.

GIBRALTAR. Unenumerated, £13.

MALTA.—Wire and cable, £234.

SPAIN.—*Barcelona:* Unenumerated, £172.

BRITISH GUIANA. *Demerara:* Unenumerated, £34.

WEST INDIES.—*Barbados:* Unenumerated, £26. *Mont Serrat:* Unenumerated, £24.

JAVA. *Samarang:* Elec. machinery, £133. *Sourabaya:* Elec machinery, £173, unenumerated, £147; *Batavia:* Wire and cable, £3,620; unenumerated, £338

SOUTH SEA ISLANDS. *Fiji:* Wire and cable, £89; unenumerated, £24

FOREIGN GOODS (duty paid and free).

Cape Town: Unenumerated, £483. *Amsterdam:* Wire and cable, £1,303. *Sydney:* Unenumerated, £18. *Barcelona:* Unenumerated, £150. *Colombo:* Unenumerated, £14. *Madras:* Unenumerated, £12. *Port Elizabeth:* Unenumerated, £137. *Dieppe:* Unenumerated, £21. *Durban:* Unenumerated, £127. *East London:* Unenumerated, £673. *Karachi:* Unenumerated, £155. *Melbourne:* Elec. machinery, £130; unenumerated, £27. *Shanghai:* Elec. lamps, 15,800 no. *Newcastle:* Unenumerated, £26. *Singapore:* Unenumerated, £39.

IN TRANSIT.

Hong Kong: Elec. glow lamps, £131.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

Messrs. Joseph J. Roche & Co. have removed to larger premises at 47, Golden-lane, London, E.C. Telephone number (City 9607) and telegraphic address (Roche City 9607) remain the same.

Plant for Sale.—An advertiser has for sale a 17 H.P. Hornsby Stockport gas engine and suction plant and dynamo.

An advertiser has for sale three Westinghouse vertical gas engines and dynamos, motor-generator, a milking booster and a 550 ampere-hour E.P.S. battery.

LIQUIDATIONS, BANKRUPTCIES, &c.

Mr. G. E. Corfield, Balfour House, Finsbury-pavement, London, E.C., has been appointed trustee in the bankruptcy of Russell E. Connold, late electrician, of 6A, The Parade, Canterbury.

A second and final dividend (1s. 2d.) is payable on June 16 at 30, Mosley-street, Newcastle-on-Tyne, to the creditors of Arthur Faraday Hawdon, electrical engineer, Yetholme, Elmfield-gardens, Gosforth.

ELECTRICITY SUPPLY.

EXTENSIONS.

Glasgow.—Last week the Corporation adopted a recommendation to put down four water-tube boilers at St. Andrew's Cross electricity works, at a cost of £10,632.

Loughborough.—The Council have applied for sanction to loans of £1,400 for laying an electric cable to the new works of Herbert Morris (Ltd.), and of £600 for a two-ton electric crane.

Newcastle (Down).—The Urban Council have passed the plans of the new electricity supply works.

Rotherham.—The Town Clerk has been instructed to approach the appropriate Government department with reference to extensions of feeders and cables in order to provide supplies of energy for power.

Upon receiving the department's approval, it is proposed to take the necessary proceedings to secure sanction to borrow not exceeding £10,000 for main extensions during the ensuing six months.

Sheffield.—The L.G. Board has sanctioned the borrowing of £75,000 for mains and £30,000 for sub-station equipment, transformers, &c.

Of the sum sanctioned for main extensions £10,000 will be appropriated from the reserve fund.

In view of the large amount of additional work and responsibility which has been cast upon the general manager of the undertaking (Mr. S. E. Fedden) owing to the war, the Electric Supply Committee recommends the City Council to grant him a bonus of £100.

Mains are to be extended in various parts of the City at a cost of approximately £620.

H.M. Treasury has intimated its decision not to withhold their sanction to a proposed loan of £137,104 for the purchase of additional plant at Neepsend power station, such plant being required for the supply of current for power.

Sunderland. The Council have approved the plans of a new sub-station at the Southwick Yard.

Wakefield. The City Council have applied to the L. G. Board for sanction to borrow £5,620 for extensions of the electric supply undertaking in order to give an extra supply of power to manufacturers in the district.

Yorkshire.—It is announced that the Yorkshire Electric Power Co. proposes to carry out extensions at its generating station at Ravensthorpe, at an estimated cost of £100,000.

GENERAL.

Aberdeen.—The Council have agreed to give a supply of electrical energy to Messrs. John Lewis & Sons for their new shipbuilding.

The firm require a supply of about 400 H.P., but the additional load will require new feeder cables from Ferryhill. Low-tension feeder cables

for 400 H.P. could be laid for £3,700, and extra-high-tension, three-phase feeder cables (for 1,300 H.P.) for £1,500, the latter cable being at present in stock. The Electricity Committee recommended that if Messrs. Lewis guaranteed a consumption for three years equal to 20 per cent. of the capital cost of the cable, and provided free of charge for at least 10 years, an approved fireproof sub-station, the requisite supply be given on the three-phase system at 400 volts, and this course was agreed to.

Barnes.—On Tuesday the electrical engineer (Mr. C. S. Davidson) reported that owing to the Summer Time Act, he estimated that there would be a loss of about £900 on the undertaking during the summer months. The Council decided to increase the charge for power by 10 per cent., and for private lighting and heating (now 3½d. per unit) by 15 per cent.

Bedford.—The Council have applied for an order to give a supply of electrical energy to new works at Biddenham, outside the borough boundary.

Birkenhead.—In consequence of the Summer Time Act the charge for electrical energy for private lighting has been increased by 5 per cent.

Bolton.—The Electricity Committee has asked the electrical engineer (Mr. W. J. Wood) to report on the letter from the Board of Trade calling attention to the considerable saving that could be effected by a system of inter-connection of electrical supply undertakings.

The electrical engineer was also authorised to purchase a coal-testing set.

City of London.—The Charing Cross, West End & City Electricity Supply Co. announce that from the end of June the charge for electric current will be :—

For lighting : Each quarter, 5d. per unit for first 3 units consumed per 30 watts of connected demand ; each quarter, 4d. per unit for the next 8 units consumed per 30 watts of connected demand, and all units in excess, 2d. per unit.

For power and heating, an addition of 10 per cent. will be made to present charges.

The above charges only relate to the City of London. The company has already made an increase of 10 per cent. to its West End consumers and there will be another increase of 10 per cent. from July 1.

Coal Supplies for Electricity Undertakings.—A conference of Metropolitan Municipal bodies owning electric supply undertakings was held at Caxton Hall, Westminster, on Friday, to consider the question of the supply of coal. Councillor Barge (Poplar) presiding.

A communication was read from the Board of Trade pointing out that in view of the possibility of a serious shortage of coal in the near future, considerable saving could be effected by the joint working of electricity undertakings and intercommunications between stations supplying tramways and railways. There were difficulties in regard to labour and materials, but the Board urged, in the national interest, that immediate steps should be taken to put into operation the existing powers for joint working.

Mr. G. H. HUME, of the London County Council, said the County Council had prepared a comprehensive scheme, and as a result of conferences it was decided that the borough councils should work out their own scheme and the different sets of companies should put forward their own proposals. The matter was urgent now, and would be still more so after the war. If no one else took action the London County Council would do so, and it would not do for the companies and the councils to complain that they had not had time to put their views forward.

After some discussion, the conference passed a resolution affirming that the authorities represented would do everything in their power within the local areas to carry out the objects of the Board of Trade in regard to the supply of coal.

Darwen.—It has been decided to increase the charge for electrical energy for power by another 5 per cent., a total of 25 per cent. since the start of the war.

Ealing.—Owing to the increased price of coal and decreased receipts in consequence of the operation of the Summer Time Act, the Corporation have made a further increase of 10 per cent., making 20 per cent. in the charges for electrical energy.

Exeter.—The charge for electrical energy for private lighting will be increased from 4d. to 5d. on July 1.

Gillingham.—Mr. Ritson, assistant electrical engineer, has been given leave of absence to enable him to join the Colours.

Redditch.—Owing to the increased cost of coal and other materials, the Council has increased the charges for electric current by 30 per cent. from July 1. The increased charges are for the period of the war only.

Sutton Coldfield.—It was reported to the Council last week that the principal of Messrs. Clive & Co., the contractors to the electricity department, having decided to give up business and join H.M. Forces, the Electric Supply Committee had agreed to take over the stock, fittings, &c., and carry on the business.

The Committee stated that they had taken the premises on a seven years' lease, but Mr. Taylor and Mr. Crockford protested against taking a lease of which they knew nothing.

The report was, however, passed.

West Bromwich.—In order to enable lower grade fuels to be used the Electricity Committee is fitting an Erith-Riley stoker to one boiler at the electricity works, at an estimated cost of £550.

West Hartlepool.—The Council have approved the following new scale of charges for electrical energy :—

General Supply.—4d. per unit for first 1,500 units consumed per quarter and 3d. per unit after, or at ordinary flat rates of 4d. and 3d. for all electricity consumed between the hours of 4 p.m. and 10 p.m. during January, February, November and December, and between 7.30 p.m. and 10 p.m. during March, April, May, June, July, August, September and October, and at 2d. per unit during all other hours.

Heating and Cooking (other than rateable value consumers).—¾d. per unit.

Rateable Value (private houses).—A standing charge of 20 per cent. on rateable value of premises, plus ½d. per unit for all electricity consumed.

Power.—2d. per unit for first 50 units consumed per quarter, 1½d. per unit for next 450 units, and 1d. per unit after. An addition of 10 per cent. to above rates to be charged during the war.

Meter Rents.—1s. per quarter for ordinary meters, 7s. 6d. per quarter for two-rate meters.

Minimum Charges.—Lighting and heating installations—2s. 6d. for each of the two summer quarters, 7s. 6d. for each of the two winter quarters. Power installations—5s. per quarter. Combined lighting and power installations—5s. per quarter.

Bulk Supplies.—By agreement.

The above scale of charges will come into operation immediately after the reading of the meters in September next.

Weybridge.—The Council has protested against the proposed increase of price of electrical energy by the Urban Electric Supply Co., as being excessive, considering all the circumstances. It suggests that, if any alteration be made, the price to the consumer should be regulated on the cost of coal, and that any increase of price should only be for the period of the war.

LIGHTING & POWER NOTES.

Electricity in Mining.—At the recent annual meeting of the Mount Lyell Co. a statement was made in regard to the three West Coast Mines, and that as the arrangements with the Tasmanian Government for the supply of 50,000 H.P. from their hydro-electric scheme had added to the importance of the company's options over those properties, the board had decided to give notice of their intention to exercise the options.

These three mines have remained unworked for many years in consequence of the complex nature of the ores, but similar ores are being electrically treated satisfactorily elsewhere on a large scale, and spelter production can now be undertaken on profitable lines. The engineering staff of Mount Lyell estimate the ore reserves at 800,000 tons for the three mines, averaging 29 per cent. zinc, 7½ per cent. lead, 9½ oz. silver, and 2½ dwt. gold. In exercising its options the board will do so conditionally upon additional time being given to form a new company and to raise the necessary capital.

Hospital Lighting.—The Keighley and Bingley Joint Hospital Board have decided, on the recommendation of the House and Buildings Committee, to wire the permanent hospital buildings and the sanatorium for the electric light, at a cost of £216.

Wimbledon.—Having considered correspondence which recently passed between the Fixed Price Light Co., Messrs. Handcock & Dykes (the company's consulting engineers) and the Borough Electrical Engineer, the Electric Lighting Committee reports that it is not prepared to approve of the use of half-watt lamps by the company's customers.

TRACTION NOTES.

Bradford.—The Council are recommended by the Electricity Committee to adopt electrically-propelled vehicles for use in connection with the work of the department, and to purchase two vehicles of this type for coal and ash cartage from the Jowett Motor Mfg. Co., the local agents for the General Vehicle Co.

Each vehicle will be of 5 tons capacity and equipped with electrically-operated tipping gear. One of the wagons will be fitted with an Edison battery of 60 cells and the other with an Ironclad Exide battery of 44 cells. The committee also proposes to obtain a third electrically-propelled wagon—a 3½-ton Baker tip wagon from Wolseley Motors (Ltd.), providing the vehicle, on examination, is found to be suitable for the work of the department.

Croydon.—The Council is to renew the tram-track between Selhurst New Road and Selhurst Railway Bridge loops, and construct a double line of track in continuation of the existing line, at a cost of £2,156.

Glasgow.—Owing to the great increase which has taken place in the number of persons of both sexes who are employed on night work, the Tramways Committee has asked the general manager to prepare a report on an application for a half-hourly service of cars on the main routes during the night.

For the year ended May 31 the traffic receipts of the tramways department were £1,149,264, increase of £78,570 over 1914-15.

The car-miles run were 24,963,309, increase 748,849; the traffic receipts per car-mile were 11·049d., increase 0·437d.; traffic receipts per passenger 0·761d., decrease 0·003d.; passengers carried were 362,371,464, increase 26,110,706.

Leeds.—A tramcar accident occurred on Wednesday morning, resulting in several people being injured.

A commercial car, used for carrying stones and clay, got out of control and ran down the hill at Wortley, and after a run of nearly a mile it crashed into a passenger car with disastrous results. Just before the accident Driver Close had unloaded a wagon of clay in Oldfield-lane, and while proceeding to turn the trolley pole in order to make the return journey the brakes became released. As the car began to move down the hill the driver made a plucky attempt to mount the platform but failed, and was thrown to the ground. The heavy car gathered speed and the trolley pole left the overhead wire and swung loose. During the career of the car the loose pole struck and cut several telegraph and telephone wires. The car encountered nothing to check its high speed until it dashed into the passenger car which was running from Lower Wortley to the Corn Exchange. The passenger car was hurled half-way round and partly through a stone wall which runs at the side of the road, while the commercial car jumped the metals but remained on the road.

London County Council Tramways.—The Board of Trade has extended for one year from Aug. 11, 1916, the time limited by the Council's 1913 Act for completion of tramways Nos. 4 and 4A, authorised by the Council's 1903 Act and has also extended for one year from Aug. 16, 1916, the time limited by the Council's 1909 Act for the widening of Farringdon-road and Clerkenwell-road, and the completion of tramways 2A, 8A and 10A.

L. & S.W. Railway Electrification.—A successful trial run over the electric system to Hampton Court was made on Tuesday.

might, however, assume proportions which would make it necessary for another organisation to take over the work. The installation of an electrolytic plant in a big way would entail the expenditure of a large amount of capital. The Board had made satisfactory tentative arrangements for the supply of electric power from the Tasmanian Government.

The Attorney-General has issued a licence for the completion of the contract dated May 20, 1914, between Siemens Bros. Dynamo Works (Ltd.) and Sydney Municipal Council for the supply of cables for the municipal electric lighting system.

At a recent meeting of Melbourne Council the electric Supply Committee presented a proposal to reduce the present tariff for the supply of electricity to the municipalities of Footscray, Port Melbourne, Brunswick and Williamstown, and to the Brunswick and Coburg tramway trust. From Nov. 1, 1916, the following reductions will be made in all bulk supplies: Up to 500 kw., from the present rate of £5 a kilowatt per year to £4. 10s., and for any excess above 500 kw. £4 a kilowatt, plus the present rate of 0·65d. a unit up to 1,000,000 units a year, 0·6d. for the next 1,000,000 and 0·55d. a unit for any excess above 2,000,000 units.

The official opening of the Wynyard (Tasmania) electric light undertaking took place recently. The plant consists of an 84 B.H.P. Hornsby suction gas engine driving a 45 kw. d.c. 460-volt dynamo with static balancer, and a 15 B.H.P. d.c. motor driving two 5 kw. d.c. booster generators. The storage battery consists of 256 chloride type cells of 460 ampere-hours capacity. The electrical portion of the power house plant was supplied by Sutherland & Ashman. There are overhead mains and the insulators are Australian made. The copper mains were supplied by the British Insulated & Helsby Cables (Ltd.) and the rubber-covered wire by W. T. Henley's Telegraph Works (Co. (Ltd.). The street lights, of which there are 50 (42 100 c.p. and 8 500 c.p.), and all meters and line hardware were supplied by Grant, Warren & Co. There are 150 houses wired and connected, while the contractors (F. Byrne & Co.) have a further 40 houses yet to finish, making a total of 190 connected to the plant in the first six weeks of operation. There are 90 electric irons on the system to date, and orders for more are being placed. The whole of the work was designed and carried out under the supervision of Mr. V. J. Crowley, and the Council's engineer-in-charge is Mr. A. L. Kerr.

Doncaster (Victoria) Shire Council's electric undertaking is now in operation. Single-phase current is obtained from the Melbourne Electric Supply Co., at 4,000 volts 50 cycles, and transmitted by overhead wire 5¼ miles east over the Doncaster and Mitcham roads. The insulators were made by the Australian Porcelain Works, and were tested to 16,000 volts, and the transformers were supplied by the Australian General Electric Co. There are 112 consumers and 40 street lamps. The installation was carried out under the supervision of Mr. V. J. Crowley, and Mr. John Vergers has charge of the undertaking.

Frankston (Victoria) Gas Company has applied for an order in council for electric lighting within the municipality.

The Kilmore (Victoria) Electric Supply Co. has sold its plant to the Shire Council for £2,500.

The Public Works Department has offered to supply Moss Vale (N.S.W.) municipality with current from Port Kembla at £8 per kilowatt, plus 1d. per unit. The cost of current to the Council for 1914 and 1915 respectively has been 3·35d. and 3·26d., not including depreciation, renewals, &c. The Council would have to provide the transformers. The Department is to be asked to prepare a draft agreement and to quote on a basis of 50,000 units minimum.

EMPIRE NOTES.

Australasia.—The Lighting Committee of Laidley (Queensland) Council has canvassed the business people relative to the electric lighting of the town, and they, as well as a number of private householders, and the commissioner for railways, have expressed a desire that electric lighting be adopted.

The Electric Energy Supply Co. (Ltd.), Warwick (Queensland), made a net profit of £599 for the half year ended Dec. 31, 1915 (against £397 for the previous term). Units sold for the year were 100,395, against 69,756 in 1914. The company has secured a contract for five years for lighting the town. The duplication of the station plant is in progress. The new plant will have a capacity of 160 kw.

Warwick (Queensland) Council, having made arrangements with the local electric light company, the local gas company has declined to continue the lighting unless the Council pays 12s. 6d. per lamp per month until June 30, the end of the company's term. The Council declined to pay the increased charge, and ordered the company to remove the lamp-posts at once.

The accounts of the New Plymouth (N.Z.) municipal electricity undertaking for the year ended March, 1915, show revenue £7,901, working expenditure £2,772 and other costs including interest and sinking fund and depreciation, £4,617, leaving net profit £721.

The New Zealand Government has granted a licence to Sumner Borough Council to erect and maintain electric lines for lighting, power and heating purposes in its district. Current will be taken from the Lake Coleridge supply.

The proposal of Featherston (N.Z.) Town Board to borrow £3,600 for installing electric lighting has been approved.

The ratepayers of Taihape (N.Z.) have approved a proposal to borrow £3,500 for additional plant for the water supply and electricity works.

Proposals for the installation of an electric lighting scheme for Birkenhead and Northcote (N.Z.) districts are being discussed by the respective Councils. A report has been prepared showing that the expenditure would be £40,000.

Deposits of china clay at Ngaruawahia (N.Z.) are now being used in the manufacture of various articles, including telegraph insulators.

The chairman of the Amalgamated Zinc (De Bavay) (Ltd.) (Mr. W. L. Baillieu) referred at a recent meeting of the company to the proposal to manufacture electrolytic zinc. He foreshadowed the possibility of a separate company being formed for that purpose, in which the De Bavay shareholders would have an interest. At present the Amalgamated Co. was doing the whole of the work in connection with the scheme, but it

India.—"Indian Engineering" says there has as yet been no development of the municipal resolution for the electrification of the pumping works of the water supply of Bangalore, the matter being still before the Government. While the proposal is an excellent one, such a scheme is considered less urgent than the augmentation of the filters.

The report of the directors of the Bombay Telephone Co., submitted at the recent annual meeting of the company, states that the result of the past 12 months' working shows a profit of Rs.3,63,946-11-2, from which the directors have set aside Rs.1,80,000 for depreciation, leaving, with Rs.14,253-14-5 brought forward from 1914, Rs.1,98,200-9-7. Out of this a dividend of Rs.5 per share (equal to 20 per cent.) is to be paid, Rs.13,500 paid as a bonus to the staff, and Rs.16,825-9-7 to be carried forward. There has been a total increase of 604 subscribers, yielding an increase in revenue of Rs.1,15,501-6. On Dec. 31 last there were 4,337 exchange and private lines working in Bombay, Karachi and Ahmedabad with a total gross revenue of Rs.7,97,248-3.

FOREIGN NOTES.

Italy.—A concession has been granted to the municipality of Rome for the construction and working of a normal gauge electric railway from the Piazza Venezia to Ostia Nuova.

Japan.—According to the financial and economic statement of Japan for 1913-14, the aggregate mileage of railways worked in Japan was 7,291, of which 5,473 miles were State owned. Passengers were 211,251,883 and traffic receipts equalled £14,194,177.

The electric railways at the end of 1914 numbered 66, with an aggregate capital of £10,707,313, and the total mileage of their open lines was 691

and that of the lines not yet open 242 miles. The companies which had not yet opened their lines numbered 27, with an aggregate capital of £2,085,425, and the total mileage of their projected lines was 282 miles. In addition to the above there were electric railways owned by the Tokyo, Osaka and Kyoto municipalities with an aggregate capital of £13,994,589, the total mileage of their open lines being 120 miles and that of the lines not yet open 47 miles.

A consular report states that imports into Yokohama in 1914 included insulated wire valued at £31,717 (compared with £163,830 in 1913) of which 46 per cent. came from the United Kingdom and 39 per cent. from Germany. The decrease in these goods from Germany was £113,437.

The Acting British Consul at Tamusi, Formosa, reports that a company has been formed at Tainan for the construction of an electric tramway about 3 miles in length from Tainan to the port of Anping.

The capital of the company is about £40,800, but the details of the scheme have not yet been decided upon. "On account of the present high price of rails it is probable that old rails will be used."

Morocco.—A Consular report states that improvements are being made at the Port of Saffi. A large new warehouse is almost completed and a large quay with a small stone jetty equipped with two electric cranes for unloading lighters, are being constructed.

Russia.—H.M. Consul at Batoum states that there are great possibilities for British trade in the Caucasus.

In the import trade German manufacturers frequently gave financial assistance, especially to small dealers, by a system of credit which met with the latters' approval. The present time is a favourable one for activity by British manufacturers. They should send out travellers speaking Russian, with price lists in Russian, prices being worked out in roubles at the current rate of exchange. The manufacturers of other countries are very alert just now in the Russian markets. Dealers in the Caucasus have been accustomed to the visits of commercial travellers who show them samples, and are prepared to book orders on the spot.

The electrical trade might be developed in the Caucasus. Until the outbreak of war, and for some time after, the electrical engineering appliances and materials required locally came principally from Germany. If the intention to capture German trade under this head is to be realised, British manufacturers should take advantage of the present opportunity to prepare for the competition that will exist after the war. The needs of the Caucasus in all manner of electrical appliances are very great, and when normal conditions are resumed there is no reason why British sources of supply should not be preferred to those of Germany. The quality of the articles produced in the United Kingdom is admitted to be superior to that of German-made goods, but the question of price will have to be studied closely, together with that of the terms of payment.

Uruguay.—The "Review of the River Plate" says the Uruguayan State Electrical Department contemplate according a considerable reduction of the price of electric current, in order to generalise its use :—

The price proposed is about 2 cents (Uruguayan gold) per kilowatt. It is proposed to import a large quantity of cheap electrical cooking stoves from the United States. The construction of new power houses at various towns in the interior is being hurried on.

MISCELLANEOUS NOTES.

Clyde Labour Agreement.—An important agreement for the dilution of labour in the shipbuilding and engineering yards on the Clyde has been signed. The agreement provides for :—

1. Co-operative efforts to increase production by the adoption of all expedients which tend to increase and maintain the output.

2. The interchangeability inside the boilermakers' and iron and steel shipbuilders' trade of the various classes of persons who are members of that trade, and with that purpose in view the suspension for the period of the war of all internal lines of demarcation.

3. The utilisation to the best advantage of existing skilled men or the skilled men interchanged, and the use, so far as practicable, of pneumatic, hydraulic and electric tools.

4. The upgrading in the boilermakers' and iron and steel shipbuilders' trade of workmen to do more skilled work wherever the nature of the work and the qualifications of the men make such procedure practicable.

5. The introduction into the boilermakers' and iron and steel shipbuilders' trade of (*a*) skilled men from allied trades, (*b*) skilled men from other trades, (*c*) unskilled men and women in all cases where the work is of such a character or the conditions are such as to enable the labour introduced to perform the work with reasonable efficiency.

6. The relaxation of the existing demarcation restrictions, or the admission of semi-skilled or female labour not to affect adversely the rates customarily paid for the job. In cases where the men who ordinarily do the work are adversely affected thereby the necessary readjustments shall be made so that they can maintain their previous earnings.

7. A record of the nature of the departure from the conditions prevailing when the establishment became a controlled establishment to be kept.

Customs Duties.—A recent Presidential decree states that the duty upon importation into Venezuela of electric batteries (described as Pilas electricas) is 0·391 bolivares per kilog (=£11. 0s. 10d. per cwt.).

Debts Owing by Enemy Firms.—The Chancery Division of the High Court recently ordered an inquiry what debts of the enemy New York Hamburger Gummi Waaren Compagnie of Hamburg to persons within the United Kingdom remain unpaid, and claims are to be sent by July 10 to the Public Trustee, Public Trustee Office, Kingsway, London, W.C.

Every claimant holding any security is to produce same before Mr. Justice Younger, Room 297 of the Royal Courts of Justice, London, on July 24, at noon.

The Controller of the Union Electric Co. (Ltd.), Mr. P. D. Leake, notifies in an advertisement that creditors of this company must send particulars of their debts or claims, &c., to him at 25, Abchurch-lane, London, E.C., by July 22.

Enemy Firms Wound Up.—The Board of Trade have ordered the winding up of 194 businesses controlled by alien enemies. In the latest lists are included :—

Badische Co. (Ltd.), 2, Samuel Ogden-street, Whitworth-street, Manchester, dye manufacturers (Controller : W. S. Mounsey, 3, Lord-street, Liverpool) ; Bayer Co. (Ltd.), 20, Booth-street, Manchester, dye manufacturers (Controller : S. Pearson, 13, Spring-gardens, Manchester) ; The Berlin Aniline Co. (Ltd.), 30, Princess-street, Manchester, dye manufacturers (Controller : P. Higson, 42, Spring-gardens, Manchester) ; Kalle & Co. (Ltd.), 25, John Dalton-street, Manchester, dye manufacturers (Controller : W. Eaves, 15, Fountain-street, Manchester) ; Walter Ostermann & Co., 10, Monument-street, London, E.C., dealers in chemicals (Controller : P. D. Leake, 25, Abchurch-lane, E.C.), to whom claims by July 22) ; Quarzlampen Gesellschaft m.b.h., 62, Red Lion-street, London, W.C., dealers in quartz lamps and accessories (Controller : R. W. Brown, 12, Old Square, Lincoln's Inn, W.C.) ; Coke Oven Machine Co. (Ltd.), care of Messrs. Gillespie Bros. & Co., 29A, Charing-cross-road, London, W.C., manufacturers of coke oven machinery (Controller : John Duncan, 149, W. George-street, Glasgow, and 15B, Fenchurch-street, E.C.) ; Union Electric Co. (Ltd.), 47-57, Park-street, Southwark, London, S.E., electrical engineers (Controller : P. D. Leake, 25, Abchurch-lane, E.C., to whom claims by July 22) ; Reinemann & Co., late 7, New Zealand-avenue, London, E.C., dealers in bronze powder, &c. (Controller : A. Dangerfield, 56, Cannon-street, E.C.) ; Chas. H. Blume, Western-road, Mitcham, Surrey, varnish manufacturer (Controller : J. W. Barratt, 19A, Coleman-street, E.C.) ; G. Dittmann (Ltd.), 58, City-road, E.C., agent for dyes, &c. (Controller : S. J. Field, 17, Shaftesbury-avenue, W.).

Claims against Krupka & Jacoby (Ltd.) to the Controller, Mr. T. W. Lee, Bassishaw House, Basinghall-street, London, E.C., by July 10.

Claims against the Schorah Electrical Co. to the Controller, Mr. C. E. Barker, 21, Finsbury-pavement, London, E.C.

Fatality.—A fatal accident occurred at the East Bridge-street electricity works, Belfast, on Thursday last.

Wm. M'Donnell, foreman electrician, was working at a switchboard when he sustained an electric shock. Artificial respiration was resorted to, but proved unavailing.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during May, 1916, and (*b*) the aggregate figures from Jan. 1 to May 31, with increase or decrease compared with corresponding periods of 1915 :—

Electrical machinery, (*a*) £121,199 (decrease £60,031), (*b*) 492,926 (decrease £277,768) ; including generators and motors other than for aeroplanes, motor cars and cycles, (*a*) £20,181 (decrease £19,492), (*b*) £71,528 (decrease £49,200) ; and electrical machinery unenumerated, (*a*) £101,018 (decrease £40,539), (*b*) £415,398 (decrease £228,568) ; telegraph and telephone cables other than submarine, (*a*) £11,924 (increase £8,408), (*b*) £43,661 (increase £31,136) ; telegraph and telephone apparatus, (*a*) £62,146 (increase £50,021), (*b*) £153,707 (increase £123,221) ; other electrical wires and cables, rubber insulated, (*a*) £15,231 (increase £4,207), (*b*) £49,688 (increase £8,972) ; with other insulations, (*a*) £210 (decrease £739), (*b*) £3,214 (decrease £8,100) ; carbons, (*a*) £9,731 (increase £2,235), (*b*) £43,034 (decrease £32) ; glow lamps, (*a*) £24,882 (increase £15,268), (*b*) £111,295 (increase £57,849) ; arc lamps and electric searchlights, (*a*) nil, (*b*) nil (decrease £1,153) ; parts of arc lamps and searchlights (other than carbons), (*a*) £6,835 (decrease £1,412), (*b*) £31,922 (decrease £3,255) ; primary and secondary batteries, (*a*) £15,684 (increase £4,452), (*b*) £85,975 (increase £31,704) ; meters and measuring instruments, (*a*) £3,068 (increase £80), (*b*) £15,394 (increase £4,402) ; switchboards, (*a*) £4 (decrease £179), (*b*) £257 (decrease £2,889) ; electrical goods and apparatus unenumerated, (*a*) £36,774 (increase £16,530), (*b*) £127,722 (increase £52,714). Total of electrical goods and apparatus other than machinery and uninsulated wire, (*a*) £186,489 (increase £98,901), (*b*) £665,869 (increase £294,479).

Exports.—The exports of electrical machinery, material, &c., (*a*) during May, 1916, and (*b*) from Jan. 1 to May 31, with increase or decrease compared with corresponding periods of 1915, were as follows :—

Electrical machinery, (*a*) £120,787 (decrease £29,869), (*b*) £510,720 (decrease £82,488) ; including railway and tramway motors, (*a*) £2,055 (decrease £12,946), (*b*) £15,302 (decrease £55,205) ; other generators and motors except for aeroplanes, motor cars and cycles, (*a*) £55,164 (decrease £23,584), (*b*) £262,629 (increase £1,825) ; and electrical machinery unenumerated, (*a*) £63,568 (increase £6,661), (*b*) £232,589 (decrease £29,108) ; telegraph and telephone cables, submarine, (*a*) £15,375 (increase £11,996), (*b*) £100,777 (decrease £48,877) ; other than submarine, (*a*) £59,285 (increase £13,754), (*b*) £261,201 (increase £76,936) ; telegraph and telephone apparatus, (*a*) £14,618 (decrease £3,142), (*b*) £107,475 (increase £20,334) ;

other electrical wires and cables, rubber insulated, (*a*) £43,546 (increase £15,441, (*b*) £185,672 (increase £68,589); with other insulation, (*a*) £99,950 (increase £62,555), (*b*) £334,370 (increase £176,310); carbons, (*a*) £613 (decrease £190), (*b*) £4,143 (increase £1,604); glow lamps, (*a*) £19,565 (increase £9,007), (*b*) £69,878 (increase £15,470); arc lamps and searchlights, (*a*) £447 (increase £93), (*b*) £5,298 (increase £3,002); parts of arc lamps and searchlights (other than carbons), (*a*) £381 (decrease £3,169), (*b*) £4,988 (decrease £2,529); primary and secondary batteries, (*a*) £29,721 (increase £15,769), (*b*) £108,600 (increase £26,357); meters and measuring implements, (*a*) £15,734 (increase £879), (*b*) £74,980 (increase £10,595); transformers, (*a*) £12,340 (increase £9,626), (*b*) £30,243 (increase £7,997); switchboards, (*a*) £8,116 (increase £1,920), (*b*) £29,687 (increase £7,057); electrical goods and apparatus unenumerated, (*a*) £61,460 (increase £13,046), (*b*) £243,657 (increase £4,532). Total of electrical goods and apparatus, other than machinery and uninsulated wire, (*a*) £381,151 (increase £147,590), (*b*) £1,561,169 (increase £367,977).

TENDERS INVITED.

Coal Conveyors, Bunkers, &c.

Salford Corporation invite tenders by noon Monday, June 26, for Coal Conveyors and Bunkers. Particulars from the Borough electrical engineer, Mr. J. A. Robertson, Electricity Works, Frederick-road, Salford. *See advertisement.*

Wolverhampton Corporation require tenders for the supply of Coal and Ash-handling Plant at the electricity works. Applications must be made to the Chief Engineer and Manager by June 16 for plans and specification, and tenders must be delivered within 14 days after receipt of same.

Warrington Electricity and Tramways Committee require tenders by noon June 27 for (1) Coal Elevator and (2) Vertical Steam Boiler Feed Pump. Specifications, &c., from the Borough Electrical and Tramways Engineer.

Telegraph and Telephone Material.

Tenders are invited up to Aug. 16 for the supply to the Australian Commonwealth Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

Tenders are also invited up to July 19 for the supply to the Australian Commonwealth Postmaster-General's Dept. (State of Western Australia) of Insulators (schedule 510). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, Perth (W. Australia), requires tenders by 3 p.m. June 21 for 10,000 Flat g.i. Combiners, 100 Lead Earth Plates, 12,000 Screw Plugs and 10,000 Cross-arm Straps (schedule 505 W.A.), until 3 p.m. June 28 for Paper-insulated Lead-covered Cable (schedule 489 W.A.), and until 3 p.m. July 19 for 96 Terminal Blocks (schedule 495 W.A.). Specifications from the Deputy Postmaster-General, Perth, W.A.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the Australian Commonwealth Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

The Deputy Paymaster-General, Perth (W. Australia), also requires tenders by 3 p.m. July 12 for supply of 3,000 Dry Cells for the Australian Commonwealth Postmaster-General's Dept. Specification, &c., from the Deputy-Postmaster-General.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the Australian Commonwealth Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

The Deputy Postmaster-General, Melbourne (Victoria), requires tenders by 3 p.m. June 27 for 18,551 Stalloy Telephone Receiver Diaphragms (schedule 1303). Specification, &c., from the Deputy Postmaster-General.

Steelwork.

Wigan Electricity Committee require tenders by 10 a.m. June 20 for Steel Construction work of extension of boiler house. Specification, &c., from the Borough Engineer.

Halifax Electricity Committee require tenders by 10 a.m. June 17 for Steelwork over the dam at the electricity works. Specification, &c., from the Borough Engineer.

Street Lighting, Generating Plant, Gas Engines, Dynamos, &c.

Oamaru (N.Z.) Borough Council requires tenders by 4 p.m. June 23 for the supply of Overhead Mains and Street Lighting Equipment (contract No. 2); Power Station Equipment (Pelton Wheels, Alternators, &c.) (contract No. 3); Service Meters (contract No. 4); and Line Transformers and Accessories (contract No. 5). Specifications, &c., may be obtained at the Council's offices on deposit of £1. 1s. for each contract.

Pahiatua (N.Z.) Borough Council requires tenders by noon July 10 for (contract No. 1) Overhead Wires, Poles and Street Lamps; (No. 2) Gas engines, Producers, Dynamos and Auxiliary Apparatus; (No. 3) Accumulators. Specifications and plans from the Town Clerk, Pahiatua.

Electrical and General Stores, Wiring, &c.

London County Council Asylums Committee require tenders by 11 a.m. June 19 for supply of Electric Lamps. Forms of tender, &c., from the Clerk, 2, Savoy-hill, London, W.C.

West Ham Guardians require tenders by 10 a.m. June 22 for three months' supply of Electrical Fittings, Oils, &c. Forms of tender from the Clerk, Union-road, Leytonstone, N.E.

Hull Guardians require tenders by noon June 19 for six months' supply of electrical requirements, &c. Forms of tender, &c., from the Clerk, St. Mary's-chambers, Lowgate, Hull.

Brighton Guardians want tenders by 10 a.m. June 20 for the supply of Electrical Fittings to the Poor Law Institutions and Warren Farm Schools. Forms of tender from the Clerk.

Bristol Guardians require tenders by noon June 21 for the supply of Electrical Fittings, Ironmongery, Oils, &c. Forms of tender, &c., from the Clerk, St. Peter's Hospital, Bristol.

Salford Corporation require tenders by noon June 26 for supply of Cable Accessories, Carbon Brushes, Demand Indicators, Castings, Tools, Steam Tubes, Oils, &c. Specifications from Borough Electrical Engineer, Frederick-road, Salford.

Rotherham Corporation require tenders by July 3 for 12 months' supply of Tramway Stores and Materials, Cables, Trolley Wire, &c. Specifications from the Engineer and Manager, Electricity Works, Rotherham.

Signal Lighting Transformers.

The Victorian Railway Commissioners want tenders by 11 a.m. July 26 for 400 Signal Lighting Transformers (contract No. 29,997). Specifications from the Commissioners' Offices, Spencer-street, Melbourne, Victoria.

TENDERS RECEIVED AND ACCEPTED.

London County Council Education Committee have accepted the following tenders for electric lighting of schools:—

Southampton-street School, Camberwell.—H. J. Cash & Co. (Ltd.), £115. 11s. *Haverstock hill Schools.*—H. J. Cash & Co., £301. 10s.

Glasgow.—The following tenders have been accepted for electrical supplies:

Carron Co., W. Lucy & Co., Falkirk Iron Co., D. King & Sons and J. Allan (Cen.) & Sons, c.i. boxes, section pillars, &c.; Callender's Cable & Construction Co., single, concentric, triple concentric and e.h.t. cables; W. T. Glover & Co., h.t. cables; Craigpark Electric Cable Co., rubber-covered cables and flexibles; Ferranti (Ltd.), Chamberlain & Hookham and British Westinghouse Co., meters.

Metropolitan Water Board.—The tender of the "Z" Electric Lamp Mfg. Co. has been accepted for the supply of lamps for the period ending March 31 next.

Rotherham.—The Electric Light Committee has accepted the tender of the Rees Roturbo Mfg. Co. (at £322) for the supply of a feed pump.

Sheffield.—The City Council have accepted the tender of E. Taylor (Ltd.) for ash hoist foundations, at £256. 14s. 11d.

RAWTENSTALL.—The Council have accepted the following tenders: British Westinghouse Co., transformer and switch panel; W. T. Glover & Co., cable; Oates & Green, conduits; British Thomson-Houston Co., switchgear.

BRADFORD.—The Corporation has accepted the following tenders: Hadfields (Ltd.), 100 steel-tyred wheels with axles, £19. 11s. 6d. per set; Jowett Motor Mfg. Co., two electric vehicles for coal, &c., carting; Brush Electrical Engineering Co., one 250 k.v.a. three-phase transformer.

Commonwealth Contracts.—The following tenders have been accepted by the Australian Government Departments: —

Postmaster-General's Dept., Melbourne.—British Gen. Elec. Co., 65 detectors £3. 3s. each, 8,527 jacks 7½d. each; Western Elec. Co., 400 buzzers £33. 15s. per 100, 110 ditto £22. 18s. 4d. per 100, 2,000 indicators 3s. 3d. each, 2,840 ditto £300 per 1,000, 608 jacks 7d. each, 1,770 switching keys £250 per 1,000, 550 ditto £20 per 100, 230 ditto £18. 15s. per 100, 370 microphones £31. 15s. per 100, 3,560 relays £300 per 1,000, 2,650 resistances £45. 16s. 8d. per 1,000, 5 miles wire £15. 6s. per mile, 3 miles ditto £19. 8s. 6d. per mile, 5,000 cords 2s. 1d. each, 900 receivers 5s. 6d. each; Noyes Bros., 50 miles wire £10. 3s. 6d. per mile.

Postmaster-General's Dept., Sydney.—Automatic Telephones (Australasia), additional automatic telephone apparatus for Chatswood telephone exchange, £222. 6s. 6d.; G. E. Crane & Sons, 400 lead earth plates, 7s. 11¾d. each; Western Elec. Co., 100 miles cable, £17. 15s. per mile; Noyes Bros., 100 miles tinned copper wire, £11. 17s. 6d. per mile.

Postmaster-General's Dept., Adelaide.—Siemens Bros. & Co., semi-automatic switchboard, Port Adelaide, £9,570; Western Elec. Co., automatic or semi-automatic switchboard, Norwood, £8,750, ditto, Unley, £8,750, 50 telephone sets 27s. each, 25 ditto 25s. each.

Postmaster-General's Dept., Perth.—Western Elec. Co., telephones 29s. 6d. each, 50 ditto 76s. each, 400 lamps 6¾d. each, 40 ditto 6¾d. each, 6 ditto 10d. each, 202 meters, 1 high-range Evershed megger £29; Gen. Elec. Engineering Co., 1,000 lamps, metal filament, 1s. 7d. each, 100 ditto 2s. 6d. each, 200 ditto, carbon filament, 8d. each; J. Bartram & Son, 50 telephones, £3. 1s. each; British Insulated & Helsby Cables, 1,150 yds. cable (as per schedule 470), 200 opal caps 2s. 1d. each, 40 ditto 3¼d. each, 4 ditto 4d. each, 30 condensers 3s. 2d. each, 2 ditto 3s. 2d. each, 60 cords 3s. 6½d. each, 2 induction coils 13s. 9d. each, 1 indicator 11s. 6d., 42 strips jacks 14s. 6d. per strip of 10, 73 strips ditto 15s. 3d. per strip of 20, 42 strips ditto 7s. 3d. per strip of 10, 23 keys (listening, ringing and meter) 7s. 9d. each, 1 meter key 3s. 6d., 1 party line key 9s., 1 strip order wire keys 29s. 9d., 50 plugs 4s. 6d. each, 438 relays 5s. 9d. each, 38 retards 5s. 3d. each, 1 pilot relay 5s. 3d. each, 33 resistances 1s. 6d. each, 1 retardation coil 8s. 9d., 14 terminal strips 6s. 3d. each, 2 designation strips 8s. 3d. each, 3 terminal strips (item 35), 38 sockets for lamps 8½d. each, 3 ditto 1s. 6d. each, 2 ditto 7s. 6d. each, 2 terminal bars for line lamps 3s. each, 16 ditto, for party line key (item 40), 90 terminals 3½d. each, 3 telephone sets 33s. each, 30 cord weights 1s. 6d. each; H. Rowe & Co., 1 high-range Evershed megger (with leather case), £34.

Postmaster-General's Dept., Brisbane.—J. Paton & Co., 15 magneto bells, 7s. 3d. each; 200 carbon blocks, 9d. each; 8,000 pair fuse clips, 6s. 3d. per 100; 2,000 heat coils, 28s. per 100; 120 induction coils, 3s. 10d. each; 20 ditto, 2s. 10d. each; 200 carbon diaphragms, 4d. each; 350 ear-pieces, 1s. 1d. each; 75 ebonite handles for micro-telephone, 3s. 6d. each; 50 micro-telephones, 28s. 5d. each; 3 gross springs, 60s. per gross; 125 switches, 20s. 1d. each; 56 telephonometers, 32s. 10d. each; 6 gross paper washers, 5s. 3d. per gross; Western Elec. Co., 18 induction coils, 14s. 6d. each; 30 ditto, 19s. 6d. each; 18 ditto, 5s. 9d. each; Brisbane Elec. Co., 3,000 dry cells, 3s. 4d. each; 100 ditto, 8s. 6d. each; 600 ditto, 3s. 6d. each; Western Elec. Co., 100 repeating coils, 34s. 6d. each; 12 ditto, 27s. 6d. each; 20 condensers, 7s. 6d. each; 12 condensers, 2s. 3d. each; 500 stalloy diaphragms, 2s. 9d. per 100; 250 crystallate ear-pieces, 4d. each; 250 ditto, 5d. each; 250 ditto, 3d. each; 400 ditto, 3⅓d. each; 10 generators, 37s. 6d. each; 25 handles, 2s. 6d. each; 50 howlers, 17s. 9d. each; 200 mouthpieces, 1s. 9d. each; 500 ditto, 3½d. each; 30 shutters, 9d. each; 250 terminal strips, 4s. 9½d. each; 15 switches, 35s. each.

Victorian Railway Commissioners.—India Rubber, Gutta Percha & Telegraph Works Co., fuse distribution boxes, at rates; Ferranti (Ltd.), transformers for signal cabins, £788. 17s. 10d.; J. H. Holmes & Co., three-phase motors for workshop and other machinery, at rates; Knox, Schlaff & Co., storage battery freight truck, with spare parts, £426. 16s.

N.S.W. Railways and Tramways Depot.—W. T. Henley's Telegraph Works Co., 400 yds. submarine cable, £110.

Metropolitan Board of Water Supply, Sydney.—Zollner (Ltd.), centrifugal pumps and electric motors for No. 1 pumping station, Ultimo, £1,553. 7s.

Queensland Public Works Dept.—Edison & Swan United Elec. Light Co., storage battery (£1,280. 15s. 6d.) and Brisbane Elec. Co., high-speed engines and electrical plant (£4,055) for Goodna hospital for insane.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Birmingham.—The accounts of the electric supply department for the year ended March 31, adopted by the Council last week, show total capital expenditure £2,384,293 (increase £145,652), of which £565,180 has been repaid.

Revenue was £507,503 (compared with £388,511 in previous year), working and general expenses were £316,219 (£196,134) and gross profit was £191,284 (£192,377). Interest, discount on issue of bills, redemption, sinking fund, &c., required £77,698 (£70,857), payment to tramways department for interest and sinking fund in respect of feeder cables, &c., £1,007 (£1,008), payment to Taine and Rea Drainage Board for interest and sinking fund in respect of intercepting sewers and railway siding £1,084 (nil), interest on deposits £110 (£84), carried to renewals and special expenditure account £22,000 (£25,000), and the surplus for the year was £29,497 (£35,385). The year's contribution to the rates is £25,498 (£35,385). The reserve fund amounts to £88,128 (£85,543), and the renewals fund to £62,679 (£56,379). Lamp connections are equivalent to 333,741 (315,594) 60-watt lamps, and motor connections to 106,637 (76,563) H.P. Units sold were 117,016,321 (82,909,182). Average price obtained was 1·04d. (1·125d.) per unit.

Colchester.—The tramway accounts for the year ended March 31 show total capital expenditure £69,471 (no increase), of which £23,785 has been repaid.

Revenue was £15,740 (compared with £13,821 in previous year), working expenses were £10,670 (£9,569), interest required £1,852 (£1,986), repayment of loans £2,590 (£2,496) and special allowance to wives and dependents £186 (£171), leaving net profit £440 (compared with a deficit of £402). Tickets issued were 2,816,617 (2,434,786), car-miles run 331,099 (332,963), and units used 454,827 (445,214). Total revenue was 11·41d. (9·963d.) per car-mile, and average working expenses, including power, were 7·734d. (6·898d.). Average fare charged per mile was 0·96d. (as in previous year).

Leeds.—The accounts of the electricity supply department for the year ended March 31, which were passed before the Electricity Committee last week, show total capital expenditure £1,519,614, and the net amount of debt is now £1,001,578.

Revenue was £187,724 (compared with £170,021 in previous year), working expenses, insurance, &c., amounted to £75,143 (£65,621), leaving gross profit £112,581 (£104,399). Interest required £35,845 (£32,547), leaving net profit £72,720 (£69,248). Redemption required £55,630 (£45,024) and £8,373 (£12,053) was contributed for capital expenditure, leaving surplus profit £8,716 (£12,170).

In his report, the manager, Mr. C. Nelson Hefford, says the net result of the war conditions has been to impede the progress of the business for the time being, the income being less and the expenditure increased. There was no increase of charges for current in the year under review, and an increase of no more than 10 per cent. has been considered necessary for the current year. Units sold were 44,789,222 (compared with 43,145,978 in previous year). Traction units show a decrease of 3,855,719. Owing to restrictions on the laying of cables the consumers only increased from 14,121 to 14,929. For the first time power supply was the largest source of income, £91,885 (against £72,545). Sales for street lighting decreased 58 per cent. Heating units were 673,855 (440,161), exclusive of consumption by consumers using electricity for heating and who take their supplies on the residential bulk system. These consumers took 328,266 (47,102) units. Under this system a fixed annual charge is made based on rateable value of premises, plus ½d. per unit. Increase in working expenses is accounted for to the extent of £6,768 by the advance in the price of coal, although the department had favourable contracts. There were at March 31, 1916, 95 employés serving with H.M. Forces, and the amount paid to their dependents was £2,041. Aggregate horse-power of motors connected is 38,054 (31,114). Working expenses per unit sold were 0·40d. (0·36d.), and all expenses, including capital charges, taxes and contributions to capital expenditure, amounted to 0·55d. (0·88d.). Maximum load was 16,700 kw. (increase 230 kw.), the capacity of the plant remaining unaltered, viz., 26,600 kw.

Lincoln.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £90,916 (increase £5,466), and the outstanding debt is £46,548.

Revenue was £17,420 (compared with £15,020 in previous year), and working expenses were £10,516 (£7,189), leaving gross profit £6,923 (£7,831). Repayment of loans and interest required £5,202 (£4,668), and the net profit was £1,689.

The report of the engineer (Mr. Stanley Clegg) says the output was 3,152,831 units, increase 38 per cent. It is almost entirely the power supply which has caused this expansion of nearly a million units. For the first time private lighting shows a decrease (94,618 units).

There has been a good deal of discussion on the relation between the supply of electricity for power and for lighting, and the relative advan-

tage or otherwise of the supply of cheap electricity for power purposes. Mr. Clegg has gone into the question of the amount of plant which it would have been necessary to have had installed even if the supply had been confined to lighting, and no motors of any description had been connected. He took observations from pre-war Saturday night loads on the works, takeng care to ascertain that none of the large power consumers were running at the time. From these figures he found that, in order to guarantee continuity of supply and provide against breakdown of any one of the larger sets, it would have been necessary that the whole of the present machinery should have been installed, with the exception of the turbo-alternator and its boiler equipment. The capital expenditure on the works would have been about £65,000, which also excludes all mains specially laid for power purposes, leaving the balance of the capital expenditure (£25,000) as being expended solely for the supply of power, which would be represented by the turbo-alternator set and power mains. Interest and sinking fund payable during last year was £5,202. This would mean that £3,700 was chargeable to the lighting plant and £1,500 to the power plant. The income derived last year from lighting was £7,755, which, after the payment of working expenses, would have to meet the above charge of £3,700 before any surplus profit could be shown, whereas, on the other hand, the income derived from power was £9,625, which, after payment of working expenses, even on its much larger equivalent unit output, only has to meet capital charges of £1,500. The spare plant installed for the lighting and included in the figure debited to lighting, however, also serves as a spare for the power plant, and some allowance may be made on the above capital distribution for that reason. These figures show conclusively why it is possible, and reasonable, to sell electricity used continuously for power, as opposed to electricity used only intermittently for this purpose, at a very considerably lower rate than for lighting, and yet carry on a profitable business. There is not the least doubt that this last year, had it not been for the very large increase in power supply, the results, from a financial point of view, would have been very different.

Though there may be a certain falling off after the war, the firms who are now users of electric motors, and have experienced the advantage of their use over many other prime movers, will no doubt continue their use in the development of their ordinary trade. During the year it has been necessary to turn down more than one application for power, the principal one being for 150 h.p. for a 24-hour per day demand. Despite the falling off in electricity used for lighting, there has, nevertheless, been an increase in the number of lamps connected of 3,219 30-watt equivalents, compared with 2,700 last year, and the increase in the horse-power of motors connected is 255. This latter increase, however, does not include the large extensions which have been made at Messrs. Clayton & Shuttleworth's, of which particulars have not been obtained, but which must represent a figure much larger than the above total. Coal cost 0·383d. (0·256d.) per unit, total working costs were 0·800d. (0·753d.), and interest and sinking fund required 0·396d. (0·489d.). In spite of large increases of cost of coal, &c., the total cost per units is less—viz., 1·196d. (against 1·242d.)—owing to the extraordinary increase in output. Average weight of coal used per unit was 4·095 lb. (against 4·13 lb.). Units generated were 3,735,182 (2,674,871), and sold 3,152,831 (2,291,114). Total maximum supply demanded was 1,351 kw. for lighting, &c., and 100 kw. for traction. Equivalent 8 c.p. lamps connected are 132,235 (121,853).

The tramway accounts show total capital expenditure £41,987 (no increase), of which £13,922 has been repaid. Revenue was £7,424 (£6,598), working expenses were £4,215 (£3,941), interest required £1,529 and sinking fund £1,071 (both as in previous year), leaving a surplus for the year of £608 (compared with £57). Passengers carried were 1,992,213 (1,713,512), car-miles run 117,070 (118,440), and total units used 177,636 (173,895). Total revenue per car mile was 12·03d. (10·59d.), and working expenses, including power, were 6·88d. (6·37d.). Average fare charged per mile was 0·428d. (as in previous year).

Mr. Clegg says in his report on the tramways, if more cars could be manned even larger profits could have been made, but the Corporation may expect to lose more of their men during the present year, and it will probably be difficult to maintain even the present service. Although car-miles run have been about 1,100 less, total running expenses have increased £274, due to increased wages and increased cost of material. There is a large saving on the upkeep of permanent way, but the track is not in as good a state as usual. Electrical equipment of line (repairs to "G.B." equipment), on the other hand, shows a large increase, the total cost being £229, as against £149 last year. The year just completed was the tenth year of the agreement entered into with the "G.B." Surface Contact Co. for guaranteed upkeep, and, taking it into account with the other years, the average cost of upkeep of the "G.B." equipment for the period is now brought up to £130, as against £90 (i.e., £30 per mile of single track), the figure of the guarantee, or an increased cost of nearly 50 per cent. The extra cost this last year has been due to less favourable results obtained by the use of English carbons installed some two years ago, as compared with the life obtained from the previous ones, which were of French manufacture. Before putting the English type into use, experiments had been conducted with them over some three or four years, and from these trials good results had been obtained, but the bulk, unfortunately, have not come up to the samples, with the consequence that most of them had to be renewed after an average life of only about two years. However, experiments have been made during the last 12 months with a modified type of carbon, and it is hoped to get better results in future. The cost of upkeep of feeders has also been large, owing to the trouble which the floods have caused in recent winters. Upkeep of cars shows an increase of £73. This total was increased owing to failure of armatures and "G.B." magnet bobbins, due to exceptional snowy weather. 84 other municipal tramways operating on the overhead system for 1915 show an average figure for their total cost of 6·987d. per car-mile run, so that this year Lincoln is 0·107d. below the average. Lincoln has, by a small margin, run the least car-miles of any municipal tramway, the next being Lancaster, with 170,337 car-miles, and a total cost of 7·39d. per car-mile. The following is a comparison of the Lincoln figures for this year with those of Wolverhampton (the only other surface contact system remaining in this country) for the year ended March, 1915: Traffic expenses per car-mile, Lincoln, 2·67d. (Wolverhampton, 2·65d.); repairs and maintenance, 1·68d. (1·75d.); management and general expenses, 1·66d. (1·17d.); power expenses, 1·47d. (1·46d.); total, 6·88d. (7·03d.). Car-miles on the Wolverhampton tramways were 1,181,309, compared with Lincoln 147,070.

Manchester.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £3,112,406 (increase £60,091), and the outstanding debt is £1,738,726.

Revenue was £620,060 (compared with £543,546 in previous year), and working and general expenses were £371,514 (£295,444), leaving gross profit £248,486 (£248,102). £25,419 (£25,618) has been placed to renewals suspense account and £125,695 (£119,092) to sinking fund; interest required £67,919 (£68,466) and £30,000 (as in previous year) has been paid to City Fund in aid of rates, including £547 taken from reserve. The reserve fund amounts to £11,335 (£11,515), and renewals suspense account to £191,215 (£185,974). Kelvins generated were 181,322,835 (162,699,530) and sold 141,551,699 (127,735,646). Average price obtained was 1·03d. (1d.). Total maximum supply demanded was 52,976 (50,460) kw.

The report of the Electricity Committee calls attention to the fact that the expenditure included £11,110 for war service allowances and £11,308 additional income tax, due to the increase of the rate from 1s. 8d. to 3s. in the £. Borrowing powers for £126,420 were secured during the year. At the Stuart-street station the British Westinghouse Co. have completed the contract for a 5,000 kw. turbo-alternator, and a repeat order has been placed with them. Babcock & Wilcox have completed the contract for two water-tube boilers. To meet extensive demands for electric power contracts have been placed with Richardsons, Westgarth & Co. for a 15,000 kw. turbo-alternator plant, and with Babcock & Wilcox for additional water-tube boilers. The following contracts have also been placed: Mather & Platt, electrically-driven circulating water pumps; Babcock & Wilcox, coal-conveying plant; Strachan & Henshaw, ash telepher system; Aiton & Co., Newton, Chambers & Co. and Stavely Coal & Iron Co., pipework; British Thomson-Houston, e.h.t. switchgear; Klein Engineering Co., water coolers. Average price of coal has risen 3s. per ton during the year. Average weight of coal has risen 0·13 lb. per Kelvin sold. Static transformers aggregating 3,750 kw. have been added to Harpurhey sub-station in connection with the 11,000 volt bulk supply to Middleton Corporation. A list is given of 21 important firms to whom new or additional supplies of power have been or will shortly be furnished. About 11¼ miles have been added to the mains. The whole of the plant and mains has been kept in the highest state of efficiency out of revenue. The efficiency of the distributing system was 85·29 per cent.

COMPANIES' MEETINGS AND REPORTS.

BRITISH ELECTRIC TRACTION CO. (LTD.)—The directors' report for the year ended March 31 states that the gross profit amounts to £244,061. 19s. 9d., compared with £235,508. 5s. 4d. for 1914-1915. After deducting general expenses and amount written off sundry assets (£34,895. 14s. 10d.) there remains £209,169. 4s. 11d., to which is to be added the amount brought forward (£71,398. 17s. 4d.), making £280,568. 2s. 3d. Deducting debenture stock interest (£91,259. 15s. 8d.) there remains £189,308. 6s. 7d. The directors recommend that £20,327. 11s. be placed to reserve, that a dividend of 6 per cent. for the year be paid upon the cumulative participating preference stock (£12,761. 13s. 1d.), and a dividend of 3 per cent. for the year upon the ordinary stock (£39,787. 18s. 1d.), leaving to be carried forward £86,128. 4s. 5d. The scheme of reduction and rearrangement of capital has been confirmed by the Court, and given effect to in the accounts.

The investments consist of shares and debentures in tramway, omnibus, electricity supply, manufacturing and other companies, Government, municipal and sundry other investments. They stand at £4,276,857. 10s. 11d., after deducting £1,001,602. 5s., by which amount the capital has been reduced. The revenue from investments amounted to £222,330, representing an average yield of 5·19 per cent. for the past year. In respect of the award of the arbitrator in regard to the sale of the tramway undertaking of the Devonport & District Tramways Co. to Plymouth Corporation, it is estimated that the company will receive about £86,000 in respect of its holding in the Devonport Co.

BRUNNER, MOND & CO. (LTD.)—At the annual meeting on Friday a dividend of 27½ per cent. (less tax) was declared on the ordinary shares, and the proposed working agreement with the Castner-Kellner Alkali was approved.

HAVANA ELECTRIC RAILWAY, LIGHT & POWER CO.—The gross earnings for 1915 were $5,511,302 (against $5,396,713), operating expenses and taxes $2,337,506 ($2,595,321), net income $3,293,796 ($2,801,392), other income $147,874; gross income $3,351,671 ($2,903,511), fixed

charges $1,115,413 ($1,091,139), surplus $2,236,257 ($1,809,371) and total surplus $3,711,655, which was disposed of as follows: Dividends paid during year (6 per cent. on preferred and 5½ per cent. on common stock, $1,722,162; transferred to sinking reserve, $101,535; applied in redemption of consolidated mortgage bonds, $178,000; profit and loss balance carried forward, $1,709,956. The expenditure on new construction during year was $1,258,091.

LANCASHIRE POWER CONSTRUCTION CO. (LTD.)—The directors' report for the year ended March 31 states that the trading profit of the Lancashire Electric Power Co. for the year 1915 amounted to £32,235. 9s. 8d., to which has to be added interest on hire purchase plants, &c., amounting to £607. 2s. 3d., making £32,842. 11s. 11d., compared with £30,471. 10s. 8d. for 1914. With £3,421. 13s. 7d. brought forward, the amount available for division is £36,264. 5s. 6d. After paying debenture interest (£4,500), placing £15,000 to reserve, a dividend of 3 per cent. on share capital is recommended (£14,700), leaving to be carried forward £2,064. 5s. 6d. The units generated amounted to 35,768,064, against 32,157,185 in 1914, and 28,191,442 in 1913; the maximum load in kilowatts was 10,740, against 10,210 and 9,720; the horse-power connected 29,000, against 27,018 and 23,900. The receipts were £72,395, against £65,433, the profit on trading being £32,235, against £29,961 and £22,785 respectively.

The revenue account of the Lancashire Power Construction Co. shows that the total receipts for the year ended March 31, 1916, amount to £19,200, and after deducting therefrom the expenditure of £15,257. 11s. 1d. the available balance is £3,942. 8s. 11d., which it is proposed to carry to reserve.

RANGOON ELECTRIC TRAMWAYS & SUPPLY CO. (LTD.)—The chairman (Sir Frederic W. R. Fryer, K.C.S.I.) stated that they were paying a dividend at rate of 3 per cent. (tax free) on the ordinary share capital, which was at the same rate as last year, carrying forward £2,783. Owing to the continuance of the war there had been a decrease in the takings of the tramway and motor omnibus services compared with 1914 of approximately £2,800. During the current year the traffic, while keeping steady, did not so far show any marked tendency to improve over the figures for 1915. The gross receipts for current supplied for private lighting and power showed an increase of 13·77 per cent., against 11½ per cent. in 1914. The working expenses were 41·64 per cent. of the receipts, against 43·14 per cent. The house-wiring and supply department continued to be satisfactory and to make fair profit. The high cost of coal and all materials still continued, and signs were not wanting that the increase was likely to be even more acutely felt during the present year. The directors hoped that the 10 per cent. increase which they had made in the charges for current would prove in some measure sufficient to counteract the influence of the cost of materials. To meet the increasing public and private demand for electrical energy the directors foresaw that further capital expenditure would in all probability have to be incurred.

RICHARDSONS, WESTGARTH & CO. (LTD.)—Mr. D. B. Morison presided at the meeting last week, and said that all their works were very fully employed, but they were suffering severely from shortage of labour. The profits for the past year were £76,240, being the largest since 1903. At the commencement of the war they had a very large amount of work contracted for at a small margin of profit. After completing the machinery for 26 steamers at the original contract prices, and all at an increased cost, the position became so difficult by reason of their inability to obtain materials except at current rates that, in order to accelerate deliveries, they offered to complete at net cost, plus a small profit. Their customers met them very fairly in the matter, with the result that 70 per cent. of the outstanding marine contracts were arranged on that basis. No allowance for depreciation was made during the years 1908 to 1914 inclusive. At the rate of £15,000 per annum, which, in his opinion, was the minimum required, the depreciation yet to be provided for that period amounted to £105,000. That still left the main question of reconstruction untouched. Partnership with the Leylands Motor Co. commenced on Jan. 1 of this year. In reply to criticism of the accounts, he said the average profits from the formation of the company until the end of last year were about £50,000 per annum, and although the next three or four years must somewhat raise that average, a not unreasonable forecast was that ultimately manufacturers would have to submit to stress, the intensity of which would be unparalleled. It was, therefore, imperative that such profits as they are permitted to retain by the Government should be largely utilised in modernising the plant. It would be in the best interests of the industries of this country if the Government would consent in old-established concerns like theirs, where modernisation was imperative, for a liberal amount to be set aside from profits for bringing the plant up to date before any portion was taken by the Government, as unless this country was able to successfully compete with other countries after the war it would be unable to meet its enormous liabilities.

SINGAPORE ELECTRIC TRAMWAYS (LTD.) Sir Frank A. Swettenham, G.C.M.G., who presided at the meeting last week, said that the net profit for the year 1915 was £3,883. Compared with 1914, the traffic receipts increased by £2,340, and the sale of electrical energy by £1,305. Power expenses were £1,600 less than in 1914, due to the larger proportion of the total power generated by the Diesel plant. They carried 15,438,809 passengers, against 14,921,852. The total expenses represented 62·2 per cent. of the total receipts, while the Singapore expenses were 59·5 per cent. of the Singapore revenue, compared with 56 and 54·3 per cent. respectively for 1914. In many instances their stores were costing more than 100 per cent. over pre-war prices, and the tendency was to go higher. The new and higher rates came into operation on Jan. 1 last, and the returns since that date justified their action, for their receipts were 13 per cent. higher. An estimate had been prepared of the track renewal work required, and, as stated in the circular issued in January last, amounted to £103,000. The work might be extended over a period of eight years. It was practically impossible to obtain material at present, certainly as regards rails and other steel work, and the price of cement was too prohibitive to allow of large works being undertaken. Apparently that state of affairs would continue till the end of the war, and the board had no option but to postpone the commencement of the renewal work. The result of any lengthy delay in commencing the work must be to increase the cost of track and car maintenance. The three new Diesel engines had been running for some time. Two of them were to supply the Municipal Commissioners with energy for lighting the Tanglin district. The municipality had not completed their arrangements for taking the supply, but the delay was automatically extending their contract, which ran for 10 years from the date when they began to take current.

WAYGOOD-OTIS (LTD.)—For the year ended March 31 the profit was £12,798, to which must be added the provision for dividend on preference shares to March 31, 1915, not paid (£1,875), less balance of last year's profit and loss account (£138), making a total of £14,534. Depreciation of plant, patterns, &c., absorbs £3,900. Otis amalgamation expenses £1,022, chairman and managing directors' remunerations, salaries of directors, &c., £6,542, and national service grants to dependents of employees £2,396, leaving a balance of £671.

NEW COMPANIES.

COLEMAN & APPLEBY (LTD.) (144,022.)—Reg. June 5, capital £3,500 in £1 shares (3,000 6 per cent. cumulative preferred), to enter into an agreement for purchase of business of Langbein-Pfanhauser Works (Ltd.), and to carry on in the United Kingdom and its colonies or elsewhere the business of electro-metallurgists, electroplaters, manufacturers of and dealers in dynamos, electric motors, switches, and all kinds of electrical apparatus and instruments, machinery and materials for grinding and polishing, and all kinds of chemicals, electrolytic solutions, &c. Private company. First directors are O. J. Neale (chairman), C. B. Appleby, H. S. Coleman and one other to be appointed by the subscribers (all life directors). The directors may not allot any shares or register any transfer of shares to a foreigner or a foreign corporation, or a corporation under foreign control, without consent of Board of Trade.

GEORGE H. ALEXANDER ENGINEERING CO. (LTD.) (143,995).—Reg. June 1, capital £15,000 in £1 shares (5,000 preference), to take over the business carried on as Geo. H. Alexander, to carry on the business of mechanical, electrical, aeronautical, marine and general engineers, machinery manufacturers, &c. Private company. First directors are G. H. Alexander (chairman), H. W. Alexander and A. H. Alexander. Reg. office: 34, Waterloo-street, Birmingham.

MANDER & CO. (LTD.) (143,989).—Reg. May 31, capital £2,000 in £1 shares, to take over the business of electrical and mechanical engineers carried on at Birmingham, and to adopt an agreement with A. F. Mander. Private company. First directors are A. F. Mander and J. E. Bendall (both permanent). Reg. office: 125, Hockley-hill, Birmingham.

MOORE & AVERY (BLACKBURN) (LTD.) (143,986).—Reg. May 31, capital £1,000 in £1 shares, to develop and turn to account any patents, licenses, inventions, &c., to carry on business as manufacturers of and dealers in machinery, plant and appliances, electrical engineers, munition manufacturers, founders, &c. Private company. First directors are R. Moore, A. Avery, F. Boothman and G. E. Walker (all permanent).

OLIVER LING & CO. (LTD.) (143,911.)—Reg. May 23, capital £20,000 in £1 shares, to carry on the business of railway, electrical, mechanical and general contractors and engineers, to construct and equip railways, light railways, aviation grounds and works connected with aerial transport and construction, &c., and to adopt an agreement with J. R. Ling. Private company. First directors are F. L. Oliver, J. R. Ling and O. G. C. Drury. Reg. office, 38, Victoria-street, S.W.

STRAND ELECTRIC & ENGINEERING CO. (LTD.) (143,933.)—Reg. May 25, capital £750 in £1 shares, to carry on the business of manufacturers of and dealers in machinery, gas, steam and oil or petrol engines, electric motors and lamps, electrical accessories and apparatus, and any kind of electrical, mechanical or automatic apparatus for the production of electrical stage effects, cinematographs, &c. Private company. A. T. Earnshaw signs documents as managing director. Reg. office, 66A, St. Martin's-lane, E.C.

TELEPHONE MOTOR WORKS (LTD.) (143,934)—Reg. May 25, capital £1,000 in £1 shares, to take over the business of motor engineers, makers and repairers, &c., carried on as the Telephone Motor Works. Private company. First directors are A. J. Watt (man. director) and C. W. G. Green. Reg. office: 15B, Allsop-place, Baker-street, W.

CITY NOTES.

MEMORANDA (June 14).—**Bank rate 5 per cent. (since Aug. 8, 1914). Consols 61¼. Consols Pay Day, July 5. Stocks and Shares Ticket Days, June 28 and July 12. Pay Days, June 29 and July 13. Price of silver, 30⅛d.**

AUTOMATIC TELEPHONE MFG. CO. (LTD.)—The preference share and transfer books will be closed from the 17th to 24th inst., inclusive, for preparing the dividend warrants on the 6 per cent. preference shares for half-year ending 30th inst.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units sold to consumers during the four weeks ended April 28, 1916, amounted to 1,917,213, compared with 1,804,722 units in the corresponding four weeks of 1915.

CANADIAN ELECTRIC POWER COMBINATION.—The Civic Investment Industrial Co. has been organised with an authorised capital of $75,000,000 (£15,660,000), to take over the undertakings of the Montreal Light, Heat & Power Co. and the Cedars Rapids Mfg. & Power Co., and to operate them under an agreement for 98 years. The Civic Company propose to issue $65,000,000 (£13,000,000) capital, and will take over the Montreal Light, Heat & Power Co. on the basis of three shares of the new company for one share of the power company, and one share in the new company for each share in the Cedars Rapids Co. The new company will commence operations on Aug. 1.

NATIONAL ELECTRIC SUPPLY CO. (LTD.)—An interim dividend at the rate of 5 per cent. per annum (2s. 6d. per share) has been declared on the ordinary shares for the past half-year.

NORTHERN COUNTIES ELECTRICITY SUPPLY CO. (LTD.)—The report for 1915 states that after providing for debenture interest and including £1,155 loss on conversion and realisation of Consols, the debit to profit and loss is increased to £6,654.

PROVINCIAL TRAMWAYS CO.—An interim dividend of 8d. per share has been declared on the ordinary shares on account of the profit which may be made in the financial year ending Sept. 30, 1916.

SHAWINIGAN WATER & POWER CO. (LTD.)—A dividend at the rate of 7 per cent. per annum has been declared on the common shares for the quarter ending June 30.

YORKSHIRE (WEST RIDING) ELECTRIC TRAMWAYS CO. (LTD).—The directors have decided to pay on July 1 an interim dividend of 3 per cent. (being at rate of 6 per cent. per annum) on account of the dividend accrued on the 6 per cent. cumulative preference shares.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date June 13, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17½d.
Solid Drawn Copper Tubes	19½d.
Brazed Copper Tubes	19½d.
Brazed Brass Tubes	19½d.
Brass Wire	17½d.
Copper Wire	20d.
Rolled Brass	17½d.
Brass Sheets	18½d.

	per ton.
Copper Sheets	£168 0 0
Spelter	£71 0 0

	per ton.
English Lead	£32 15 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£100 0 0
Clean Brass Scrap	£67 0 0
Braziery Copper Scrap	£86 0 0
Old Lead	£27 10 0
Old Zinc	£48 0 0
Hollow Pewter	£125 0 0
Black Pewter	£85 0 0
Gun Metal	£80 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date June 13, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£65 0 0
Clean Copper	£98 0 0
Braziery Copper	£86 0 0
Gun Metal	£80 0 0

	per ton.
Old Lead	£23 10 0
Tea Lead	£27 0 0
Old Zinc	£52 0 0
Hollow Pewter	£130 0 0
Shaped Black Pewter	£90 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £86; Commercial Tinman's Solder, £112; Blowpipe Solder, £122.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, June 13. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., June 13.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	8	5 12 6	Feb, Aug
10	6%	Do. 6% Cum 2nd Pref.	10⅛	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅛	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	81¼†	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 8	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	7 3 3	..
5	5%	Do. Ord.	3¼	7 1 7	Aug, Feb
5	4½%	Do. City Pref.	3	7 10 0	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅛	6 5 6	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	1..⅛	6 12 8	Feb, Aug
10	6/0	Do. 6% Pref.	10⅛	5 16 4	Mar, July
St.	5%	Do. 5% Deb. St.	99½	5 0 6	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10⅜	6 12 7	Mar, Sept
10	6%	Do. 6% Pref.	10¼	5 18 6	Feb, Aug
St.	4½%	Do. 1st Deb.	86½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	83	5 8 5	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	75½	5 18 10	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6/-	London Elec. Supp. 6% Pref.	4	6 17 2	..
St.	4%	Do. 4% Mort. Debs.	82½	4 17 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅜	6 6 2	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92½	5 8 3	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref.	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	2¼	7 5 5	Mar, Sept
		Electricity Supply—*cont.*			
5	8%	St. James' & Pall Mall Ord.	5⅛	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅛	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	71½	6 5 10	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅛	6 18 5	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5⅛	5 17 11	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4½	5 5 11	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	80	6 5 0	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	75	8 0 0	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	71½	5 12 3	..
St.	4%	Do. do. Assented Def. Ord.	65⅛	6 1 8	..
St.	4½%	Do. 4½% Pref.	80½	5 11 10	Jan, July
St.	4%	Do. 4% Deb. St.	76½	5 4 7	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	70⅜	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅜	5 16 1	Jan, July
St.	4%	Do. 4% Pref.	65½	6 2 2	Mar, Sept
St.	4%	Do. 4% Debs.	73½	5 8 0	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	27⅞	3 12 11	Feb, Aug
St.	3½%	Do. 3½% Pref.	64½	5 8 6	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	61	5 14 9	Feb, Aug
St.	3½%	Do. 3½% A Debs.	66	5 6 1	Jan, July
St.	3½%	Do. 3½% Debs.	68⅞	5 2 4	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75	5 6 8	May, Nov
St.	4½%	Do. 4½% First Pref.	71	5 18 8	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	110	5 9 1	Jan, July
St.	4%	Do. 4% Debs.	73½	5 8 10	Jan, July
St.	4%	Do. 4% Debs. (1903-51)	72	5 11 1	Jan, July
St.	4%	Do. 4% Guar. Stock	68⅞	5 17 0	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2⅜	5 9 1	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅜	5 17 11	Mar
100	5%	Do. Prior Lien Debs.	94	5 6 5	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10⅞	6 19 6	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M. Ericsson Mfg. Co. 6% Pref	⅞	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	6 8 0	April
100	6%	Do. 6% Prior Lien Debs.	100½	5 19 5	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	68	5 17 8	Jan, July
5	20%	Callender's Cable, &c., Co. Ord. xd & bonus	12⅛†	8 3 3	Jan, July
5	5%	Do. 5% Pref.	4½	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅜	8 14 7	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	⅛	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	⅜†	10 0 0	May
1	7%	Do. 7% Cum. Pref.	⅜†	7 4 6	Jan, July
St.	4%	Do. 4% Debs.	71½	5 11 6	Jan, July
10	10%	General Electric Ord.	11⅛	8 15 10	July
10	6%	Do. 6% Pref.	9⅜	6 3 6	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15⅛	6 12 9	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4½	4 14 9	..
St.	4½%	Do. 4½% Db.	87½†	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	11⅛	8 16 10	Feb, Aug
10	5%	Do. Pref.	8⅜	6 2 2	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39½	6 1 6	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1⅛	4 2 9	May, Aug
1	6d.	Do. 5% Pref.	⅜	5 10 4	May, Aug
St.	4%	Do. 1st Debs.	78½†	5 0 11	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½†	4 10 5	Jun, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40⅞	10 2 6	..
St.	4%	Do. 1st Mt. Deb. St.	56†	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	103	5 16 6	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	22½	6 13 4	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	69⅞	5 14 6	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7⅛	6 10 1	May, Nov
10	10%	Do. 10% Pref.	13½	7 7 10	..
5	5/0	Direct Spanish 10% Pref.	7⅛	6 13 4	..
10	4%	Direct United States	6⅛	7 10 7	Ja,Ap,Jly,O
St.	8%	Eastern Tel. Co. Ord., xd & bonus	141½†	5 10 9	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	65⅛†	5 6 11	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	77½	5 3 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78½	5 2 3	Feb, Aug
10	8%	Do. Ord., xd & bonus	14⅜†	5 12 9	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co. with Coup. 10	37½	5 18 1	Ja, My, Jly
25	13%	Indo-European	49	6 12 8	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2⅛	4 0 0	April
1	7%	Do. 7% Pref.	2	3 10 0	July
10	1%	West India & Panama Ord.	1	10 0 0	May, Nov
10	6%	Do. 1st Pref.	7½†	8 5 6	May, Nov
10	8%	Western Telegh. Co.	14⅜	5 9 10	Mr,Jly,O,Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 7	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99	4 10 11	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅛	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	1⅛	5 3 3	Apl, Oct
St.	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Do. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6¼†	6 1	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅜	5 10 4	Jan, July
St.	4½%	Do. Deb. Stk.	85½	5 5 7	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12½	4 15 1	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10⅜	5 13 7	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	83½†	5 19 9	Ja, Apl, Jly,O
..	4%	Do. $100 Pref	70½†	5 15 10	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅜	6 5 2	Mar, Sept
St.	5%	Do. 5% Debs.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10½	5 14 3	..
St.	4½%	Do. 4½% Debs.	85	5 5 11	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6½	7 6 11	May, Nov
5	5%	Do. 5% Pref	4½	5 11 1	Mar, Sept

† Ex dividend or interest.

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,988. [Vol. LXXVII. No. 12.] **FRIDAY, JUNE 23, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 375
Arrangements for the Week .. 378
The Convention of the Incorporated Municipal Electrical Association ..... 379 & 404
Presidential Address. By A. C. Cramb 379
Boiler-House Design & Operation. By W. W. Lackie .. 381
The Generation of Electricity on a Small Scale or Bulk Supply. By H. S. Ellis. Illus. 383
The Application of Electricity to Agricultural Purposes. By W. T. Kerr. Illustrated 386
Recent Practice in the Manufacture, Laying and Jointing of 33,000-Volt 3-Phase Paper Insulated Underground Cables. By C. Beaver, M.I.E.E. Illus. .. 389
The Construction of High-Tension Cable Joints. By P. Torchio. Illustrated .. 391
Switchgear for Central Stations and Isolated Plants. Illustrated 394
SMALL STATIONS *v.* BULK SUPPLY 398
Edison Battery Vehicles in Municipal Service. By W. H. L. Watson. Illustrated 399
Electric Hot Water Supplies. By H. H. Holmes 401
The Bonecourt Boiler. Illustrated 403
LEGAL INTELLIGENCE 408
PARLIAMENTARY INTELLIGENCE 408
The "Electrician" Commercial and Industrial Section .. 409-416

NOTES.

The I.M.E.A. Convention.

ALTHOUGH the technical part of the Annual Convention of the Incorporated Municipal Electrical Association this year has been restricted to a single day, as on the last occasion, owing to the War, we think it may be said that the fare provided for the members has been more of an engineering character, and more reminiscent of past days. The Papers have been useful contributions, and have provided an ample basis for discussion, and thus we feel the Council may be congratulated on the programme they have been able to put together at a time when members have very little leisure on their hands for such matters. Apart from reports, only three Papers were presented. Of these we have dealt with that by Mr. H. S. ELLIS on "The Generation of Electricity on a Small Scale or Bulk Supply," in our Leading Article. The Paper by Mr. W. W. LACKIE deals with the important subject of "Boiler-House Design and Operation." Among other matters, reference is made to the somewhat misleading practice of expressing the results obtained from coal in terms of pounds of coal per unit generated. Such a basis, although it is convenient enough, leaves out of account the fundamental factor of the calorific value of the fuel. This may vary very considerably. Further, there is the cost of carriage. If the carriage of coal to all parts of the country were the same the basis of pounds per unit would provide results which would be more comparative, and in any case it is the cost that is eventually the important matter. Unfortunately, the cost of carriage varies materially in different parts of the country, and its proportion is not small, so that it is better to take as a basis the British Thermal Units per kilowatt hour, as Mr. LACKIE suggests, if we are to get a clear idea of what is being done in the boiler house. Mr. LACKIE also draws attention to the fact that calorific value alone is not a thoroughly satisfactory basis on which to purchase coal: account should be taken of the physical qualities as well as the calorific value.

THE third Paper was by Mr. W. T. KERR on "The Applications of Electricity to Agricultural Purposes." The subject is one which we are glad to see ventilated, and we congratulate Mr. KERR on writing such a Paper. So far, a good deal has been done in this direction in France, Germany, Denmark and other European countries. We recently called attention to the progress in the same direction in the United States. Canada also furnishes interesting examples, yet so far very little has been done in this country to obtain the patronage of the farmer. Mr. KERR shows what an excellent load may so be obtained. It is a desirable load, because it continues in one form or another throughout the year, and is not restricted to a particular part of the day. It is true that such operations as ploughing only take place during a short part of the year, but there are many other operations, such as chaff-cutting, sawing, pumping, &c., which are required more or less constantly. Moreover, the use of electricity means a considerable saving in labour, and it may mean a saving of horses, both of which facts appeal strongly to the average farmer. As will be seen on reference to Mr. KERR'S Paper, very good progress has been made at Hereford, and we see no reason why corresponding progress should not be made in other parts of the country.

The Allies and Trade After the War.

AN important economic conference of the Allies was held on June 14-17, when certain recommendations were made in regard to trade with the enemy powers during the war and after peace is declared. These recommendations are necessarily somewhat vague at the moment, and refer to three periods—namely, the war period, in which we at present find ourselves; the reconstruction period, during which we shall seek to restore to countries such as Belgium their raw materials and equipment; and, lastly, the peace period. Among other recommendations, it is suggested that during the reconstruction period the "most-favoured-nation" treatment shall be denied to the enemy powers, and protective measures shall be taken to prevent enemy dumping, and for preventing enemy subjects in Allied countries from engaging in industries which concern national defence or economic independence. One of the recommendations for the peace period provides for the assimilation of laws covering patents, trade marks and kindred matters. Although the subject of dumping has often been received with incredulity, we do not doubt that the manufacturers of this country will be relieved to see that this Conference has decided to take action to prevent the influx of

manufactured articles at prices considerably below market prices merely to obtain a footing in our markets and to damage our manufacturers.

Technical Teachers.

With reference to our recent comments on the above, we have received a letter from the Hon. Secretary of the Association of Teachers in Technical Institutions calling our attention to the work that is being done by this body. Notwithstanding the ambitious aims, objects and claims set out in a pamphlet, to say nothing of the manifold activities of the Association, the position of the technical teacher to-day is no better than it was 15 years ago, and in many respects it is decidedly worse. Local education committees still drive hard bargains, and teachers are, more or less, at the mercy of individuals. Our advice to technical teachers is to organise with the avowed object of pursuing an aggressive policy till such time as their wrongs are redressed. To do so now would be unpatriotic in addition to being unprofitable, as many teachers know who wonder what the morrow has in store for them. After the war, when public attention is focussed on higher technical education, and when there is likely to be a considerable demand for such education, is the time to be aggressive. In no other way can the technical teacher secure better conditions of employment and obtain remuneration commensurate with the cost of his training.

Joints in Extra High-Pressure Cables.

Elsewhere in this issue we publish two articles on the jointing of extra-high-pressure, three-phase, paper-insulated, underground cables. One of these, by Mr. C. Beaver, describes what may be regarded as British practice of the highest class, and the other, by Mr. P. Torchio, describes the corresponding practice in the United States. The straight-through joints described by Mr. Beaver were made on a 0·15 sq. in., 33,000-volt cable, and a pressure test of 75,000 volts for half an hour was specified. From the article it appears that the joint actually withstood 100,000 volts for 10 minutes without any signs of failure. An excellent feature of this joint is the bitumen-filled cast-iron box which encloses the hermetically-sealed cast-lead sleeve which surrounds the joint and which is wiped to the lead of the cable. The joint described by Mr. Torchio has been used on a 25,000-volt cable and a two-fold increase of pressure was applied continuously for over a fortnight without failure of the joint. One of the fundamental differences in the two methods of jointing is the filling of the box and the compound used. Mr. Beaver recommends a solid compound and a simple pouring process for filling the box; Mr. Torchio, on the other hand, uses a liquid filler and subjects the joint to a 14 lb. vacuum before filling. The method of protecting the solid insulation against electrostatic charges by means of a metal gauze is ingenious as also is the application of heavy lamp wick round the gauze to retain, by surface tension, the insulating oil in the splice. It is claimed that the joint described eliminates the trouble that has been experienced, in some cases, of the liquid filler running into the cable and leaving voids in the joint. From the two articles it would appear that the solid-filled joint is the simpler, although we have no doubt that experienced jointers quickly become familiar with both methods of jointing, and the fact that fundamentally different methods are being used for practically identical services should furnish information of considerable value to makers and users of extra-high-pressure cables.

'Stalwart Cast-Iron Columns."

A note in a recent issue of our esteemed contemporary, the "Journal of Gas Lighting," leads us to the conclusion that the writer of "Electricity Supply Memoranda" shines better as a journalist than as an engineer. Of his notes it may be said that although sometimes inaccurate they are always readable. Our friends should endeavour to reach the high standard of accuracy which they demand in others. Had they to do so we venture to think they would have more than sufficient to do in correcting their own faults to find time every week to fill columns of their "Journal," drawing attention to the joints in the armour of their trade rivals. To refer to the steel tubular poles which support tramway trolley wires as "stalwart cast-iron columns" may be clever journalism, but it is neither an accurate description of such standards nor is it engineering. It may be that to our contemporary all poles are alike.

Technical Education and the "Daily Mail."

According to our live contemporary, "British engineers have nothing to fear from German competitors in the field of sheer brain-power, but we believe it will be acknowledged that in *the source of that power—namely, a scientific State-encouraged system of technical education*—we have something to learn from our enemy." Our readers know the nature of the encouragement given by the State to technical education. Were the cause less worthy we should tire of pointing out that although grants practically as usual are being paid to local education authorities there is no technical education to speak of at the present time. In complimenting our contemporary we suggest to them the desirability of conducting a campaign to enforce a scientific State-encouraged system of technical education. Such a system when in full operation would make it unnecessary for high-salaried technical inspectors of the Board of Education either to dabble in research or to study toy-making. For many months we have been emphasising the importance of higher technical education, and many of those in high places who support us are afraid to use their pens on account of their official positions. It is sad to think that such people must perforce be silent. Is it that we are knaves in addition to being fools, in so far as when our people are rushing towards disaster we speak no restraining word lest we pay the forfeit by losing our positions?

Real Economy.

One of the economies recommended to the Southend Town Council at its meeting on the 20th inst. by a Special Committee appointed to consider the question is one likely to interest all electrical engineers and members of the Incorporated Municipal Electrical Association in particular. This takes the form of an instruction to the Highways Committee to consider the question of substituting electricity for gas in all streets, with a view to terminating in 1917 the agreement with the gas company. Such instruction, without the neat turns of speech one expects in terminating agreements, must be very annoying to the gas people in view of their recent publicity campaign. Nevertheless we compliment the Southend authorities on discovering where economy can be effected without decreased efficiency, and we have pleasure in drawing attention to the matter as it is unlikely that the gas people will do so on their economy posters which disfigure the hoardings.

Performance of 30,000-Kw. Steam Turbo-Generators.—*Erratum.* In the article on this subject in our issue of the 9th inst., the cost of the new turbo-generators and condensers was given at £1. 8s. per kilowatt. The cost should be £1. 16s. per kilowatt.

Collisions at Sea.—At the recent meeting of the Marconi International Marine Communication Co. it was stated that Mr. Marconi had invented a simple apparatus to prevent

accidents, and which would be worked from the ship's bridge by one of the crew. This invention, it is said, will put an end to all risk of collision in darkness or foggy weather.

Meter Approved by Board of Trade.—On June 19th the Board of Trade approved the construction and pattern of the Westinghouse single-phase watt-hour meter, Type K, for the measurement of electrical energy supplied on the constant pressure, two-wire, single-phase a.c. system, provided the meter be constructed as described in specification and drawings No. H3765 and in accordance with pattern meter No. 449,810 deposited with the Board of Trade, and the Board has also approved of the means provided for fixing and connecting such meters.

New Chemical Laboratories at Oxford.—The "Morning Post" referred recently to the opening of the new chemical laboratories at Oxford. When Mr. Perkin was appointed Waynflete Professor the Endowment Trustees of the University offered £15,000 towards the new buildings, the University authorities finding a suitable site. This sum was found insufficient, and Mr. C. W. Dyson Perrins, of Davenham, Malvern, and a former member of Queen's College, Oxford, offered £5,000, bringing the total to £20,000. Mr. Perrins subsequently gave a further £25,000, of which £5,000 is to be spent on equipment and £20,000 to be used as an endowment fund.

Sir R. Hadfield and Technical Training.—In replying to some of his French friends, Sir R. Hadfield (as reported in the "Sheffield Daily Telegraph") gives his opinions on this subject. In the opinion of Sir Robert, neither the scientific nor the practical man fulfils the required conditions in managing great business affairs. By the practical man is meant a man who has received a good secondary school training, but no special scientific culture, and by a scientific man, one who is a stranger to the experience and necessity of practice. It is necessary, therefore, to find a man who unites the various qualities. Non-success attends both the practical and scientific man who fails to develop the higher qualities. A man needs, above all, his personal application and intuition.

The Corrosion of Metals.—The Faraday Society has reprinted from its "Transactions" a series of Papers and discussions on "The Corrosion of Metals: Ferrous and Non-Ferrous." This comprises an introductory address by Sir R. Hadfield, F.R.S.; "Physical and Mechanical Factors in Corrosion," by Cecil H. Desch, Ph.D.D.Sc.; "The Relative Corrodibilities of Iron and Steel," by J. Newton Friend, D.Sc.; "Experiments on the Influence of Composition Upon the Corrosion of Steel," by Mr. L. Aitchison, M.Met.; "Note on the Corrosion of Iron and Steel," by S. Whyte, B.Sc.; "The Zinc-Copper-Couple Hypothesis of Brass Corrosion," by Arnold Philip; "The Corrosion of a Solid Solution," by W. E. Gibbs, M.Sc., and an account of a "Demonstration of the Cumberland Electrolytic Process for Preventing Corrosion of all Metals Immersed in Liquids," by E. Cumberland. The price of the reprint is 7s. 6d. net.

War Work.—It is announced by the Secretary of the War Office that 250 examiners of engineer's work are urgently required for service at home. The qualifications essential are: (1) An apprenticeship (or its equivalent) of not less than three years in engineering workshops, followed by further experience in shops producing engineering work of an accurate nature. Some portion at least of the experience must be recent, as the rapid advances of late years in workshop practice have rendered earlier experience quite out-of-date as regards this work. (2) Familiarity with and skill in using fine measurement tools (micrometer, vernier caliper, vernier protractor, height and depth gauges, &c.). (3) Experience in actual detailed inspection of engineering parts, and knowledge of the working methods needed for setting up for examination and measurement pieces of an awkward shape or complicated character. (4) A complete knowledge and comprehension of the meaning and object of limit systems; a working acquaintance with one or more such systems (preferably including the "Newall"), and good experience in the use of limit gauges. (5) A reasonable standard of education, and ability to render clear written reports. Rates of pay 50s. to 60s. weekly, plus allowance of 21s. weekly up to three months at one station; also a special war increase of 4s. per week, and overtime at common-time rates after 48 hours per week. Preference will be given to men over military age, men in the older married groups, and men unfit for general service; but men of any age may be taken if they are highly skilled. All applications should be addressed "Room 268, A. G. 2 B, War Office," enclosing credentials.

Electricity Defined.—From Cleveland, Ohio (U.S.A.), we have received a postcard dealing with this subject in the following terms:—

CLEVELAND,
THE FIRST CITY TO DEFINE ELECTRICITY.
A Challenge to the Leading Thinkers of Any City of the World.

Electricity is gravitation operating under specific control. It is not a distinct entity, but the relative condition of an entity. Gravitation is ether particles which have absolute motion, infinite velocities, eternal without change and which move in all directions throughout the Universe in straight lines. All other forms of motion of the ether particles are forms of energy or matter. A circuit is a region of controlled gravitation. A dynamo is a device to operate the controlled gravitation of a circuit against a resistance. The operated gravitation is termed the electric current of the circuit and which is modified by specific resistances into forms of energy as heat, light, power and battery charge. The falling apple is operated by "natural" gravitation. Should the apple "fall" sidewise by gravitation the phenomenon would be termed electrical, &c., &c., &c.

AN ENTERPRISE OF
THE CLEVELAND SCHOOL OF THE UNIVERSITY OF THE WORLD.
Instituted to Propagate the Method of Right Thinking,
By C. A. BOWSHER.
Caxton Building, Cleveland, Ohio.

Engineering Research Committee.—The Standing Committee on Engineering appointed by the Advisory Council for Scientific and Industrial Research held its first meeting on Wednesday, June 7th. The committee has been so constituted as to represent both the scientific and the industrial sides of engineering, and includes the following members nominated by the professional associations:—

Institution of Civil Engineers, Sir Maurice Fitzmaurice, C.M.G.
Institution of Electrical Engineers, Mr. J. S. Highfield.
Institution of Mechanical Engineers, Dr. Dugald Clerk, F.R.S.
Institution of Naval Architects, Sir Archibald Denny, Bart.
N.E. Coast Institution of Engineers and Shipbuilders, Mr. Herbert Rowell.
Manchester Association of Engineers, Mr. Alfred Saxon.
Institution of Engineers and Shipbuilders in Scotland, Mr. James Brown.

and the following members appointed directly by the Advisory Council: Mr. F. R. Davenport, Mr. Alfred Herbert, Prof. Bertram Hopkinson, F.R.S., Mr. C. H. Merz, Mr. V. L. Raven, Mr. A. A. Remington, Mr. G. Gerald Stoney, F.R.S., Mr. Douglas Vickers, Prof. Miles Walker. The Advisory Council have appointed Sir Maurice Fitzmaurice, C.M.G., to be chairman.

The committee was welcomed by Sir William M'Cormick, chairman of the Advisory Council, and Dr. H. F. Heath, Administrative Secretary of the Council. Sir A. Selby-Bigge, Secretary to the Committee of the Privy Council for Scientific and Industrial Research, also attended and emphasised the importance attached by the Government to the need for greatly increased activity in research in connection with industry. In Sir Maurice Fitzmaurice's opening statement as chairman of the Standing Committee, several important aspects of the Government scheme as issued in July, 1915, were referred to, and attention was directed in particular to the necessity for securing that British industries shall get as large a share as possible of the full value of the results of any successful researches, and shall retain at least the initial advantages derived from them. He felt in this connection that the committee would be in a position to advise the Government organisation for research as to the means of securing that their operations should yield the maximum benefits to the trade and industry of the Empire. Much time and money had been spent upon research in the works of individual firms whose aggregate expenditure for the purpose far exceeded the sums at the disposal of the committee of the council. But the Government had made a decided step forward by showing their interest in industrial research. Sir Maurice Fitzmaurice hoped that it would be possible to co-operate with our fellow-countrymen beyond the seas in carrying out many useful investigations.

The Late Prof. S. P. Thompson.—At a special general meeting of the Institution of Electrical Engineers held on Thursday, June 15, the President (Mr. C. P. Sparks) said, before taking the business for which the meeting was called, there was one matter to which he would give precedence. Since they last met they had all lost a friend. Dr. Thompson passed away on Tuesday (June 13) unexpectedly. He was such an old friend of so many of those present that he (the President) took the earliest opportunity of asking the Institution to pass a special resolution with regard to the great loss they had sustained. The resolution was:—

"That the members of the Institution of Electrical Engineers have learned with profound regret of the death of Dr. Silvanus P. Thompson, Fellow of the Royal Society and Past President of the Institution of Electrical Engineers, and hereby desire to express their most sincere sympathy with Mrs. Thompson and family in the great loss they have

sustained by his death; and the members desire also to express their sincere appreciation of the great services rendered by Dr. Thompson to the Institution and of his valuable work in the advancement of science and its applications."

The members, standing, passed the resolution in respectful silence.

The remains of the late Prof. Thompson were cremated at Golder's Green last Friday, and a special meeting was subsequently held at the Friends' Meeting House in St. Martin's-lane.

The meeting was very largely attended by scientific men, including: Lord Reay, Sir William Crookes, Sir J. J. Thomson, Sir James Crichton-Browne, Sir Alex Pedler, Sir Alfred Ewing, Sir Henry Trueman Wood, Sir James Mackenzie Davidson, Sir George Beilby, Sir William F. Barrett, Sir John Gavey, Sir Roland Wilson, Sir John Snell, Mr. C. P. Sparks, Colonel Crompton, Dr. Waller, Dr. A. Russell, Prof. A. Schüster, Colonel E. H. Hills, Dr. R. Mullineux Walmsley, Dr. T. Gregory Foster, Mr. Charles Hawksley, Dr. W. Eccles, Mr. F. S. Spiers, Mr. Gerald Stoney, Mr. Charles Bright, Mr. Alexander P. Trotter, Prof. R. A. Gregory, Mr. C. H. Wordingham, Prof. F. G. Baily and Prof. Margetson.

OBITUARY.

KILLED IN ACTION.—We regret to have to record the death of Private C. A. Chattock, only son of R. A. Chattock, city electrical engineer of Birmingham, who was killed in action in France on June 1. Deceased, who was 23 years of age, was educated at Hillbrow School, Rugby, and subsequently at Charterhouse School (Robinites). He studied at the Birmingham Municipal School of Art and in Paris. He was engaged on designing work when war broke out, and he joined the 2nd City of Birmingham Battalion in Oct., 1914, as a private. His battalion went to France in Nov., 1915, and he was on active service until his death occurred.

PERSONAL.

Capt. Henry Newton, of the 5th Notts and Derbyshire Regt. (attached Royal Engineers), has been awarded the D.S.O. He commanded the Ilkeston Company of the 5th Battalion (T.F.), and accompanied them to the Front.

Whilst there he was responsible for a number of inventions which were used to advantage by his own battalion, and the Brigadier-General, realising their excellence and utility, gave instructions for them to be provided for the brigade. A workshop was established in France for his operations to be conducted on the spot, and Capt. Newton was placed in command, and this particular works now employs a large number of men. Capt. Newton is a member of Messrs. Newton Bros. (Ltd.), electrical engineers, of Derby, of which he is a director.

APPOINTMENTS VACANT AND FILLED.

An engineer is required to take charge of all repairs and new work (including electrical work) at a large factory. *See an advertisement.*

Stepney (London) Guardians require for their children's homes at Stifford, Essex, an engineer to take charge of electric lighting and other machinery. Salary £2 per week, increasing to £2. 5s., with residence. Forms from the Clerk, Barnes-street, Ratcliff, E. Applications by June 21.

Mr. E. J. Walsh has been appointed manager of the Musselburgh and District Electric Light & Traction Co., in succession to Mr. Watson, resigned.

Mr. Paten has been appointed a shift engineer at the Gillingham electricity works.

INSTITUTIONS AND SOCIETIES.

Institution of Electrical Engineers.—EXCLUSION OF ALIEN ENEMIES.—A special confirmatory meeting of the Institution was held on Thursday, June 15th. The PRESIDENT moved that the resolution passed on May 25th (and set out on page 292 of our issue of June 2nd) be confirmed.

Mr. LL. B. ATKINSON, in seconding, said many of the members had learned in the course of the discussion of this subject that the Institution was a limited company, and it was a commonplace that the more satisfied shareholders were the fewer of them attended the meetings. The small ness of the attendance at that meeting might, therefore, be taken to indicate that most of the shareholders of that company were satisfied with the resolution, which he had pleasure in seconding.

The resolution was put to the meeting and carried, with only one dissentient.

Mr. ATKINSON then remarked that he was one of the members who signed the original request to the Council to deal with the matter. At that time a considerable number of members were somewhat dissatisfied because the Council itself was not moving in the matter. The Council's position was that it could not move without some members moving it to do so. After the members had done that, the President, on his own initiative, met those who were dissatisfied and heard all they had to say, and from that moment there was no difficulty. The matter was discussed frankly with the President, who formed the intermediary between those members who were dissatisfied and the Council, and from that time the matter moved rapidly, and all dissatisfaction with regard to the Council disappeared. He felt it due to the President to mention that, and he asked the meeting to join in a vote of thanks to him, both for taking the chair at that meeting and for the help he had given in getting this matter through rapidly.

Mr. A. A. CAMPBELL SWINTON seconded the motion, and it was carried, with applause.

The PRESIDENT, in acknowledging the vote of thanks, and Mr. Atkinson's remarks, said he thought they had tackled a very difficult matter diplomatically. If the result was not effective the members had only to approach the Council again. They were not hostile to matters of that kind, and he would do all he could to assist Mr. Atkinson or any Committee of Members to forward the true interests of the Institution.

The meeting then terminated.

Institution of Mining Engineers.—At the recent London meeting of this Institution Mr. Wallace Thorneycroft was nominated President for the ensuing year. Sir William Garforth stated that strong committees had been formed to advise the Advisory Council for Research, and about 30 different subjects in connection with mining were going to be investigated. It was stated that steam plants at many collieries were most wasteful. In regard to coal distillation, the waste gases from bye-product ovens amounted to 7,000-million cubic feet annually, of which only a small fraction was utilised.

Imperial Institute.—At the first meeting of the newly constituted executive council of this Institute, Lord Islington was elected chairman.

Electrical Trades Benevolent Institution.—The confirmatory general meeting of this Institution was held on Monday, 19th inst., at the Institution of Electrical Engineers, for the purpose of confirming the alterations in rules which were made at the annual general meeting. The principal alteration was to make the rule regarding the position of members who had not paid their subscriptions slightly less drastic than it formerly was. The rule formerly stated that members whose subscriptions were in arrear were entitled to no privileges whatever. The altered rule is that a member who is thus in arrears shall not be entitled to votes. There is no doubt that votes will in the near future be of considerable value, as the election of pensioners is by vote, and the list of members is steadily embracing more names of persons who might possibly be in need of such pensions.

ARRANGEMENTS FOR THE WEEK.

TUESDAY, June 27th.

ASSOCIATION OF SUPERVISING ELECTRICIANS.

7.30 p.m. At St. Bride Institute, Bride-lane, E.C. Annual General Meeting.

FRIDAY, June 30th.

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

2.30 p.m. At Westminster Palace Hotel, S.W. Eighth Annual Congress.

PHYSICAL SOCIETY.

5 p.m. At the Imperial College of Science, South Kensington.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for the Week.

Officer for the Week.—Platoon Commander C. H. C. Bond.

Next for Duty.—Platoon Commander J. O. Cheadle.

Appointments.—H. de P. Birkett to be company Sergeant Major No. 3 Company. H. J. Golding, P. H. H. Jantzen and E. A. Ullmann to be Section Commanders No. 3 Company. All to date June 3rd.

Monday, June 26th.—Technical for Platoon No. 9, 46, Regency-street, S.W. Squad and Platoon Drill, Platoon No. 10. Signalling Class and Recruits.

Tuesday, June 27th.—The School of Arms will be discontinued during the summer months. Recruits 7.15 to 8.15. Lecture 7.15, "Organisation and Discipline," by Company Commander W. Hynam.

Wednesday, June 28th.—Platoon Drill, No. 1 Platoon.

Thursday, June 29th.—Platoon Drill, No. 5 Platoon. Shooting for No. 9 Platoon. Miniature Range. Recruits 5.15 to 7.45. Instructional Class 5.15.

Friday, June 30th.—Technical for No. 10 Platoon, 46, Regency-street, S.W. Squad and Platoon Drill, No. 9 Platoon.

Saturday, July 1.—Parade 2.15. Uniform.

Sunday, July 2nd.—Entrenching at Otford. Parade Victoria (S.E. & C. Railway Booking Office) 8.35 a.m. Uniform, haversacks, water bottles. Midday rations to be carried. Railway vouchers will be provided.

Otford Camp.—On and after Saturday, June 3rd, there will be a standing Camp at Otford. See monthly orders.

Musketry.—For Nos. 1 and 2 Com., see Notice and Tables A and B at Headquarters.

NOTE.—Unless otherwise indicated, all drill, &c., will take place at Chester House.

THE CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

London, June 22nd.

Once again the annual Convention of the Incorporated Municipal Electrical Association is being held under war conditions, the choice of meeting place, as last year, being the Institution of Electrical Engineers in London. To-day, which is fortunately ideal from the weather point of view, the members have assembled to do justice to the technical fare that has been provided, while to-morrow is reserved to purely formal business. The Convention is again shorn of its social functions; nor are there any visits to works.

A considerable number of the chief engineers who are members of the Association are with the Forces, either at home or abroad, and were, therefore, unable to attend. Their duties are being temporarily undertaken by their deputy engineers, and in a number of cases these attended the Convention. There were no I.M.E.A. buttons worn this year, doubtless because there would have been no room for them, seeing that all the staffs of electricity undertakings are allowed to wear badges. Those who did not wear badges sported roses, which fortunately were in keeping with the weather of the moment.

There was a good muster of members, delegates and visitors, about 200 being present when Mr. A. C. Cramb, this year's President, rose to open the Convention. He was given a very hearty welcome, as this time he occupied the position of President by election and not acting President, as he was last year, in the absence of Major H. Richardson (Dundee).

The provinces were well represented at the Convention, there being also a goodly number of chairmen of committees as well as chief engineers. The provincial members included Messrs. S. T. Allen (Wolverhampton), F. Ayton (Ipswich), R. Ayton (Winchester), A. W. Barham (Watford), S. E. Britton (Chester), S. Blackman (Sunderland), J. Christie (Brighton), C. A. Blascheck (Canterbury), W. J. Bache (Cheltenham), W. H. Cooke (Luton), A.T.Channon (Grimsby, acting), Councillor Ellaway (Birmingham), H. S. Ellis (South Shields), S. E. Fedden (Sheffield), Ald. A. Faucett (Halifax), H. Foulds (Birmingham), E. E. Hoadley (Maidstone), W. A. Jackson (West Bromwich), D. Jones (Kilmarnock), W. T. Kerr (Hereford), W. W. Lackie (Glasgow), F. M. Long (Norwich), J. R. P. Lunn (Darlington), A. Nicholls Moore (Newport), H. W. Munro (Exeter), H. A. Nevill (Wakefield), F. Newington (Edinburgh), Ald. G. Pearson (Bristol), H. Faraday Proctor (Bristol), S. L. Pearce (Manchester), F. W. Purse (Carlisle), J. A. Robertson (Salford), W. M. Rogerson (Halifax), T. Roles (Bradford), Ald. Lt.-Col. Sinclair (Swansea), T. E. Smith (Leicester), G. Tough (Coventry), W. A. Turnbull (Aylesbury), S. J. Watson (Bury), H. Webber (Keighley), G. Wilkinson (Harrogate), P. P. Wheelwright (Blackburn), W. J. Wood (Bolton), T. P. Wilmshurst (Derby), C. H. Yeaman (Stoke-on-Trent), J. K. Brydges (Eastbourne), F. H. Whysall (Greenock).

The members from the Greater London area included Messrs. A. C. Cramb (President), J. H. Bowden (Poplar), C. S. Davidson (Barnes), J. E. Edgcome (Kingston-on-Thames), J. D. Pember (Dartford), A. H. Shaw (Ilford), W. C. P. Tapper (Stepney), W. Wyld (Hampstead), W. J. Beauchamp (West Ham).

Mr. Cramb asked the members to extend a hearty welcome to Mr. J. Roberts, electrical engineer, Durban Corporation, who was in London at this time and had been given an invitation to attend the Convention. This was unanimously agreed to. The visitors also included Sir John Snell, Mr. C. H. Wordingham (Admiralty), both past-presidents of the Association, and Mr. W. B. Woodhouse, Yorkshire Electric Power Co.

At the conclusion of Mr. Cramb's presidential address a hearty vote of thanks to him was proposed by Ald. Sinclair (Swansea) and seconded by Mr. C. H. Wordingham, who, as one of the "old stagers," spoke of the birth of the Association 21 years ago, and of its growth and development during the time intervening. The vote was carried with acclamation. An abstract of Mr. Cramb's address appears in the next column.

PRESIDENTIAL ADDRESS.*

BY A. C. CRAMB

(Chief Electrical Engineer Croydon)

The past year, during which it has been my privilege to fill the office of President, marks not only the coming of age of the Association, but also the second year of the terrible struggle which has caused the time and thoughts of members to be occupied to a great extent in matters appertaining to the war, so much so that this important stage in the work of the Association passes almost unnoticed.

In attempting to look into the future of electric supply one feels that in this as in most other matters things will never be quite the same again. I imagine that when the country settles down to peaceful times people will aim at and expect greater efficiency and progress in business, and that in co-operative action quicker and better results will be attained. The electrical industry needs in a greater degree the spirit of co-operation in furthering the expansion of its work for the benefit of the Empire and of its own members. When one considers the need for progress in standardisation, in publicity, in the field of domestic heating and cooking, and in the development of new lines of business, there can be little doubt that the future offers full scope for the energy of the Association.

The position of our Association is somewhat unique, since it represents commercial enterprises controlled by local authorities whose main work is administrative. There is no doubt that it is difficult for officials, and even members of such bodies, whose training or main experience is administrative, to regard electrical undertakings in the correct perspective, with the result that there is often a cramping influence unconsciously exercised. In some minds the only justification for the existence of such undertakings is their ability to relieve the rates, if not the ratepayers. The only reason I have heard advanced for appropriating electricity profits to this end is compensation for the risks run by the ratepayers in guaranteeing the capital. As a ratepayer I would much prefer to pay only such prices as are necessary to cover the charges of the undertaking itself, and equally my fair proportion of the expenses chargeable as rates. One is not more enamoured of this system of finance by the fact that frequently the most persistent advocate of charging higher rates for electric supply to relieve rates is not a user of electricity.

Model General Conditions of Contract.—There can be little doubt in the mind of any member of this Association of the necessity for standard conditions of contract. It is necessary, therefore, that individuals should not press their own personal ideas, one might say prejudices, to the extent of preventing the establishment of conditions acceptable by the majority. If progress is to be made, the mature opinion of the majority must be loyally accepted. Municipal engineers have in the past enjoyed the privilege of making contracts in which the contractor had little voice, and no doubt the settling of contracts in which both sides meet on more equal terms may be somewhat disconcerting at first.

The Council have not yet received any report from the Association of Municipal Corporations regarding the contentious clauses of the model conditions referred to them for consideration by this Association nearly two years ago. In the meantime individual undertakings represented on this Association are accepting these conditions, and they have been adopted by the other representative bodies concerned.

I.M.E.A. Bill.—The Association are indebted to the British Electrical and Allied Manufacturers Association for their kindly offices in endeavouring to bring about a settlement of the outstanding differences between the Electrical Contractors Association and ourselves in connection with this Bill. A joint meeting took place, and it was hoped that an agreement had been reached, but the terms, as on previous occasions, were not accepted by the Electrical Contractors Association. Our Association has made concession after concession without avail, possibly going even beyond the limits which justice to the undertakings they represent would warrant. The British Electrical and Allied Manufacturers Association have studied the Bill, and expressed themselves satisfied that the conditions are fair and reasonable.

I wonder how long this policy of obstruction by a small section of the industry will be allowed to continue seriously to curtail the development of the business, not only of electric supply undertakings, but also of manufacturers and contractors. Even when contractors are guaranteed in the Bill that all wiring work, which would be greatly increased by the passing of the Bill, is to be placed in their hands, that supply undertakings are to be limited to prices which

* Slightly abbreviated.

contractors can safely underquote, and that increased business will be brought about through hire and hire-purchase systems in which there would be no bad debts, they appear to have so little confidence in themselves that they still hesitate to join in a course which holds the promise of a considerable expansion of profitable business. Because a few supply engineers, in days gone by, have expressed impatience at the lack of initiative of certain contractors, an impression has got abroad that supply engineers are anxious to dispense with the contractor. There is little justification for this view; indeed the Bill would strengthen their position; but contractors must realise that the policy of "Get on or get out" should be equally applicable to them as to others. Parliament has already in a number of cases granted much greater powers than those asked for in the Bill, and the present state of affairs, in which one undertaking holds powers to develop its business which are denied to a neighbouring undertaking, is extremely illogical.

The Association will, of course, at an opportune time again press for the Bill, and although there may be a further delay, the powers will come and possibly in a much fuller form than is now asked for. In the meantime the electrical industry must bear with what patience it can the contemplation of the large amount of business which is being lost to gas undertakings which are not so handicapped. It has been the aim of this Association to effect an agreement equitable to the various interests, but it may become necessary to adopt a more active policy to create a greater desire for settlement.

Development Committee.—It is a matter of regret that in view of the important work awaiting this committee little progress has been made, but members have found it impossible to spare the necessary time during the past year.

The work of the sub-committee dealing with questions of electrical apparatus for cooking, heating and other domestic requirements is urgent and important. There is here a wide field ready for development; it is true the non-passage of the Bill blocks the main possibilities of business, but still much can be done in the meantime. There has been too much disjointed work in the production of cooking apparatus and a co-operative effort by manufacturers and supply authorities is urgent. There are many matters of detail, but of great importance to success, which actual experience has demonstrated, require consideration. American apparatus, although of light design and therefore not altogether suitable for British use, shows a better appreciation of the requirements necessary for satisfactory operation. The production of a suitable and reliable radiant heating unit in place of the usual hot plate is a case in which the work of the committee should yield good results. It is probable that valuable assistance could be rendered by the National Physical Laboratory in solving problems connected with electric heating and cooking. The Publicity Sub-Committee has been instructed to prepare a scheme for the development of a publicity organisation in this country.

Several attempts have previously been made in this direction, but in all cases have ceased after a certain period. Undoubtedly the question of sufficient funds has been the main obstacle. A first essential of success is the appointment of a thoroughly competent whole-time specialist in publicity, who should give his entire attention to the running of such an undertaking. The hanging up of the I.M.E.A. Bill—which contains provision for enabling local authorities to subscribe to such an organisation—also continues to prevent progress.

The Summer-Time Act will reduce the revenue of electrical undertakings, and in the case of those depending mainly on lighting for their income its effect must cause concern as to financial results.

The passing of this Act serves to emphasise the courage and foresight of those undertakings which had adopted the Norwich or some other system of standing and running charges for domestic purposes before the use of metal filament lamps became general. Although the basis for arriving at the standing charges in these cases may possibly be considered open to criticism, still, in practice, they have been found fair and workable, and the advantage to the undertaking by the adoption of such a system, in maintaining financial stability against the large drop in revenue resulting from the introduction of more economical lamps, outweighs any such objections.

The loss of revenue resulting from this Act brings home the importance of the development of the use of electricity for other domestic purposes. Gas undertakings, through having developed the heating and cooking load, can regard the loss of revenue in this direction with less concern. My own experience in bringing before the householder the merits of electricity for domestic purpose has convinced me that there is a very large potential demand if only the electrical industry is ready with a supply of suitable apparatus which can be obtained by consumers on terms comparable with those to which they have become accustomed.

One might here take the opportunity of expressing the hope that electricity committees realise that those members of the staff who have to deal with the development of electricity for domestic purposes should take every possible opportunity of gaining actual experience with various types of apparatus in their own homes, and that all reasonable facilities should be given to this end.

Coal Supplies.—The question of sufficient supplies of coal for the maintenance of electricity undertakings has been a source of anxiety during the past year to the individual members of the Association, and promises next winter to become critical. The Council have done what is possible by appointing a sub-committee to watch the question and by supporting representations to Parliament and the Board of Trade. It should be realised that the Government are in a position of considerable difficulty in regard to this matter, and that although they have apparently not been able to give much material assistance to individual undertakings, at the same time there is reason to believe that they have endeavoured to help as far as possible with due regard to other claims of equal importance.

The proposal of the Board of Trade to urge consumers to make a percentage reduction in lighting with a view to economy in coal is not likely to have the desired effect. The provision of a large number of extra meter readers would greatly increase expenses, the annoyance to consumers of frequent visits would cause unnecessary friction, probably without affecting any appreciable economy. The view that an increase in price is the more effective way of bringing about economy is undoubtedly correct.

It seems to have been overlooked that lighting restrictions and the reduced available moneys of most users have already brought about a very considerable reduction. The saving in coal owing to reduction of lighting seems also to have been greatly over-estimated, but it is the duty of every one, nevertheless, to help the Government in every reasonable way to increase the amount of coal available for export. It is to be hoped that the present interest of the Government in national economy of coal will last beyond the war.

British Engineering Standards Committee.—The work of this Committee has been approved by the Government, from whom they receive financial assistance. The Council are also giving support by subscribing to the expenses, and your Association is well represented on the various committees of the electrical section. My experience on certain of these committees convinces me that the work if carried on with energy and in a spirit of broadmindedness, will bring valuable results to the undertakings represented by this Association through standardisation tending to improve design and cheapen the cost of manufacture. I hope, therefore, that local authorities will be prepared to help forward this work by subscribing.

Financial Control.—It can be easily understood, and experience has largely proved, that the control of accounts by an official independent of the engineer-manager inevitably leads to unsatisfactory results. From the logical point of view of a ratepayer, it would be much more satisfactory if the municipal accountant, apart from matter of loans at any rate, were to act as an internal auditor.

Constitution of the Council.—The constitution of the Council has in recent years been fully reviewed by the members, but some still urge that the Council should contain a definite minimum number of members representing small undertakings. It has been further urged that, with a view to enabling all members of the Association to participate in the election of officers and members of the Council, the present arrangement of voting should be changed to a postal ballot. Members will have an opportunity of deciding this point.

British Trade After the War.—In the report of the Board of Trade Committee on British trade after the war it is proposed that local authorities, amongst other public bodies, should be under legal obligation to purchase as far as possible only goods produced in the British Empire. It is felt by your Council that discrimination between local authorities and private companies in this matter is unjust to the ratepayers, and that whatever restrictions are made with a view to assisting British manufacturers, they should be equally applicable to all interests. Members will, I believe, be generally of opinion that, although the interest of the Association in the position of British trade after the war are indirect, they are, nevertheless, important. The Council are, therefore, hoping to have their views fully set before the Electrical Trades Committee appointed by the Board of Trade to report on this question.

It had been my intention during the past year to have placed before the Council some scheme whereby the members of the Association would be kept in closer touch with the various matters which the Council have had under consideration from time to time. This would, I feel, help to maintain and probably materially increase the interest of the members in the work of the Association which at the present time tends to be confined to the duration of the annual convention. I regret, however, that present conditions made it inopportune to bring forward this question.

In concluding these remarks I feel sure that I am echoing the feelings of all present when expressing the earnest hope that before the Association meets again the British Empire will have gone far towards attaining the objects for which the present prodigious sacrifice of their manhood and wealth is being made.

BOILER-HOUSE DESIGN AND OPERATION.*

BY W. W. LACKIE.

(Engineer and Manager of Electricity Dept., Glasgow.)

Summary.—This Paper deals with questions of boiler-house design and equipment, fuel handling and storage. Regarding fuel, some experiments are given on burning coke breeze or gas coke riddlings. Such fuel costs only 20 per cent. of the price of coal, and has a calorific value of 60 per cent. of that of coal. Even a small percentage saving in fuel is worth consideration.

In this Paper attention is confined to a general survey of the boiler-house as a whole, and passing reference to certain of the details of boiler-house design and equipment may lead to a fuller consideration of these in the discussion.

In the design of a boiler-house the main object is to have the maximum of steaming capacity in the minimum of space. The necessity for this has largely been brought about by the introduction of turbine-driven generators and the ever-increasing size of generating sets.

The growth in the demand for electric energy, the much improved load-factor, and the introduction of the steam turbine about 1904, brought about a distinct change in the relative space required for engine-room plant and boiler-house plant. The turbine room came to consist of a two-storey building, the condensers being on one floor and the turbo-generators on a floor above. Instead of having 1 H.P. per square foot of engine-room floor, which was a common figure till the advent of the steam turbine, we have to-day turbine rooms with 5 H.P. per square foot, and in designs for new power stations, using 15,000 kw. to 30,000 kw. sets, this figure may go up to 20 H.P. per square foot of turbine-room floor space. With this enormous increase changes in boiler-house design are absolutely imperative, otherwise the area occupied by the boiler-house will be out of all proportion to that allotted to the turbine-room.

It is now recognised that even with improvements in boiler-house design, where very large turbo-generators are in use, every pair of such sets requires a separate boiler-house. Several present-day power houses have an evaporation of 50 lb. of water from and at 212°F. per square foot of ground space occupied by the boilers, but it is possible with improved design of the boiler-house plant to approach an evaporation of 100 lb. per square foot of floor area actually occupied by the boilers. We, therefore, find that in a large modern generating station the ground space occupied by the boiler-house is from $1\frac{1}{2}$ to $2\frac{1}{2}$ times the space occupied by the turbine-room.

The first consideration is to ensure the maximum grate area per square foot of boiler-house floor space, and it appears that burning coal with natural or induced draught at from 25 lb. to 30 lb. per square foot of grate area there is a limit to the maximum possible continuous output per square foot of grate area and that consequently there is a limit to the maximum power per square foot of boiler-house floor space. It is now recognised that a modern boiler-house should consist of three storeys at least: The basement or ground floor containing the ash-handling plant; the second floor containing the boilers proper; and the third or upper floor containing the economisers and coal-conveying machinery and probably coal storage above the boilers. Draught fans may be placed on any one of the three floors.

The question of chimneys and chimney draughts is by no means settled, but in stations where boilers of 50,000 lb. capacity are installed it is necessary to erect a separate chimney for each boiler or each pair of boilers. Steel is used in preference to brick, as with steel the chimney can be erected from the third floor, on which the economisers are placed, whereas if brick is used, foundations have to be laid on the basement or ground floor, which means a waste of valuable space and a mass of brickwork which serves no useful purpose.

It is desirable not only to deal with ashes ejected from the boilers, but also to deal with riddlings and any semi-burned fuel. These riddlings have to be returned to the coal-conveying plant, and thence to the overhead coal hoppers so as to be used again in the furnace.

The necessity for concentration of power has made the water-tube boiler indispensable in the power house. The evaporative capacity of any boiler depends upon the grate area, and consequently the maximum concentration of power is obtained when the whole of the generating and recuperating surface is assembled directly over the grate. Even with this type of plant the assembling of the heating surface over the grate area is undergoing modifications in order that the highest possible evaporation per square foot of ground space may be obtained.

* Abstract of Paper read yesterday before the I.M.E.A.

The space actually occupied by boilers at present with the necessary passages between does not as a rule exceed 33 per cent. of the total boiler-house floor area, and of this 33 per cent. the grate area only accounts for one-half.

Let us consider the case of a boiler-house which has to supply steam to two 15,000 kw. sets. There will be required for each set between 180,000 lb. and 200,000 lb. of superheated steam per hour. This would be supplied by four boilers. Each boiler will require to burn at least 7,000 lb. of coal per hour, depending upon the calorific value of the coal. This means that grates of 250 sq. ft. to 270 sq. ft. will be necessary. Such a grate area means that each boiler will occupy, with passages between, about 500 sq. ft., eight boilers will require 4,000 sq. ft., and the boiler-house will have a floor area of 12,000 sq. ft.

From what has been said it is clear that increasing the size of the boiler unit will not of itself seriously increase the power per square foot of floor area. Twenty years ago water-tube boilers of 4,000 sq. ft. to 6,000 sq. ft, heating surface were considered large. To-day boilers are made with a heating surface from 10,000 sq. ft. to 20,000 sq. ft.

The plan of installing boilers (apart from economisers) on two floors ought only to be adopted where the exigencies of the site render such an arrangement inevitable; that is to say, where land is dear or where local building regulations limit the dimensions of buildings in certain areas.

The boiler-house should be designed to admit of an ample supply of natural daylight, by placing the boilers back to back with a firing floor down each side. Light can then be had from windows in the side walls as well as from the roof. This, however, means a larger floor area and a space between parallel boiler-houses, and further increases the ground area occupied by the power station.

There is still a tendency to construct the combustion chambers of boilers much too small. A combustion chamber should be of such dimensions as to allow ample space for complete combustion taking place and the products of combustion thoroughly mixing before coming on to the heating surface. The author finds that the older boilers had 2 cubic ft. to $2\frac{1}{2}$ cubic ft. of combustion chamber per square foot of grate area. To-day similar boilers have 5 cubic ft. or more of combustion chamber per square foot of grate area, and it is generally conceded that this fact is very largely responsible for the high efficiency of boilers at widely varying loads.

It is not necessary to enter into the details of boiler fittings, but it may be said that the equipment should include two draught gauges. One of these should show the difference in pressure between the combustion chamber and the outlet from the boiler—*i.e.*, the difference in pressure across the boiler elements. This will be a measure of the flow of the gases through the boiler and will indicate when a boiler requires cleaning. The second gauge should show the difference of pressure between the ash-pit and the outlet of the boiler. This second gauge will always read higher than the first, and the difference is obviously a measure of the draught through the fire.

Steam flow meters are a necessity, as they indicate whether each boiler is doing its fair proportion of the work. One or more CO_2 recorders are found to be a valuable adjunct, as they are an index of the working efficiency. A word of warning, however, is required against assuming that high CO_2 always means high efficiency. There may be a large quantity of CO present. There should be thermometers or pyrometers with dial face on every boiler, giving the temperature of the superheated steam leaving the boiler, also the temperature of the gases at the damper.

Steam Piping.

With boilers of the size under discussion, steam piping should be carried from each boiler or pair of boilers to a receiver adjacent to the wall between the boiler-house and the turbine-room. From the steam receiver a steam pipe is led to a turbine and another pipe to the next receiver, so as to give interchange of steam from one set of boilers to another when required.

As an appendix to the original Paper the author gives the results of an interesting series of tests on steam pipe coverings to show their relative properties. Four firms were asked to cover three sample pipes, and were given a free hand as to choice of the material which would best meet the conditions. The thickness of covering was specified to be 2 in.

We may at an early date see an increase in the boiler pressure from 160 lb. and 200 lb. to 250 lb. The Commonwealth Edison Company of Chicago worked the boilers in their Fisk-street station at 200 lb. until 1907, when they adopted 225 lb. at their Quarry-street station, and in 1910 they adopted 250 lb. at their North-West station.

Fuel Handling and Storage.

A station of 50,000 kw. capacity and burning 200,000 tons of coal per annum requires coal handling facilities for a supply of 1,000 tons of coal per day, together with facilities for the handling of ashes to the extent of 100 tons per day. This means a railway siding capable of holding from 100 to 120 full trucks, and probably another siding of equal dimensions to hold the empty trucks. The provision of an adequate railway siding is, therefore, a costly adjunct in the layout of a large power house owing to the serious addition to the site which it entails. Coal-breaking machinery should be installed, for while we have in the past been in the habit of using small coal, circumstances may in the near future render it economical to buy and break larger coal. Accommodation is advisable for not less than from two to four months' fuel supply. This marginal stock enables coal to be delivered in fairly regular quantities throughout the year, and may result in lowering coal prices. The best method of storing coal is still undecided.

The cost of lifting coal from canal barges or from trucks, and placing it overhead in coal hoppers or in the coal store, is a small item in the total price of coal. In one Glasgow station there is a coal transporter fitted with a 1-ton grab. This transporter cost £2,600, and it handles coal at the rate of 40 tons per hour, and the cost of energy, labour and repairs on it brings the cost of handling coal in this way just under 1d. a ton. In another station truck loads of coal are elevated 30 ft. at one end of the coal store to an overhead platform, whence the coal is tipped into an overhead hopper or to the coal store, and the empty trucks lowered by a second elevator at the other end of the coal store. These two elevators, complete with electrically-operated capstans, cost £2,000. The inclusive cost of handling coal in this way is 3¼d. per ton, the higher cost being due to the amount of labour necessary for handling the trucks. These figures are conclusively in favour of the grab and transporter. Where coal has to be carried a short distance from coal store to boiler-house, bucket or tray conveyors appear to be the right thing. On the other hand, for longer distances, the telpherage system works out slightly cheaper, although the human element, with its attendant problems, enters more largely into the telpherage system.

For the removal of ashes, bucket conveyors have proved to be costly in upkeep on account of the wear of the axles and pulleys, but even with this drawback, bucket or tray conveyors seem to be the cheapest method of removing ashes. Suction ash plant is finding much favour on account of the absence of moving parts in its design, but the capital cost is about three times greater than that of conveyors. The cost for operating suction ash plant works out at about 5d. per ton handled, with energy at 1d. per B.O.T. unit.

A modern boiler-house calls for comparatively large overhead ash storage, from which ashes can be dropped into wagons or other vehicles for their removal to a comp. The removal and disposal of ashes is becoming a serious matter. On account of the difficulty in getting the ashes carted away it has been suggested that it would pay the large electrical undertakings to purchase 3-ton or 5-ton electrically propelled wagons for the removal of ashes, especially where convenient railway facilities are not available.

Coal-weighing machinery for each boiler or group of boilers is absolutely necessary if proper records are to be made of the boiler-house efficiency. These weighing machines should preferably be fixed between the overhead coal hopper and the boiler stoker, but some stations in America have a travelling gantry, fitted with a weighing machine at each end, the gantry travelling along the whole length of the boiler-house between two rows of boilers.

Experience with feed pumps of the direct-acting type is so good and repairs so low that it will be difficult to displace them. The total condensate from condensers should be measured by a Lea or other water recorder, and this should have an integrating attachment. Having ascertained the amount of coal used and having measured the condensate, we can get the amount of water evaporated per pound of coal used.

No very great increase in the efficiency of steam boilers can be looked for. The heat balance of many of the steam plants in operation at the present day is as follows:

Heat absorbed by boilers	78 per cent.
Heat lost in flue gases.....	15·5 ,,
Heat lost in radiation and unaccounted for	6·5 ,,

That is to say, the total loss on which any reduction can take place is 22 per cent., but it is only a small proportion of this figure which can be attacked with a view to lowering it. It would be doing negative work to discharge the gases from a boiler at a temperature lower than that of the water in the boiler.

Water-tube boilers are now designed, in conjunction with special economisers, to evaporate at the rate of 6 lb. normal load, and at overload 8 lb. and even 10 lb. per square foot of heating surface of the boiler. The heating area in most water-tube land boilers is of the order of 50 times that of the grate-area. With such proportions the general practice is to emit the gases from the boilers at a temperature 500°F. to 550°F., *i.e.*, from 100°F. to 150°F. above the temperature of the steam at the boiler working pressure. The proportion of heating surface in economiser to heating surface in boiler varies in nearly every station, but the figure of 35 per cent. may be taken as a fair average. With such a proportion, allowing for heat drop in flues, the gases at the outlet to the chimney will have a temperature of from 325°F. to 350°F., and the economiser will have utilised about 7 per cent. of the heat of the gases emitted from the boiler. The inlet water to the economiser from the hotwell will, with present-day practice, be raised to a temperature of 200°F. or 220°F. Until recently the evaporation per square foot of heating surface of boiler and economiser combined was, therefore, roughly 3 lb. per square foot of heating surface. Modern practice tends to diminish the heating surface in the boiler from 50 times the grate area to 35 times the grate area and to increase the area of the economiser to 80 per cent. of that of the boiler heating surface. The result is to put up the evaporation of the boiler at overloads to 8 lb. per square foot of heating surface, and the temperature of the gases now emitted from the boiler is considerably raised, being about 650°F. The heat, however, is taken up in the economiser, and the temperature of the feed water to the boiler is considerably increased. The net result is that we get an evaporation of 4½ lb. per square foot of heating surface of boiler and economiser combined. The overhead economiser is suitably proportioned to give the very highest combined efficiency. Boiler plants arranged in this way probably give a higher efficiency than was the case with previous designs, in as much as the radiation losses are less and the loss between the boiler and the economiser is minimised.

The modern tendency is, therefore, to supply feed water to boilers at a temperature as near as possible to the temperature of the water already in the boiler, and the boiler simply adds latent heat and superheat to the steam. Each boiler has its own economiser, and the economiser is really an integral part of the boiler unit.

Tests on two boilers are given in the original Paper. The first tests were made on an ordinary land type water-tube boiler supplied eight years ago. The second tests were carried out on a modern boiler, designed as above indicated, and the results of the test bear out the contentions with regard to evaporation per square foot of heating surface and of floor area occupied.

Fuel.

The selection and purchase of fuel is a question dependent upon the position of the site relative to the nearest coalfields and upon the nature of the load. Power stations near the coalfields can use low-grade fuel, whereas it is often more economical to use high-grade fuel in stations remote from the coalfields, as the same freight has to be paid for ash as for carbon.

The kind of fuel also depends upon the nature of the load as it is a recognised fact that a higher overload duty can be obtained from a boiler fired with good quality coal with a given draught than can be got with low-grade fuel. If a station has a purely lighting load, and consequently a low load-factor, it is often more economical to use the best coal, because, with the higher overload thus made possible, the number of spare boilers can be kept down to a minimum.

It is now common practice to buy fuel on a calorific basis, but it must always be remembered that along with calorific value and analysis there are to be taken into account physical properties. For instance, two samples of coal may show an approximately similar calorific value figure and present wide differences of behaviour in the furnace. Actual boiler tests must, therefore, be made with sample truckloads of coal if the best and most economical selection is to be made. The author does not advocate a slavish adoption of the calorific value basis in the purchase of coal, for the simple reason that coal is not a manufactured article but a natural product, and if we are to hold the colliery owner or his agent responsible for its calorific value he will undoubtedly and quite properly cover himself by increasing the price accordingly; whereas if the coal contractor is not tied down, the customer is sharing the risk inseparable from a natural product. The contractor can be and should be generally tied down to supply from particular pits.

A practical test in a boiler specially equipped for the purpose is a very reliable guide to calorific value. The results of such tests should be reduced to a common basis. A good unit of comparison is the cost of evaporation of 1,000 lb. of water from and at 212°F. or the number of pounds of water evaporated for 1d. of coal, including coal and ash handling, which varies with the quality of the coal. It is usual to express the coal economic result for the whole station in pounds of coal per kilowatt-hour generated at the switchboard, but as this must obviously vary with the calorific value of the coal and the steam consumption of the engine or turbine plant, the better unit to use for general comparison is the British Thermal Unit per watt-hour.

Even this is not perfect, as it does not allow for the variation in load-factor between different power stations, but it does enable comparisons to be made irrespective of variations in calorific value. In two of the Victoria Falls power stations the economic result obtained in the way proposed gave in one station 27 B.Th.U.s per watt-hour, and in another 26. Both of these stations had very high load-factors, whereas in many of the London stations, where the lighting load is predominant, the average result is in the neighbourhood of 40 B.Th.U.s per watt-hour. Daily samples of coal, as delivered, should be sent to the laboratory of the undertaking for calorific analysis. An assistant, working with a bomb calorimeter, can test 12 samples a day working from 9 to 1 and from 2 to 5 o'clock. These tests are recorded in a coal test-book for reference. As the results of tests obtained by any or all of the methods above referred to are tabulated and arranged, an index of the pits in the coalfield, from which the fuel supply is mainly or wholly drawn, can be compiled, and coal prices as received can be equated on a calorific value basis.

An interesting experiment has been carried out in one of the Glasgow gas works recently. Gas coke breeze or gas coke riddlings were burned successfully on chain-grate stokers with forced draught. A special form of arch had to be built. This breeze can be bought at 20 per cent. the price of coal and it has a calorific value of at least 60 per cent. of coal. There is a large amount of ash, but the experiment went to show that with intelligent superintendence good results could be obtained with this class of fuel, although the actual output of the boiler was considerably reduced.

With regard to the whole question of fuel, experience seems to show that it is preferable to buy the best, for while good results may be obtained with inferior fuel, careful and constant attention to the fires is necessary with such fuel, whereas with first quality fuel very little attention is required.

Boiler-House Staff.

The substitution of mechanical and electrical machinery for hand labour has led to the substitution of the boiler-house engineer for the fireman. A competent boiler-house engineer is an indispensable adjunct to the boiler-house staff, and the man who knows his business can easily earn the substantial salary which he can command in this capacity. He trains his own labourers, but the human element should be cut down as far as possible. Everything possible should be done to obviate wastage of the heat value of coal in the boiler-house before the steam reaches the turbine. Many opportunities for waste, and consequently opportunities for devising ways and means to avoid waste, are still present.

In this Paper the possibilities of further improvement have been indicated as regards space, material, heat, labour and time; and the saving which would accrue even from the partial elimination of present waste under these various heads would represent a considerable proportion of the total charges on revenue in a large electricity supply undertaking. Thus a saving of 1 per cent. in the coal bill of the Glasgow electricity department would this year represent a sum of £2,000.

It is only in recent years that we have come to realise the meaning and the value of a pound better steam consumption in a steam turbine. We now put a money value on steam consumption per $\frac{1}{10}$ lb. and stipulate for heavy penalties in the event of failure to comply with guaranteed consumption after allowing a tolerance of $2\frac{1}{2}$ per cent. With an equipment such as has just been described weekly returns can be prepared giving all the particulars any manager wants to satisfy himself that the plant is being properly handled and is doing its work efficiently. Turbine-room data being also available, a weekly sheet showing running statistics may be easily made out. An exchange of such data between undertakings of about the same size would be mutually beneficial.

Several very fine records of efficiencies have been attained in America. At the Conner Creek plant of the Detroit Edison Company they have two 20,000 kw. sets, and each turbine is supplied with steam by two boilers, each having 23,500 sq. ft. of heating surface. The plant is operating at the present time and producing a kilowatt-hour on 1·42 lb. of coal, *i.e.*, a little less than 20,000 B.Th.U.s per kilowatt hour. This shows an efficiency from coal to electrical energy of 17 per cent. The Chicago Commonwealth Edison Co., in their Fisk-street station, have two turbo-alternators of 20,000 kw. to 25,000 kw. capacity. Over a whole year's run the coal used per unit of output was 1·92 lb., and the average value of the coal as fired was 10,120 B.Th.U.s per pound. This gives an average of heating units in the coal as fired per unit of output of 19,450, and also shows a thermal efficiency of some 17 per cent.

In conclusion, the author refers to Prof. Bone's recent lectures dealing with fuel economy and the utilisation of coal, and to the Committee appointed by the British Association to look into and report upon the question of fuel economy.

THE GENERATION OF ELECTRICITY ON A SMALL SCALE OR BULK SUPPLY.*

BY H. S. ELLIS.

(Borough Electrical Engineer, South Shields.)

Summary.—This Paper deals with the capability of small stations to produce electrical energy cheaply as compared with the taking of a bulk supply. The view is supported that once a small station—*e.g.*, of 2,000 kw.—is in operation it does not pay to take a bulk supply. In support of this contention an examination is made of costs per unit of existing stations, first cost of plant, efficiency of plant, &c., as influenced by its size.

In a prefatory note the author refers to and gives brief extracts from Papers by various engineers dealing with the question of centralisation.

Some of the more important items which go to make up the cost of generating electricity are—

(*a*) Working costs on a large scale.
(*b*) Working costs on a small scale.
(*c*) Capital charges on generating plant in large power stations.
(*d*) Capital charges on generating plant in small power stations.

Working Costs per Kelvin Sold.

With regard to present-day "working costs," the author draws attention to two tables in the original Paper, which definitely show the effect of load-factor and load on all the items which go to make up what are commonly termed working costs. The effect of load and load-factor on the total working costs is shown graphically in Fig. 1. The figures, from which Fig. 1 was drawn, are the result of averaging the costs of several undertakings in each group.

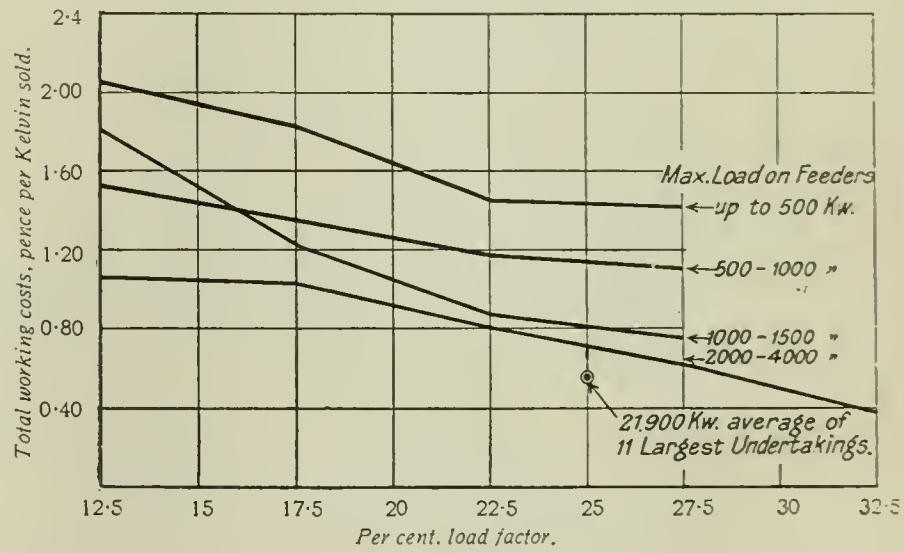


Fig. 1.—Curve of Total Working Costs per Kelvin Sold.

Note.—Two groups (4,000-7,000 and 7,000-10,000 kw.) have been left out (*see* Table No. 1).

The combined effect of load and load-factor on the various items which go to make up the "total working costs" is shown in Fig. 2. This shows very clearly the possibilities in the direction of cheap power, but it must not be forgotten that the load-factor in no case exceeds an average of 25 per cent., so that it would appear as if the larger undertakings had gained very little, compared with the smaller undertakings, by increased load as far as load-factor is concerned.

The best way of improving the load-factor of a system is to increase the number of different industries connected thereto. The large power companies are much better off in this respect owing to the fact that they embrace very large areas, thus enabling them to tap industries seldom if ever found within the boundaries of any one town. On the other hand, the power companies suffer owing to the fact that they have to cover a much greater area to secure the same income as would be obtained within the boundaries of a large town.

No better example of the generation and distribution of electricity on a large scale can be given than that of the Newcastle-on-Tyne Electric Supply Co. and its affiliated companies, which operate over an area of more than 1,400 sq. miles. In some instances a very considerable amount of electrical energy is supplied from generating stations running entirely on waste heat.

Some years ago the above company tried to persuade the South Shields Corporation to take their supply from the company; but the engineer at that time (the late Mr. J. H. Cawthra), assisted by Mr. (now Sir) John Snell, appeared to have satisfied the authorities that by the time proper allowance was made to cover the interest and sinking fund charges on plant already installed, plus the cost of

* Abstract of a Paper read yesterday before the I.M.E.A. in London.

converting the company's extra-high-tension three-phase alternating-current supply to direct-current and single-phase alternating-current, there would be no saving whatever. The Corporation proceeded with their extensions, and the results have been entirely satisfactory.

Coal Costs.

The most important item as far as costs are concerned is undoubtedly coal, as this accounts in many cases for about half, and in most cases for at least one-third, of the total working costs. It has often struck the author as strange that so much time and thought should be given to the question of saving ½ lb. of steam per kelvin and yet practically nothing is done collectively to reduce the price of the coal delivered. As things are at present, we are all more or less in the hands of the colliery owners or coal merchants, and under the present circumstances one dare not enter into a contract extending over a long period of time for a supply of current "in bulk" without including a clause in the agreement by which the price is varied to suit a rise or fall in the cost of coal.

If Dr. Ferranti's dream of a national scheme for electric supply is ever to be realised there will have to be some sort of national control over what constitutes the greatest item of cost of electric supply. By this it is meant that the colliery will have to be as much a part of the electric supply undertaking as are the generating station and the distributing system. It is not intended to convey the idea that the author would neglect to do his best to save steam, but it is intended to emphasise the importance of some sort of joint action

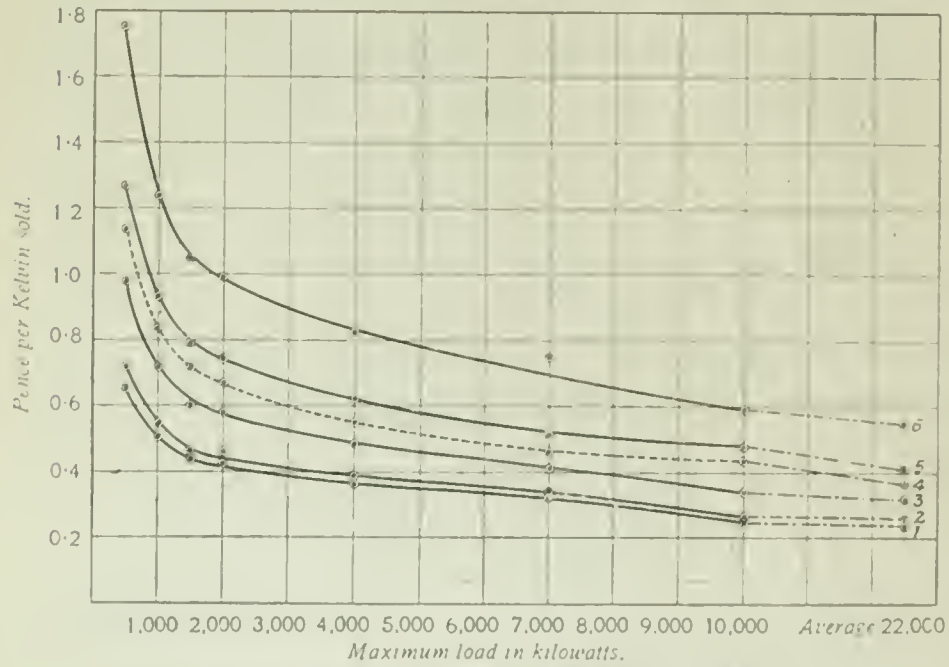


Fig. 2.—Curves of Working Costs per Kelvin Sold.

Curve No. 1 Coal and other fuel.
,, No. 2 Above plus oil, waste, water and stores.
,, No. 3 All above plus wages of workmen.
,, No. 4 Works cost less allowance for distribution repairs and maintenance.
,, No. 5 All above plus repairs and maintenance.
,, No. 6 All above plus management, salaries, office and legal expenses, &c., or total working costs.

being taken by those who contemplate the generation of electricity on a large scale to ensure first of all that they can depend, in the future, upon a proper supply of coal at reasonable prices.

There is not the slightest doubt in the author's mind that the steady all-round increase in the price of coal during the past 10 or 15 years has to a great extent, if not entirely, neutralised the effects due to improvements in the design and consequent increased efficiency of steam raising and electrical generating plant, and that the lower costs obtained have been due largely to the effect of the improved load-factor on the other items which go to make up the total works costs.

One of the chief reasons for the steady increase in the price of coal for electricity works is without doubt the wider market which is opening out for the use of small coal and "duff." This is now made up into briquettes, and sold at moderately high prices for use in connection with mechanical stokers. Many collieries have installed elaborate coal-washing plant, with the result that they are now in a position to sell "washed duff" at prices very little below the prices of the better qualities.

Cases of very low costs which have come to the author's notice from time to time, and more particularly whilst writing this Paper, would appear to be accounted for, partly at any rate, by an accident, such as close proximity to the colliery. It does not always follow, of course, that the proximity of the generating station to the coal mine will result in low costs. The author's experience has been quite the reverse, for the simple reason that local collieries, shipping upwards of 2,000,000 tons of coal annually from staiths situated within a radius of ¼ mile of the electricity works, are either unable or unwilling to supply even a small quantity like 10,000 tons per annum at a price less than that which electric supply engineers would consider a very high one. It is evident, therefore, that the putting down of a generating station at the pit-mouth is of no use whatever unless the output of the pit is to be used primarily for the purpose of generating electricity, or unless a contract be made for supplies over a very long period. The latter course is followed in the case of all waste-heat power stations.

The figures of working costs of undertakings in the metropolitan area are notable examples of the effect of the cost of coal in London, where the record for low total working costs in municipal stations is held by Poplar and Stepney, the figures given being 0·51d. and 0·58d. respectively, and for coal costs 0·25d and 0·34d., respectively. These figures are, nevertheless, high when compared with those of even the smaller provincial stations in the Midlands and in the north of England.

Steam Generating Plant.

We now come to that part of our business over which we have full control. It is assumed that there is a proper supply of suitable coal at a reasonable price, and it is also assumed that up to this point (the purchasing of coal) the larger undertakings have little, if any, advantage over the smaller ones.

For equal load-factors, it is doubtful whether there is much difference in the relative efficiencies of large and small plants—that is, provided the stand-by plant is proportionate in each case. But this is just where the larger station is likely to gain, as the smaller station, working with, say, two boilers on load, will require a third (equal to 50 per cent. of the total) as stand-by; whereas, owing to the normal overload capacity of any boiler, the larger station, working with, say, 10 boilers, can with safety run without any stand-by boiler at all, since in the event of any boiler giving trouble the remaining nine can be overloaded to make up for the faulty one

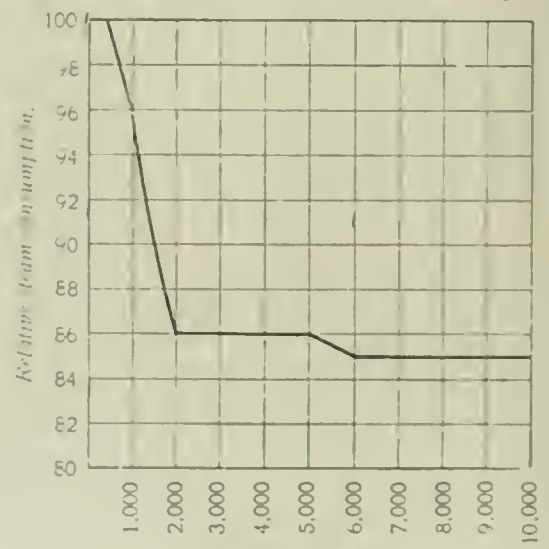


Fig. 3.—Approximate Ratios of Steam Consumption of Various Sizes of Turbines.

until such time as another boiler is got away. It is evident, therefore, that, although the efficiency of the running plant may be the same, and very likely is the same, in each case, the smaller generating station has a greater percentage of stand-by losses.

Careful study of evaporation tests has satisfied the author that large boilers have very little, if any, advantage over smaller ones from the point of view of efficiency, whatever may be their advantages from the point of view of cost, floor space, &c. Under normal test conditions it would appear that 78 per cent. is an average efficiency for the boiler and superheater, with about 85 per cent. for the boiler, superheater and economiser, although in one case the efficiency was recorded as being 87 per cent. Such high efficiencies would, however, only be obtained under the exceptional conditions which prevail when tests are being carried out.

Electrical Generating Plant.

The next matter of importance, as far as the cost of generation is concerned, is the conversion of the energy. It is not within the scope of this Paper to deal with gas or oil engines inasmuch as these are, as far as central station work is concerned, more the exception than the rule.

Fig. 3 shows very clearly the rapid relative decrease in steam consumption per kelvin of modern high-speed turbine plant from sizes of 500 kw. to 2,000 kw., and the remarkably slight fall between sizes of 2,000 kw. and 10,000 kw. It would appear from this curve that where the conditions as regards steam and vacuum are similar the larger stations have had the advantage over the smaller ones as far as the electrical generating plant is concerned and this is un-

doubtedly true as regards almost every make of turbine of the impulse or reaction types or combination of these types. How long this will continue it is impossible to say, but tests on a 1,000 kw. "Brush-Ljungström" turbine show that a machine of this type is capable of developing its full rated output with a steam consumption of only 12·75 lb. per kelvin. These results compare favourably with those obtained in connection with machines of 12,000 kw. and 15,000 kw. capacity, and certainly make one think that the big difference in efficiency which has hitherto existed between large and small units is fast disappearing.

In an Appendix to the original Paper the author shows that whereas large turbines previously had the advantage over smaller ones to the extent of about 3½ lb. of steam per kelvin they can now only claim an advantage of about 2 lb. per kelvin or about 15 per cent.

Having referred in detail to the steam consumption of turbines, some reference will now be made to the steam consumption of modern high-speed reciprocating engines suitable for the smaller generating stations where the largest unit is in the region of 750 kw. to 1,000 kw. In such cases a 1,000 kw. engine set at a speed of, say, 250 revs. per min., will consume at full load about 15·85 lb. of steam per kelvin when running condensing (26 in. vacuum) and with steam at 180 lb. per square inch, superheated to 550°F., which figure compares favourably with those obtained from most steam turbines of similar output and under similar conditions. The figures for the smaller sets under similar running conditions are briefly as follows: 16, 16·4 and 19·3 lb. per kelvin for sizes of 750, 500 and 250 kw. capacity respectively. The results at ½ and ¾ load exceed the above figures by about 5 per cent. and 10 per cent. respectively.

Total Working Costs per Kelvin Generated.

In order to obtain reliable figures under this heading careful consideration had to be given to the records of numerous undertakings, and as a result the following conclusions were arrived at:—

(*a*) From the figures under the heading "Repairs and Maintenance," a figure has to be deducted to cover repairs and maintenance in connection with the distribution system which was found to equal (approximately) 10 per cent. of the figures appearing under the heading "Works Costs," Fig. 2.

(*b*) The distribution losses are (approximately) 15 per cent., which figure can safely be applied to all classes of undertakings both large and small.

When due allowance is made for the above items (*a*) and (*b*) the following figures are obtained:—

Table I.—*Costs per Kelvin Generated.*

Load in kw.	Works costs. Pence.	Relative works costs.	Total working costs. Pence.	Relative total working costs.	Per cent. Load-factor.
Up to 500	1·00	100	1·43	100	About 15
500–1,000.....	0·75	75	0·996	70	,, 15
1,000–1,500.....	0·64	64	0·846	59	,, 20
1,500–2,000.....	0·60	60	0·845	59	,, 20
2,000–4,000.....	0·51	51	0·668	47	,, 20
4,000–7,000.....	0·42	42	0·566	40	,, 25
7,000–10,000	0·39	39	0·518	36	,, 25
10,000 & upwards .	0·333	33·3	0·450	31	,, 25

A summary of the figures on which Figs. 1 and 2 and Table I. are based gives the following approximate result, which indicates the tremendous amount of waste in connection with the generation of electricity:—

Kelvins generated.	Cost of fuel.	Total working costs.
1,300,000,000	£1,438,000 0·265d. per kelvin.	£3,363,516 0·62d. per kelvin.

Had the question of electricity as generated by electric supply companies, private individuals and railways fallen within the scope of the Paper it might not have been a difficult matter to show how by means of centralisation it might be possible to reduce the above figure, 0·265d., by, say, 25 per cent. (not to mention the total costs figure, 0·62d.), and so effect a saving of upwards of £1,000,000 on coal alone. The natural argument against such a statement would be that centralisation could not deal with more than a small percentage of these undertakings owing to their geographical position.

Capital Costs.

This Paper must necessarily include some reference to capital costs—not only of plant already installed but of plant to be installed—in order to compare figures of the total cost of supplying electricity from large and small power stations. For this purpose reference has been made to the figures appearing in "Gareke's Manual." The results obtained are as follow.

Table II.—*Cost per Kilowatt installed of Generating Plant, Land, Buildings, &c.*

(Nothing is included for anything outside the generating station.)

Load in kilowatts.	Cost per kilowatt of generating plant installed.
Up to 500	£40 0
500–1,000	27 0
1,000–1,500	25 0
2,000–4,000	22 10
10,000 and upwards	20 0

The impression created on glancing at the above figures is that the smallest undertakings have not been able to benefit by the low costs per kilowatt of turbine plant. This is no doubt a fact because it has already been shown that below about 1,000 kw., turbine plant does not compare favourably with reciprocating plant as regards steam consumption. Therefore, the capital cost per kilowatt in such cases remains high owing to the presence of reciprocating plant. Furthermore, in the case of those stations where turbine plant has been installed, the capacity of the plant installed has been increased by perhaps hundreds per cent. without a single extra pound expenditure on land and buildings. The tables and diagrams given by the author emphasise the above statements and give one a very fair idea of the future possibilities of generating cheap electricity.

Fig. 4 shows the cost per kilowatt of generating plant and it will be observed again how the steam engine holds its own against its competitor in the sizes from about 750 kw. downwards. The figures also show that there is nothing gained, as far as the cost per kilowatt

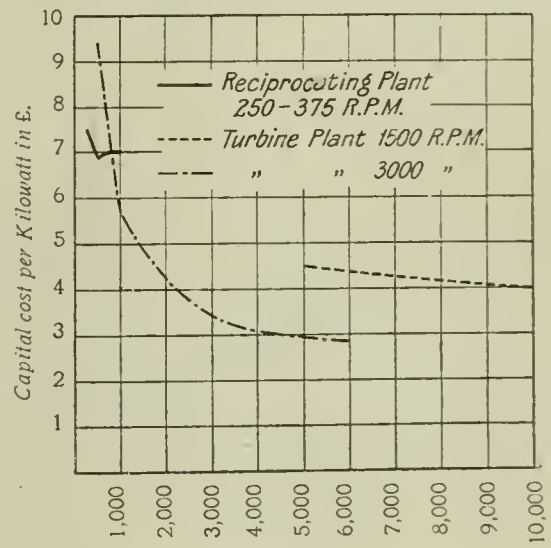


Fig. 4.—Capital Cost of Electric Generating Plant (including Turbine or Engine, Generator and Condensing Plant).

of turbine plant is concerned, by adopting the larger sizes, since owing to the reduced speed of the larger sets (1,500 revs. per min., as against 3,000 revs. per min.) there is quite an appreciable increase in the cost per kilowatt. Hence, in the case of South Shields it was possible to install 2,000 kw. turbo sets which probably cost no more per kilowatt than the large sets installed in the generating station of the Newcastle Electric Supply Co. and without further expenditure on land, buildings, &c. It is in such cases as these that it will be extremely difficult to make out a favourable case for supplying *in bulk*.

With regard to steam generating plant a glance at Table III. will suffice to show that as far as the boiler-house plant is concerned, there is nothing like the same relative difference in cost between large and small units as exists in the case of the engine-room plant, although it should be pointed out that the figures do not include buildings, foundations, coal bunkers, conveyors, &c.

Every electric supply engineer knows that it is quite possible nowadays under normal conditions to put down a very large power

Table III.—*Relative Cost of Steam Generating Plant Including Boiler, Superheater, Stoker, Economiser, Boiler and Economiser Brickwork and all Fittings, Ladders, Galleries, Doors, &c.*

(Steam, 200 lb. per square inch: Superheat, 200°F.: Coal, 12,000 B.T.U.s.)

Evaporation from and at 212°F.	Relative cost.	Cost per 1,000 lb. steam.	Cost per kilowatt.*
12,000	100	£170	£3·4
20,000	84	142	2·85
30,000	77	130	2·55
40,000	72	122	2·45
50,000	69	118	2·35

* All these figures are calculated on the basis of 20 lb. of steam per kelvin.

station for about £10 per kilowatt of plant installed, and it is more than likely that this figure might under very favourable circumstances be reduced to £8 per kilowatt. It can also be shown that a small station, say, 2,000 kw. to 5,000 kw., would not cost more than £20 per kilowatt, and a very small station (below 2 000 kw.), £30 per kilowatt. The larger station would have an advantage over the smaller one owing to the lesser proportion of stand-by plant, and also by reason of lower working costs.

For the purpose of showing as clearly as possible what might be done, under normal conditions, in the way of generating electricity on a large scale, Fig. 5 has been prepared. It will be noticed that in order to have some basis to work on, the figure 0·265d. has been taken as being a fair figure for total working costs in a station having a load of 80,000 kw. and a load-factor of 25 per cent. This figure is split up into various items of cost which in turn are divided into fixed charges and running charges.

In comparing the figures represented in this curve with those of Figs. 1 and 2, it must be remembered that since the latter are average figures there are some stations which generate at a cost considerably below the average. Careful investigation would undoubtedly show that there are cases of comparatively small stations where it would

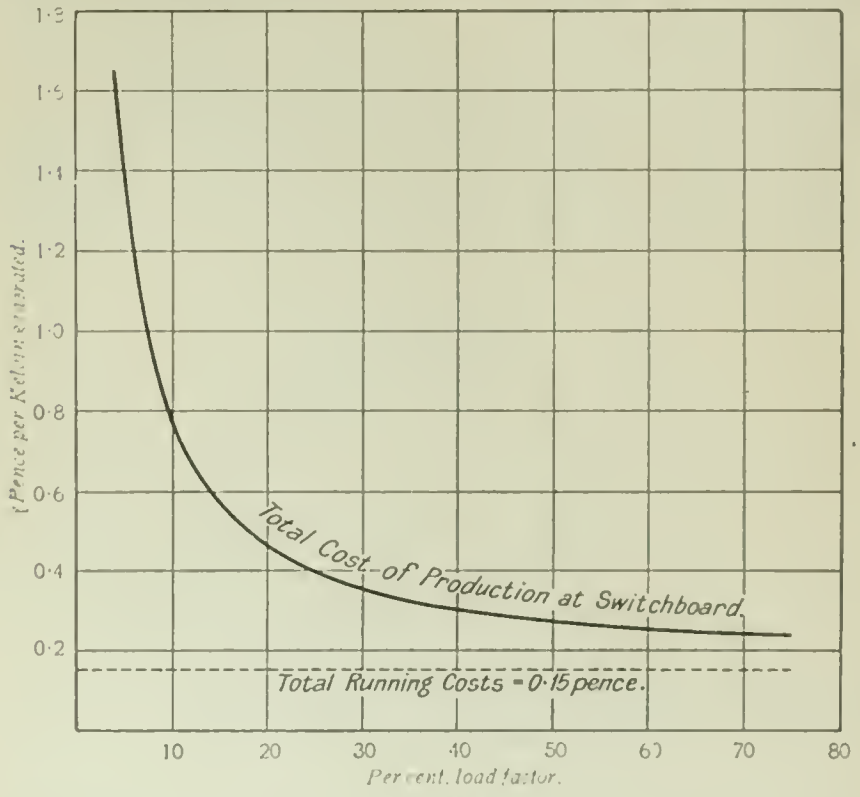


Fig. 5.

Estimated Cost of Production per Kelvin Generated for Generating Station of 100,000 kw. (Plant installed).

Load = 80,000 kw. Capital cost of plant installed = £1,000,000. Interest and sinking fund = £100,000. Total working cost (pence per kelvin) on basis of 25 per cent. load factor and allocated as follows:

Item.	Fixed charges.		Running charges.	
Coal, &c.	25 p.c.	0·04	75 p.c.	0·12
Oil, stores, water, &c.	50 ,,	0·005	50 ,,	0·005
Wages of workmen	75 ,,	0·015	25 ,,	0·005
Repairs and maintenance	50 ,,	0·015	50 ,,	0·015
Rent, rates and taxes	100 ,,	0·02	,,	--
Management salaries, &c.	100 ,,	0·02	,,	,,
Totals		0·115		0·145
			Say	0·150
Total working cost		0·265 pence.		

Note.—Nothing outside generating station is included.

certainly not pay to take a bulk supply. In the majority of cases, however, it would appear that a bulk supply would be of considerable advantage. It must not be forgotten that the curve represents an ideal state of things which can only be arrived at providing all, or at any rate most, of the existing undertakings agree to sink their individuality in that of the larger scheme.

Transmission.

There does not appear to be any serious difficulty in the way of a bulk supply scheme from the point of view of transmission, except as regards the capital cost, which in the case of a large system might very nearly equal the capital cost of the generating station. It is also doubtful whether any responsible public electric supply engineer would care to run the risk of being entirely dependent on overhead lines for his supply. It would be advisable, therefore, that any hypothetical estimate of the cost of the transmission system, should be based on underground cables, or on a combination of underground and overhead mains carefully interconnected and led to the point of distribution along different routes.

The disadvantage of the adoption of extra-high pressures is that step-up, as well as step-down, transformers would have to be used with the result that the transformer losses alone would amount to a considerable sum per annum. In addition to the above losses it is necessary to allow for the losses in the cables, not to mention the heavy losses which will undoubtedly be incurred when it is necessary to convert the three-phase energy to direct-current or alternating-current at a different periodicity to that of the bulk supply system.

The author is of opinion that by the time all these things have been taken into account it will be a very difficult thing to prove that an isolated bulk supply authority is in a position to generate and distribute electrical energy at a price which will allow of a reasonable profit, although the case might be altered materially by the linking-up of other large undertakings in which case the capital cost per kilowatt of load could be substantially reduced.

Conclusion.

It is desirable that steps should be taken thoroughly to investigate the whole question of electricity supply in this country, because every day increases the obstacles and delays electrical development. One of the obstacles to be surmounted is local jealousy. There are cases where such jealousy appears to have been overcome and the author hopes that those who have experience of such cases will come forward and give the Association the benefit of their experience.

It would appear that the first thing to be done would be to appoint a representative Committee consisting of members of the I.M.E.A., and this Committee should have power to co-opt members of other scientific societies. The duties of such Committee would be to make a thorough investigation into the whole subject of electricity supply, with a view—

(*a*) To standardise as far as possible the generation and distribution of electricity throughout the whole country.

(*b*) To conserve the supply of fuel used in electricity works and to make a thorough investigation of the important question of extracting from the coal valuable by-products.

(*c*) To make use of waste-heat wherever possible.

(*d*) To cut down the percentage of spare plant by judicious linking-up of adjacent networks. (There are numerous instances where this could be done right away.)

(*e*) To promote legislation whereby facilities may be obtained such as are absolutely essential to the scheme and such as do not exist to-day.

THE APPLICATION OF ELECTRICTY TO AGRICULCULTURAL PURPOSES.*

BY W. T. KERR.

(City Electrical Engineer, Hereford.)

Summary.—The author gives an account of the supply that is being given to the farmers around Hereford, and the importance of an agricultural load is strongly emphasised.

Up to the present time the use of electricity in farming has not attracted the attention that it undoubtedly deserves on the part of the electric supply authorities, electrical manufacturers and engineers in this country. This is the more surprising in view of the very close attention which has been given to the subject on the Continent of Europe and in America, and the important and extensive schemes for supplying agricultural areas which have been carried out in different countries.

In placing the following rough notes before you, the author wishes to emphasise the fact that there is awaiting development in this country an enormous business of a similar kind, which will also place at the disposal of the agriculturalist a labour-saving source of power and light superior to any other. The writer's conclusions are based on some year's experience in farm supply work in the neighbourhood of Hereford, where it is quite reasonable to suppose that conditions are not more favourable than in many other parts of the country for this particular class of supply.

The last report of the Ontario Hydro-Electric Commission contained some particulars of farming supply in Ontario, with data as to energy used on farms: the average yearly consumption per farm for all purposes was 1,700 units, and the average revenue £27.

Light Transmission Lines.—In the Hereford district a system of light transmission lines has been erected to reach the agricultural consumers. These are built with larch poles, 28 ft. long, with cross-arms of quarter oak 2 ft. 6 in. by 3 in. by 3 in., the bottom arm 3 ft. The lines are usually now made up to 7/10 B.S.G. bare stranded aluminium, weighing about 0·032 lb. to the yard, and costing before the war 1s. 0½d. per lb., with two No. 12 galvanised guard wires below, which are also used as the neutral, the supply being given at 440 volts, three wire (220 volts for lighting).

The total cost, including labour, works out at £110 per mile. These

* Abstract of a Paper read before the Incorporated Municipal Electrical Association yesterday.

lines have withstood the gales of December, 1915, and March, 1916, without a breakdown.

The farthest distance a supply is given is 3,400 yds. from the generating station, 1,200 yds. of which is by overhead lines; these radiate in five districts from the station to an average distance of 3,000 yds.

When erecting the poles, it has been found better to place them close into the hedges, otherwise the cattle use them for relieving themselves of insect life, to the detriment of the line; also farmers object to their being placed any distance out in the fields, and the hedges and ditches act as a guard.

Such lines can be arranged with quite long spans, 75 yds. in places, between the poles, to cut across corners, if the route is carefully considered before the erection.

Tappings to consumers are taken off by means of a twin-lead cable clipped to the pole. It is very important to seal both ends of the cable where the leads are taken off, and this is usually done at the top of the pole by securing a small type sealing box to the pole and taking-off leads, leaving a short bare space on the wire between the lead-covered and rubber-covered leads where the thimble is sweated, and afterwards sealing this with compound.

The connection to the aluminium wire is made by means of a "jim crow" shaped clip, which grips the wire in two positions, the lead being sweated to a screw used for tightening in the centre, and the whole joint afterwards painted over with aluminium paint; no trouble whatever has been experienced with such a joint, although one section has been in constant use for nine years, connecting up a supply to a 50 H.P. motor from an aluminium overhead line running alongside a main line railway.

In an average case, a 10 H.P. motor will meet all the power requirements of a farm, except for thrashing and cider milling, but motors up to 20 H.P. have been hired out for these purposes, which are only seasonable jobs, and do not require a permanent fixing.

Way-leaves.—The greatest obstacle to cheap rural supply is the question of way-leaves; when it is necessary to go outside the boundary of a Provisional Order area to supply in a district without such an order, many unnecessary legal difficulties are encountered.

One experience has been that a line to supply a farm building and residence was held up over 12 months, although it was only necessary to cross two small meadows, certain members of the local District Council viewing the application for permission to supply electric power as a means of negotiating for an extension of water supply to a house quite 2 miles away.

Application was made to the Board of Trade for an over-riding order, and they suggested further negotiations before granting it. When an agreement was eventually come to, the legal costs amounted to more than twice the cost of the transmission lines, and the prospective consumer had been kept waiting for a period of 12 months, although the installation had been put in, and it was only necessary to cross a field to give the supply. This, obviously, is not as it should be; such obstacles prevent proper development and are a bar to progress.

Farm Installations.—A description of the plant and power uses on a Hereford dairy farm may be of interest. The installation consists of an 8·5 H.P. open-type motor, running at a speed of 960 revs. per min., with the starting panel mounted alongside. The vacuum pump for the milking machinery requires 1½ H.P. This machine is used twice daily, for about two hours in the morning and 1¼ hours in the afternoon. The cows milked average about 70, and the machinery has a capacity of 88. The farm bailiff states that it would require five men at least, who are expert milkers, to do the work in the same time, or with his present staff five or six hours a day longer.

A motor is used to drive the root pulping and chaff-cutting machines on the floor above, the machines being so placed in order to keep out all the dust which generally arises when dry hay is being cut. Experience shows that owing to the easy starting of an electric motor the exact quantity of food can be cut and mixed fresh as required, a very important result being a greater yield of cream in the milk. A machine for kibbling corn and rolling oats is installed, also a circular saw for splitting wood and fencing material.

This represents a typical installation, but there are many other operations that could be done most efficiently by electricity by any farmer enterprising enough. In the future an apparatus for electrically heating water will be installed. The farm buildings are lighted throughout, there being 25 lamps of 25 c.p., and, in addition, the bailiffs' house and some cottages are supplied off the same line through "Penny-in-the-Slot" meters. The units consumed on this farm for year ending 1915 amounted to 2,411, at 2½d. per unit, and the revenue reached £25, or an average of 9s. 7d. weekly.

The use of electricity from the farmers' standpoint means a considerable saving in labour, although the operations could be performed, as on many other farms, by oil or gas engines. Engine stopping and starting, however, requires time, and it would also be necessary to send men and carts for oil or coal to the nearest town or railway station, all of which takes time, and should be added to the cost of any other type of power, but rarely is taken into account.

There are many operations requiring power always to be found

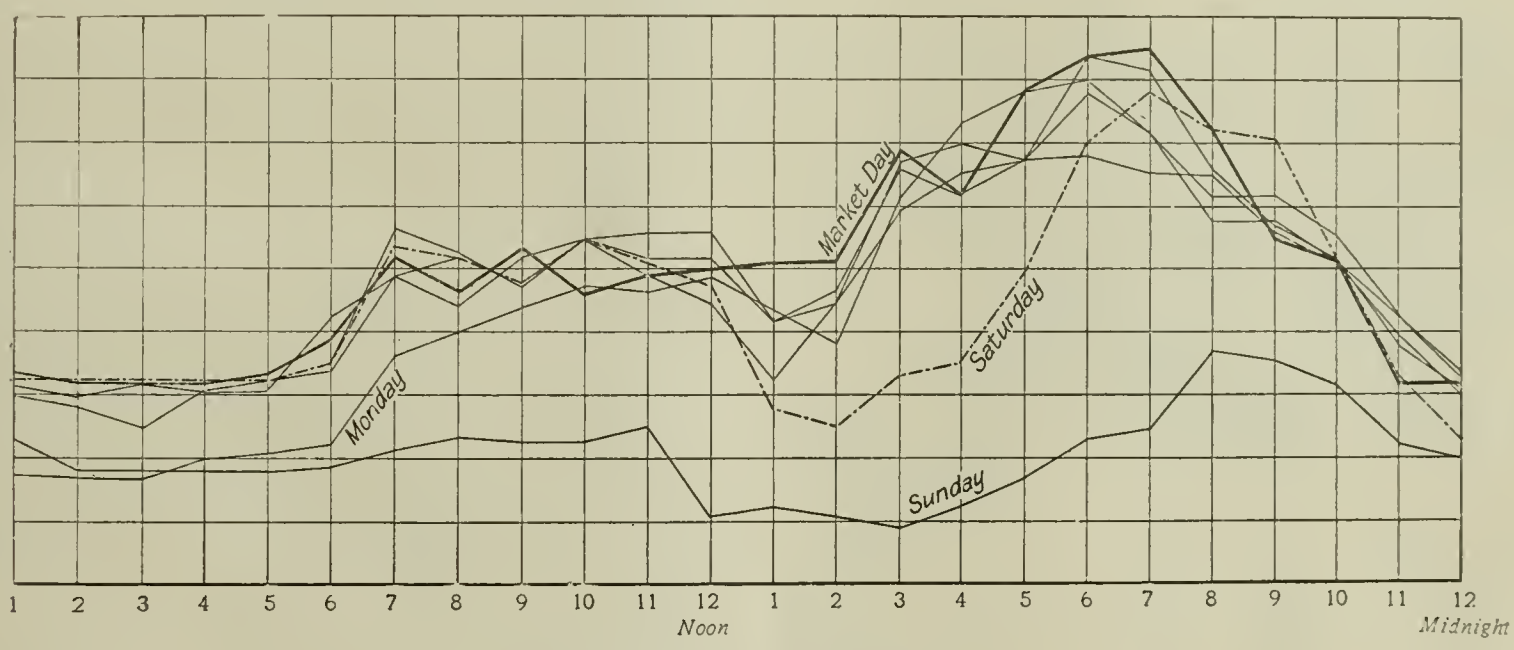


FIG. 1.—LOAD CURVES AT HEREFORD.

in agricultural areas, which are peculiar to the particular district, for example, in cider mills. Machines are used for the drying of spent apples after the juice has been extracted, and the apples afterwards used for cattle food; one large machine of this description requires about 25 H.P., and runs for three months, 24 hours daily, with as few stops as possible. The same motor is used for sawing wood during other months of the year.

Similar drying machines are used for grains and spent hops, the grain being used as a cattle food and the spent hops for bedding, while the seeds from the hops are used for the preparation of a dye stuff. In the greater part of the hop-growing district, the demand per farm would run up to 25 H.P., which would be used for spraying the hopyards, driving fans and pocket-filling presses: it is possible that electroculture would be of assistance in extinguishing blight, and this would open up a field of incalculable value.

Ploughing.—The introduction of electrical ploughing, and of electrically-driven wagons for the general hauling work is a possible development of the near future. It requires about 1·5 acres of land to provide food for each horse kept on a farm, and the work being seasonable, at times many horses are needed for a few weeks together; and again there are many weeks when horses cannot be used owing to the land being in such a state due to weather conditions.

An electrically-driven plough or wagon would not be standing in a stable, eating its head off, and the elimination of horses would release further land for cropping. From a mechanical point of view, it would not be a difficult matter to design a machine that could be used alternately to plough, or to drive a thrasher, and which could be run into position to drive the general farm machinery. With a

suitable pulley and geared countershafts for varying speeds, 10 H.P. to 12 H.P. would cover the power requirements for all usual operations, and the machine would be a farmer's "Mary Ann." But the vital necessity is a permanent power supply available in the farm, the rest would be simple, as no other form of power could be utilised in such a manner; the ordinary size of battery used on an electric vehicle would be sufficiently large to plough a good many acres of land, and could be charged in the usual way at night, with a boosting charge during the day if necessary.

A petrol-driven two-furrow plough weighs about 20 cwt., and develops about 11 H.P., requiring about 2 gallons of petrol, or benzine, per acre, with a certain amount of lubricant. The total weight of a battery on a 1-ton van, for a 50-mile radius, is about 1,260 lb., giving a speed of 12 miles per hour; the total weight of the chassis is 3,400 lb., and if we substitute the plough blades for the weight of a pair of wheels and gear it to travel about 120 ft. a minute, it would be fair to assume that a battery-driven plough is not an impossible machine. The battery charge capacity being equal to 18 kw., the cost would be very low, at usual power rates, per charge.

Most farms have a certain area of arable land permanently used for cropping, round which light overhead lines could be erected to

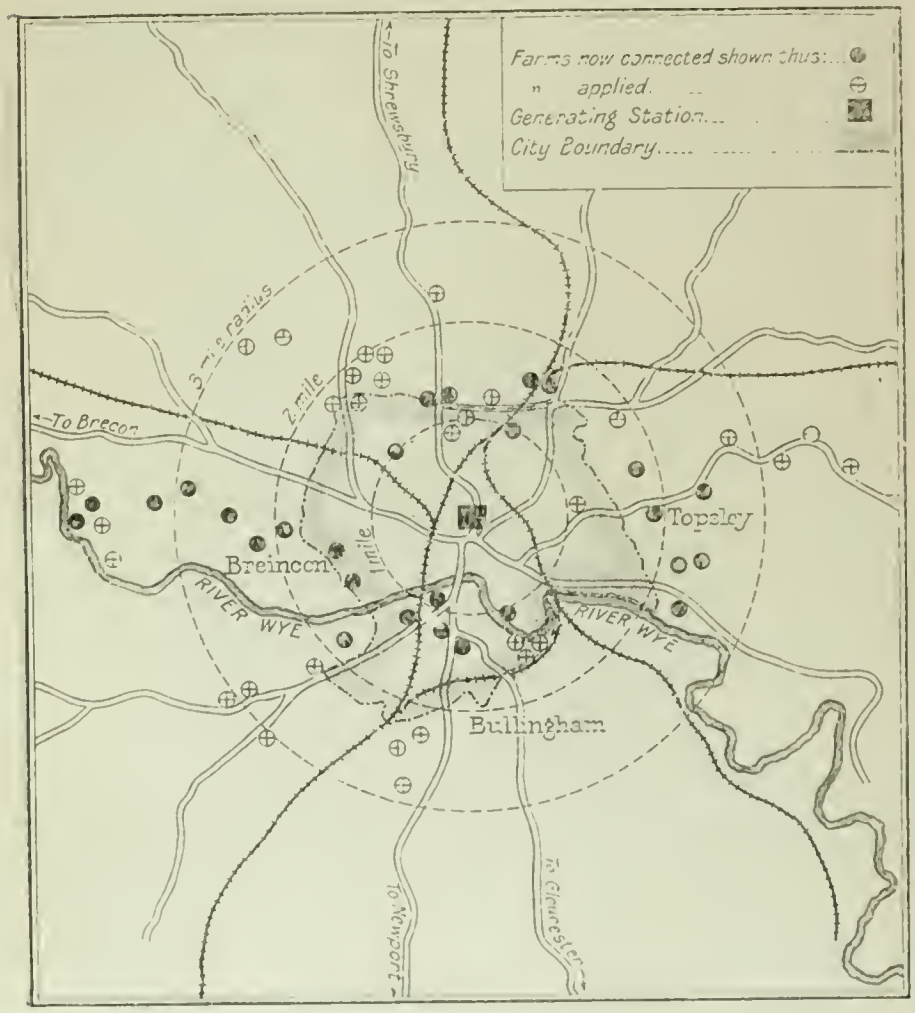


FIG. 2. MAP OF HEREFORD.

certain points, and by means of a trailing cable carried on a drum, geared with the speed of the plough to pay in and out (the cable being sheathed with tough rubber compound), the double winding rope hauling ploughing gear of the usual type could be dispensed with, and a plough carrying a single motor and controller used. The slow rate of speed of a plough along a furrow would not endanger the life of a trailing cable.

Electric ploughing on an extensive practical scale has been carried out in Germany, Sweden, Italy and France, the results being usually stated to be in favour of electricity as compared with either animal, steam or oil ploughing tackle. German investigators have declared that for really heavy ploughing, the only competitor of steam is electricity. Much of the published data regarding ploughing costs is, however, not really comparable, as the local conditions, depth of ploughing, &c., greatly influence the results obtained.

Agricultural Districts.—In the Hereford supply area the district is typically agricultural. The horse power of motors in use and units consumed generally in carrying out the operations are as follows:—

Cider making	101 H.P.	... 67,401	units
Milling	142 H.P.	... 347,856	..
Farmers' supply	196 H.P.	... 19,673	..
Water pumping	157 H.P.	... 331,295	..
Sawmilling	130 H.P.	... 22,801	..

Fig. 1 is a curve of the daily output for one week.

A scheme of high-tension three-phase supply has been prepared for the Hereford area, which it is proposed to carry out after the war, there being a growing demand for electricity from farmers and private residences that cannot be met by a 440-volt three-wire supply. There are as a rule five farms to the mile along an average road; there are also many ordinary country residences. We can estimate an average revenue of at least £100 per annum from the five farms, and anything from £20 to £200 from the private houses. Large country residences are only too anxious for such a permanent source of supply, and 6d. a unit could be quite easily obtained.

A few notes have been taken of the consumption and generating costs of several large mansions in the Hereford area, of which the following is typical: The installation consists of engine (oil) of 16 B.H.P.; battery, 54 cells of 400 ampere-hour capacity; 300 25 c.p. lamps installed. Average cost of "Royal Daylight" oil for 12 months, 10d. per gallon; 2½ units of electricity delivered into house for every gallon used—4d. per unit for oil. There were also 25 gallons of cylinder oil used at 3s. 2d.—£3. 19s. 2d. The cost of small repairs battery, bolts, brushes, but not including repairs to wiring in the house, amounted to £4. 12s. 3d. Wages of man to look after engine, &c., 28s. per week, plus house and coal, 10s. per week—£98. 16s. An allowance of 15 per cent. depreciation must be made on cost of the battery.

Electric cooking and heating offer enormous possibilities if a permanent supply were available, and it is no exaggeration to say that such a supply will be received with open arms by the residents, who are under no misapprehension as to being able to produce electricity cheaper themselves. Such consumers have heard so much about the "battery will not do it," and paid so many repair bills, that they will take the first opportunity to get rid of the private generating plant.

The average revenue in such a case should amount to between £150 and £200 per annum; the owners in most cases would be quite willing to meet the cost of the service extensions, running over their own estates, from the main supply, or agree to a minimum charge of 10 per cent. on capital cost of extension, with a kilowatt demand and small charge per unit.

High-tension Supply.—In recent years a good deal of attention has been given to the future development of electric supply in this country on a wholesale scale, and some engineers—Dr. Ferranti and Mr. Chattock, for example—have pictured a future in which electricity supply will be run in the national interests, and the country will be served by a network of transmission lines. Such lines will in most cases have to pass through agricultural districts, which, if properly exploited by the existing supply authorities, would be in such a state of development that a paying load could be obtained along the route to commence with. In such a case it may be assumed that it would cost something like £2,000 to cut into the extra-high-tension lines for a supply of low-tension energy.

Existing data shows that the average consumption of current in an agricultural district with a population of 22,500 is 58 units per head, so that taking the county of Hereford as a whole, with a population of 114,296, the possible sale of energy on the same basis would amount to, say, 6,637,000 units. This supply would be given in an area 40 miles long by 35 miles wide, with a central distributing point. Throughout England, towns of any size of over 20,000 population are 25 to 30 miles apart, with smaller towns of up to 10,000 people between; this is the case in all the agricultural areas, and the distribution lines from most extra-high-tension transformer stations would thus extend to about 15 miles radius.

It will be seen that the estimated output of 6,637,000 units, at an average price of 3d. per unit, would represent a revenue of £82,962, or taking as a basis the number of farms in the county—3,573 of an average of 150 acres—and allowing the same yearly revenue as already obtained from farms connected to the Hereford City supply, viz., £25, we obtain a revenue of £89,325 from farms alone. If the farms did not all elect to use electricity, there would still remain numerous country houses and rural industries as available consumers, as well as village water supply and electric lighting installations. It is probable that the estimated consumption given would be exceeded.

There are many other directions in which electricity is making headway in connection with agriculture which should not be overlooked, and the foremost of these is "Electro-Culture." Experiments that have already been carried out have given most favourable results, notably those of Mr. J. S. Newman, of Bristol, and Miss Dudgeon, of Lincluden, Dumfries.

The author gives brief particulars of the large increase obtained in potatoes and in oats by electro-culture. From the farmer's point of view the first cost of the installation appears to be the dominating factor, while so far as the central station is concerned it must be

admitted that the power requisite would be comparatively small—Mr. J. E. Newman estimated that 1 h.p. would be sufficient for 50 acres. The fact of electricity being required for such a purpose would, however, inevitably lead to its adoption for lighting and power purposes.

Some of the other uses of electricity in agriculture are the incubation of chicken, which has been described by Mr. T. Thorne Baker. Eggs hatched in incubators sometimes yield a percentage of weakly chickens, so that many young chicks die during the first few days. The application of suitable high-frequency current for the chicks almost entirely prevents this death, owing to its stimulating effect, while they gain weight on their normal amount of food at an increased rate, becoming in two months as heavy as chicken grown for three in the ordinary way. They get their second feather very early, and are obviously finer birds. A chicken farmer growing "petits poussins" for the epicure's table—a commerce of noteworthy profit—could thus produce nearly 50 per cent. more chickens per annum at a cost which works out very much lower than the cost of providing the electricity.

The author gives some particulars of the working of electric incubators.

In one of the stock-raising farms in the United States electricity has been put to a novel use for the winter fattening of sheep. The sheep pens are wired, and the electric light is turned on during the winter months from 4 p.m. to 9 p.m. Under this artificial illumination the sheep continue to feed until the lights are extinguished at 4 p.m. the lamps are again turned on and then burned until daylight, and again the sheep feed. In this way the sheep are made to feed during the equivalent of a long summer day, and thus, despite the winter season, are brought quickly to the condition for marketing.

The foregoing notes represent only a brief outline of the possible directions for electrical development in connection with agriculture. No reference has been made to the domestic uses of electricity on the farm, which will almost certainly exceed those of the town consumer; nor has any mention been made of future developments in connection with the production of artificial fertilisers by electrical means. For the moment it is sufficient to point out that electric power and light appeals so strongly to the agriculturist that but little exertion would be required on the part of the central station authorities to secure a really profitable business.

The writer feels, however, that successful as individual efforts might be, the results obtained would be insignificant compared with those which might be secured were an organised campaign in favour of agricultural electrical supply to be instituted, and efforts made to equip demonstration farms in suitable districts near existing towns. The writer hesitates to add to the many activities of this Association, by suggesting additional responsibilities—especially at the present time—but there is no doubt that its members have the matter in their own hands, and that concerted action is strongly called for, both for private reasons, to frustrate the efforts of the oil engine makers to monopolise the farmer's power business, and on national grounds, because it is imperative that no effort be spared in obtaining the mutual support of our industries with a view to securing the maximum of industrial efficiency after the war.

RECENT PRACTICE IN THE MANUFACTURE, LAYING AND JOINTING OF 33,000-VOLT 3-PHASE PAPER INSULATED UNDERGROUND CABLES.

BY C. BEAVER, M.I.E.E.

In view of the considerable general interest in this branch of cable work evinced by the discussion on the writer's recent Paper* on "Cables," a short description of results obtained in practice based on the methods which were then advocated may be of further interest.

The chief points of departure from what has hitherto been generally regarded as common practice relate to the method of impregnation of the cable dielectric, and the construction of the joints.

It may be remembered that the method of impregnation advocated by the writer entailed a process of drying and impregnating the paper before its application to the conductors. The primary object of the method, which the writer introduced about 18 years ago, and which has been successfully used ever since, was to ensure uniform impregnation throughout every part of a cable dielectric, not only in a radial sense but also throughout its length.

The common method of drying and impregnating the paper dielectric in vacuo after application to the conductors and their assembly, entails prolonged exposure to heat as compared with a few seconds only in the case of impregnation of the paper in sheet form prior to lapping on the cable. Further, in the common method the period of heating has to be increased according to the thickness of dielectric, whereas in the prior impregnation process the heat treatment of the paper is always constant, and of minimum duration.

It has also been recognised for many years that the common method also entails a tendency to lack of radial uniformity throughout the wall of dielectric because of a separation of the solvent from the solute portions of the impregnating medium, so that to some extent the compound in the interior portion of a dielectric may be of different composition to that in the outer part of the dielectric wall. This may adversely affect the potential gradient in the dielectric.

There are other factors which militate against uniformity when the impregnating operation is performed after the application of the paper to the cable. For instance, the impregnating compound will have paths of varying resistance opposed to its passage from the exterior surface of the wall of paper to the conductor; paths following spaces between convolutions and between the surfaces of contiguous layers being obviously of less resistance than paths composed entirely of fibrous material.

In multicore cables the wall of paper on the cores is also subject to varying mechanical pressure tending to compress it along the lines of contact of the cores, and to slightly loosen it elsewhere.

While the effect of these factors may be quite negligible in thinly insulated low-tension cables, it is clear that the only way to render the tendencies innocuous in the case of thick walls is to vary other factors in the impregnating process, such as the time of immersion in the hot compound, and this is bound—and can easily be proved—to be detrimental.

A general disadvantage is that any variations or shortcomings in the whole operation cannot be visually checked as they can in the case of impregnation before application, in which every square inch of paper passes before the eyes of the operator.

Apart from the general advantages appertaining to the definite and constant character of the prior impregnation method, it is therefore specially desirable in the case of extra-high-tension cables having very thick walls of dielectric, and the results obtained on a recent large contract for 0·15 sq. in. 33,000 volt cable afford an excellent demonstration of its efficiency.

The cables in question had a total radial thickness of dielectric of 0·60 in. between conductors and between conductors and the lead sheath. Single wire armouring, consisting of a layer of No. 10's S.W.G. galvanised steel wire laid on a jute bedding, was applied to the major portion of the cables. The chief function of this armouring was to act as an earth shield rather than as mechanical protection, as the cables were laid solid in cast-iron troughing.

Cables which were laid direct in the ground, and were therefore more liable to mechanical injury, had further protection applied to them in the form of double steel tape armour, and were finished with impregnated jute lappings.

The official factory tests consisted of a pressure test of 75,000 volts maintained for 30 minutes between conductors, and between conductors and the lead sheath, and a bending test in which 6 yd. lengths of the finished (armoured) cable taken at random were bent six times in reverse directions round a cylinder having a diameter equal to ten times the overall diameter of the cable. These lengths were afterwards submitted to the same pressure test as the cables from which they had been cut, and subsequent attempts to test them to destruction at about 100,000 volts were in every case unsuccessful.

The guaranteed insulation resistance was 600 megohms per mile at 60°F. The average value actually obtained was about

* "Journal" I.E.E., Vol. LIII., No. 238, Dec. 15, 1914, p. 57.

700 megohms per mile at 60°F. The guaranteed maximum capacity was 0·26 microfarad per mile at 60°F. The maximum actually obtained was 0·24 microfarad per mile at 60°F.

The design of the straight through joints used on these cables was based on the principles described in the writer's Paper on "Cables" above referred to, the chief feature being, firstly, substantial conductor jointing ferrules turned with curved surfaces and ends designed to avoid concentration of stress which might arise either from an edge effect on the ferrule itself, or from a point effect due to the exudation of solder globules at the ends of the ferrule; secondly, the use of specially designed thoroughly vitrified unglazed porcelain spacers, which permit the elimination of wrappings of tape or paper, and reduce the dependence on jointer's workmanship to a minimum; and thirdly, a special design of cast lead sleeve made in three parts, constructed to permit of efficient filling under ordinary atmospheric pressure conditions.

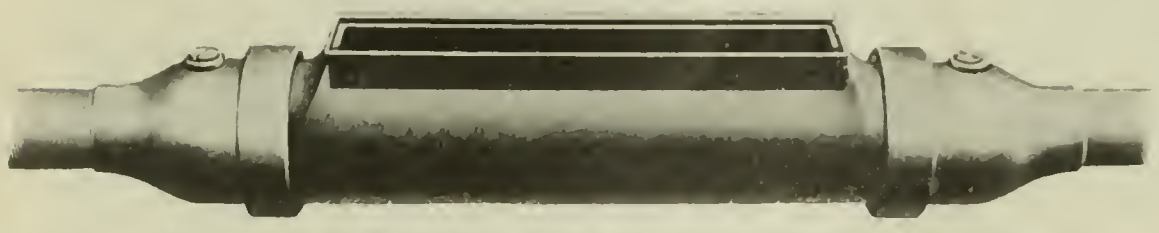


Fig. 1.—Cast Sleeve with Lid Removed.

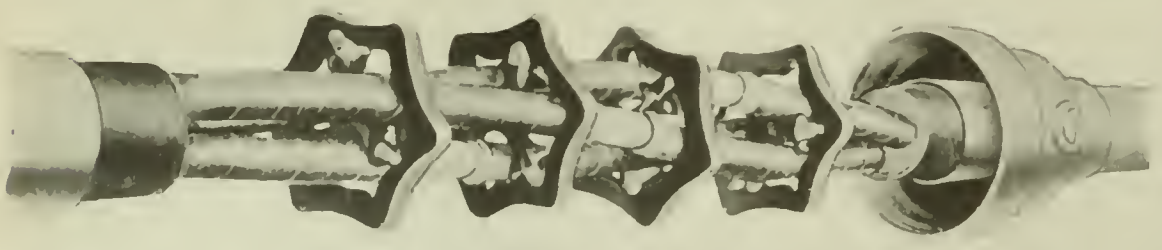


Fig. 2.—Showing Porcelain Spacers.

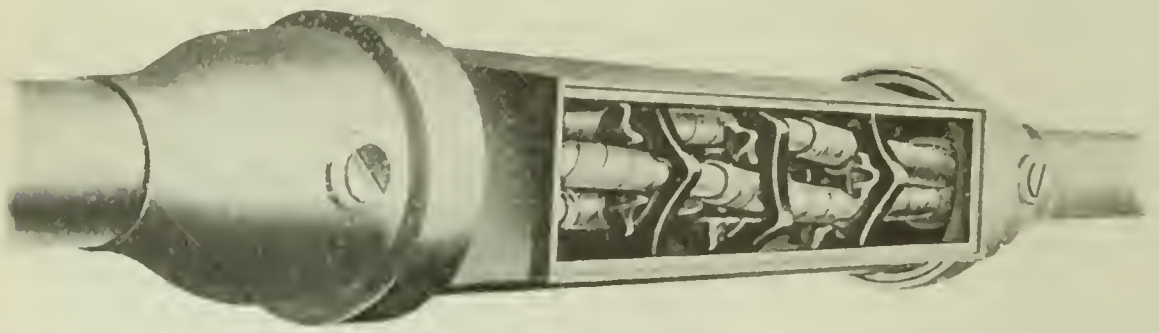


Fig. 3.—Joint Ready for Plumbing.

Figs. 1, 2 and 3 illustrate these features. Fig. 1 shows the cast lead sleeve with lid removed. The end portions of the sleeve, fitted with vent plugs, are cylindrical, and screw on to the central portion which is flask shaped in section. The rectangular opening provided for compound filling by a simple pouring operation is closed after the sleeve is filled by a lid which is soldered all round its edges. The seating provided for the lid is such that no solder globules can penetrate to the interior of the sleeve. The general design ensures that nothing but smooth surfaces of bold curvature exist in the vicinity of the conductor joints, anything in the nature of projections or edges being as far removed as possible therefrom.

Fig. 2 shows the joint with porcelain spacers in position prior to the assembly of the three parts of the lead sleeve over it, these, as well as the hexagonal outer collars of the porcelain spacers being threaded over the cable before the conductor joints are made.

The web portions of the spacers are slipped between the cores at equal distances from the staggered conductor joints, and given a right-angle turn to get them into a vertical plane, and the outer porcelain collars are passed on to their respective web pieces and turned through an angle of about 60 deg. to lock the two parts together.

Fig. 3 shows the joint in its cast lead sleeve, assembled ready for the plumbing and compound filling operations.

Fig. 4 shows one of several joints on the lead covered cable prepared for the high-pressure tests, and Fig. 5 shows the joint as laid, complete with armour bond and enclosed in a cast-iron box for mechanical protection.

The pressure tests on sample joints were specified to be similar to those applied to the cables—viz., 75,000 volts for half an hour between conductors and between conductors and sheath. After successfully withstanding this test the pressure was raised to 100,000 volts for 10 minutes without any sign of failure. The test was repeated after an interval of 24 hours with similar results.

With regard to the efficiency of filling, any lack of homogeneity in the mass of compound would have been fatal under the stresses entailed by these pressures, but subsequent dissection of the joints showed that no such imperfections existed.

As mentioned above, the method of filling employed in these joints is a simple pouring process, and in view of the diverse opinions held in various quarters on the subject of joint box filling, it may not be out of place to point out that given a suitable design of box the various methods of filling under pressure which have been advocated are less desirable than simple pouring methods which follow the natural behaviour of a given compound under the heating and cooling conditions entailed in the operation of filling.

The fallacious ideas which exist on this subject have their origin in misconceptions as to what actually happens during a box filling operation. The fact that compounds such as are generally used for the purpose are of such composition that they have no definite melting or boiling points leads to a disregard of the fact that at the pouring temperature they are usually giving off gases in more or less appreciable quantities due to slight distillation of some of their constituents. This can be proved by rapidly "freezing" the compound from the molten to the solid state, when the mass will be found to be more or less honeycombed with gas bubbles, the size and disposition of which will depend on the rapidity of "freezing" i.e. on the opportunity given to the original minute bubbles to join and form larger bubbles and to pass along the path of least

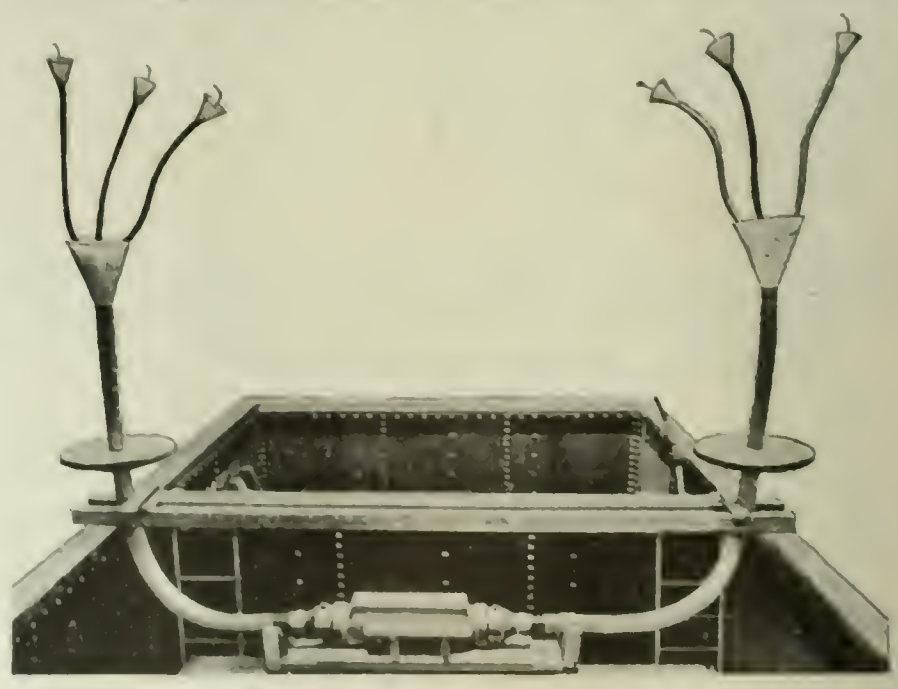


Fig. 4.—Joint Ready for High-Pressure Test.

resistance to a point of escape from the liquid compound. With these facts in mind several things immediately become apparent. For instance, that cavity troubles which are sometimes ascribed to the physical contraction of the compound on cooling, or to an drawn from interstices of the cable, are more often due to gases produced from the compound itself.

That a vacuum tends to increase the risk of cavity trouble—especially if unsuitable temperature conditions exist at the

time of filling and during the cooling period after filling because it greatly facilitates the distillation effects which produce the gases.

That pressure does not appreciably assist in getting rid of occluded gases in the compound.

Even in the case of the complete joint illustrated in Fig. 5, in which the matter is complicated by a further heating process due to the filling of the outer cast-iron box with bitumen at a high temperature after the cast-lead sleeve is sealed up, the results of dissection showed perfect homogeneity in the compound with which the lead sleeve was filled, and in all cases the cable ends on either side of the joints were found to be solidly filled with compound for a distance of about 8 in. from the end of the lead covering of the cable.

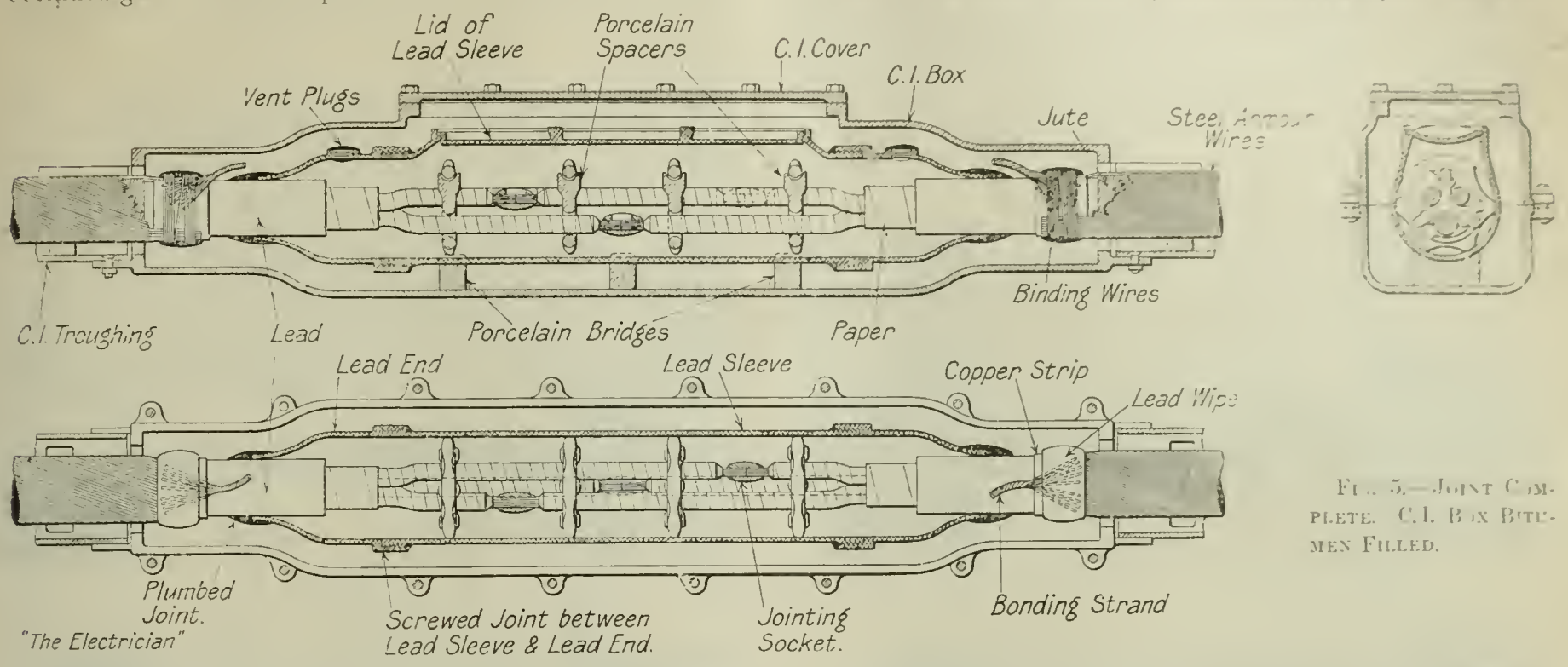


FIG. 5.—JOINT COMPLETE. C.I. BOX BITUMEN FILLED.

That unless facilities are provided for the escape of the gases, efficient and homogeneous filling is largely a matter of chance, depending on temperature conditions before, during and after the filling operation.

THE CONSTRUCTION OF HIGH-TENSION CABLE JOINTS.*

BY P. TORCHIO.

In late years the concentration of power generation has required the operation of underground cables at relatively high transmission voltages. Up to the present time cable splices for these high voltages have usually been made with insulating fibrous tapes or tubes and hard compound fillers, which have been generally satisfactory for pressures up to 13,000 volts. Many troubles have ensued, however, when joints so constructed have been used with extra-high voltages.

The need of improving the methods of making such cable splices was recognised several years ago by the New York Edison Company, and extensive studies and tests with different kinds of joint-filling compounds were conducted in connection with different types of carefully made joints; but all these joints failed to give uniform and satisfactory results. Paraffin compounds were found unsatisfactory, because on cooling they contract, leaving pockets. Heavy gum compounds having high melting points did not flow into the crevices, and, moreover, under short-circuit stress cracks were formed which did not heal and finally caused breakdown. Later, experiments were conducted with liquid fillers (fluid at low temperatures) such as resin or mineral oils used in the insulation of cables. The chief difficulty found with liquid fillers is that they may run into the cable and leave voids in the joint. After considerable experimenting, however, this difficulty was completely overcome by a design of joint briefly described as follows :—

The cable splice is hand-wrapped with oil-saturated paper tape, insulating oil being brushed all over the surface of each layer. In a similar manner over the three conductors, properly spaced and packed with a saturated filler, is wrapped an outer jacket, which is then pierced at several points, so that the oil will freely enter the interior of this jacket. Over the jacket is applied copper gauze, and around it a heavy lamp wick. The object of the metal gauze is to provide a continuous metallic cover around the solid insulation to protect the latter against electrostatic charges, even if some of the oil leaves the joint, and still allow the oil free access through the holes of the gauze. The lamp wick is applied to retain by surface tension the insulating oil in the splice, even if the oil should leave the annular space between the insulation and the lead jacket. The latter is made somewhat larger than usual to hold an extra amount of insulating oil to feed the lamp wick. After the joint is completed it is subjected, by means of a vacuum pump, to a vacuum of about 27 in. to 29 in. and then filled with a liquid compound. To supply any oil absorbed by the joint and the cable connected to it a special pressure cup full of oil is applied and left connected for 24 hours, after which time the cup is removed and the hole capped and sealed.

Splices of this type are being used on three 25,000-volt underground cable transmission lines. Under laboratory test they have withstood without failure 50,000 volts three-phase for over 340 hours, when the test was discontinued. Out of more than 30 experimental splices of all types, the oil-filled ones were the only ones which withstood indefinitely the 50,000-volt three-phase test. Some of these splices were tested with equally satisfactory results, even when drained of all the oil in the annular space between the joint and the lead sleeve. Up to the present time 290 cable splices have been in service for about eight months without a failure supplying energy to a large 24,000-volt single-phase railway served by the United Electric Light & Power Co. Prior to the development of these joints even the best-made joints of the older types failed as often as once a month on less than 16,000 volts.

The joints referred to were made with three-conductor 350,000 circ. mil, paper-insulated lead-covered sector-type cable. The insulation around each conductor is 8·5 32 in. thick, and the insulating belt is 4/32 in. thick, making a total of 17 32 in. between any two conductors and 12·5/32 in. between any conductor and ground. The neutral of the system is grounded.

METHOD OF PREPARING CABLE FOR JOINTING.

Before preparing the cables for splicing they were carefully aligned, as it is very undesirable to bend or make any change in the position of cables after they are soldered. With this done 8·5 in. of the lead sheath was stripped off the ends to be joined, the belt insulation removed except for 1·25 in. next to the lead armour, and 1·125 in. of insulation cut off the end of each conductor at right angles thereto with a special tool provided for the purpose. The ends of the lead armour were then "belled," as this operation cannot be performed so easily after the conductors are soldered. To prevent accumulation of dirt and penetration of moisture, the space between the belled armour and the insulation was packed with insulating compound and wrapped with clean cheesecloth, which was allowed to lap over the armour. Split connectors 2 in. long chamfered 0·5 in. on each end to remove sharp edges (which would cause static discharge) were then fitted over the ends of abutting conductors, and soldered. All metal points, such as those formed during soldering, were then removed by filing and rubbing with emery

* From the "Electrical World."

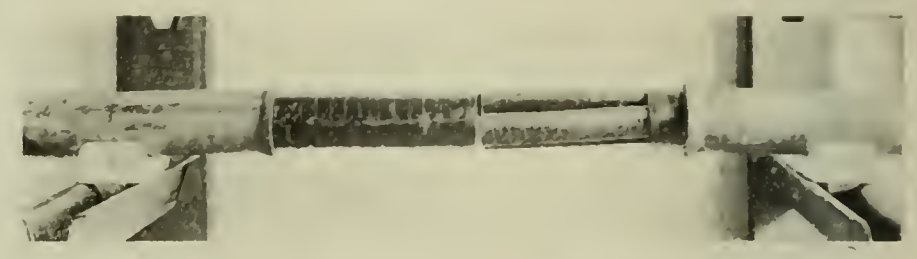
cloth, and the space between conductors was thoroughly cleansed of all emery, copper or solder particles.

Following this operation, but not until the splicer was ready to continue with insulating the joint, the mill insulation on each conductor was pencilled or tapered toward the connectors, as shown in one of the accompanying illustrations, to increase the leakage path from each conductor to the outer layers of the mill insulation. Compound was then packed in the recess between each connector and the pencilled ends of the corresponding conductor insulation and impregnated jute rove wrapped tightly in this space, each turn being drawn tight so as to force the compound out between the separate turns of the rove. The operation was continued until a straight line was obtained between the highest points of the pencilled insulation and the chamfer on the connector.

Before proceeding with insulating the joint, the outer layer of mill insulation on each conductor was removed to ensure surfaces free from deposits of moisture and dirt and to secure a more perfect bond for the hand-wrapped insulation which was applied later.



Cut ends of cables in position for joining.



Lead armour removed from cable ends and belled.



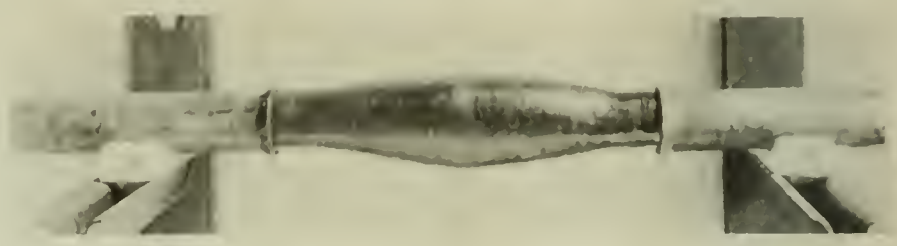
Paper belt stripped from insulated conductors, cheesecloth wrapped around belled armour, and connectors soldered to conductors.



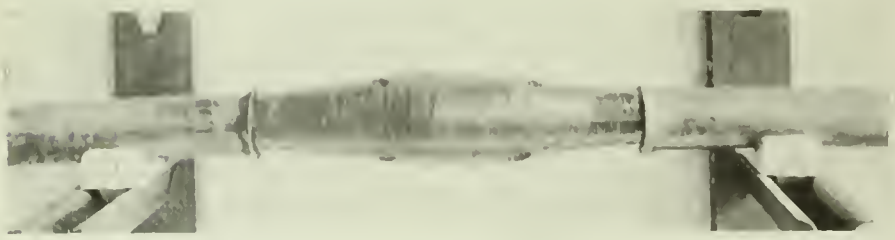
Insulation on each side of connectors has been tapered and lower conductor wrapped with paper tape.



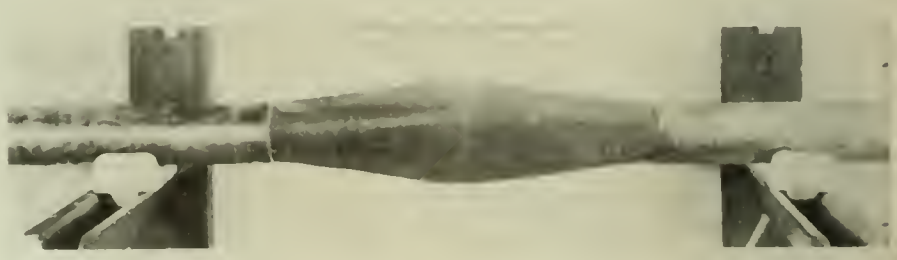
Space between conductors filled with compound and impregnated jute rope.



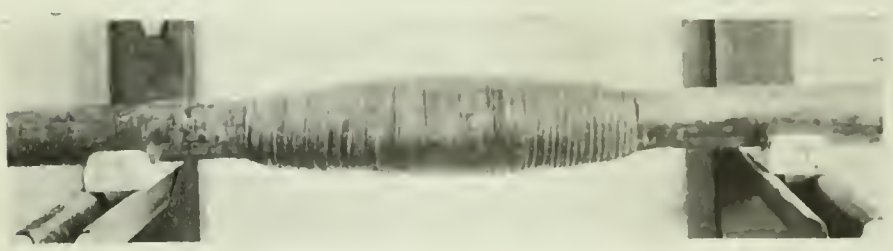
Paper-tape belt applied.



Holes pierced through compound and belt, and passing between conductors.



Copper-gauze stocking applied around joint.



Gauze wrapped with cotton wick.

FIG. 1.—STEPS IN THE PROCESS OF SPLICING 25,000-VOLT THREE-PHASE CABLE.

This was considered important, as otherwise discharge paths might occur along these surfaces. A liberal coating of compound was then applied to the conductor to be insulated and paper tape, impregnated with the same compound under a 29 in. vacuum, wrapped tightly around each conductor. For convenience in handling, to obviate the necessity of unduly spreading the conductors during the process of insulating, and to minimise the possibility of contamination with moisture and dirt (usually caused by rerolling tape on a job), the paper tape was furnished in small rolls 0·75 in. in diameter. The tape was 0·875 in. wide and 6 mils thick.

APPLICATION OF PAPER-TAPE INSULATION.

Starting on a connector, in applying the tape, the length of each succeeding layer was increased to meet the bevelled surface of the rove filler. When the high point of the tapered mill insulation was reached the wrapping was extended out in both directions to within 1 in. of the crotch of the three conductors. Then each succeeding layer was shortened so as to produce a long, even slope extending from the point 1 in. from the crotch to the highest point of the mill insulation taper. At this point the thickness of the hand-applied insulation was made 1¼ times that of the mill insulation. Each layer of tape received an application of compound before applying the succeeding layer, and each turn was drawn tightly to remove all evidence of air bubbles between layers. It may be pointed out that all materials used in splicing were packed and delivered in units sufficient for only one splice.

After each conductor had been individually wrapped with paper tape as described, the space between conductors was packed with compound and a quantity of impregnated rove fillers were laid parallel with the conductors and pressed into the spaces between them. Before the belt insulation was applied 0·375 in. of the 1·25 in. of mill insulation left at each end of the splice next to the armour was tapered. Then impregnated paper tape 1 in. wide and 6 mils thick was wrapped around the three insulated conductors, first filling the concavities at each end of the splice, then extending the tape over the rest of the joint until a belt 1¼ times as thick as the jacket mill belt had been applied on an even slope. The same precautions to eliminate voids were observed in applying the belt as in insulating the individual conductors.

When the hand-applied belt was completed it was pierced in six places to permit escape of air and free admission of compound. The holes extended through the joint and between the conductor insulation. After removing the cheesecloth which had been previously bound around the belled ends of the armour the belt was tightly wrapped with a copper-gauze stocking, made of 30-mesh No. 30 wire, long enough to extend under the lead armour 0·5 in. at both ends. This was smoothed out so it would bear evenly on all parts of the

splice and soldered in five places along its longitudinal seam exclusive of the ends. The belled armour was then beaten down on the stocking and soldered to it, thus establishing a metal sheath around the joint which has the same potential as the lead armour. This insures a definite distribution of potential over the conductor insulation and belt, independent of the insulating material later placed between the copper stocking and the lead jacket.

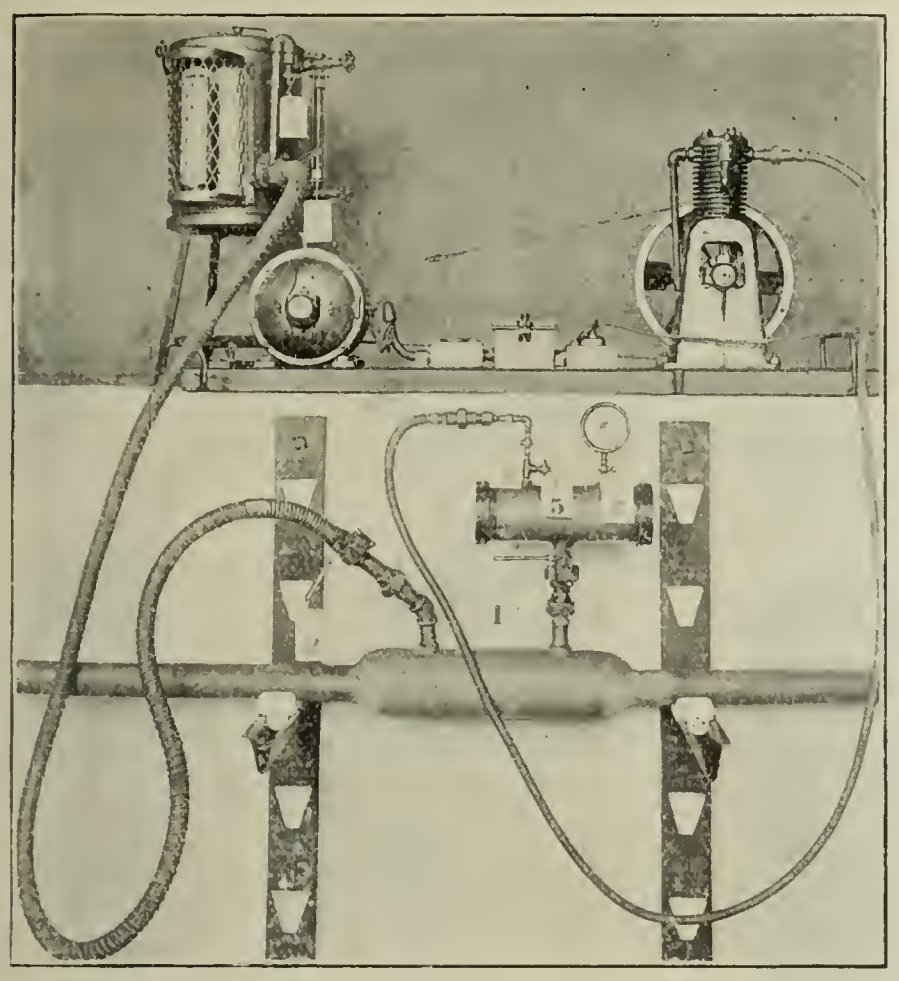


Fig. 2.—Connections of Apparatus for Creating Vacuum in Joint and Filling with Compound.

Around the copper-gauze stocking was wrapped cotton wick 1·5 in. wide and approximately 3/32 in. thick. One layer was wrapped over the central portion of the splice, and toward the ends layer on layer was built up to form a reservoir of compound which would supply the single layer by capillary action. Thus the splice is kept saturated even if some of the compound from the spice is absorbed during service by the cable. The lead sleeve was applied in the usual way, but pipe taps were provided at each end for connecting apparatus used in exhausting air from the joint and filling it with compound.

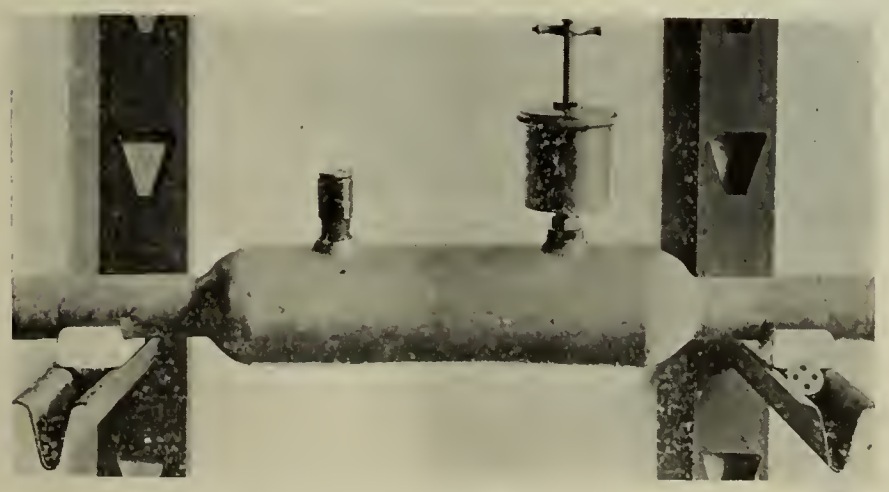


Fig. 3.—Apparatus Supplying Compound to Compensate for Absorption by Cable.

Vacuum Pump for Filling Joint with Compound.

The procedure in filling the completed joint with compound was as follows: The vacuum pump was started with all valves and cocks closed to test the tightness of the connections. Then cocks 4 and 7 were opened to test the receiving chamber. Valve 1 was next opened to determine whether the lead sleeve and connections with it leaked. Last in the testing preliminaries, valve 2 was opened. If 27 in. of vacuum was maintained after each of these successive operations the pumping was continued for 15 minutes. By connecting a vacuum gauge to a splice in an adjacent manhole 300 ft. away, it was observed that a 7 in. vacuum was obtained. It was also found that at least 28 in. and, in a number of cases, 29 in. of vacuum was maintained during the last 10 minutes of the pumping period.

After pumping had been concluded valve 2 was closed to prevent compound rushing into the joint when valve 1 was opened, and possibly forming a pocket in the splice by taking the short route between the compound entrance and the vacuum connection. Valve 3 was then opened to bring compound down to valve 2, which was subsequently slowly opened, 30 seconds being required for this operation. Cocks 4 and 7 were then closed to prevent the gauge and suction connections being filled with compound, which rushed in as valve 1 was opened to admit compound to the receiving chamber. Compound was allowed to rise in the receiving chamber until a

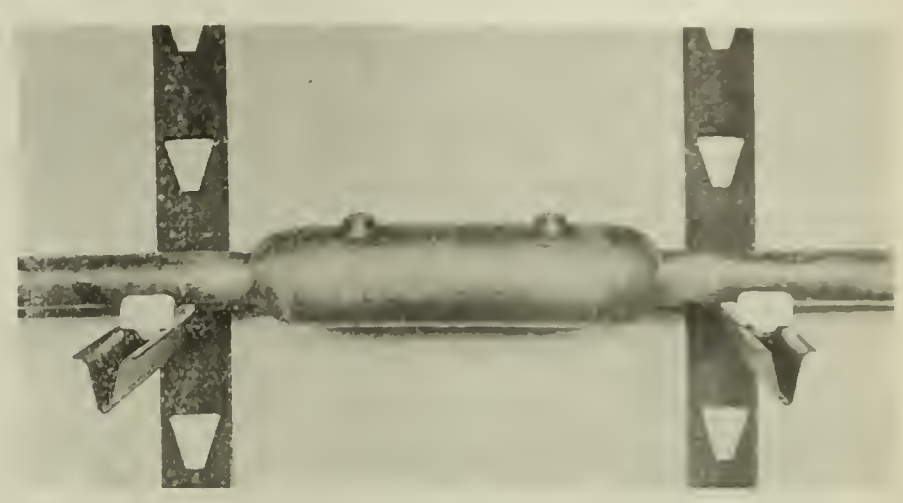


Fig. 4.—Completed Cable Joint with Apertures Closed by Plugs.

layer of clear compound was observed in the lower half of the chamber through a glass window provided in one end. Valve 2 was then closed to stop the flow of compound and cock 5 opened to admit atmospheric pressure and compress the compound in the splice. Valve 2 was then opened to flood the splice at atmospheric pressure, and the remaining valves were closed and the apparatus disconnected.

Compensating for Absorption of Compound by Cable.

After the suction and filling apparatus was disconnected a 1 in. pipe nipple with a coupling attached to provide a female thread for the splice plug was connected to one end of the splice, and in the

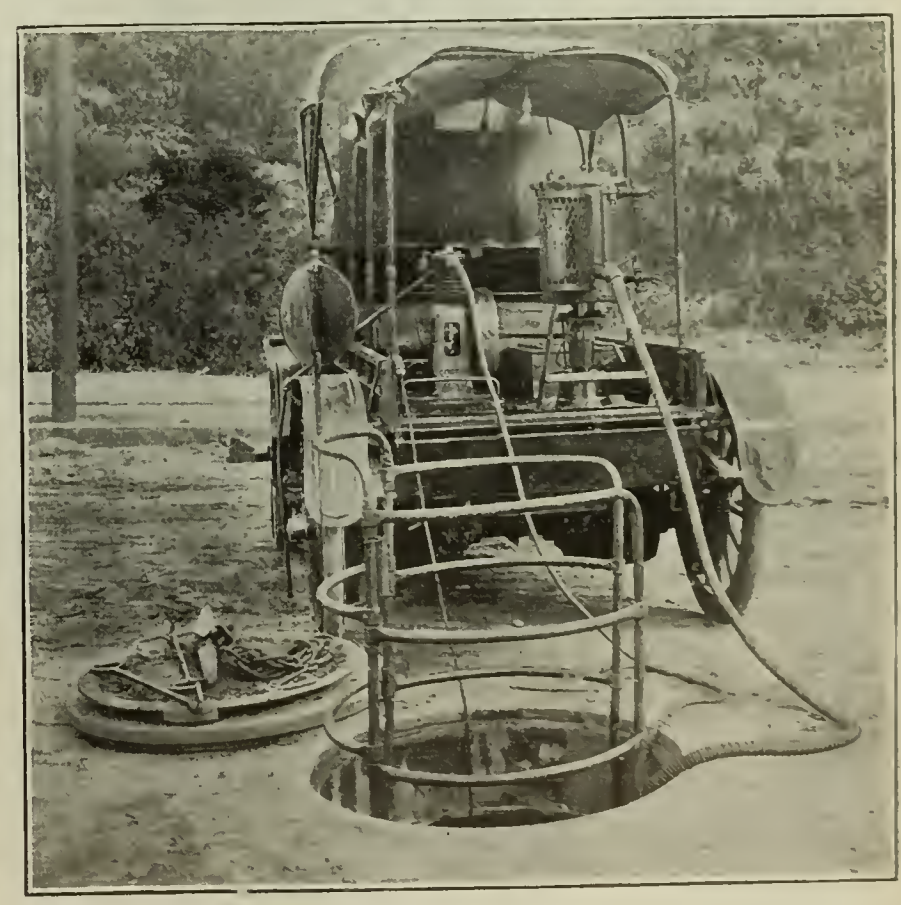


Fig. 5.—Joint-filling Apparatus Mounted on Electric Vehicle.

other end was screwed a self-acting grease cup. Compound was poured in the cup in a liquid state and permitted to overflow through the nipple at the other end of the splice. When a clear surface of compound was presented at the nipple the plug was screwed in. The cup was then filled with compound and the T-handle screwed up to the highest point so the spring-actuated piston would feed compound into the splice while contraction of the compound due to cooling or absorption by the cable was in process.

After 24 hours the grease cup and the nipple on the other end of the splice were substituted by plugs if the amount of compound absorbed by the splice appeared normal.

SWITCHGEAR FOR CENTRAL STATIONS AND ISOLATED PLANTS.

Few engineers realise, until they have the problem to face in a concrete form, how much special knowledge is required in the design and installation of modern switchgear.

The following article deals with the design and selection of switchgear for modern electric distributing systems, and deals not only with the prineiples involved, but with many practical details.

Central station control apparatus must, of necessity, undergo almost constant change in design, owing to the ever-increasing capacities employed. The increase in length of transmission lines necessitate the more general use of higher voltages, and distribution systems are ever presenting fresh problems. It necessarily follows, therefore, that the design of switchgear to meet the requirements of any modern power system is a matter calling for a high degree of technical skill, and an expert knowledge of switchgear problems.

With the development of the large power station, the old type of flat switchboard has given place to the high-tension cell structure with low-tension remote control panel. Large units are often

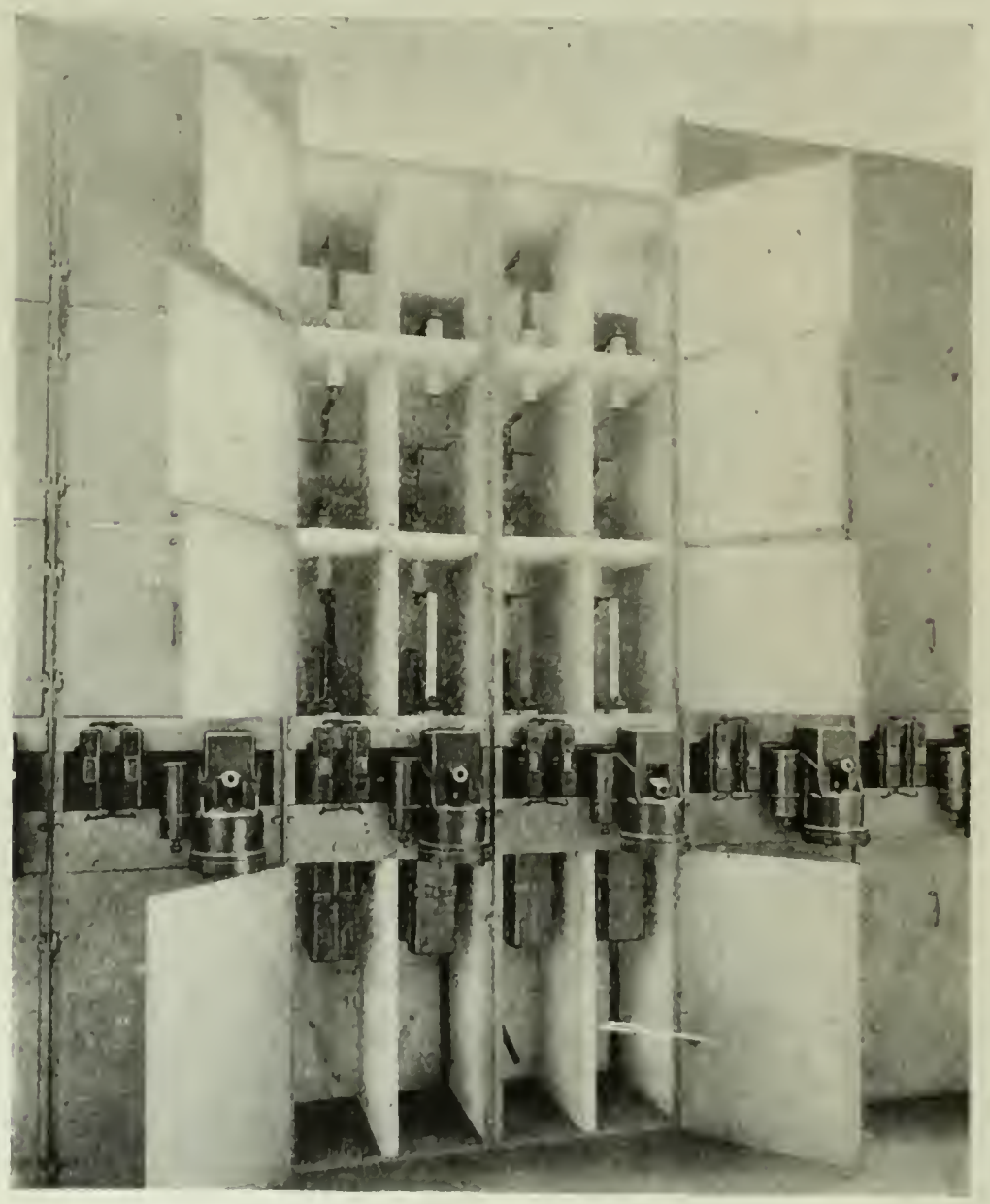


Fig. 1.—E.H.T. Two-phase Switchgear showing Solenoid-operated Oil Switches in Stone Cellwork.

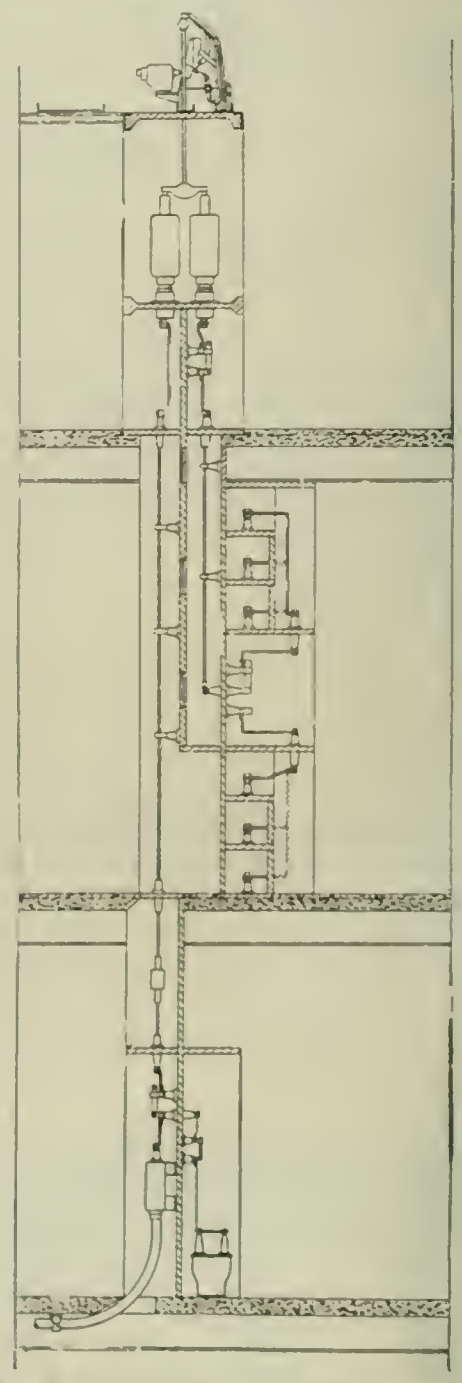


Fig. 2.—E.H.T. Switchgear Mounted in Three Separate Cell Structures, with Duplicate 'Bus Bars and Motor-operated Oil Switches.

controlled by electrically-operated oil switches installed in the position most convenient for the extra-high-tension 'bus bars, connections, &c. (sometimes in a basement or separate switch room), and operated from a bench board or panel situated so as to give the operator a clear view of the engine room.

The cell structure is quite an important feature in modern high-tension and extra-high-tension switchgear design. Concrete or moulded stone is much more generally used than brickwork for this purpose. In many cases the whole 'bus-bar chamber, or switch compartment, is moulded in one piece with the principal fixtures moulded in position. This practice certainly gives much more satisfactory results than brickwork, as variations in brick dimensions make accurate work very expensive, since accuracy in placing fixtures often necessitates cutting away or making abnormal bonds in the brickwork.

Moulded stone 'bus-bar chambers are usually designed to enclose the 'bus bars on three sides, and for extra-high-tension work barriers are frequently moulded in so as to separate the phases.

Severe mechanical stresses are sometimes set up by heavy overloads or short circuits, and for this reason 'bus bars and connections on large plants have to be firmly mounted, and isolating switches are fitted with locking devices so that they cannot be forced open.

In stations where either head room or floor space is limited it is often advisable to build separate cell structures for the oil switches and 'bus bars. The B.T.-H. motor-operated oil switch is frequently mounted in this way, and a very convenient arrangement of gear with this switch is shown in Fig. 2, where the current and potential transformers are indicated on the ground floor, the 'bus bars (in duplicate) on the first gallery, and the oil switches on the second gallery.

Undoubtedly the most vital part of the control system is the oil switch, and there should be no question as to its ability to perform the functions demanded of it. A main oil switch in a power station has not only to endure stresses similar to those borne by the other high voltage apparatus, but also those added by the necessity of breaking the circuit without undue disturbance under the various abnormal conditions which may arise.

By calculation from the characteristics and impedances of the plant and circuits employed, it is possible to make estimates of the maximum currents which could flow into a dead short-circuit at any point in the system. These maximum values may never be reached, but they form comparative data upon which the service required of a switch can be based.

It is found that these values, taken on the assumption of instantaneous development of the fault, may be very large. Lapse of time reduces them rapidly, so that a slow action of the switch, or a time lag in the tripping device, eases the rupturing conditions to a notable degree. However, modern protective systems give instantaneous operation, and the rating made possible with delayed action is no longer the important one to consider.

Switches should be rated and selected according to the maximum possible short-circuit they can rupture with safety to themselves, or upon the kilovoltampere capacity of the plant in connection with

which they can be proved to operate with success under the given conditions. The former covers all situations, the latter applies to switches close to the generating plant, where there is no limiting action due to feeder impedance, &c.

A source of electrical energy may momentarily develop current greatly in excess of its normal capacity, and a switch in the main station may be required to interrupt the entire power developed under short-circuit by all the generators and synchronous apparatus connected to the system.

Modern alternating-current turbo-generators on dead short-circuit may develop instantaneously 10 to 15 times their normal full load current, dropping in about one second to the sustained value of two to three times normal. Relays, tripping devices and switches take, say, 0·2 seconds to operate, and the initial rush may then have dropped about 50 per cent. Therefore, in generating stations, switches with instantaneous automatic trips may have to rupture a short-circuit current about three times as great as if tripped by hand, or under a fixed time lag exceeding one second.

In sub-stations this difference becomes less pronounced owing to the smaller influences of the generator in the total of the current limiting factors.

It has never been possible to test effectively the largest oil switches by any artificially arranged experiments, the results arising on emergency and in service being so diverse even under the same conditions. Even the fact that a given switch has shown satisfactory results for a year or more, and has been known to open severe short-circuits, gives no guarantee that it is suitable for the service, and will safely cope with a similar short-circuit on the next occasion. A small tank-type switch has been known on test to open an enormous short-circuit, yet experience had shown that this same switch could not be relied upon to open, without destruction, one-fifth of the amount under the same external conditions.

Many factors in the action of circuit rupturing have not yet been fully investigated, and there is much misconception even about the more obvious factors. For example, rupturing capacity has been widely covered by specifying the length of break, ignoring all other factors, yet experience has now shown that this factor is one of the less important ones.

No switch should be selected for use where safe rating and reliability are important that has not been proved by long service under severe conditions.

Probably no firm in this country has devoted more attention to these matters than the British Thomson-Houston Co., Ltd., of Rugby, and many large switchgear installations handled successfully by this firm have been described briefly in these columns from time to time.

The minute attention which this firm has paid to switchgear design, coupled with their unrivalled experience in meeting the requirements of different classes of service, naturally places them amongst the specialists to whom one looks for the latest developments in this class of apparatus.

Although each large power scheme must be considered on its own merits, there are many cases which call for similar treatment and standard apparatus can generally be employed.

Take, for example, the case of a station in which there are several three-phase generators and feeders up to about 2,000 kw. capacity. The apparatus required for the generator side is indicated in the accompanying diagram (Fig. 3). This shows four possible combinations, two for a system with the neutral earthed, and two for a system with insulated neutral. In each case the first diagram indicates the minimum equipment required to control the generator, and the next diagram shows the maximum equipment which is likely to be required, assuming the synchronising panels to be separate from the generator panels.

The actual equipment must, of course, be determined by the local conditions, but where standard apparatus is adopted, certain fundamental rules must be borne in mind when selecting the equipment.

Generators will usually carry 25 per cent. overload for a half to two hours at 80 per cent. power factor, and the capacity of the generator switchgear should be fixed accordingly, while for feeder panels the capacity should be based on the size of the individual feeders.

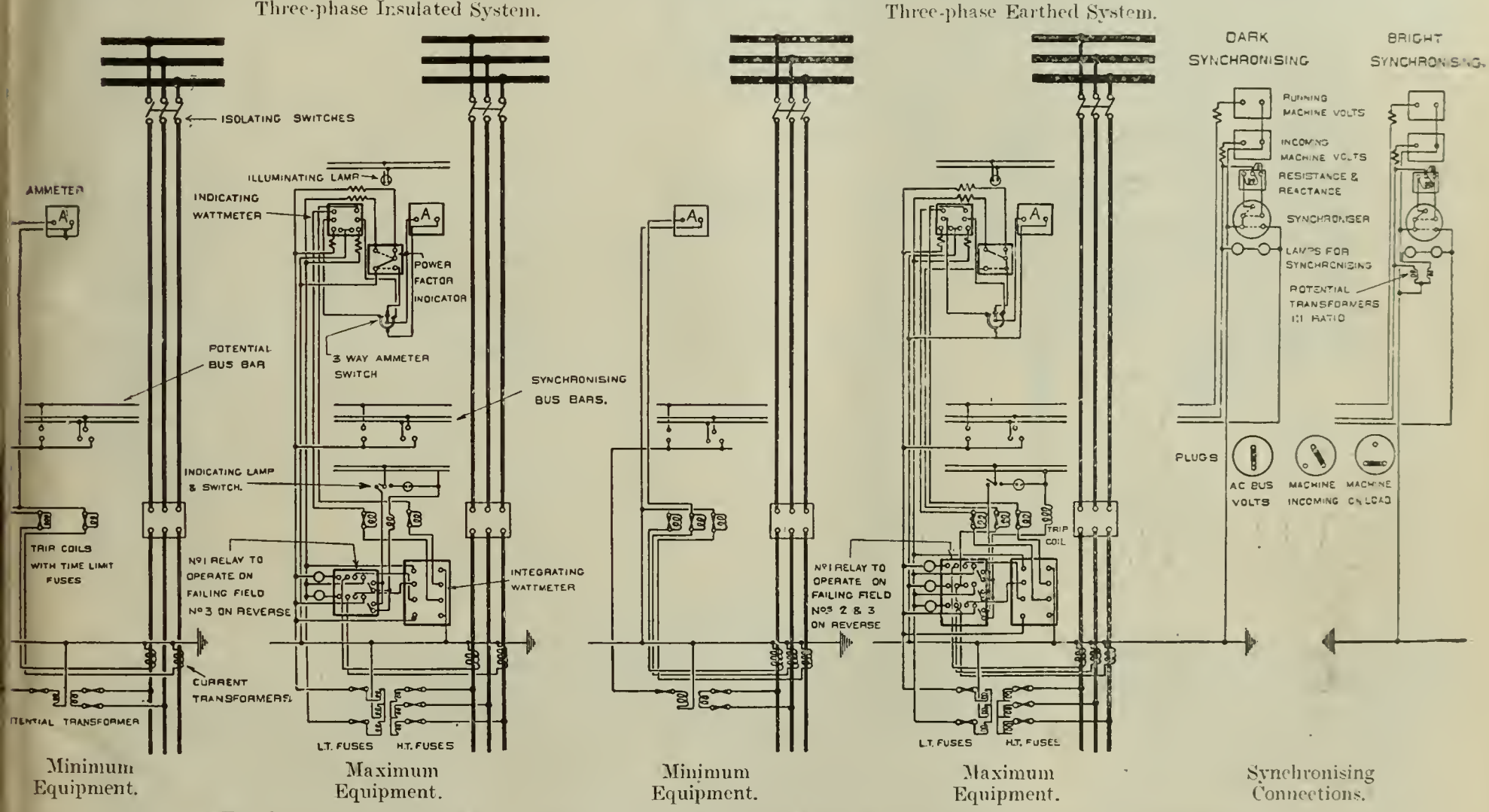


FIG. 3.—TYPICAL DIAGRAM OF CONNECTIONS FOR STANDARD ALTERNATING-CURRENT GENERATOR PANELS.

Air-break switches, fuses and circuit-breakers are seldom used for large capacity alternating-current circuits. Oil-break switches fitted with free-handle mechanism and overload trip coils are almost universally employed.

It is of the first importance that the oil switches shall have sufficient rupturing capacity to deal with all the conditions arising in service, without requiring more than occasional inspection, and they should be able to deal with the severest short-circuits without causing any risk as to failure of supply, injury to plant, or danger to human life.

Main alternating-current ammeters are useful for indicating the amount of current carried by the machine winding, which is the determining factor in the heating of the machine. Field ammeters are useful in that they indicate the amount of current taken by the field, and are more especially useful on emergency in locating a breakdown. They may generally be omitted where indicating wattmeters or power-factor indicators are furnished.

It is customary to supply ammeters on feeder circuits. Indicating wattmeters may be advantageously substituted in cases where the power factor varies considerably, and where it is desired to read the amount of power taken by individual circuits, as, for example, by different departments in a mill installation.

The use of indicating wattmeters is very necessary on all generator panels if machines are to be operated in parallel, so that the load may be properly divided between the various machines in the station, and idle current losses avoided.

If indicating wattmeters are used, power-factor indicators are not directly necessary, although they are a convenience in operating the plant, as by operating all the machines at the same power factor, the generating plant will run with the best electrical efficiency and with the least heating.

On all plants it is desirable that a record of the units generated should be kept, so that it can be checked against the record of coal consumption in order that the plant may be maintained at proper efficiency.

Wattmeters should be installed on the generator panels in preference to the 'bus bars or feeder circuits, as in this position they give higher accuracy, owing to the better load factor, and are not affected by changes in the total capacity of the plant. Wattmeters in the 'bus bars are also objectionable in that they necessitate the introduction of current transformers connected in the 'bus bars, where they cannot be conveniently isolated.

Voltmeters should be mounted at the end of the board and provided with plugs so that they can be connected to any panel. The main voltmeter should be in a position where it can be seen from any of the rheostat handwheels; also the 'bus-bar voltmeter and the incoming machine voltmeter should be close together, so that they can be readily compared when synchronising.

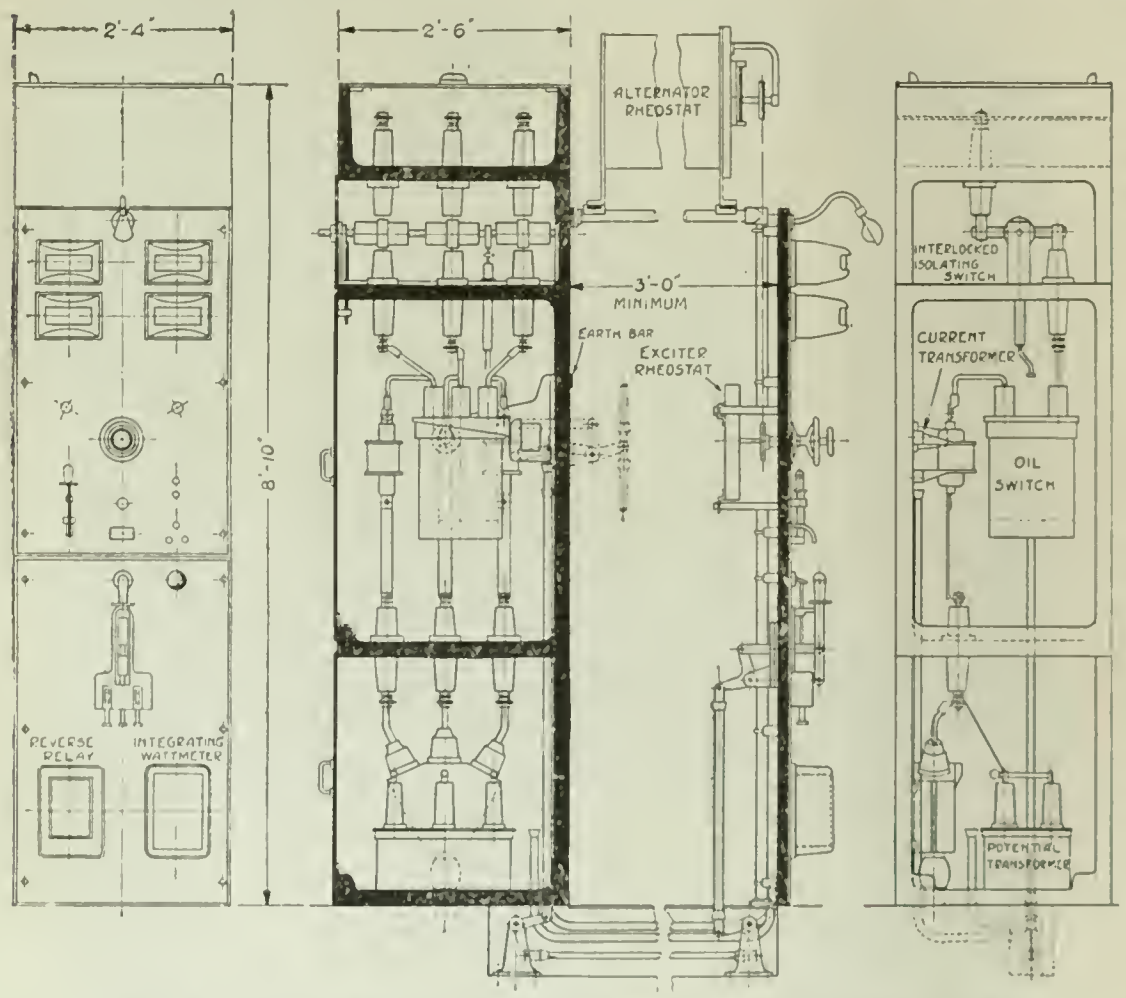


Fig. 4.—Elevations of Typical Generator Panel for 6,600 volts.

Reverse current relays serve to disconnect faulty generators with a minimum of disturbance to the system and damage to the plant. They are especially useful in connection with extra-high-tension turbo-driven alternators, and in cases where continuity of service is of the first importance, and the disconnection of one faulty machine does not involve a shut down. In other cases their use is generally not justified owing to the extra cost and complication. Double-pole relays should be used when the mid-point of the generator is insulated, and triple pole if the mid-point be earthed. Large machines should be protected by the "circulating current" protective system, and furnished with automatic field switches to minimise destruction in case of failure.

Earth detectors should be used on insulated systems, and mounted on rigid brackets on the top of the switchboard or in some convenient location where connections to them can be taken directly from the 'bus bars. It is important on high-voltage boards that these earth detectors be mounted in such a position that they cannot be accidentally touched.

The use of isolating switches is necessary on all plants above 250 volts where it is impossible to shut down the whole board for cleaning and inspection.

A line of panels has been standardised by the British Thomson-Houston Co. to meet the requirements of this class of service up to 6,600 volts. All the high-tension apparatus is mounted in a moulded stone cell structure, and the low-tension apparatus on a slate or marble panel in front, leaving ample room between the two, so that all parts are accessible.

Access to the high-tension gear in the cells is obtained by removing the sheet-iron doors at the back, which are interlocked with the oil switches and isolating switches, so that no parts can be touched until the cell is made "dead."

The cell work and panel are made large enough to contain the maximum equipment if required, and are designed so that similar units can be mounted side by side to form a complete switchboard. A section through a typical generator panel is shown in Fig. 4.

The particular panel illustrated is designed for stations where space is not too limited, and where it is impossible or undesirable to shut down the plant for cleaning or repairs. The standard line of panels referred to, however, covers a wide field, and panels similar to the one illustrated have been designed to meet the limitations of small stations where little or no space can be allowed between the control board and the cellwork. Similarly where the expense of isolating switches is considered unnecessary, and a complete shut down is possible, smaller and cheaper panels can be supplied.

Where the supply is only 650 volts—and sometimes for a 3,300-volt service—the cellular structure is not always necessary, and for such cases the oil switches, transformers, &c., are mounted on the back of the low-tension control board, thus giving a very compact and inexpensive panel. For small central stations and isolated plants it is generally possible to obtain a complete switchboard by a judicious selection of standard panels.

The ever increasing scope for power supply companies' operations has brought sub-station equipment well to the front, and here again the switchgear presents its own particular problems.

A few years ago a prominent consulting engineer stated that the ideal sub-station was a group of ironclad apparatus that could be dumped in an open field and left to the mercies of the English climate. Although no supply company has yet had the temerity to adopt the suggestion, there is not so much to be feared from the switchgear standpoint as might at first be supposed. Some of the totally enclosed ironclad switchgear units recently developed might very well come through such a test with honours.

A small switchboard consisting of seven ironclad units on the "draw-out" principle, as developed by the B.T.-H. Co., is shown in Fig. 6. This type of ironclad gear is particularly suitable for mining and industrial service, and for sub-stations where compact, dust-proof and drip-proof switchgear is required for circuits up to 3,300 volts.

The oil switch, instruments (where mounted with the oil switch) and automatic features are mounted on a sliding carriage, and connected to the 'bus bars or cables through plug contacts. All essential pieces of apparatus may be freely inspected after they have been made "dead" by withdrawing the carriage. The simplicity of the design ensures that all parts are readily accessible, and large flanged joints are provided throughout. The switches have an accelerated gravity break, a double break on each pole, an ample head of oil, barriers between phases, exceptionally large clearances between all live parts and earthed metal work, and no metal work in the neighbourhood of the sparking fingers.

The gear is provided with all the ordinary attachments, and some novel combinations of automatic and safety devices to meet the different requirements of service, and to minimise the risk of accident through ignorance or forgetfulness.

From the illustration given it will be seen that two sizes of switch body are used, but the pedestals are uniform and can therefore be lined up to make a complete switchboard irrespective of the capacity and equipment of the individual units. Cable connections can be brought in through the top or bottom or at the ends of the 'bus bars. The connections may be made on individual switches. Potential transformers and voltmeters can be furnished on individual switches or connected to the 'bus bars. Normally the potential transformer is connected with one terminal on the live side, and one terminal on the dead side of the switch, but special connections can be made so that the voltmeter indicates the 'bus-bar voltage or feeder voltage with the oil switch open.

A typical equipment is indicated diagrammatically in Fig. 5, from which it will be seen that the instruments and their fuses are attached to the switch body, and can therefore be isolated by withdrawing the body from the connection chamber.

The handles are interlocked so that it is impossible to withdraw or close the isolating contacts unless the oil switch is in the off position. The switch body cannot be opened, and the oil tank cannot be

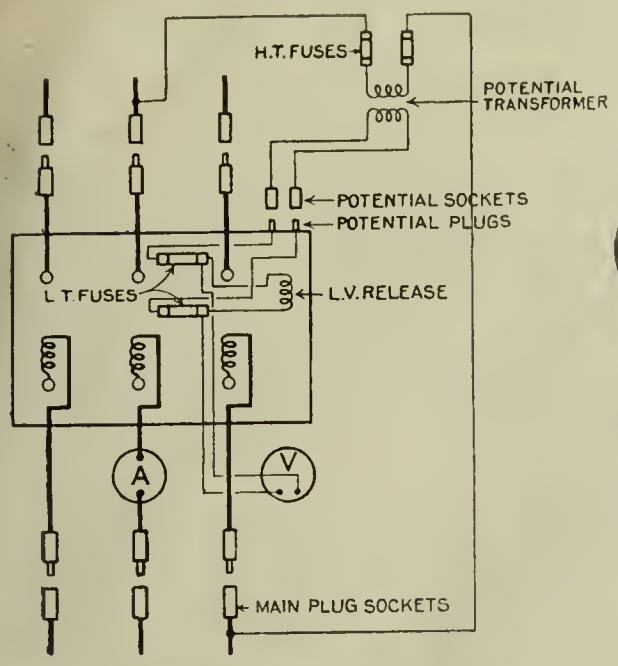


Fig. 5.—Connections for a Typical Draw-out Switch Pedestal.

removed unless the isolating contacts are first separated, making all parts dead. The cover must be closed before the isolating switch contacts can be closed, and it is impossible to push home the switch accidentally without first replacing the can.

Catches are provided to ensure that the bodies are not withdrawn too far when it is not desired to remove the switches altogether. These catches also prevent the exposure of the live plug contacts, whilst examining a switch on site. Catches are also provided to temporarily support the oil tanks, whilst removing or replacing the fixing bolts.

Another type of switchgear unit developed by the B.T.-H. Co. has come very much to the fore, particularly for sub-stations on circuits of 3,300 to 11,000 volts. In this type the whole of the equipment, with the exception of the 'bus bars and cable boxes, is mounted on a movable truck which can be withdrawn into the space allocated

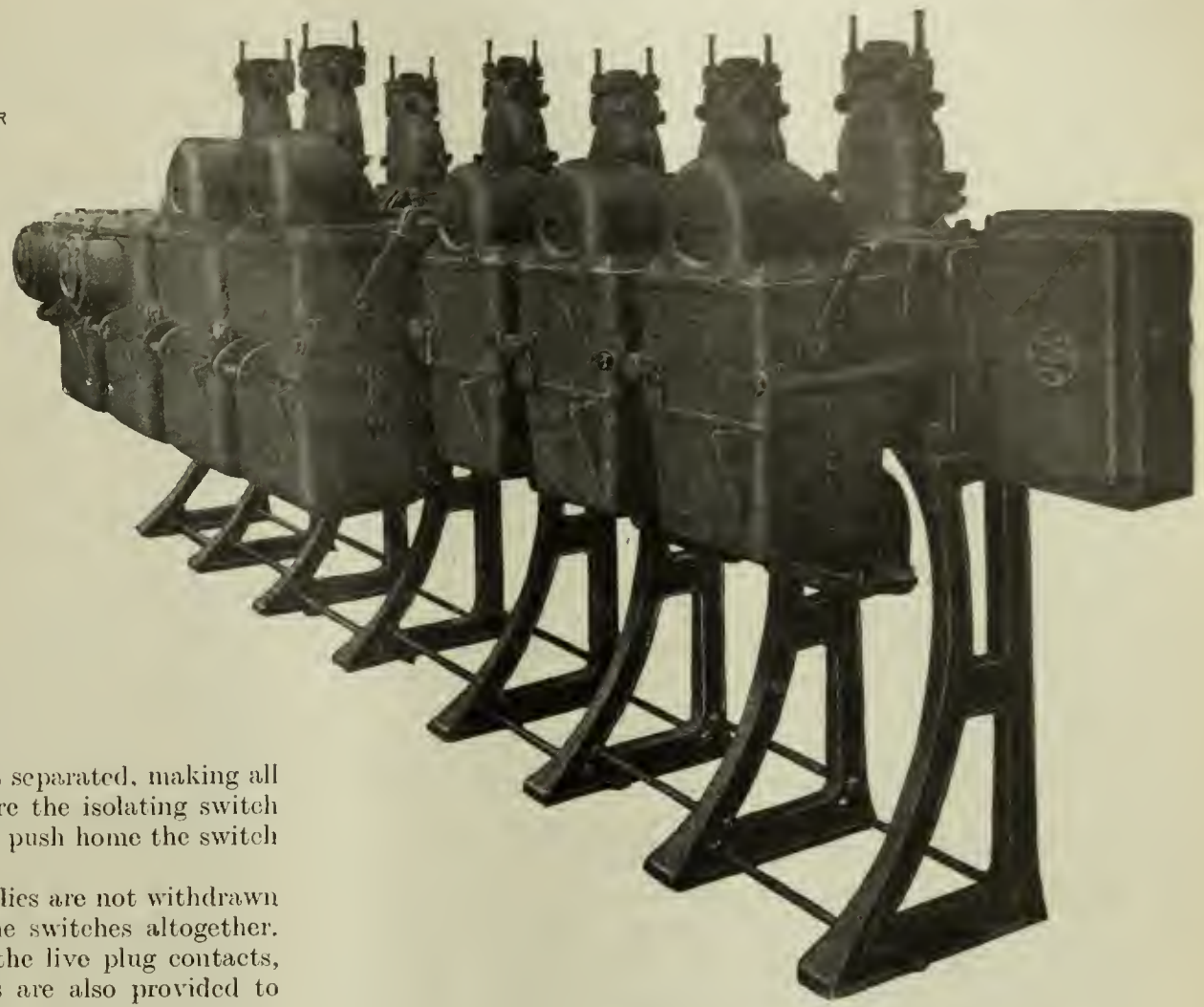


Fig. 6.—Totally Enclosed Ironclad Draw-out Switchgear.

with contact blades mounted in the fixed portion of the structure. These contact blades are sunk into the porcelain insulators so as to obviate danger of accidental shock or short circuits when the truck is removed. The same insulators also support the 'bus bars in the 'bus-bar chamber, and the cable terminals in the cable-box chamber.

A locking device is provided to prevent the plug contacts being closed or separated, except with the oil switch in the off position. All parts are held together by means of bolts and lock nuts, so that any part can be readily removed and replaced in a sound mechanical manner. No bitumen, rubber, or other inflammable insulation is used. The small wiring between the current transformers, trip coils, and instruments is permanently connected up and mounted on porcelain insulators attached to the frame of the truck. The whole gear is arranged so that ample clearances are allowed between the conductors, and from conductors to earth.



Fig. 7.—12-Panel Truck Type Switchboard for 6,600 volts.

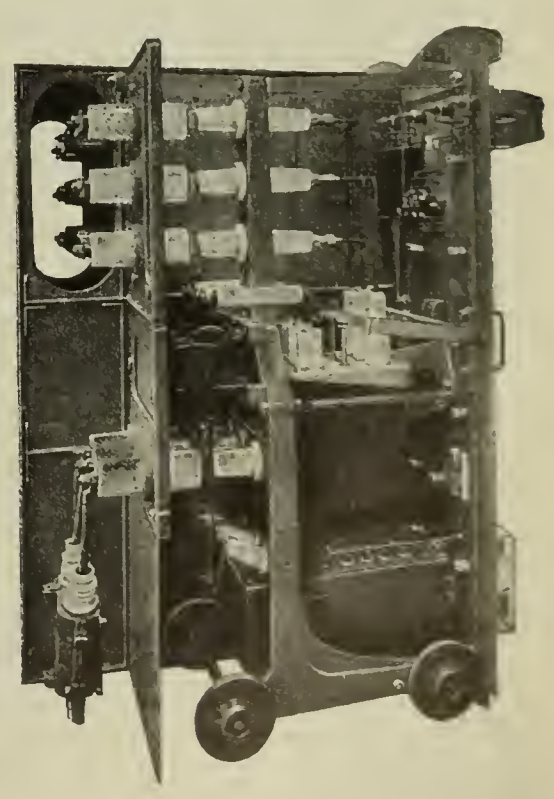


Fig. 8.—View showing Interior of Truck Panel with Truck in Position.

to the switchboard attendant, and can then be wheeled away to any suitable position for inspection.

The main frame is usually mounted near the sub-station wall, and forms a chamber for the 'bus-bars and cable boxes. The truck carries contact jaws mounted on porcelain insulators which engage

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U K) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.
THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Ready Shortly.*
THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*
THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Nearly Ready.* 8s. 6d. nett, post free 9s.
PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*
THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.
WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.
ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.
LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.
ELECTRIC BLASTING APPARATUS AND EXPLOSIVES: With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.
THE SHOT-FIRER'S GUIDE: A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.
THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.
THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*
LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.
ELEMENTARY THEORY OF ALTERNATE-CURRENT WORKING. By Capt. C. L. Hall, R.E. 3s. 6d. nett.
ELECTROMAGNETIC THEORY. By Oliver Heavisde. Vol. I. Price 12s. 6d. Vol. II. Price 12s 6d. Vol. III. 21s. nett. {postage 3d.
COMMON BATTERY TELEPHONY SIMPLIFIED. By W. Atkins. *Third issue* 3s. nett.
ELECTRIC CRANES: THEIR DESIGN, CONSTRUCTION AND APPLICATION. By H. H. Broughton, M.I.E.E. Price 25s. nett, postage 9d. (abroad, 1s. 8d.)
ELECTRICAL TESTING FOR TELEGRAPH ENGINEERS. By J. Elton Young. Price 10s. 6d. nett, post free 11s
STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Price 7s. 6d nett.
ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie A.M.Inst.C.E. *New Edition in preparation.*
AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation.*

ENTIRELY NEW BOOK.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s.** nett, post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

SMALL STATIONS *v.* BULK SUPPLY.

We have recently heard a good deal in favour of bulk supplies and the desirability of developing an interconnected system on a large scale. It is, therefore, interesting to look at the whole question from the opposite point of view and consider the claims of the small generating station. The material for doing so at the moment is provided by Mr. H. S. ELLIS in a Paper read this week at the Annual Convention of the Incorporated Municipal Electrical Association. This Paper is entitled "Generation of Electricity on a Small Scale or Bulk Supply," and will be found in abstract in another column.

It may be remembered that Sir JOHN SNELL in his Presidential Address to the Institution of Electrical Engineers referred to the question of bulk supply being taken by existing electricity works, and remarked: "It may be generally said that once a small station is built and the expenditure has been incurred, then, and so long as the system is kept within the defined limits of extension, the extra operating cost of the addition to the local power station is then cheaper than any commercial feasible bulk supply." This sentence may be taken as the summary and conclusion of the Paper by Mr. ELLIS.

If a single extension is to be made to a station, and the capacity of plant is then to remain stationary, we fully agree with the above sentiment. This, however, is seldom the case except in tramways. Let us consider for a moment that an extension is to be made at the present time involving a set of 2,000 kw. If a turbo-generator is put down, a certain additional expenditure is incurred. If in place of this turbo-generator we put down converting plant and take a bulk supply, then the whole plant of the station should be replaced by converting plant in order to get the best conditions. But this means a considerable capital expenditure on new plant, greater than that involved in the putting down of a new turbo-generator, and at the same time it means that a great part of the capital expenditure on plant hitherto will no longer be productive: consequently, the capital charges are so high that the scheme shows up to a disadvantage. The conclusion, therefore, is reached that it is desirable to put down another turbo-generator. In, say, five years' time the same question again comes up and, for the same reason, the same decision is reached, although by that time the power company would be prepared to give still better terms. But by the addition of further steam plant the operating conditions of the station have become still more efficient: once again it is decided to put in more steam plant, and so the process continues.

On the other hand, if converting plant had been put in at the time of the first proposed extension, then by the time the second extension was required a good deal of the old capital would have been wiped off: and, what is more important, by the time the second extension was made, the proportion of unproductive capital would have been much less. In other words, the effect of the unproductive capital becomes less and less. Moreover, energy from bulk supply is supplied at a cheaper rate as time goes on and as the bulk supply becomes more generally used. The fallacy, if it can be called a fallacy, consists in looking at the present instead

of at the future. Every engineer will admit that electrical energy can be generated much more cheaply in large generating stations than in small stations, and the more varied the load, and the greater the number of stations to which a bulk supply is given, the higher is the load-factor on the power station and the lower the cost of generation. It is, therefore, much better to look to the future and to gain this desired end than to look at a small advantage at the present moment which leads really to the postponement of our ideals and to general waste. Mr. Ellis himself admits that the best way to improve the load-factor of a system is to increase the number of different industries connected thereto, and that this is not always possible in the case of municipal undertakings, as they are limited to their own boundaries. On the other hand, it is true that the Power Companies suffer from having to cover a larger area with mains for a given load, but this state of things would be largely compensated if towns were more willing to take bulk supplies.

Mr. Ellis mentions the fact that large boilers are not more efficient than comparatively small boilers, and that in the case of large steam turbines one cannot expect the steam consumption to be much below 12 lb. per kilowatt-hour—a figure which can be approached by much smaller plant. This is true, but on the other hand more economical running can be practised in large stations than in small. In a recent discussion, Mr. C. H. Merz stated that large units of plant in interconnected stations would result in a saving of 30 to 60 per cent. of fuel per unit sold. Apart from this, the saving which is most obvious is in capital charges. Mr. Ellis only takes stations up to 10,000 kw. or thereabouts, and places the cost at £20 per kilowatt. In regard to large power stations, however, the cost may be more nearly £10 per kilowatt. It is also noticeable that the cost per kilowatt of generating plant, including turbines, generators and condensing plant is put by Mr. Ellis at £4 per kilowatt, and the cost shows a minimum of £2·9 per kilowatt for plant of 6,000 kw. capacity. It is explained that the cost per kilowatt rises in the large sizes owing to the lower speed of rotation. We do not think, however, that such a figure can be accepted if higher powers are taken, and the argument is carried further. For example, the 30,000 kw. set of the Interborough Rapid Transit Co., which showed on test steam consumptions down to 11·2 lb., cost only £1 16s. per kilowatt, including generators and condensing plant.

We also notice that Mr. Ellis deals chiefly with load-factors up to 25 per cent. The load-factor of a large system, however, can be very much more than this and may rise above 50 per cent. There is also one other objection which is made to bulk supplies, namely, that they are generally carried by overhead lines and that these may be severely damaged by storms. Although the risk of damage is undoubtedly greater than with underground cables, there is not much likelihood of trouble if the lines are properly erected, unless their weight is materially increased by frozen snow. In any case important supplies would generally be provided by duplicate mains along different routes, and protected so that any faulty line would cut out automatically.

In conclusion, although the small station (by which we mean stations of, say, 2,000 kw.) are fully justified where bulk supply is not available, it appears to us that a bulk supply should be taken wherever possible, even where the results obtained for the moment do not show a financial advantage; for it is only by following such a policy as this that the greatest economy can be obtained in the future, and that the advance of electricity supply can be pushed forward with the greatest rapidity.

EDISON BATTERY VEHICLES IN MUNICIPAL SERVICE.

BY W. H. L. WATSON.

During the past year great strides have been made in the progress of the electric vehicle in the service of municipalities. Particularly gratifying is the earnest manner in which these vehicles have been considered by those officials responsible for the management of cleansing departments, &c. In this direction steam and petrol-driven tipping vans have been experimented with, but in most cases their use has been discontinued, except for the purpose of taking large loads to the destructor or tip, the method being to carry loads from a central depot where the refuse has been dumped temporally. There is considerable divergence of opinion as to the desirability of retaining the horse for the actual house-to-house collection. It is hoped that at the forthcoming annual convention of the Institute of Cleansing Superintendents, to be held at Cardiff on the 17th–20th prox., under the presidency of Mr. W. Harper, engineer to the city of Cardiff, that the discussion following a Paper to be read by Mr. John Terry, of Nottingham, on "Results Obtained by Electric Vehicles in the Removal of House Refuse" will prove that the electric vehicle is economical and entirely suitable for the whole of the operations of house-refuse collection, including the actual house-to-house collections.

While appreciating the great interest shown by municipal officials in the "electric," it is surprising that more committees have not made a start by purchasing at least one of these vehicles. This is probably accounted for by the urgent instructions of the Local Government Board to restrict expenditure to the utmost limit. In the larger cities financial difficulties have not proved so great, and already several of these money-saving devices are in service. That they are "money savers" is beyond dispute, thanks to the satisfactory reports which have been made by such prominent officials as Messrs. W. Greig (Glasgow), J. Jackson (Birmingham), J. A. Priestley (Sheffield), J. Terry (Nottingham), all of whom are cleansing superintendents in their respective cities.

In addition, equally excellent statements have been made by the following municipal surveyors and engineers: Messrs. S. E. Britton (Chester City Council), Reginald H. Crummack (Dover Borough Council), L. Roseveare (South Shields Borough Council), W. J. Steele (Newcastle-upon-Tyne City Council), G. Bruce Tomes (Barnes Urban District Council). As the result of the careful inquiry and examination and the ultimate reports of these gentlemen, their respective Councils have adopted the electric vehicle, with satisfactory results. The later reports show that not only is the expected economy forthcoming, but in many instances a substantial saving in labour has been found, the result being that repeat orders have been placed. As the result of these recommendations, many other Councils have signified their intention of utilising "electrics" at an early date. The number of vehicles now in use, or on order, are as follows:—

Sheffield City Council	5
Nottingham ,,	4
Birmingham ,,	2
Glasgow ,,	2
Chester ,,	4
Newcastle ,,	1
Dover Borough Council	6
South Shields Borough Council	1
Heston and Isleworth Urban District Council	1
Smethwick Borough Council	1
Pontypridd Urban District Council	2
Barnes Urban District Council	4

It seems hardly necessary to describe the equipment of these vehicles, as they have been dealt with so thoroughly by the electrical press. For the information of those who are not aware of these particulars, the following is a description of the vehicle chiefly in use:

The G.M. Edison vehicle usually supplied to date consists of a frame of rolled steel channel section, reinforced by a hard-wood filler. The wheels are fitted with Timken roller bearings. The electric motor, with ball bearings, is set behind the rear

axle, and drives a bevel gear on the countershaft through a flexible steel blade. This blade effectually prevents even the slight jolt that normally would be felt in starting, and makes the acceleration remarkably smooth. From the countershaft the drive is continued to the rear wheels by two roller chains. The controller, ampere-hour meter and safety switch are assembled under a small bonnet at the front of the vehicle, and, therefore, easily accessible for adjustment or inspection. The battery is carried on the top of the frame instead of being slung underneath: consequently the operation of flushing the cells is attendant with very slight effort. The speed control is effected through a small lever on top of, and concentric with, the steering wheel. Two foot brakes, one acting on the countershaft and the other on the rear wheels, are fitted. In fact, the simplicity of the control is such that a few hours' practice is sufficient to accustom an ordinary man to the proper manipulation of the chassis.

The first important test was made by Mr. G. Bruce Tomes at Barnes. The report of this test was given considerable



Battery-driven Dust Van supplied to Dover Corporation.

prominence. It is, therefore, interesting to reproduce these figures and note how they compare with actual working tests since recorded:—

Average number of loads per day	5
Total ,, ,, week	30
Average ,, miles per day	22·65
Total ,, ,, week	113·5
Average electric energy per day	21·15 units
Total ,, ,, week	126·9 ,,
Number of fillers (two days only two)	3
Total time collecting	35 hrs. 40 mins.
Total time journeys to and from destructor and tipping	14 hrs. 30 mins.
Average time collecting per day (omitting Saturday)	6 hrs. 16 mins.
Average time on journeys per day (omitting Saturday)	2 hrs. 38 mins.

Estimated saving with four vehicles, £5. 18s. per week; and if one foreman can be saved, £7. 13s. per week. Total horse haulage now used = 62 horse-days. 16 horse-days are displaced by this van. Cost of electric van per day, £1. 1s.

With this information to hand, the Sheffield Corporation then decided to make a trial with two vehicles, which have now been in successful service approximately nine months. At the completion of 21 or 22 weeks' work, Mr. Priestley advised his Council to make a further purchase, with the result that three more vehicles have been placed on order. In his detailed report, Mr. Priestley states: "The vehicles are engaged in the collection of bin refuse, each employing one driver and three fillers, the former assisting in loading where practicable. During night shift ash-pit refuse is collected, each vehicle employing one driver and one filler, both men assisting in loading. The refuse in this case being shovelled into the vehicles from heaps previously wheeled out.

No. 1 vehicle was put to work on long-distance journeys, the refuse being delivered at Lumley-street destructor. It has replaced three horses on each shift; but as two-thirds of the dead refuse was previously tipped in the neighbourhood of collection, whereas it is now brought to the destructor, which is central, thereby saving the cost of tip, the extra distance covered by the vehicle is considerable, and could not have been done by the number of horses previously employed. This fact should be borne in mind when the relative costs are compared.

No. 2 vehicle is employed on comparatively short journeys, upon which horse-drawn vehicles are usually assumed to possess an unquestionable advantage. It has replaced two horses on day shift and three on night, the tipping being the same for both electric and horse wagons.

Although I propose to take the mean cost per ton of the two vehicles in comparison with the average cost over the whole city for horse labour, this is not strictly fair to the "electrics," as the mean of the combined mileage is considerably greater than the average for the remaining districts of the city."

The consumption of electricity averages 1·55 kw.-hours per mile, which is quite reasonable, considering the hilly character of the city and the heavy nature of many of the roads traversed in collection. A charge of 1d. per unit is made for current used, but this is not actual expenditure, as the electricity is obtained from the destructor installation, the refuse consequently producing power for its own collection. Tyres are amply provided for by the allowance of 1d. per mile. The comparison of costs is as follows:

No. 1 Vehicle.—Day Work Costs for 22 Weeks.

Refuse collected	858 tons 6 cwt. 1 qr.		
Wages	£154	15	8
Vehicle costs	40	7	1
Electricity, 3,269 units	13	12	5
Tyres, 2,168 miles	9	0	8
Cost per ton, 5s. 0·8d.	£217	15	10

Cost of One Month's Work on Same Districts with Horse Labour.

Refuse collected	167 tons 19 cwt. 2 qrs.		
Cost	£59	1	9
Cost per ton, 7s. 0·4d.			

No. 1 Vehicle.—Night Work Costs for 21 Weeks.

Refuse removed	1,142 tons 19 cwt. 1 qr.		
Wages	£72	3	8
Vehicle costs	38	10	5
Electricity, 2,927 units	12	3	11
Tyres, 1,880 miles	7	16	8
Cost per ton, 2s. 3·4d.	£130	14	8

Cost of Three Months' Work on Same Districts with Horse Labour.

Refuse removed	473 tons 11 cwt. 2 qrs.		
Cost	£77	10	3
Cost per ton, 3s. 3·2d.			

No. 2 Vehicle.—Day Work Costs for Six Weeks.

Refuse collected	314 tons 4 cwt. 3 qrs.		
Wages	£47	10	5
Vehicle costs	10	19	3
Electricity, 670 units	2	15	10
Tyres, 417 miles	1	14	9
Cost per ton, 4s. 0·1d.	£63	0	3

Cost of One Month's Work on Same Districts with Horse Labour.

Refuse collected	204 tons		
Cost	£38	16	0
Cost per ton, 3s. 9·6d.			

No. 2 Vehicle.—Night Work Costs for Six Weeks.

Refuse removed	406 tons 13 cwt. 2 qrs.		
Wages	£21	18	0
Vehicle costs	10	19	3
Electricity, 758 units	3	3	2
Tyres, 459 miles	1	18	3
Cost per ton, 1s. 10·3d.	£37	18	8

Cost of One Month's Work on Same Districts with Horse Labour.

Refuse removed	440 tons 8 cwt.		
Cost	£55	10	2
Cost per ton, 2s. 6·2d.			

Mr. J. Terry of Nottingham, informed his Council that the cost of collecting dry ashes during a period of 21 weeks with the new electric dust van was as follows:

Depreciation, 10 per cent.	£42	10	6
Insurance	3	13	6
Oil, water, repairs, &c. (estimated)	9	5	6
Tyres, 1,428 miles at 1·1d.	6	11	1
Current at 1¼d. per unit	11	1	11
Wages	120	18	9
	£194	1	3

The total weight of refuse removed was 1,047 tons 5 cwt. 2 qrs., which is equivalent to 3s. 8½d. per ton. To do the same work with horses would have cost 4s. 4d. per ton. This district, while not so hilly as Sheffield, is of an undulating character. The refuse was taken to the destructor, which is the central part of the city.

The following is an extract of an interesting report by Mr. S. E. Britton, city electrical engineer at Chester, on an Edison vehicle used for refuse removal in Chester :—

The trials indicate that the maximum capacity of this type of vehicle fitted with a tipping body under present conditions is seven 2-ton loads in 10 hours over an average distance of 4 miles per load—that is, 38 loads per week, 3,952 tons and 7,904 miles per annum, and four wagons, 15,808 tons and 31,616 miles per annum.

Chester produces about 12,500 tons of refuse per annum, and as four wagons would be required for systematic working in place of the 10 horses and carts, each wagon should make 30 2-ton trips per week, 3,120 tons and 6,240 miles per annum, and four wagons, 12,480 tons and 24,960 miles per annum.

On that basis I estimate the annual running costs as follows :—

Four drivers at 30s. per week	£312	0	0
Tyres, 24,960 miles at 0·8d.	83	4	0
Repairs and maintenance, 34,900 miles at 0·5d.	52	0	0
Maintenance of battery, 24,960 miles at 0·3d.	31	4	0
Insurance at £10 each	40	0	0
Electricity, 37,440 units at 1d.	156	0	0
That is, 25·93d. per load.	£674	8	0

(In justice to the makers, I should state that they put the cost of tyres, repairs and maintenance of chassis, and maintenance of battery at 0·64d., 0·49d. and 0·16d. respectively, a reduction of £32. 5s., making the above estimate £642. 3s.)

The purchase of four wagons involves an expenditure of about £4,000. It has been suggested to the Local Government Board by the Electric Vehicle Committee that loans for electric vehicles should be granted for a period of 10 years. In this particular case the annual mileage is very low, and the life should be well in advance of 10 years.

The annual interest and sinking fund on a loan of £4,000 for ten years at 3½ per cent. interest is £490. 18s. 4d. The total annual cost of this scheme as compared with the present arrangements and estimate for 1915-16 is :—

Interest and redemption on £4,000	£490	18	4
Working costs for four wagons	674	8	0
Part of foreman's time	45	0	0
Twelve men (two parties of six loading wagons)	900	0	0
Extra man and materials at tip	112	0	0
Insurance	7	0	0
	£2,229	6	4
Estimate for 1915-16	2,529	0	0
Balance in favour of electric wagon	£299	13	8

It should be noted that the foregoing estimate provides for 12 men to load the wagons, but as the quantity of refuse to be dealt with is 30 loads per wagon per week, and not 38, the work should be done by 10 men, which is equivalent to a further sum of £150 per annum in favour of the "electric."

I predict that the use of the electric wagon in Chester would prove a valuable alteration in local administration, and appreciably add to the comfort of the citizens, and, where electricity is available, enterprising local authorities will rapidly adopt it for the removal of refuse and watering and sweeping of streets.

Dover now has six vehicles in service, and from the running costs made up to date it seems certain that the estimated saving of £1,500 a year will be easily attained.

In Hounslow, which is a very flat district, and the vehicle employed being used solely on short journeys, Mr. Carey, the surveyor, states that he would prefer to use the vehicle for a longer period before making a definite statement, but he already has ample evidence to show that electricity is cheaper than horses.

It is also interesting to note that the success obtained in house-to-house refuse collection is affecting other municipal departments, several of whom have placed orders for varying classes of work as follows :—

Ilford	One 4-ton coal van
Leicester	One 4-ton coal van
Bradford	Three 5-ton coal vans
Plymouth	One 3-ton coal van
Poplar	One 4-ton coal van

In some of these instances vehicles of varying makes, and using various kinds of batteries, are being employed on exactly similar work, with a view to proving beyond question the merits of the several types concerned, thus showing that municipal electrical engineers are not desirous of pressing the use of any particular kind of electric vehicle on their confrres, without taking ample steps to demonstrate the validity of their claims for battery traction.

It is certainly a sign of the times, states the "Sanitary Record," and a significant one, too, that the number of electric vehicles in use in the United Kingdom is 660, compared with the comparatively insignificant total of 150 a year ago.

There is little doubt that the complaints one hears as to the alleged inefficiency of motor vehicles for municipal purposes is due to the ignorance which prevails concerning vehicles of this type. The substitution of motor for horse traction has been carried out in some quarters with a suddenness which has taken responsible officials unawares, and they have not had time to study the innovation with the care and attention it deserves. Hence breakdowns, costly repairs, and the generally unsatisfactory and disappointing feeling which has been engendered among a body of men unused to the new order of things. It is perfectly clear that in order to obtain successful results, officials who have control of motor vehicles should undergo a course of specialised instruction calculated to fit them for their new duties and responsibilities.

ELECTRIC HOT WATER SUPPLIES.

BY H. H. HOLMES.

"Electric power at 1d. per unit." "Foolhardy: impossible to do it at a profit." "Electric room heating can never take a place in the heating world." "Fearfully costly and gives no decent results." "Electric cooking! Yes, might be possible one day, but in our time . . . ?"

Thus the average electrical man of not so many years ago. But the public always had a greater faith in the power of electricity, to solve its domestic and factory problems, than the man who ought to know, and, as usual, the public was right. Electric power to-day at 1d. per unit is a "cinch" for the central station. Electric heating manufacturers cannot keep pace with the demand for apparatus. Electric cookers are now installed in their thousands and at an ever-increasing rate.

But talk to your electrical man about electric hot water supplies for a house, and you will hear the same old cries again. "Impracticable as compared with gas or coal, and costly, hopelessly costly."

But electric hot water is by no means so hopeless a proposition, and if the signs of to-day count for anything it will not be many years before more electricity will be sold for hot water supplies than ever will be sold for cooking—not that cooking will not progress, but because electric hot water will demand a greater number of units per household and offers greater possibilities in the way of cheap generation to the central station.

Many factors have combined to keep back electric hot water apparatus from general adoption. In common with cooking and room heating, it suffered from the high charges per unit for current, and the problem of the apparatus was tackled accordingly, the purpose being to provide a load which would induce the central station to quote a low rate.

The first real efforts to provide practical electric hot water plants were in the shape of the 100 per cent. load-factor or heat-storing apparatus. The inventors apparently forgot that 100 per cent. load-factor is not necessarily the best possible load for an existing station, and that so long as the demand is an "off peak" demand, quite as low or even lower prices could be quoted as for a 100 per cent. load factor, and they apparently overlooked the fact that cheap units alone would not give low quarter's bills. A 100 per cent. load-factor apparatus must mean 24 hours per day continuous heat loss or, in other words, *the maximum possible heat loss.* To convert a hot water demand load-factor of about 2 per cent. into an electrical load-factor of 100 per cent. necessitated a large storing capacity and thus a heavy, large and expensive apparatus.

In the light of latter-day experience, these considerations seem clear and simple enough, but much may be forgiven when it is remembered that 100 per cent. load-factor was the ideal of

the central station engineer and nothing short of the offer of such a load or coaxing with a cudgel would tempt him to offer prices which would make business possible, even under the best conditions.

This 100 per cent. load-factor apparatus was given a very fair trial, and although it failed to meet the general conditions required, there are still a few remaining in operation which have worked quite well ever since they have been installed, but these are used in peculiar circumstances, where the limitations of the apparatus are cancelled out by like limitations in the demand for hot water.

The objections to this type of apparatus are numerous, but they chiefly are :

1. The demand for hot water in the average residence is mainly for baths, and the whole requirement is taken in something under one hour in the 24 (the demand for washing-up, &c., is so comparatively small that it can almost be ignored). The apparatus thus has to store in 23 hours enough heat to meet the demand of one hour. This necessitates large storage capacity, and on large storage capacity follow high total heat losses and unduly expensive apparatus.

2. The utility efficiency (units consumed per gallon of water used) can but be low, for the heat losses of the apparatus continuing day and night are the maximum possible.

3. The apparatus provides for no emergency demand, such as would occur when visitors stop over the week-end. Alternatively, if the loading or storage of the apparatus be so adjusted as to provide for such an emergency, then the heat losses must be considerably increased, for under normal conditions of demand the temperature will obviously rise beyond the required limit.

4. Few houses are inhabited all the year round ; most families take a holiday for at least one month in the year. All current used at such a time is wasted ; whether it be used or not, it must be paid for, for the station engineer has calculated on a 100 per cent. load-factor, and if it be not provided he must charge a higher price.

5. A very small water leak at any tap seriously impairs the capacity of the apparatus.

By the time this type of apparatus had been found useless for general work, the point seven-fives, point fives and their various combinations had got to work, and there was no longer necessity to dangle luscious load-factors before the central station manager. By this time also the mains superintendents had become less exacting, and having become accustomed to 3 kw. and 4 kw. fires, were less chary of going a step further and allowing 7 kw. or even 10 kw. and 12 kw. sudden demands. In short, the pioneer had no longer to worry about loadings and prices for current, though he had to remember that the better the load he provided for the station the better were his prospects of obtaining a still lower price for current, or, at the worst, a maintenance of the existing rate.

The electric geyser now came into use for small demands, but even for wash-hand basin work the loading had to be fairly high (5-8 kw.) and for bath work so high (up to 25 kw.) that switchgear at once became a more expensive item of first cost than the hot water apparatus itself. A switch to break a 25 kw. load is no nice companion in any bathroom, and remote control was essential with all its expense.

At first sight the geyser would appear to be the most efficient way to obtain hot water, and it is, if the temperature of the water be measured at the geyser outlet, but it can give no points in efficiency to other apparatus if the temperature be measured in the bath itself when it is full ; even with a loading of 25 kw. the geyser would have to run for seven minutes or so to provide a bath, and the heat losses of the water run into the bath in that time are very considerable.

The next trial was by means of a circulator used in the same way as a gas circulator. The chief reason for the adoption of this type was that it allowed for the use of the existing hot water tank and cistern in the house, without alteration other than connecting the circulator to the pipes between the usual kitchen range boiler and the tank. It soon became evident that automatic temperature control must be provided if current consumption was to be kept down and the Grundy thermostat was generally adopted.

The heat losses of this circulator arrangement, though not high, were greater than need be, and as the apparatus occupied space which could often ill be afforded and was expensive in manufacture, it was discarded in favour of the apparatus which has now become standard.

This standard gear consists of an ordinary well-lagged water tank of desired capacity, fitted with an immersion heater and thermostat. The immersion heater of a standard type passes through a circular hole in the bottom or side of the tank, the joint being made water-tight in the usual way. These immersion heaters are quite small, take up very little room in the tank, and are loaded to a consumption of 4 kw. (in the standard bath tank two immersers are used, or even three where very quick heating is required).

The advantages over the earlier types of apparatus are :—

1. *The first cost is low :* the immersers are comparatively inexpensive and the fixing work on the tank is very little.

2. The heat losses are reduced to a minimum, for the whole of the heat produced passes directly to the water, the only losses being those of conduction and radiation from the tank.

3. The existing hot water tank in the house can be used, although in large installations it is undesirable to do so, as will be seen later.

4. The heaters being always surrounded by water, work under the very best possible conditions.

The problem of electrification of the domestic hot water supply is directly analogous to the electrification of the power plant of a factory. The demand for hot water at any particular tap represents the demand for power by a machine. The heat losses in the pipes represent shafting losses. The long runs of circulating pipes represent long lines of shafting.

But whereas the individual drive is not always the best and cheapest in factory work, for domestic hot water supply individual apparatus at each point of demand will always give the best results, except in very few instances.

Most electric hot water installations up till recently depended on a central hot water tank supplying the whole premises by means of pipes. On careful test it was found that the heat losses in the pipes in the best cases were at least equal to the energy usefully consumed, and in the worst cases less than one-fifth of the energy used was represented by hot water in the bath or sink. The reason for ever adopting a central tank probably is that hot water is required at most times in the working day, and it was thought that the pipe losses would not be more than the losses of several separate tanks. Notwithstanding that there are many instances of central tank electric hot water schemes giving great satisfaction, close investigation shows conclusively that it is a most inefficient arrangement, even if thermostatically controlled (and all hot water systems should be so controlled, unless the apparatus be used only by he or she who pays the current bill).

The best practical arrangement has proved to be the provision of separate hot-water tanks at each point where hot water is drawn. The tanks are electrically loaded at bath points to provide a bath of hot water in 20 minutes from the time of switching on, and the current is thermostatically cut off after the desired temperature is reached : the current cannot be switched on again except by hand. The tank being well lagged, the water keeps hot several hours, and the heat losses inseparable from a constantly ready hot-water supply are thus eliminated. The initial cost of the apparatus is quite low ; the size of tank adopted is 15 to 20 gallons, the temperature at which the thermostat operates being fixed at 150° F. to 160° F. The cold water inlet only is controlled by a tap, the outlet being left open. When a bath is required, the cold water cock is opened, and the hot water forced out of the tank, followed by sufficient cold water to bring the bath temperature down to 95° F. to 100° F. In practice there seems to be no disadvantage by reason of the apparatus taking 20 minutes to heat up, and no complaints arise on that head.

For sinks and cleaning water a quite small apparatus is provided. The tank or container is heavily lagged and holds

about 1½ gallons; the temperature at which the thermostat operates is fixed at 190°F. The loading is 4 kw., and thus 1½ gallons of water at 190°F. can be procured every 10 minutes.

The provision of water for wash-hand basins—*i.e.*, when hot water is required at a moment's notice throughout the day—can be dealt with by a 4 gallon tank controlled thermostatically to switch *on and off*, and thus provide a constant supply. The heat losses in so small a tank need not exceed 70 watts. In most cases wash-hand basin supply is really unnecessary, consumers preferring to do without the small extra convenience such a service affords.

Apart from the great advantages of simplicity and economy in current consumption, the general arrangement described has the additional recommendation that the cost of running a prospective installation can be very nicely calculated, for the heat losses are almost negligible and current consumption is directly proportional to gallons of water required. An ordinary bath of 25 gallons of 95°F. can be obtained for a consumption of 3½ units. Hot water requirements for washing-up account for 1 unit for every 4 gallons at 130 deg.

In many districts in England the rates offered for electric hot-water service are quite low enough for successful competition with gas; but there are still a large number of station engineers who do not offer low rates possibly because they are not yet convinced that it would pay to do so.

Two tentative objections might be raised to the cultivation of a hot-water load:—

1. That it would be of poor load factor.

2. That the up-to-date apparatus, demanding as it does heavy instantaneous demands, would cause severe mains trouble and pressure variation.

It is true that by itself a hot-water load has a poor load factor, but to a central station supplying light and power the load factor of any particular consumer or group of consumers is of no importance. What really matters is the load factor of the whole system, and if any new load will improve the system load factor then a low price can be profitably offered.

Any load which does not increase the station peak must increase the system load factor. The chief demand for hot water in a well-to-do residential district is mainly in the morning before 10 a.m., and as such does not increase the station peak. In the poorer districts the demand is in the evening, but long after the time of station peak has passed.

It may be that some hot-water load will come on at peak time—the bathing of young children at early bed-time might be such a load; but this is such a small proportion of the total demand for hot water that it is comparatively unimportant.

Further, it is always possible to keep such a demand off peak by fixing a time switch to cut off current during peak hours. Such an arrangement would not interfere with the hot-water service, for the apparatus last described could quite easily be adapted for these circumstances. The temperature at which the thermostat operates would be raised a few degrees, and the current switched on quite early in the afternoon. The lagging of the tank would prevent much heat loss, and the bath water at the right temperature would be drawn off some hours afterwards. In practice such an expedient would probably be found unnecessary.

The trouble of pressure variations due to heavy loading is one which many mains engineers fear and drastically prevent by prohibiting altogether the installation of the apparatus. Pressure variation occurring in the daytime is not of great importance, and even did it occur it would probably pass unnoticed. In practice it is quite unusual to experience pressure trouble due to hot-water requirements; so little demand is made in lighting hours, and the residential load of cooking and heating has increased to such an extent that demands of even 20 kw. on a well-laid-out system cause no inconvenience.

It is true that trouble will be experienced at the end of a long feeder, but in such case the consumer would be debarred from using anything but lighting, and if the suppliers (with half-watt lamps in sight) are going to depend for service on lighting only their chance of making a profit will be small indeed.

In the Marylebone district the demand for hot-water apparatus is an ever-increasing one, and the installations carried out have proved eminently satisfactory, to both user and current supplier. The possible business needs only advertisement to be obtained and kept and hot-water supply looks likely to be one of the most profitable departments of the concern.

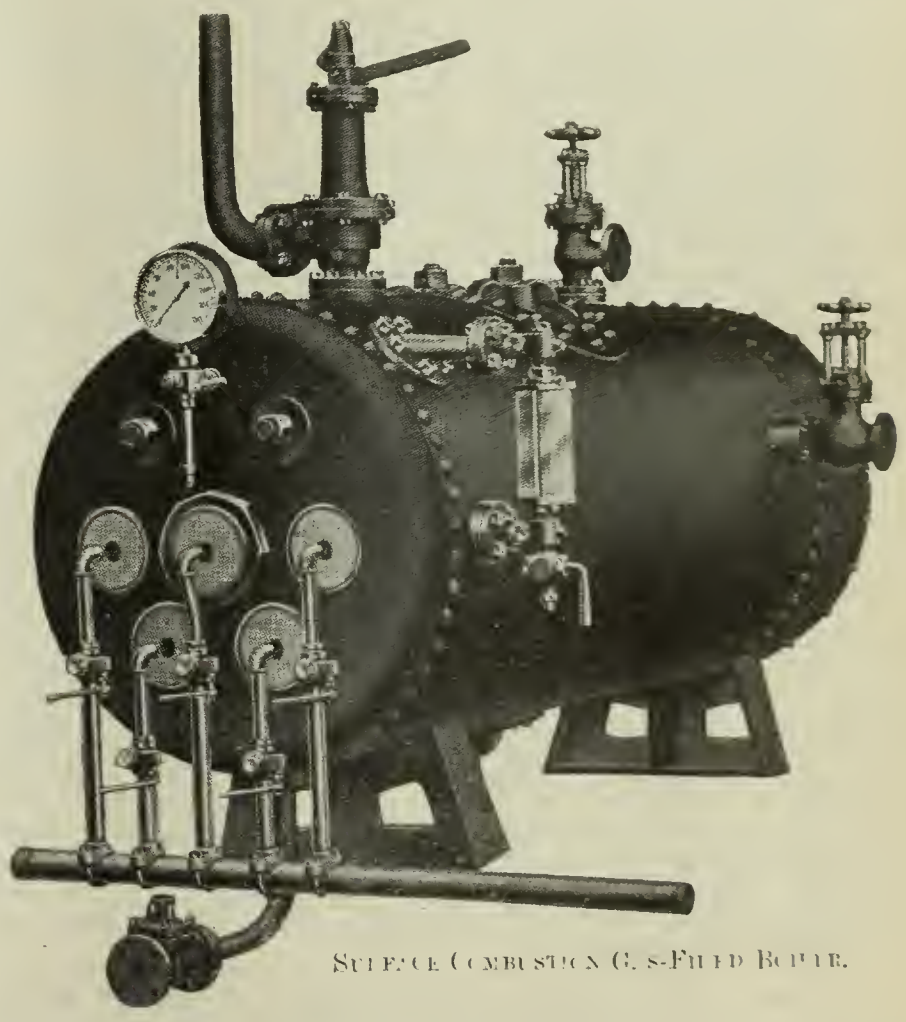
THE BONECOURT BOILER.

It is interesting to note that a very great advance has been made recently in the detail construction of surface combustion and waste heat boilers by the Bonecourt Waste Heat Boiler Co. (Ltd.), who are prepared to quote for gas-fired boilers to evaporate up to 70,000 lb. of steam per hour each, and also for Bonecourt patent waste heat boilers.

These boilers consist of a cylindrical drum traversed from end to end with fire tubes, in which is put refractory packing of suitable shape and dimensions. This packing has a double function in the gas-fired boilers:—

1st. It enormously accelerates the combustion which enables great quantities of fuel to be burnt in a very restricted space.

2nd. It causes the heat generated to be transmitted to the heating surface chiefly by radiation instead of by conduction, and consequently the transmission of heat to the heating surface is also very greatly accelerated.



Surface Combustion Gas-Fired Boiler.

In the waste heat boilers the refractory packing in the tubes has the second function only.

In the gas-fired boilers, tubes of 6 in. bore and 13 ft. long have been adopted as a standard, and the amount of steam obtainable from each tube is 400 lb. from and at 212°F. per hour. In the waste-heat boilers, tubes of 3 in. bore have been adopted.

The acceleration of combustion in the gas-fired boilers and the acceleration of heat transmission in both types of boilers necessitate the bringing of the heat to be transmitted to the heating surfaces at a much higher rate than in ordinary practice; consequently the speed of the gases over the heating surfaces and over the refractory in the tubes is very high, and it is impossible for any dust contained in the gases to lodge in the tubes. Even if there were deposits, it is an easy matter to pull the packing out and to put it back again.

Combustion takes place in the gas-fired boilers with practically no excess of air, the temperature of the gases leave the boiler at not more than 30°C. above the temperature of the steam, and practically the whole of the shell can be efficiently lagged, so that it is obvious that the efficiency of these boilers must necessarily be abnormally high as is found to be the case. An average evaporation up to 20 lb.

of steam per square foot of heating surface is obtainable, and consequently steam can be raised very rapidly.

As compared with the ordinary type of boiler, a multitubular fire tube boiler requiring neither brickwork setting or flues is clearly a very much more efficient method of recovering the sensible heat of the products of combustion discharged from industrial furnaces and gas engines, as the hot gases being *within* the tubes and the water being around the tubes, there is only one direction into which the heat can flow—namely, into the water. Moreover, as no brickwork setting or flues are required, there is no opportunity for cold air to leak into such flues and cool the products before they reach the heating surfaces. Up to the present time, however, the employment of multitubular fire tube boilers has been quite impracticable for recovering the waste heat discharged from large industrial furnaces, owing to the small evaporation obtainable per unit of boiler heating surface and the consequent bulky nature of the boiler necessary for dealing with large volumes of waste products. The Bonecourt patent waste heat boiler, however, by evaporating steam per unit of boiler heating surface at approximately three to five times the rate of other fire tube boilers, has entirely altered the question.

The company has just issued a pamphlet, in which these points are emphasised.

BOILER-HOUSE DESIGN AND OPERATION.

An abstract of Mr. Lackie's Paper on this subject will be found on p. 381 of our present issue. The following is an account of the discussion which followed the reading of the Paper:—

Mr. S. E. Fedden (Sheffield) thought the maximum steaming in the minimum space was not the main point. The load factor was the first important point, as on this depended the amount of coal and ashes one would have to handle. If the load factor rose largely it might be impossible to handle the coal and ashes in boiler house as originally laid out. In his opinion the boiler house was now more important than the turbine room. He had, therefore, started shift engineers merely to look after the boiler house. With regard to CO_2, he had not been able to obtain more than 8 to 9 per cent. of CO_2, and this depended on the extent to which the grates were covered. He did not think it was practicable to get much CO. Steam flow meters he had found unsatisfactory. As to mechanical stokers, he had made experiments by using various types at Sheffield. Chain-grate stokers with coal of 14,000 B.Th.U. required 17·72d. per ton for maintenance. With coal of low calorific value (10,000 to 11,000 B.Th.U.) the maintenance was 4·6d. The underfeed stoker required 5·7d. for maintenance, but this figure rose rapidly if the fires were banked. A bucket conveyor handling washed coal cost 1·18d. per ton handled; with unwashed coal it was higher. In the case of ashes, the figure rose to 17·76d. It was quite desirable to have an engineer to watch the ash which should be analysed every week. He found at one time they were turning out ash having 4,648 B.Th.U. calorific value; this was reduced by an engineer to 3,152, and risk of fire in the dumping heap was reduced. The salary was, therefore, easily saved. The quality of riddlings did not seem to vary much from end to end when working with a well-covered grate, but they varied otherwise. Thus a well-covered grate gave riddlings of 9,596 B.Th.U., whereas when burnt half way the value was 6,066. Loss in soot in boilers, &c., was quite appreciable, and varied with the position of the soot. This was shown by the following figures:—

—	Front bank.	Super-heat.	Front chamber.	Back chamber.	Front economiser	Back economiser
Fixed carbon	4·70	8·35	19·55	23·22	20·10	22·55
Ash	95·30	91·65	80·45	76·78	79·90	77·45
Coal, B.Th.U.	694	1,232	2,890	3,430	2,970	3,320
						Oxidation.

The quality of coal had much deteriorated since the beginning of the war. The ash had risen from 10 per cent. up to 29 per cent.

Mr. J. Christie (Brighton) referred to the firing of boilers by gas. The difficulty of providing sufficient space for the boiler plant, coal and ash handling plant for very large units would become increasingly serious. Why should not gas recovery plant and gas firing be used instead of coal firing? He had arranged a large scheme of this kind with the Coahte Co.

Mr. S. L. Pearce (Manchester) said that the author of the Paper had been to America, and no doubt many of the views expressed were prompted by that visit. In regard to Mr. Lackie's axiom that the main object of the boiler house was to have the maximum steaming capacity in the minimum of space, he sympathised with Mr. Fedden's views. They now crammed as much steam-raising plant as possible into existing buildings, simply because it was necessary at present to get the last ounce of steam, but he did not think that the sole criterion. Turning to the question of three *v.* two story boiler houses, Mr. Pearce showed by means of slides the proposed Barton station at Manchester. In this the economisers were arranged behind the boilers. On each boiler house, owing to lighter steel structural work, and despite the fact that additional ground space was necessary, there was a saving of some £8,000 over a triple story building. Expressed as percentage, such boiler houses could be erected at a cost of about 20 per cent. less than the three-story building. In regard to the question of clean and light boiler houses, he had seen numerous stations with economisers above the boilers, but he had not seen one with a reasonable amount of natural light. With the Barton arrangement all the light necessary came through the roof lights. The question of light also turned on the type of chimney, the arrangement of one chimney per boiler or one steel chimney with induced draught for two boilers. They were bound to get dust which obscured the skylights. At Barton the overall width of the four boilers would correspond with the length of the turbine room. This was designed for 160,000 kw. plant. So long as they could with the two-story arrangement get in the boiler plant required with the corresponding length of the engine room, he failed to see any advantage in the overhead economiser arrangement. The author stated that modern turbine rooms could accommodate 20 H.P. per square foot of engine room floor, but this seemed to him an excessive figure. In the Barton arrangement it was about 10, representing 20,000 kw. units. In regard to the question of ashes, he did not think Mr. Lackie advocated that ashes and riddlings be sent down indiscriminately; it was another matter to have one or two boilers to deal with them. The author's layout did not provide for spare plant; it was absolutely essential to have a big reserve, not only in the steam available, but also in the boiler units themselves. He did not think the arrangement of boiler houses with firing from two sides had anything to commend it. He endorsed Mr. Fedden's experience regarding steam flow meters. At the present time, he was afraid that the word steam meter was a synonym for inaccuracy. In regard to the author's steam-piping arrangement, it was hardly necessary to bring down piping into a common receiver. The possible interruptions from leaking joints need not be seriously considered. In regard to the coal-handling plant, in the tentative arrangement proposed for the Barton station, liberal use of coal conveyors was made, and he was glad to have Mr. Lackie's assurance that coal-conveying plant was likely to work out the cheapest. Provision was made at Barton for from two to three months' coal stocks, and the coal was received either from railway or from the canal. There was a tendency in many power stations to neglect feed pumps, which seemed to be "stuck away anywhere." He was much impressed by the arrangement adopted in the new Paris station, a modification of which was shown in the design. The pump hall was between the turbine room and the boiler house. On the floor of that hall were the centrifugally-driven steam pumps, which he said were to be preferred to reciprocating pumps, and in their experience were most satisfactory. In regard to ash handling, provision should be made to remove the ashes by rail, road, or water, and it was important that the ashes should be separated from the soot, as each had a market, but there was no market for the two mixed. Mr. Pearce concluded his remarks by showing on the screen a table of details of some water-tube boilers, demonstrating the comparative difference between American practice and what might be termed representative British practice. British practice erred perhaps on the safer side than the American, in that the boilers were designed for long continued operation with a pretty big margin. Several of the high values quoted in the case of the American boilers were obtained with one or other form of the underfeed type of stoker, working under forced draught.

Details of Some Large W.T. Boilers.

—	Detroit.	Chicago.	Man-chester.
Heating surface in square feet	23,650	12,250	11,000
Economiser surface in square feet	None	8,500	5,000
Superheater surface in square feet	...	612	3,924
Grate area in square feet	400	274	312
Evaporation in lbs. per hour	130,000	70,000	50-60,000
Consumption of fuel per square foot of grate area per hour	...	45 lb.	21-26 lb.
Gauge pressure in lbs. per square inch	200	210	225
Superheat	...	225° F.	275° F.
Diameter of tubes	4 in.	4 in.	3 13/16 in.
Waste evaporated per hour per square foot of heating surface	5·64	6·53	4·75
BHS GA	59/1	44/1	35/1
Temperature of feed water	...	250° F.	210° F.

Mr. John Roberts (Durban, South Africa), who was given a hearty welcome on his introduction to the Convention, took the opportunity to express his thanks for the invitation to attend the meeting, on his own behalf and that of the members of the Association of South African Electrical Engineers. This association had been formed more or less at his instigation, and was very helpful to engineers in the Union in charge of large and small plants. He hoped that one day that association might be affiliated with the I.M.E.A. Regarding Mr. Lackie's Paper, he was unable to offer any criticism, because in South Africa they did not design "super-stations" such as were now going down in this country. At Durban he was putting down a 15-20,000 kw. plant, and he thought that enough had not been made of a steam raising unit comprising boiler, grate, superheater, economiser, draft plant, and chimney all on one foundation. Such units were now available, and were proving most useful in economising floor space.

Mr. David Wilson (Babcock & Wilcox) stated that boiler makers were adapting themselves to limitations of space. In high-rate boilers it was

specially necessary to be careful with the feed water. The output was now largely a matter of combustion. He agreed with Mr. Lackie that it would not pay to burn very low-grade fuel, but good results were obtainable with such fuel nevertheless. Thus, at Detroit an efficiency of 17 per cent. was obtained with coal of 13,000 B.Th.U. calorific value as fired. At The Hague the efficiency was 15 to 16 per cent. with coal of over 13,000 B.Th.U. At Dunston the efficiency was 15 to 16 per cent. with coal of only 10,000 B.Th.U. as fired. At the Victoria Falls works, which produced 2,000,000 units per day, the efficiency was about 13 per cent., with coal of under 10,000 B.Th.U., and a large percentage of only 7,500 B.Th.U. In all these cases induced-draught was used. Mr. Lackie had mentioned a performance of 9 lb. to 10 lb. per square foot of grate area. He (the speaker) presumed that the reference was made to anthracite, as much larger outputs were obtained with other fuels. Finally, he would like to remark that boiler makers were not sitting still, but were carrying on a great deal of investigation.

Mr. C. H. Wordingham had come to the same conclusion as Mr. Lackie, that with large units it was necessary to have back-to-back boiler houses. The question of heat insulation materials was very important, and the figures given by Mr. Lackie were valuable. He thought it questionable if much was to be gained by enormous turbine units, such as 50,000 kw., owing to complications in the boiler-house. There was probably a future before gas firing, owing to Bonecourt and other developments, but in order to benefit by this to the full he thought that co-operation between the electric and gas interests would be necessary.

Mr. W. M. Selvey thought that the idea that there was any necessary connection between the space devoted to boilers and the space devoted to turbines was purely conventional. It was evident that the design of the boiler house was now the main feature of a power station, and that the engine-room was only a small annexe. Mr. Lackie, while still considering the idea of cramping the boiler house to make it fit the engine room, was concerned with the proportion of grate area per square foot of boiler house space. This would be a fruitful point of view to take at any time. The marine boiler design of Messrs. Babcock & Wilcox lent itself very much to effective use in this direction, but our other successful boiler builders in this country such as the Nesdrum, Stirling, Woodeson and the like had not properly tackled this question. In this connection he would call attention to the arrangement of Stirling boilers at Detroit. As a practical fireman he was of opinion that it was a great mistake to cut down the alleys between the boilers, or what would be in some modified types the platform at the back of the boiler. He was certainly not enamoured with the idea of elevating riddlings to the coal bunkers, except, say, to some special hopper at the end of the station, from which such stuff can be drawn for banking boilers or for combustion into some special allocated boiler. This question of riddlings was of much more importance with the old open-link grates, but nowadays with close-link grates the amount dropped was exceedingly small and was largely mixed with ash. In regard to stokers, attempts to do away with the travelling grate type had in the end resulted in an appreciation of its good points, and in a return to the idea, but with considerable advance in construction. One thing that was desirable was to provide emergency travel rates on the ordinary chain-grate two or three times as fast as at present. Thickening up a fire was not the correct way to produce rapid combustion. It necessitated much more draught on the grate than the thinner fire run faster ; it gave rise to much higher internal temperature in the fuel. This was more likely to cause burnt links, it facilitated the formation of fluid clinker, and, lastly, the high draught necessitated had a great tendency to lift ash, both solid and fluid, up on to and among the tubes, Another objection to getting heavy overload out of a boiler by thick fires was that it was almost impossible to check such fires when once well alight. Coming to the larger question of fuel, it should be noted that in the future the electrical industry will be the biggest coal buyer and coal user. In this respect " electrical generation " would then have to organise itself as a manufacturing concern on the broadest possible lines, and to carry on its own researches. The attempt to co-operate with gas engineers was, he thought, doomed to failure. One of the most striking developments going on at the present time was the way in which the size of the colliery generating station is rising. Any scheme of linking up, such as has been discussed at the Institution of Electrical Engineers lately, would largely depend on the co-operation of colliery engineers, and they themselves were in several directions privately considering a considerable electrical linking up of allied coal interests. The possibilities in this direction appeared to have received very little attention either from the technical press or from the technical institutions. The difficulty of stations at the pit head was mainly one of water, and we must be prepared to sacrifice a very considerable degree of that efficiency which we had been accustomed to regard as essential in our big stations for the sake of getting poor fuel very cheap and having facilities for coal delivery and ash ejection, such as we should never get in the vicinity of our large towns, It was no handicap to have stations, say, of 30 per cent. or 40 per cent. less efficiency than we had been accustomed to think of as imperative if we could get fuel from half to one-third of the price per the B.Th.U. value in the fuel. The question of coke production and by-products was a difficult one. The uses for coke were strictly limited and no stoker so far designed could operate satisfactorily from a mechanical point of view with this intensely hard fuel. The burning of coke on a fixed grate was another matter.

Mr. T. Roles (Bradford) thought Mr. Lackie's Paper was fully justified by his remark showing the value of saving 1 or 2 per cent. of the coal. There were very few stations in which a saving of 1 per cent. could not be effected. In regard to the question of boiler-house space, he thought that space might be saved by modifying the grate of the land type of Babcock boiler. Steam pressures had not been raised during recent years, and it was difficult to decide whether higher pressures should be adopted in new stations. The cost of development work in this direction would have to be paid for by those who gave the first order. He thought that the boiler makers, turbine makers and valve makers should come together and decide what should be the standard pressure. The Engineering Standards Committee and the B.E.A.M.A. might do something in this direction.. He had come to the conclusion that coal at 16s. to 17s. per ton might be cheaper than coal at 11s. owing to higher calorific value. He thought that quotations giving evaporation per square foot of heating surface were misleading. He had recently been offered boilers (of the same width and length, and therefore of grate area) of 9,460 sq. ft., 8,000 sq. ft. and 7,000 sq. ft. heating surface. The smallest heating surface would no doubt have given an excellent evaporative performance, but he came to the conclusion that the cost of the extra tubes was so small that it was economical to have them.

Mr. McKay (Stirling Boilers) remarked that some years ago they manufactured boilers for 350 lb. pressure, and the only trouble they found was with the water gauges. He wished to support the two-floor type of boiler house. The figures given by Mr. Fedden for maintaining chain-grate stokers did not apply generally owing to the coal used which was destructive in its nature, owing to high temperatures.

Mr. J. Horace Bowden (Poplar) asked for information on an American stoker which he had seen at Glasgow and which seemed to be very good for forcing boilers. With regard to ashes, he thought it should be possible to handle these in the same way as at sea.

Mr. G. Wilkinson (Harrogate) hoped that the effect of Mr. Lackie's Paper would be to make us dissatisfied with boiler-house practice. There seemed to be two lines of improvement. One was to improve the heating surface and the other to improve the radiating surface. High evaporation was possible if the heat could be applied. Gas, as Mr. Christie pointed out, was a possible solution, but the trouble he would find would be in disposing of the coke. Therefore it would be better to use up the coal completely in making the gas. Gas would give simpler boilers, more room and valuable by-products.

Mr. J. P. Gregory (B.T.-H.) spoke of the importance from a commercial point of view of raising the boiler pressure, and also the temperature of superheat. At their Rugby works his company had made an experiment with a high-pressure plant, and this had ceased to be an experiment, the unit having become a permanent part of their power station. The unit comprised a marine-type boiler, complete with economiser, superheater and induced draft plant, 1,500 kw. turbo-generator, surface condenser and turbo-driven auxiliaries. The hot air from the alternator was turned into the boiler furnace. The boiler pressure was 400 lb. per square inch and 700°F. superheat. Tests had shown remarkable results, which would doubtless be published in due course. It had, however, been shown that with 350 lb. per square inch, 264°F. superheat and 28½ in. vacuum (assuming 80 per cent. boiler efficiency), the overall efficiency of the unit was 19·12 per cent. The same unit with 200 lb. pressure and 200°F. superheat showed only 17·3 per cent. overall efficiency.

Baillie Smith (Glasgow), referring to Mr. Wordingham's remarks that in the future the electricity supply and the gas engineers would work conjointly, said that two years ago a joint sub-committee was formed in Glasgow from the Electricity and Gas Committees to make practical investigations and experiments in the gas firing of boilers. The results had been more encouraging than anticipated, particularly with low temperature carbonisation. The by-products had proved valuable, and coke was obtained in such a form that it could be burned in the open grate. If sold it fetched a good price, or if not sold it could be satisfactorily burned under the boilers in place of coal. He hoped that a Paper on the subject would be read at next year's Convention.

Mr. H. Martin (Victoria Falls & Transvaal Co.) would have liked Mr. Lackie to have given his views as to possible economies in the boiler house. There were many avoidable losses in the handling of boilers, particularly on varying loads. A steam meter should be a very useful instrument in boiler testing. He (the speaker) had found a special mercury manometer along with Pitot tubes, of value in showing the great sensitiveness of water-tube boilers to draught and general handling. A boiler could easily become a condenser on a superheated steam range.

THE GENERATION OF ELECTRICITY ON A SMALL SCALE OR BULK SUPPLY.

At the opening of the afternoon session the Chairman said that on the previous day there had been a conference of the Council of the I.M.E.A. and the power companies' officials on the question of the Board of Trade circular regarding linking up It was proposed to appoint a joint committee to go into this question and report. The matter was likely to become very prominent in the next year or two ; therefore, Mr. Ellis's Paper touched a subject of considerable importance.

An abstract of Mr. Ellis's Paper on this subject will be found on p. 383 of our present issue. The following is an account of the discussion which followed the reading of the Paper :—

Mr. Robertson (Salford), who opened the discussion, said the question of small stations or medium-sized stations versus large stations was one

requiring a great deal of investigation. The question could not be decided by taking records of works costs. Items such as rent, rates and taxes, as shown by Mr. Ellis's table, varied as much as 600 per cent., and management charges varied quite as much. He instanced the case of a station which paid £4,500 for services which another station with a similar output got for something like £700. Therefore something a great deal more exhaustive than simply a table of works costs was necessary to come to a conclusion. Referring to the table (p. 19 of Paper), giving approximate ratios of steam consumption of various sizes of turbines, there was a drop from 1,000 kw. to 2,000 kw. of 10 (96 to 86), then a straight line from 2,000 kw. to 5,000 kw., then a drop of one point to the 6,000 kw. size, then a straight line up to 10,000 kw. He had figures from a well-known manufacturing firm showing a difference of 15 per cent. between the 2,000 kw. and 5,000 kw. sizes. This was for 3,000 revolutions, and if this was considered too high, then for 1,500 revs. per min. with steam consumption of 13·4, there was an advantage of 9 per cent. in favour of the 5,000 kw. size over the 2,000 kw. size He was in general agreement with Mr. Ellis regarding what might be called medium size stations that could usefully employ 3,000 kw. sets or over. If up to date, efficiently managed, and with area of supply fairly compact, there was nothing yet in the way of a bulk supply that could improve on the costs of such a station. Some half a dozen stations in the Lancashire area were producing energy with average load factors at costs better than any figures published for large municipal stations, whatever companies' stations may do. There was considerable margin for saving in the smaller stations, and probably in the near future many of these in industrial areas might have to shut down their generating plant in favour of a bulk supply from a large station in the vicinity. The small station in a residential district was in a different position, but the small station in an industrial area had little excuse for existence in these days of national efficiency. With the 25,000 kw. plant there was little to chose between costs and those for 100,000 kw. The personal element had, of course, to be taken into account. In running a station with 5,000 kw. or 3,000 kw. they could come very close to the ideal costs they sometimes heard about regarding the large super stations to be built. Referring to Table I., he thought he recognised the station in the last line of the group 7,000–10,000; the works costs of 0·79 were in the last published returns of two years ago. In the interval, by scrapping certain old plant and substituting two modern turbo sets, the costs were reduced something like 30 per cent., although coal had gone up 20 per cent. In that particular station a 750 engine generator 14 years old was substituted by a 5,000 kw. turbine running day and night, excepting a few hours on Sunday, for over a year saved £60 a day in fuel, and paid for itself in just a little over a year. They must take into account that some stations were modernised, and some were in the process of being modernised. Regarding Mr. Ellis's recommendations, he did not know on what ground the author based his faith in the Association to carry out such a programme. Frankly he had no faith in the Association being able to do any of these things. He did not speak in a hostile spirit, but the Council was composed of busy men, who could not possibly deal with questions of the magnitude outlined With regard to future loads, after the war there would be an increased demand for power, if we were to maintain our position in the world's markets. Stations in the industrial districts were so grouped that nearly all could be linked up at little expense or delay. Reducing the amount of reserve plant was only one advantage. The fact that plant at another station could be called upon to feed round a ring main was a very great advantage. If the most efficient plant was connected to the mains, efficiency of 100 per cent. might be obtained. They could shut down stations at week-ends and during light loads for repairs and overhaul of plants; but perhaps the strongest claim of all was that of reliability, particularly was this so at the present time.

Mr. T. Littler (late Alderman, West Ham) said that any scheme of linking up in London must include both the companies as well as the municipal undertakings. There had been a great retarding of municipal electricity supply in London on account of the petty jealousies which seemed inseparable from municipal working. He thought that the commercial driving force of the companies combined with the broad outlook of the municipalities would achieve a result which would be most helpful in this matter of reducing the cost of general electricity supply.

Mr. E. T. Williams argued at some length the desirability of looking broadly at the matter of electricity supply on a large scale, and not merely from the point of view of linking up. Engineers were to be congratulated upon the energy and despatch which they had thrown into the matter of linking up during the past few months. He disagreed, however, with the idea of local and separate areas being linked, much in the way that Mr. Robertson was doing. He cited the policy upon which the Canadian Pacific Railway had laid down its lines, and put into service a number of liners, a policy in which they looked many years ahead and steadfastly refused to be guided by the outlook at the immediate moment. Electricity supply from large stations was the problem for engineers, and it would be a grave mistake to perpetuate by linking up, small stations which ought to be wiped out.

Mr. J. W. Meares (Electrical Engineer to the Indian Government) said the author had prepared an interesting table on average costs. He had done the same thing. Averages were notoriously unreliable, but they had a general value as showing the trend of affairs. A table which he showed on the screen gave particulars of Indian electric supply undertakings. Some of these, though small undertakings, showed surprisingly good costs, because they had good load factors, due to the fan load. They were not hampered by legislation in India, as were the English undertakings. He had found that under the Act dealing with the matter, posts for overhead lines to stand the wind pressure specified would have needed to be made of concrete, and about a yard square. They just went on with ordinary poles, and no notice was taken. Accidents would, of course, happen occasionally. For instance, a service line broke, and a man got curled up in it and was killed. They did not alter their rules on account of occasional accidents, but with a view to the development of the business generally. An inspection of orange peel and banana skins was more needed in London than an inspection of electric lines.

Mr. C. H. Wordingham thought that in regard to any big scheme we must face the question whether the supply was to pay for itself, or to be partly paid for by the community at large. He thought that we ought not to rely on the public purse, for if we were to rely upon it, then the gas industry and other industries would expect the same treatment. It was all very well to run down the inefficient station, but it was due to such stations that the electricity supply industry had arisen. He thought it would be useful for the Government to lay down rules according to which capital might be spent on existing stations. He did not believe much in deductions from statistics; they were often misleading.

Mr. W. B. Woodhouse (Yorkshire Electric Power Co.) said there were two schools of thought in regard to linking up. One favoured the creation of a new organisation, and the other the utilisation of existing works. He thought the existing works should be utilised as much as possible. The knowledge of local conditions possessed by the local men would be wasted if we started at the other end by creating a magnificent electricity board for the whole country. They had seen in the north the misfortune of trying to work undertakings there from London. The companies appreciated the broad mindedness with which the M.E.A. was prepared to discuss the subject with them, and he thought if the existing undertakings were left to themselves a little while they would find a solution.

Mr. S. J. Watson (Bury) thought that although a good deal might be said in favour of the small station, there was a good deal to be said on the other side. In the future he did not think it would pay to scrap much of the existing plant. One of the speakers had referred to the difficulties of linking up in the London area, such as differences in period of tenure, and small progress made by companies. He would like to emphasise the progress of other companies, such as the Yorkshire and Lancashire companies, which had unlimited tenure, as compared with the small progress made by companies with limited tenure. It was only natural that short tenure should lead to small progress. He thought that interlinking would be only a preliminary step, and would give rise to Boards with some control as a later result. If only local jealousies could be removed there should be great progress by means of linking up.

Mr. H. W. Bowden (Poplar) said the Paper contained a good deal on linking up, but little on bulk supply. Poplar had been linked up with Stepney for years, and was now linked up with Hackney, while negotiations were proceeding for linking up with the South Metropolitan Co., and with West Ham. Many years ago he came to the conclusion that it would not be worth while for Poplar to take bulk supply, except for the purpose of delaying capital expenditure, until a power load could be foreseen, which would give a load to a large new unit of something like 70 per cent. They had agreed with Stepney that neither Poplar nor Stepney should spend capital on extensions until their loads had reached a certain figure. The benefit derived from linking up in the way of permitting the shutting down of plant for holidays, or for overhauling, would amply repay the expense. With regard to coal clauses he thought a desirable clause would be to the effect that in the event of the books of the electric supply department showing that the cost of fuel per unit in any quarter had increased, the price charged should be increased by the extra cost of fuel per unit generated during the quarter. That was a better basis than fixing the price in accordance with what one bought the coal at.

Ald. Sinclair (Swansea) gave an instance of the freeing of spare plant by linking up. He thought that linking up was most important. Many small stations had been very efficiently run, and had therefore maintained their existence, as also stations of manufacturers. In regard to local jealousies, he thought these would create more difficulty with local authorities than with companies.

THE APPLICATION OF ELECTRICITY TO AGRICULTURAL PURPOSES.

An abstract of Mr. Kerr's Paper on this subject will be found on p. 386 of our present issue. The following is an account of the discussion which followed the reading of the Paper:—

Councillor Longford (Hereford) thanked the Association for giving a farmer the opportunity of expressing his views, and eulogised Mr. Kerr's endeavours to extend electric supply to farmers. He instanced the many operations he was able to perform on the farm by its assistance, more economically and efficiently than by previous methods. He was satisfied with the results he had obtained, but wanted something more. He wanted to plough the land by the aid of electric power, a particularly important matter now that labour was difficult to obtain. He wanted to snap his fingers at a dry season, and operate a motor irrigating the land. Then they could wash trees, &c., attacked by insect pests much more expeditiously if electric power were available, than with hand pumps. He had first used steam power, which he scrapped for an oil engine. He was glad to be rid of the steam engine, as it was a thirsty, hungry, noisy,

smoky, dirty thing. (Laughter). In regard to milk supply, cleanliness was, of course, most important. Farmers were poor, and looked at every penny, but he suggested they should present the proposition in a way showing that it was possible to procure an electric motor at something like half the cost of a steam or oil engine ; there was no need for a driver (saving something like £78 per annum in wages), the motor took little space, and could be started easily. They never had to send to the station for coal or other fuel, and did not require a house to store these fuels. He also emphasised the importance of having electric light at the farm, and said that he thought the linking up referred to in the previous Paper would give the farmer that of which he was in need.

Mr. F. Ayton (Ipswich) thought Mr. Kerr's Paper would be found most useful. He doubted the feasibility of an accumulator plough. The question of wayleaves was important, and he thought the Association should approach the Board of Trade in the matter. It might be necessary to start a three-phase supply at certain stations for agricultural purposes, but this could be easily done by means of a motor-generator, which was the method he had adopted at Ipswich.

Councillor Dymond (Hereford) said a map in the Paper showed that out of 56 farms thereon, 19 were connected to the mains, and the other 37 had made applications, so that their agricultural population did not require educating. Leaving out four large consumers, they had 983 consumers from whom they received an average of £5. 12s. apiece, and 19 agricultural consumers yielding £25 apiece, so the agricultural demand was worth cultivating. A great hindrance to the development of this demand was the difficulty in obtaining wayleaves. It was a heartbreaking business, and had to be gone through in the case of every individual consumer, unless it happened that you wanted to get several at the same time. This was a suitable time to get the agricultural load, as the agricultural world, and particularly the Board of Agriculture, were preoccupied with the subjects of labour saving and increase of production. The agricultural societies should be got to pass resolutions, and these should be taken to the Board of Agriculture, and through them, to the Board of Trade to get the latter to remove the regulations as to going into neighbouring areas. Since a small amount of electric energy brought a great profit to the farmer by means of electric culture, he thought supply authorities should be entitled to charge at a higher rate than 8d. per unit.

Mr. W. B. Woodhouse (Yorkshire Power Co.) called attention to the smaller fire risk to farmers using electricity. From the point of view of the farmer, the diminution of smoke by use of electricity was also important, as shown conclusively by investigations carried out at Leeds. Such points should appeal to the farmer in facilitating wayleaves.

Mr. W. C. Bexon (Kilmarnock) had experienced difficulties in wayleaves from the farmers themselves, but progress had nevertheless been made in giving an agricultural supply.

Mr. S. E. Fedden asked questions in regard to the operation of milking machines by electricity, and also asked if it were not a fact that, with hens producing double the usual quantity of eggs, the yoke of the egg became exceedingly pale, and they wore out the internal economy of the poor hen ? (Laughter.)

Councillor Longford, dealing with the farming questions which had been asked, said that the advantage of electrifying the land would be to draw ammonia from the air ; the land quickly recovered after crops had been taken from it. In regard to milking machines, the cows were not forced to give the milk, but modern machines ceased working when there was less pressure on the teat. They were an absolute success. He could not answer Mr. Fedden's query regarding the hens, as he had had no experience with regard to them.

Mr. Low (Marykirk) (in writing) described a small water-power installation which he had used some years ago for agricultural purposes. For transmission he used strands of No. 4 S.W.G. hard-drawn copper wire at a height of 16 ft., with 65 yds. between the poles. He found that a 15 h.p. motor running at 660 revs. per min. was sufficient for threshing. He also used the power for a cream separator and other work. The only precaution that was desirable was to run the motor for half an hour or so during the wet weather to keep the insulation dry and in good condition. He felt doubtful as to the feasibility of electric ploughing. On the other hand, he had obtained good results in converting timber, using a 15 h.p. motor. Electricity was also used for heating and ventilating. A 1 h.p. motor was found convenient for driving a mangle, and a 2½ h.p. motor was used for a cold storage plant. The latter was run for five hours twice a week. He had also found good results from electroculture, but had not been able to arrive at the cost, as there was considerable difficulty in carrying out tests. Control tests were difficult owing to the effect of the wind, which carried electrified particles to a considerable distance. In such observations he had worked with an electroscope and a sodium candle to collect the electricity in the air. The most satisfactory result he had obtained was a difference of 20 per cent. in hay. He felt sceptical as to the story of fattening sheep, but he felt sure that there was a considerable future before agricultural work as a whole.

Mr. Kerr's reply was postponed for publication in the "Proceedings," and a vote of thanks to him for his Paper closed the meeting.

Spanish Patent Law.—A Royal Decree, dated Feb. 25, extends until a date to be fixed after the termination of the war, the time for establishing the right of priority in respect of patents in regard to which such time had not fallen due before July 31, 1914. Such concession will be given to all those countries according similar treatment to Spain.

THE ELECTRICAL CAPACITY OF GOLD-LEAF ELECTROSCOPES.*

BY T. BARRATT, D.SC., A.R.C.S.

Summary.—The method of sharing charges is used to find the capacity of electroscopes, the deflection of the instrument itself being used to determine the volt drop. The capacity was found to be independent of deflection.

The modern gold-leaf electroscope has for some considerable time been employed by workers in radioactivity as an instrument of precision comparable with that of other instruments used in electrical measurements. Many workers in other branches of physics, however, still appear to regard the instrument as of merely historical interest.

The method that appears to be generally used in the laboratory is to charge the electroscope to a known potential, allow it to share its charge with a small sphere of a few centimetres diameter, and deduce the capacity of the electroscope from the observed drop of potential. Unfortunately, however, the capacity of the electroscope when in contact with the sphere is very different from its true capacity, and Harms remarks that results differing by 25 per cent. will be obtained by this method.

Apparatus and Method of Experiment.—Preliminary experiments showed that the use of a parallel-plate air condenser in place of a sphere overcame this difficulty. There is nothing new in the method except in some of its details. For example, contact is made between condenser and electroscope, not once, but if necessary several times, the electroscope being earthed each time after contact. A long thin copper wire (gauge 30) is attached to the insulated plate of the condenser, which consists of plate glass covered with thin tinfoil (the two sheets of tinfoil facing each other), and insulated by three pieces of sulphur, whose thickness is accurately measured by a micrometer screw gauge. If the sulphur be scraped by a sharp penknife its insulating powers are almost perfect. The condenser is surrounded by a guard ring, so that its capacity is known with accuracy. In the present series of experiments a second condenser (without a guard ring) was used, its capacity having been first carefully compared with that of the guard-ring condenser. The capacity included that of the attached copper wire.

It is found by experiment that the potential, as indicated by the position of the leaf, is slightly reduced when the attached wire from the condenser is disconnected and earthed. The percentage reduction is found to be the same, within errors of experiment, for all values of the potential. It varies slightly for different electroscopes, but is never more than about 2 per cent. If the potential is reduced from V to V' on removing and earthing the wire, then, as the charge on the leaf system is unaltered, the capacity is changed from C to C', where $C'V'=CV$, or true capacity $C'=CV/V'$.

For example, in the case of the electroscope examined in Section III. (i.), $V=300$, $V'=294$, $C=7{\cdot}13$.

Hence, true capacity $=390\times 7{\cdot}13/294=7{\cdot}27$ cm.

If V is the original potential of the condenser and C its capacity, v_n the final potential of the system after n alternate earthings and recharging as above, and c the required capacity of the electroscope, it can easily be deduced that

$$v_n=\left(\frac{C}{C+c}\right)^n . V,$$

or

$$\log (C+c)=\log C+\frac{1}{n}(\log V-\log v_n).$$

Table I.

Dimensions of plates of air condenser : 35 cm. × 24 cm. ; distance apart, 0·480 cm. Capacity of condenser and wire = 1·44 cm. Correction for obtaining "true capacity" = 2 per cent. [*See* Section II.]

First potential, V.	Second potential, v_n.	No. of charges n.	Capacity c of electroscope.	True capacity c' of electroscope.
100 volts	79 volts	5	6·95 cm.	7·09 cm.
100 ,,	62·5 ,,	10	6·93 ,,	7·07 ,,
100 ,,	49·5 ,,	15	6·91 ,,	7·05 ,,
150 ,,	118·0 ,,	5	7·10 ,,	7·24 ,,
150 ,,	92·5 ,,	10	7·13 ,,	7·27 ,,
150 ,,	73·0 ,,	15	7·08 ,,	7·22 ,,
200 ,,	122·0 ,,	10	7·29 ,,	7·43 ,,
250 ,,	153·0 ,,	10	7·24 ,,	7·38 ,,
300 ,,	185·0 ,,	10	7·13 ,,	7·27 ,,

* Abstract of Paper read before the Physical Society of London.

Determinations of Capacity.—1. *Cubical Lead Electroscope.*—The edge of the electroscope was of length 20 cm. A central copper rod, length 18 cm., passing through sulphur in a glass cylinder 5 cm. long, 1·5 cm. diameter, carried a leaf 4·5 cm. long, 1 mm. wide.

In a similar way an emanation electroscope and small cubical electroscope were tested, and the results given in the Paper. Another test gives the capacity of an ionisation vessel and gold-leaf electroscope.

Discussion of Results.—The consistency of the results enumerated above may appear somewhat surprising to one not acquainted with the possibilities of a modern gold-leaf electroscope. If proper precautions be taken, a particular experiment can be repeated again and again with practically the same result, and the conditions can be widely varied without much alteration in the final value obtained for the capacity of the electroscope. The divergence of the leaf appears to have very little effect on the capacity of the system as a whole, except, perhaps, when the leaf is nearly in contact with the rod supporting it, in which case the capacity would appear to be slightly lower.

LEGAL INTELLIGENCE.

North British Railway Co. v. Lord Advocate (Postmaster-General).

Last week this case before the First Division of the Court of Session (before the Lord President and Lords Johnston, Mackenzie and Skerrington). The question was whether the railway company were entitled to additional compensation in respect of wayleave for telegraph wires along the railway lines, which was acquired by the Postmaster-General under two agreements dated respectively July 16, 1868, and July 20, 1869, in terms of which the company received a capital sum of £100,000 and an annual payment of £2,250. It was contended on behalf of the company that the meaning of the clauses in dispute was that the Postmaster-General was entitled to free wayleaves only in respect of wires erected in the first 15 years (up till 1885) and that wayleave should be paid for all wires erected since then. The Postmaster-General claimed that the company had been fully compensated and were not entitled to further payment. The case came before Lord Dewar in the Outer House, when his Lordship decided in favour of the Postmaster-General, who, he held, had acquired the right not for 15 years but in perpetuity. By a majority the First Division reversed that judgment and found for the railway company. Lords Johnston, Mackenzie and Skerrington were the majority, while the Lord President said he had reached the conclusion that Lord Dewar's judgment was right.

American Tungsten Lamp Patent Litigation.

The "Electrical World" announces that the Court of Appeals has affirmed the decision of the United States District Court sustaining the Just and Hannaman patent for tungsten filament incandescent lamps, thus placing the control of the tungsten lamp situation in the United States in the hands of the General Electric Co. and its licensees. The patent specification which was declared valid by the lower Court contains a broad claim for an incandescent lamp filament consisting of tungsten in a coherent metallic state and homogeneous throughout. The District Court held that the invention was for a product and not a process, thus covering lamps with squirted filaments as well as those with drawn-wire filaments. This decision is in conflict with judgments of the Chancery Division and Appeal Court in this country, as in December last the Just and Hannaman patent was held to disclose a process and not a product.

American Wireless Patent Litigation.

At Seattle (Wash.) on April 29, the attorneys for the complainants in the action brought by the Marconi Wireless Telegraph Co. against the Kilbourne & Clark Mfg. Co. asked for and secured a continuance of the trial until July 18, on the grounds that the Marconi Company had been in error as to the characteristics of the "Simpson" mercury valve transmitter of the Kilbourne & Clark Mfg. Co., when complaints were originally filed in Brooklyn and Buffalo (N.Y.); and therefore their engineers would have to have additional time in order to make tests upon which to base their claims of infringement of the Marconi patent. The defendants opposed the continuance, and only acquiesced when it was agreed that all expenses incidental to the postponement would be paid by plaintiffs, and that no attempt would be made to enjoin or serve notice on any of defendants' customers pending the conclusion of the trial. The continuance was (we are informed) secured by plaintiffs after the hearing had entered the seventh week, and Judge Neterer, of the Federal Court, had heard all the evidence against defendants' "Thompson" standard impulse transmitter and standard receiver.

PARLIAMENTARY INTELLIGENCE.

WATER POWER DEVELOPMENT.

The Conway and Colwyn Bay Joint Water Supply Board, having come to terms with the Aluminium Corporation for the enlargement of the Board's lake, Llyn Cowlyd are proceeding in the present session of Parliament for an Act to authorise the carrying out of the works. The Bill seeks to empower the Board and the Corporation to form a reservoir by enlarging and extending Lake Cowlyd, and to divert water from other parts of the mountain country into the lake, and to provide that the surplus water, after providing for the needs of the Cowlyd Board district, may be used by the Aluminium Corpn.

Shropshire, Worcester & Staffordshire Electric Power Bill.—The Shropshire, Worcestershire & Staffordshire Electric Power Co. is promoting a Bill in the current Session for the amendment of existing and for new capital powers, borrowing and debenture stock, power to acquire and work generating stations, &c., exemption from distress and execution of electric apparatus let on hire, &c.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914 SPECIFICATION.

13,674 DICKSON. Telephone transmitting apparatus.

22,807 COMPARE. Wireless control systems.

A wireless control system for indicating or controlling any operation or series of operations from a distance by radiant energy, comprising a plurality of oscillators or vibrators so arranged that radiant energy can affect only one of such oscillators or vibrators at a time, and when this one has attained a predetermined amplitude of vibration or oscillation this will cause or permit another of said oscillators to be set in motion and so on, and the last of said oscillators or vibrators upon attaining its predetermined amplitude of vibration or oscillation will then cause or permit the desired operation to be effected.

23,505 ALLGEMEINE ELEKTRICITATS-GES. Transformer connection for three-phase metal vapour rectifiers. (3 12 13.)

The primary or the secondary side of the transformer is given a zig-zag connection, which renders it possible to construct three-phase rectifiers of high efficiency, and it becomes unnecessary to adopt the method hitherto employed for improving the power factor and to arrange the transformer with a six-phase secondary element, which caused the number of anode entrances, which it is difficult to maintain tight, to be largely increased.

1915 SPECIFICATIONS.

717 BOWDEN & THOMPSON. Protection of electric cables. (16 7 15.)

2,897 BRETTELL. (Leffler.) Electric railway systems.

4,378 RODRIGUEZ. Telegraphic printing-apparatus.

5,486 B.T.-H. Co. (G.E. Co., U.S.) Methods of and means for controlling alternating electric currents.

Consists in connecting in the circuit which carries the alternating current to be controlled a reactance which is varied by means of the controlling current directly or by means of currents relayed from the controlling current and proportional thereto. In wireless signalling systems this resistance may be connected either in series or in shunt to the antenna circuit, and the controlling current may be a pulsating direct current of a character determined by the resistance variations of a telephone transmitter.

6,480 TURNER. Telephone systems. (20 6 14.)

7,151 CADENEL. Electric switches.

7,213 WAHL. Electric cell, battery, or refill for use in connection with portable electric lamps and for other purposes.

7,304 BOURNE. Heaters for electric radiators and the like.

7,374 MILTON. Electric ignition apparatus. (15 5 14.)

7,467 HAMILTON, WALL & FERRANTI (LTD.). Electric current limiting devices.

7,546 SMITH. Electric accumulators or storage batteries for use in electric battery lamps.

7,579 HEURTLEY. Telegraphy.

7,829 NISHIMOTO. Process for manufacturing metallic filaments for incandescent electric lamps and for other purposes.

9,582 AUTOMATIC TELEPHONE MFG. CO. & BATES. Telephone systems.

9,627 DE FORTUNY. Dry batteries.

10,050 AKTIESALSKABET ELEKTRISK BUREAU. Impulse senders for subscriber apparatus in automatic exchange systems. (14 7 14.)

10,668 DEUTSCHE SCHWEISSMASCHINEN-BAU-UND VERTRIEBS-GES. Electric welding transformers. (22 7 14.)

11,072 KAT & CALLENDER'S CABLE & CONSTRUCTION CO. Identification of electric cables.

11,144 IGRANIC ELECTRIC CO. (Cutler-Hammer Mfg. Co.) Electric heaters.

12,402 ELECTRIC & ORDNANCE ACCESSORIES CO. & LANGRISH. Electric motor controllers.

Consists in carrying the contacts that connect up the parallel resistance (and which are independent of the armature circuit) upon a separate movable member which, during the initial movement of the controller, is temporarily mechanically connected by suitable means to the main barrel or moving element of the controller, so as to move therewith, but on further movement is automatically disconnected and returned to its "off" position, so as to disconnect the parallel resistance.

12,434 WESTERN ELECTRIC CO. Loaded telephone line system. (12 9 14.)

13,769 WESTERN ELECTRIC CO. (Western Electric Co.) Loading coils for telephone lines. (Addition to 12,434 15.)

13,869 AUBERT. Electric current duration meters. (1 10 14.)

15,128 LINCOLN. Electric measuring instruments of the thermal type. (12 11 14.)

15,792 OSIUS. Electric motors.

16,044 SATINOVER. Electric killing apparatus for flies or other insects. (27 11 14.)

16,393, 16,479 WESTERN ELECTRIC CO. (Western Electric Co.) Loaded telephone line system. (Addition to 12,434 15.)

17,322 STONE & HORNBY. Make-and-break devices for magneto-electric machines used in conjunction with internal-combustion engines.

17,974 WILLIS & COOKE. Electric couplers for organs.

1916 SPECIFICATIONS.

1,247 IGRANIC ELECTRIC CO. (Cutler-Hammer Mfg. Co.) Resistance units and the manufacture thereof. (26 1 16.) 100,417.

1,876 WESTERN ELECTRIC CO. (Western Electric Co.) Machine switching telephone systems. (8 2 16, 100,459.)

2,743 RUSTIGE, F. J. H. Searchlight apparatus. (23 2 16, 100,462.)

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked • are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

May 29, 1916.

7,595 COTTER & HOLLINGSBER. Trolley heads of electric tramways.

7,607 RELAY AUTOMATIC TELEPHONE CO. & HERINK. Relay switches.

7,616 RITCHIE. Electric signalling apparatus.

May 30, 1916

7,639 OSBORNE. Signalling lamps, &c.

7,649 CROWLEY. Electric brakes, chiefly for locos.

7,652 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems.

7,672 ALLISON & MORRIS & WHITTAM. Manufacture of stems for metallic filament electric lamps, and apparatus therefor.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	409	Central Station Promotion of Electric Vehicle Use. By W. P. Kennedy	2*
Imports and Exports of Electrical Manufactures	410	Municipal Battery Vehicles in Service. Illustrated	4*
Business Notices	410	Piano Moving by Electric	6*
Liquidations, Bankruptcies, &c	410	"Orwell" Vehicles at Birmingham. Illustrated	6*
Electricity Supply	410	Coal Hauling by Electric	8*
Lighting and Power Notes	412	A Municipal Electric Garage. Illustrated	8*
Traction Notes	412		
The Round Table	77	Empire Notes	413
Gas and Oil Dynamos. Illustrated	78	Miscellaneous Notes	413
Electric Heating and Cooking in Glasgow. Illustrated	79	Tenders Invited	413
The Taylor Stoker. Illus.	82	Tenders Received & Accepted	414
Electric Vehicle Progress Supplement—No. 29.		Municipal Accounts	414
The Battery Vehicle in Municipal Service. Illus.	1*	Companies' Meetings and Reports	415
		City Notes	416
		Electrical Companies' Share List	416

COMMERCIAL TOPICS.

The Paris Trade Conference. Perhaps the most important conference which has been held during the war was that which took place at Paris last week, when the delegates of the Allies met to consider questions affecting international trade during and after the war. The results of the gathering are bound to be of a far-reaching character and to have important effects, not only upon the future trade and commerce of the British Empire, but also upon our trade relations with our Allies. We have pleasure in setting out an abstract of the resolutions passed at the Conference.

War Period.—Co-ordination of the laws and regulations in the Allied countries prohibiting all trading with the enemy.

Absolute prohibition of importation of goods originating in or coming from enemy countries.

Sequestration or control of businesses owned or operated by enemy subjects, and for winding up some of them, &c.

Stringent measures for restriction of enemy supplies.

Reconstruction Period.—Devising of joint means to secure to countries suffering from acts of destruction, unjust requisition, the restoration of their raw materials, industrial and agricultural plant, stock, and mercantile fleet, or to assist them to re-equip themselves in these respects.

Denial to the onemy Powers, for a period to be fixed by agreement, of "most-favoured-nation" treatment.

Conservation for, and interchange between, the Allied countries of their natural resources.

Protective measures against enemy "dumping" and for preventing enemy subjects in Allied countries from engaging in industries which concern national defence or economic independence.

Peace Period—Measures to be Taken.—To render the Allied countries independent of enemy countries in raw materials and manufactured articles essential to the normal development of their economic activities. (These measures are to be direct not only to the sources of supply, but also to their financial, commercial and maritime organisation.) They may consist of subsidies or financial assistance for the encouragement of scientific and technical research, &c., or of customs duties or prohibitions.

To facilitate and improve the interchange of their products by improving transport services, postal, telegraphic and other means of communication.

The Allies undertake to convene a meeting of technical delegates for the assimilation (as far as possible) of the laws governing patents, indications of origin, and trade marks, and for the adoption of an identical procedure in regard to patents, trade marks, and literary and artistic copyright which have come into existence in enemy countries during the war.

* * * *

British-made Electrical Accessories. There exists in almost every industry a craving amongst the distributors of its products for the ultra-cheap article. In the electrical business this is probably more true of electrical accessories than it is of any other piece of electrical apparatus. The history of the manufacture of ceiling roses, lamp holders, tumbler switches and cognate electrical accessories by British firms has never been written in detail. We believe there was a time when genuine attempts were made to establish factories for the production of these articles on a quantity basis in this country, but the effort came to nothing because the market was flooded with accessories which were almost equally as good but which emanated from German works and were offered at prices which were little higher than the English maker's works costs. The Continental producer was able to push the would-be British maker out of the market, and he succeeded in doing this for two reasons: his labour was cheaper than our own and, by one of those curious and inexplicable trade anomalies he could have Cornish clay for his porcelain delivered at his works via the Rhine waterway at a cheaper rate than the Hanley potteries could obtain it over rail in this country. On the other hand, there must be taken into account that inordinate desire for the cheap article which seems to be ever present in the breasts of British electrical contractors. At the outbreak of war it was thought that patriotic motives would bring about change in the situation, and there might be some hope of the manufacture of these accessories becoming reorganised and re-established by British capital. If the reports that we are receiving of the extraordinary influx of Japanese electrical accessories are of any value, then it would appear that what we lost to the Germans before the war we are now to lose to the Japanese during (and after) the war. The situation has been materially altered in so far as the British manufacturer is concerned; even were he able to obtain permission to use his machinery and also the raw material wherewith to produce, it is doubtful if the requisite incentive would make itself felt and result in the production of electrical accessories for the Home and Colonial market. The position is aggravated somewhat by the fact that the electrical contractor remains unpatriotic and will still buy in the cheapest market, and in the case of the Japanese manufacturer he excuses himself on the ground that Japan is our military ally. Without wishing in the least to deprecate the efforts of the last-named country, we are disposed to deplore an industrial situation which makes it possible for our own productive efforts to be discounted mainly on the grounds of cheap labour. Presumably, the Japanese manufacturer is taking advantage of the market, such as it is at the present moment, and is finding a sale at low prices for accessories which are being taken into stock by certain factors and electrical contractors. These will be utilised when the demand for them assumes more normal preparations, and in the meantime the hope of the establishment of factories in this country for the production of these accessories upon the grand scale will be dissipated for many years to come. In this connection we call attention to the fact that H.M. Trade Commissioner in New Zealand (Mr. R. W. Dalton) has forwarded an extract from the local press calling attention to the growth of Japanese trade with the Dominion, especially since the war. The value of imports from Japan rose from £84,629 in 1904 to £.87,501 in 1914, and it is expected that the figures for 1915, and more especially those for the current year, will show a remarkable advance on the 1914 imports. The fruits of the labours of the Japanese Trade Commission, which visited New Zealand some months ago, have been abundant, and that from causes not at the time fully appreciated—viz., the difficulty that New Zealand importers experience in obtaining supplies from the United Kingdom. Among the principal goods of Japanese manufacture supplied to a great extent by Germany before the war, which are now being sold in New Zealand, are electrical goods, optical goods, clocks, toys, &c. As there are no facilities for direct shipment to New Zealand, goods from Japan have to be transhipped, and this causes extra delay, risks and freightages; nevertheless, the low cost of manufacture in Japan is an ample set-off against the great increase in freights.

* * * *

The Future of the Electric Vehicle. It is not always safe to take a lead from American experience, particularly as the condition of things generally in the United States differs so much from that which obtains here. A considerable interest, however, attaches to the prevailing opinion in America regarding the immediately prospective keen competition of the petrol with the electric vehicle. In the "Electric Vehicle Progress" Supplement, published with this issue, we reproduce an abstract of a Paper read before the National Electric Light Associa-

tion by Mr. W. P. Kennedy, in which it will be noticed that he foretells a period of exceptionally keen competition as between the petrol and the electric vehicle, especially for commercial purposes. American automobile engineers have evidently extended their works to cope with an unprecedented war demand for petrol vehicles on the part of the Allies. At the peace these extensions will, it is suggested, be kept in full swing, with the result that the American market will be flooded with commercial petrol cars. Over-production will bring prices to such a level that the buyer may be tempted to purchase the petrol rather than the electric vehicle, without regard for economy, and merely on the score of first cost. The strong point for the electric which Mr. Kennedy makes, is that its superior economy in its field over the petrol machine should be actually guaranteed, and in this way it will be able to hold its own, no matter how severe the competition may become. Looking at the facts squarely, they amount to this. The electric vehicle industry must be prepared to withstand the shock which a low-purchase-price petrol vehicle boom may administer. This shock, if it is going to be felt in the United States, will, as matters now stand, be also felt over here. Petrol vehicle producers in this country have put in war extensions for production purposes probably quite as much as the Americans, and they, too, may threaten the market of the electric with the low first-cost machine. The rock upon which this class of competition should split, so far as the electric battery vehicle is concerned, is this matter of the guarantee of such economy in operation as will wipe out the initial outlay upon the vehicle within a definite period. We doubt whether any maker of a petrol commercial vehicle would feel justified in giving any such guarantee, simply because he would have no definite operating results upon which to base it. In the case of the electric, those results have unquestionably been obtained, and in the face of prospective severe competition on the petrol side we think the battery vehicle makers should take the utmost advantage of them.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From June 12, 1916, *to* June 17, 1916.

IMPORTS.

GOOLE.—*Sweden:* Elec. machinery, 26 pkgs.

GRIMSBY.—*France:* Unenumerated, 23 pkgs.

LIVERPOOL.—*U.S.A.:* Unenumerated, 268 pkgs. *Sweden:* Elec. machinery, 12 pkgs.; carbon candles, £10. *Spain:* Elec. carbons, 41 pkgs.

LONDON.—*U.S.A.:* Elec. lamps, £1,096; carbon candles, £95; wire and cable, £20; unenumerated, £10,259—356 pkgs.; elec. motors, 74 pkgs.; telephone material, £647. *Holland:* Elec. lamps, £3,194; wire and cable, £82; unenumerated, £1,633. *Japan:* Elec. torches, 31 pkgs.; elec. ingots, 10,851 pkgs.; unenumerated, £1,235. *France:* Carbon candles, £314; unenumerated, £173 8 pkgs. *Denmark:* Unenumerated, £44.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Unenumerated, £237. *Melbourne:* Wire and cable, £3,443; elec. machinery, £1,061; unenumerated, £1,757. *Sydney:* Elec. machinery £1,124; wire and cable, £4,701; unenumerated, £954. *Wellington:* Elec. machinery, £112; wire and cable, £79; unenumerated, £63. *Christchurch:* Unenumerated, £8. *Lyttelton:* Elec. machinery, £64; wire and cable, £589; unenumerated, £734. *Invercargill:* Elec. machinery, £1,067. *Dunedin:* Wire and cable, £119; unenumerated, £498. *Adelaide:* Unenumerated, £520. *New Plymouth:* Unenumerated, £64.

AFRICA. *Durban:* Wire and cable, £484; elec. machinery, £20; unenumerated, £27. *Cape Town:* Unenumerated, £63. *Port Elizabeth:* Elec. machinery, £105; unenumerated, £169. *Mauritius:* Unenumerated, £40.

EGYPT.—*Alexandria:* Wire and cable, £405; unenumerated, £61. *Port Said:* Unenumerated, £98. *Port Sudan:* Unenumerated, £37.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Wire and cable, £1,660; unenumerated, £3,790. *Penang:* Wire and cable, £587; unenumerated, £567. *Sourabaya:* Unenumerated, £160. *Rangoon:* Wire cable, £120. *Singapore:* Elec. machinery, £1,232; wire and cable, £4,593; unenumerated, £901. *Malacca:* Unenumerated, £12. *Calcutta:* Wire and cable, £2,397; unenumerated, £563. *Madras:* Elec. glow lamps, £24; wire and cable, £116; unenumerated, £3,459. *Ceylon:* Unenumerated, £133. *Karachi:* Unenumerated, £64 *Bankok:* Wire and cable, £184, unenumerated, £384. *Port Swettenham:* Wire and cable, £170; unenumerated, £79.

CHINA.—*Shanghai:* Elec. machinery, £281; elec. glow lamps, 5,242 no.; unenumerated, £152.

U.S.A.—*New York:* Unenumerated, £287. *Hongkong:* Elec. machinery, £51, wire and cable, £917; unenumerated, £975. *Hankow:* Wire and cable, £38; unenumerated, £73. *Saigon:* Elec. lamps, 1,000 no.

SOUTH AND CENTRAL AMERICA.—*Monte Video:* Unenumerated, £10. *Rio de Janeiro.* Wire and cable, £550; unenumerated, £60. *Buenos Aires:* Wire and cable, £3 790, unenumerated, £1,696.

HOLLAND.—*Amsterdam:* Unenumerated, £378. *Rotterdam:* Elec. machinery, £302; telegraph material, £650; unenumerated, £20.

FRANCE.—*Paris:* Elec. machinery, £147; unenumerated, £311 *Dieppe:* Elec machinery, £158; wire and cable, £40; unenumerated, £108 *Havre* Unenumerated, £237. *Bordeaux:* Wire and cable, £1,034, unenumerated, £332

JAPAN.—*Yokohama:* Elec. lamps, 126 no., unenumerated, £1,240.

RUSSIA.—*Vladivostock:* Unenumerated, £60. *Petrograd:* £340

NORWAY.—*Christiana:* Wire and cable, £54; unenumerated, £40

GIBRALTAR.—Unenumerated, £73.

MALTA.—Wire and cable, £13-; unenumerated, £55

SPAIN.—*Barcelona:* Unenumerated, £57; *Bilbao:* Elec. machinery, £30, unenumerated, £50. *Santandir:* Unenumerated, £144

PORTUGAL.—*Lisbon:* Elec. machinery, £58; wire and cable, £30; unenumerated £633.

BRITISH GUIANA.—*Demerara:* Unenumerated, £29.

FOREIGN GOODS (duty paid and free).

Amsterdam: Unenumerated, £195. *Sydney:* Unenumerated, £36. *Madras:* Unenumerated, £103. *Port Elizabeth:* Unenumerated, £56. *Durban:* Unenumerated, £77 *Bilbao:* Unenumerated, £200. *Alexandria:* £35. *Brisbane:* Unenumerated, £433. *Petrograd:* Unenumerated, £142. *Rotterdam:* Unenumerated, £35.

IN TRANSIT.

Hong Kong: Elec. glow lamps, £3,122. *Shanghai:* Elec. glow lamps, £346.

BUSINESS NOTICES.

Claims against Jas. Brockie, mechanical engineer, 41, London-road, Forest Hill, London, S.E., are to be sent by July 3 to the Hon. W. J. H. Boyle, 132, York-road, London, S.E.

In future the title of Messrs. Eckstein, Heap & Co. (Ltd.) will be Erskine, Heap & Co. (Ltd.). Lancashire Switchgear Works, Caroline-street, Broughton, Manchester.

After June 19 the address of the Cyanide Patent Supply Co. (Ltd.) will be 28, Victoria-street, Westminster, S.W., and the telephone number will be Victoria 7849.

The partnership between Robert Ormes, Harold K. Gossip and Hy. Jones (trading as Ebury Electrical Engineering Co. and Ebury Garage), 80, Ebury-mews, Victoria, London, S.W., has been dissolved so far as concerns Mr. Gossip. Debts by Messrs. Ormes & Jones, who continue the business.

Water Power for Sale.—An advertiser has for disposal water power (up to 190,000 H.P.) in Western Norway.

Patent Development.—The proprietors of patents Nos. 15,951/1913 and 10,868/1914, for "Improvements in safety devices for electric conductors" and "Improvements in and relating to electrical condensers and a process of manufacture thereof," desire to enter into arrangements for exploiting same in this country. Particulars from Messrs. Haseltine, Lake & Co., Patent Agents, 28, Southampton-buildings, Chancery-lane, London, W.C.

Hydro-Electric Plants.—Messrs. Boving & Co. (Ltd.), Imperial-buildings, 56, Kingsway, W.C., claim to be the largest firm in this country which has specialised in hydraulic power machinery, turbine plants, pumps and pipe lines.

Whereas the pumps and a certain number of high-pressure turbines have always been made in this country, the other machinery has hitherto been imported. The firm have, however, now made arrangements for having all their machinery for the requirements of the Empire manufactured in this country. Their capacity for the last few years has been about 100,000 H.P. turbine installations each year, 10,000 tons of welded pipe lines and 5,000 H.P. per annum pumping installations. The firm state that they aim entirely at the highest quality both in material, workmanship and efficiency. They have their own offices in many parts of the world, and agencies are established throughout. Water-power engineering is of the highest importance to the Empire, whose resources should be developed properly, and they claim they are capable and ready to tackle problems relating thereto.

LIQUIDATIONS, BANKRUPTCIES, &c.

First meetings of creditors and contributories of the Colston Electrical Works (Ltd.), 9, Denmark-street, Bristol, will be held on June 28 at 26, Baldwin-street, Bristol.

Claims against John Boult and John Hugh Bolt (trading as John Boult), electricians, 3, Grosvenor-street, Chester, and against the separate estate of John Boult, are to be sent by July 5 to Mr. P. S. Booth, 2, Bixteth-street, Liverpool.

An application for the discharge of Geo. F. M. Cornwallis West, Automobile Club, Pall Mall, London, S.W., has been withdrawn.

ELECTRICITY SUPPLY.

EXTENSIONS.

Carnarvon.—The Corporation have decided to put in another Diesel engine at an estimated cost of £2,380.

Greenock.—The Secretary for Scotland has sanctioned the borrowing of an additional sum of £45,000 for extensions of the electricity undertaking, repayment to be spread over 25 years, and the new work will be begun at once.

The sanction is conditional on the whole surplus revenue of the undertaking, after meeting working expenses, depreciation and debt charges, being transferred annually to the reserve fund until this fund has reached its maximum.

Swansea.—Mains are to be extended to Prince of Wales-road at a cost of £250.

The Board of Trade's letter re the interconnection of supply undertakings in order to effect saving in coal has been referred to the Chairman and Vice-Chairman of the Electricity Committee, together with the Engineer with a view to the proposals being extended, in a similar manner as the Corporation's arrangement with the Tramways Company, to other large independent consumers of electricity.

Wigan.—The Corporation have asked the L. G. Board to sanction a sum of £3,517 for boiler, &c., in addition to the £53,920 applied for in May for extensions of the electric supply undertaking.

It has also been decided to apply for a loan of £961 (instead of £781, the former estimate) for cable, switchgear and transformer in connection with the proposed supply of electricity to Northern Coarse Spinners (Ltd.)

Ald. GRIMSHAW, in moving the adoption of the minutes of the Electric

Light Committee at the meeting of the Council last week, said that some doubt had been expressed as to whether the firm that had the erection of boilers in hand could do it within the specified time. They had obtained a guarantee that the two boilers would be under steam on Oct. 28. With respect to their balance-sheet, they had made a greater loss than anybody anticipated. Their increase on coal alone amounted to £6,000, and that was really the bedrock of all the other increases under the different items. Water and gas had cost them more by £265, wages had gone up by £435, repairs and maintenance of engines and boilers £1,141, and other machinery £488. As regards the increase in the amount of coal, their extra output had cost them about 1,600 tons, and they had paid through the year on a total of 22,600 tons 2s. 8d. a ton more than they had paid the previous year. He wished he could persuade all the people in Wigan to use electric smoothing irons and frying pans and bed warmers, and all that sort of thing ; but he did wish to say that if people wanted a clean light, and one that was of little trouble and of good service to them, they had better go in for electric light. Further, if the small business people would use electric motors for their business they would find them a great advantage, and he was certain they would save money by doing so, especially if the way of doing the work now happened to be by hand. When the new boilers and plant were in working order they would effect great economies, and the position would be much improved.

Wolverhampton.—The Electricity Committee proposes to apply for sanction to borrow (1) £600 for sub-station equipment, (2) £34,240, being amount of £53,900 for extensions contained in the report of the electrical engineer (Mr. S. T. Allen) of February last, less £19,660, for which borrowing powers have already been asked.

Subject to authority being obtained for borrowing the necessary money, the committee recommends the Town Council to proceed with the remainder of the scheme of extensions as contained in Mr. Allen's report.

GENERAL.

Aylesbury.—The Council have offered to supply electric current to the Dominion Dairy Co. at 1½d. per unit for 20,000 units per quarter and 1⅜d. per unit after.

Ealing.—The Council have granted a further war bonus of 2s. a week to the employees of the electric supply department.

Gillingham.—The question of the insurance of the two Diesel engines at the electricity works was considered by the Corporation last week.

The premium for insuring the M.A.N. engine up to £2,000 would be about £60, and the Mirrlees, Bickerton & Day engine up to £1,000 about £50. It was recommended that the Council do not entertain the question of insurance, but take their own risk, and that the question of creating a sinking fund be referred to the Finance Committee.

The report was approved.

Itchen.—For the past 10 years the members of the Council have been discussing the advisability of establishing municipal electricity works, and at the last meeting of the Council a motion to instruct the consulting engineers (Messrs. May & Hawes) to prepare plans, &c., was defeated by seven votes to four.

Pinner.—The Colne Valley Electric Supply Co. has notified Hendon Rural Council of its intention to lay supply mains in Pinner.

Redditch.—The Council have made an increase of 30 per cent. in the charges for electrical energy for lighting and power.

The Council have congratulated Second-Lieut. Norman Fletcher, who was a switchboard attendant at the electricity works at the outbreak of the war and enlisted in October, 1914, on his having obtained a commission.

Reigate.—The capital account of the electricity supply department is to be overdrawn to the extent of £231 to carry out certain work for increasing the capacity of two sub-stations.

Sheffield.—At the meeting of the City Council last week the Establishment Committee reported that they could not approve of a recommendation of the Electric Supply Committee that a bonus of £100 should be given to the general manager of the electric supply department, Mr. S. E. Fedden.

Councillor Stembridge said the action of the Establishment Committee was one of the best examples of false economy to be discovered. They took no steps to inquire as to what the extra work of Mr. Fedden amounted to. The Electric Supply Committee, which was entrusted with very grave responsibilities, and was a trading Committee, had passed a resolution asking the Council to vote a bonus of £100 to Mr. Fedden. He was not present at the meeting of the Electric Supply Committee, and he did not know why the words "with the approval of the Establishment Committee" were incorporated. After the war broke out their electric supply plant had to be supplemented at a cost of £500,000. Their power was increased by no less than 45,000 H.P., of which 24,000 H.P. was still waiting to be utilised. Before the war 6,000,000 units were used, at present 120 million units were used per annum, and when all the applications were connected, supply would be 200 million units. That gave a small idea of the extra work that the Electric Supply Department had done since the war, and in spite of that fact the Establishment Committee, instead of considering the question of a permanent increase of salary to their general manager, turned down a paltry proposal to present him with £100. He was not sorry that it had been turned down, because the Council would soon have to consider the question of Mr. Fedden's salary. Mr. Fedden was getting £900 per annum. In Birmingham the salary was £1,400, in Liverpool £1,500, in Manchester £1,500, in Nottingham £1,350, and in Salford £1,000 per year.

Councillor Evans said it was his intention to move an amendment, but he would now support a proposal for an increase of Mr. Fedden's salary. The action of the Establishment Committee was shabby in the extreme.

The Establishment Committee's minutes were carried, and the proposed bonus was rejected.

Councillor Bailey moved that the resolution of the Electric Supply Committee "that the sum of £10,000 be appropriated from the reserve fund in respect of mains extensions" be not confirmed. He did not see why they should take £10,000 from an already too small reserve fund to extend mains. They should extend the mains to supply new works, but if they were to do that they should look at the other side of the balance-sheet. He thought the Electric Supply Committee were bringing to a state of bankruptcy a great municipal undertaking. Before the war they were selling electricity at a price which it was very debatable would cover the cost of production. Twelve months ago the gas company had put up their price 40 per cent., and the Electric Supply Committee ought to have put up theirs by at least 30 per cent. If they did not increase the price now they would not be able to do it after the war.

Councillor Neal said he did not wish to derogate from what Councillor Bailey had said on the question of the price of electricity. It was a matter which called for the serious attention and immediate decision of the electric supply department. He challenged the resolution on two grounds : First, that it was a misappropriation of the reserve fund, and secondly that it was an attempt to undo the war policy deliberately settled by the Council with reference to extensions. The electric supply department by that method were proposing to overrule entirely the control which the Council had exercised over extensions, not for the works, but for private and domestic purposes.

Ald. Hobson said the charge for electricity was of very great importance in relation to the commercial work of the city. Electricity, in fact, was becoming as vital a necessity to Sheffield trade as was the Mersey to Liverpool or the Ship Canal to Manchester. They must look at the broad interests of the community when they were settling those prices. The point which he thought wanted taking back was the resolution to use up the reserve fund. It would be improper to use a revenue reserve for a capital purpose.

Councillor Stembridge said if Mr. Fedden's advice had been accepted the price for electricity would have been raised about the same time as that for the consumption of gas. He agreed entirely with Mr. Fedden's report, and he believed the Electric Supply Committee were unanimously in favour of the report recommending an increase in the rates. He felt it was a case of now or never. If peace were declared that day it would find the Council saddled with a very considerable expenditure in connection with the work of the Committee, which would have to be met by an increased revenue, a revenue which ought to be brought about in the way Councillor Bailey had suggested.

Councillor Evans (chairman of the Electric Supply Committee) said the question was whether the excessive cost of coal and other commodities did not justify a serious consideration of whether an increase in the charge for electricity should not be brought forward. As regarded taking the £10,000 from the reserve fund, they were having many applications for electricity for lighting purposes, and surely as a business concern they ought, if it was at all possible, to take on those extensions. He sometimes thought the Council was jealous of the progress made by the electric supply department, but he would prophesy that the department was going to be their largest revenue earning concern.

Ald. Styring said Ald. Hobson had stated perfectly correctly the general attitude the Corporation had taken with reference to the supply of electric power. The electric light department was differently placed from any other undertaking, inasmuch as it had in the gas company a competitor which was in a position to supply power on very economical lines indeed. If the Sheffield steel industry was to progress as it ought to do the department must be in a position to supply electric power on extremely economical lines. He had listened with a great deal of pain to the speech of Councillor Bailey, who would not have said a quarter of what he had said if he had spoken with knowledge of the facts. The curse of the electricity undertaking ever since it had been in the hands of the Corporation was that it had been attacked by people who did not know what they were talking about. The development of the undertaking had disproved the evil prognostications and the criticisms that had been made over and over again. With regard to the price of electricity, he thought it was no secret that they expected that when the accounts of the department were made up for the last year there would be a very substantial profit shown, and therefore it would be quite beside the mark to say they should not take that £10,000. He did not agree with the policy of leaving money locked up in the bank when by the expenditure of a few pounds on mains they could constantly be increasing their business. There was far too much criticism of the undertaking by people who did not trouble to get at the facts, and came and made flamboyant speeches in that Chamber and elsewhere which were extremely detrimental to the interests of the concern.

Councillor Evans took back that part of the minute relating to the use of the reserve fund.

Southend-on-Sea.—The Electric Lighting Committee has made an arrangement with the various contractors for the disposal of the plant ordered for the Leigh and Thorpe Bay sub-stations.

Delivery of the plant was countermanded in consequence of the action

of the L.G. Board in prohibiting the raising of moneys by local authorities during the war. The plant included five Diesel engines (manufactured by Messrs. Belliss & Morcom), three 200 kw. dynamos (by the Phœnix Dynamo Mfg. Co.), and two 180 kw. dynamos (by the British Thomson-Houston Co.), the amount of the accepted tenders totalling £16,359. With the exception of two six-crank engines, all the machines were ready for delivery last summer. A substantial portion of the plant has been sold to a foreign Government, and the Committee has provisionally effected the following arrangement: Messrs. Belliss & Morcom are themselves to sell the one six-crank and the two four-crank engines which have been completed, retaining the price obtained and undertaking to deliver to the Corporation, within six months of an order requiring them to do so, similar engines at the original contract price. The construction of each of the second and third six-crank engines is to be proceeded with, and delivery made, within six months from an order given by the Corporation, the order as regards either engine not to be given earlier than the cessation of hostilities. The price to be paid for the second engine is the original contract price, plus two-thirds of the increased cost (if any) at time of manufacture, regard being had to the value of the work already executed; the price to be paid for the third engine is the original contract price, plus the whole of such increased cost (if any), in default of agreement as to the cost of either engine, the matter to be determined by arbitration. As part of the arrangement the firm waive any storage and interest charges, with which, they claim, they would be entitled to debit the Corporation, and which up to March 31 last they put at approximately £640, and they are themselves to bear one-third of the increased cost (if any) of the second six-crank engine at the time of manufacture.

Only one of the three 200-kw. dynamos is to be sold by the Phœnix Dynamo Mfg. Co., who will retain the price obtained, and they undertake to replace the dynamo after the cessation of hostilities on an order requiring them so to do, at the original contract price. The Corporation are to take delivery of the remaining two dynamos, which were completed in July last, and to pay the original contract price therefor, plus interest at 5 per cent. on that sum from date of completion, which interest amounts to £45. The two 180-kw. dynamos are to be sold by the Corporation at £1,216 (less 5 per cent.), the Corporation discharging their liabilities to the British Thomson-Houston Co. The original contract price of the dynamos was £725, and the amount to be paid to the contractors in respect of the dynamos, storage, packing for export and carriage, will be approximately £900, leaving a profit of about £250, which will be held against a probable increased cost on the original contract price of the dynamos when required after the war.

The electrical engineer (Mr. R. Birkett) has been authorised to offer the 350-kw. Willans engine at the generating station for sale at £2,000.

The Borough Surveyor has received instructions not to light, during the summer months, any of the street lamps in the town, except eight lamps on the outskirts.

It was reported at the last meeting of the Lighting Committee that a tradesman who carried out the work of cleaning the interior of various houses and also furniture by means of a vacuum cleaner, had, for the purpose of operating the machine, used the current supplied under the contract rate to such premises. The Committee resolved to charge the tradesman in question at the rate of 6d. for a period not exceeding three hours, or 1s. per day in respect of the current used for the purpose referred to, and that this rate be charged for all current used in vacuum cleaners where the consumption thereof does not exceed ¼ unit per hour.

The Committee appointed to consider the question of effecting economies in public expenditure, expresses the opinion that it would be impracticable at present to reduce the amount of the estimate (£3,900) for street lighting during the current financial year. With the view, however, of lessening the future outgoings, they have recommended the Corporation to request the Highways Committee to consider the question of substituting electricity for gas in those streets at present lighted by the latter illuminant.

It is proposed to dispense with the services of the electric light canvasser as a war-time economy.

Swinton.—It was reported at the last meeting of the Council that next winter it would be found that in some parts of the district, especially during the late afternoon, the cables would be fully loaded.

In view of the difficulty of obtaining sanction to the borrowing of capital for carrying out extensions, it might not be possible for the Council to accept certain applications for supply, particularly for power. The electrical engineer (Mr. H. C. Busbridge) therefore suggested that the public should be warned, before placing any orders for electrical machinery or installation work, that they should ascertain whether the Council were in a position to supply current.

It was also reported that the Lancashire Electric Power Co. would probably be laying high-tension cables from the sub-station in Bridge-street to give a supply of current to Deane Mill.

Mr. Busbridge was instructed to prepare a report on the rates charged to consumers, with special reference to power users, and the cost of electricity purchased by the Council.

Walsall.—The total number of units sold (1,089,322) during the March quarter shows an increase of 131,314 over the corresponding period of 1915.

The Electricity Committee proposes to extend mains to the works of Craddock & Sons at Wisemore.

Walton.—It was reported at last week's meeting of the Council that the Board of Trade had considered the application of the Urban Electric Light Supply Co. to be allowed to discontinue the present maximum demand charges.

The Board's representative intimated that he should recommend the board not to accede to the application for a minimum charge asked for by the company, viz., 11s. 7d. per quarter, and that he should recommend that the maximum charge should be increased to 7d. per unit. The representative of the Council urged that the maximum charge should be 6d. per unit, feeling the company had some grounds for increasing the charge. But whatever the board finally decided upon would last for five years, and it was left to the Walton and Weybridge Councils to come to some arrangement with the company so as to formulate a scheme that would be advantageous to all concerned.

LIGHTING & POWER NOTES.

Ballymoney (Ireland).—The question of the electric lighting of the district was under consideration by the Urban Council last week when it was decided to communicate with the L. G. Board regarding the powers possessed by the Council for raising a loan.

Electric Radiators.—At the last meeting of the London County Council it was decided, on the recommendation of the Fire Brigade Committee, to invite tenders from selected firms for the supply of electric radiators at 13 fire stations.

Electricity in Mining.—At the recent meeting of Pease & Partners (Ltd.), the chairman (Mr. A. F. Pease, J.P.) said that they had bored the holes at the Thorne Colliery and made preparations for freezing, but had then suspended operations as from Aug. 14 last. The plant was ready to start as soon as the war was over. The electric plant was running, as they had entered into arrangements with the Yorkshire Electric Power Co. for a supply to their customers, and there was a loss on that working. There was a prospect of them getting a larger load, which would materially reduce the loss.

TRACTION NOTES.

Ashton.—The Council have decided to promote a bill in the next session of Parliament to obtain powers to enable the Corporation to acquire the undertaking of the Oldham, Ashton & Hyde Electric Tramway (Ltd.) within the areas of Waterloo and Bardsley.

Ald. R. S. Oldham explained that they had powers to purchase the lines in the borough, and by acquiring the length in Waterloo and Bardsley they would be able to open out to Oldham, which would be of benefit to both towns.

Electric Traction in Germany.—The "Daily Mail" states that just before the war the German State Railway Administration was planning to electrify the bulk of the lines for both passenger and goods traffic, but it was recently stated in the Bavarian Parliament by a Government spokesman that experiences acquired during the war were not such as to recommend wholesale substitution of electric for steam power on the State railways.

Glasgow.—Owing to the increased cost of living motor men and conductors have demanded an increase of 6s. weekly in wages, which are 27s. for conductors and 31s. for motormen.

L. & S. W. Railway.—With the completion of the electrification of the Hampton Court line (including Surbiton, Thames Ditton and Hampton Court section) the whole of the first portion of the London and South-Western Railway Company's electrification scheme will have been completed (except the short length between Surbiton and Claygate).

The new services between Waterloo and Hampton Court commenced on Sunday, and trains are run every 20 minutes on Sundays and week-days, thus giving three additional electric trains per hour each way between Waterloo, Clapham Junction, Wimbledon, Malden and intermediate stations. Over 20 riverside resorts are now linked up with Waterloo by these electric services.

Manchester.—The Tramways Committee have started a motor omnibus service between Slade Lane, Longsight and Withington.

Southend-on-Sea.—The Committee appointed to consider the question of effecting economies in public expenditure has considered the possibility of saving money by reducing the tramcar service, but it is of opinion that this step would be inadvisable, both from the point of view of public service, and that of economy, as the capital charges in respect of the service would continue whether the cars were in use or not. The Committee, however, recommends the Corporation to dispense with the services of the traffic superintendent.

EMPIRE NOTES.

Australasia.—The accounts of the electrical undertaking of the Kalgoorlie (Western Australia) Council for the year ended Nov. 1, 1915, show units generated amounted to 1,094,876 (increase 43,576) and sold 783,031 (increase 6,174).

Total revenue was £17,836 (against £17,721), working expenses were £11,575 (against £10,726), gross profit was £6,260 and the credit balance at bank £2,301. The electrical engineer (Mr. Curle Smith) points out that the engines had shown a marked falling off in efficiency, as reflected in the fuel costs, which were rather over £1,000 more than the previous year. A new engine was installed about the middle of the period, and it had the effect of neutralising the losses due to the deterioration of other engines. Comparing the fuel costs for the two months before the new engine was installed, the saving came out at 23 per cent., and a further saving could be effected by putting in another engine of similar efficiency. The time payment system of installing lamps had proved attractive, 471 lamps having been put in (against 370), the total horse-power of motors connected being 565.

India.—The Registrar of Joint Stock Companies for the United Provinces says in his report for the past year there is a scarcity of ventilating fans in consequence of the war.

Several consignments of fans are stated to have gone down in sunken vessels; the Government have bought (or are buying) up all fans obtainable, and prices have advanced generally 33⅓ per cent. English-made fans are almost out of the market, and American and Italian fans are slow of delivery, though large stocks have been on order for long periods. Small self-contained oil-driven electric sets, of which the military authorities are buying all available stocks, are at a premium. The recently-enhanced Customs duty—as a result of which prime movers, such as engines, motors, dynamos and electric fans pay 2½ per cent., while such goods as copper wire and switchboards pay 7½ per cent.—has nothing whatever to do with the scarcity, though it slightly affects prices.

MISCELLANEOUS NOTES.

Council for Organisation of British Engineering Industry.—Mr. F. Dudley Docker, C.B., chairman of the Metropolitan Carriage, Wagon & Finance Co. (Ltd.), has joined the Committee of this council.

Customs Decisions.—The Commissioner of Customs of the Union of South Africa has decided that the import duty on incandescent bulbs for pocket electric torches is 3 per cent. ad val. (the whole duty being allowed as rebate in the case of British goods), and that X-ray plates are to be admitted duty free.

Enemy Firms Wound Up.—The Board of Trade have ordered the winding up of 199 businesses controlled by alien enemies.

The latest list includes the Standard Cable Mfg. Co. (Ltd.), 18-19, Queenhithe, London, E.C., agents for cable manufacturers. (Controller: J. S. Feather, 35, Great Tower-street, E.C.)

Inquest.—An inquest was held on Saturday on Walter Percy Harris, 33, an electric fitter, who was killed on the 15th inst.

It was stated that Harris was employed by the British Westinghouse Co. (Ltd.) at the electric sub-station of the L. & N.W. Railway Co. at Kilburn. He was engaged in connecting some cables, and as there was an obstruction he went to a cubicle containing live wires with the object of finding out what the obstruction was. He had been warned of the danger. It appears that he struck a spanner against a live wire at the top of the cubicle, and he received a shock from electric current at 11,000 volts.

The jury returned a verdict of accidental death, and added a rider to to the effect that greater care should be taken in guarding live wires.

Prohibition of Exports from Sweden.—The following articles have been added to the list of goods which are now prohibited for exportation from and for transit through Sweden:—

Electrical safety appliances, as specified under No. 1,077 of the Swedish Customs Tariff (safety appliances n.s.m., including also safety plugs, fusible pieces, cartridge pieces and excess voltage apparatus), box current regulators, with coverings or inner parts of other metal than iron; mountings for incandescent lamps, with coverings or inner parts of other metal than iron.

Telegraphic Communication with Mongolia.—It is reported from Petrograd that a triple Convention between Russia, China and autonomous Outer Mongolia regarding the telegraphic cable to Outer Mongolia has been officially published.

Trading with the Enemy.—The "London Gazette" of June 16 contains additions to and alterations of the Statutory List of persons and firms with whom trading by persons and firms in the United Kingdom is prohibited.

The additions include: Spain, Siemens-Schuckert Industria Electricia (Barcelona, Madrid and Valencia).

It is also announced that all proclamations relating to trading with the enemy abroad apply to persons or firms of enemy nationality in Persia, Morocco or Portuguese East Africa.

TENDERS INVITED.

Turbo-Alternator Surface Condenser and Auxiliaries.

The Corporation of ABERDEEN invite tenders for the supply, delivery and erection at their electricity works, Millburn-street, Aberdeen, of one 5,000 kw. Turbo-Alternator to run at a speed of either 1,500 or 3,000 revs. per min., together with surface condenser and auxiliaries. Specification, general conditions and form of tender from the city electrical engineer, Mr. J. Alex. Bell, to whom tenders are to be delivered by noon July 7. *See also an advertisement.*

Telegraph and Telephone Material.

Tenders are invited up to Aug. 16 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, PERTH (W. Australia), requires tenders by 3 p.m. June 28 for Paper-insulated Lead-covered Cable (schedule 489 W.A.), and until 3 p.m. July 19 for 96 Terminal Blocks (schedule 495 W.A.). Specifications from the Deputy Postmaster-General, Perth, W.A.

Tenders are also invited up to July 19 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of Insulators (schedule 510). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

Telegraph and Telephone Material.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

The Deputy Paymaster-General, Perth (W. Australia), also requires tenders by 3 p.m. July 12 for supply of 3,000 Dry Cells for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy-Postmaster-General.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

The Deputy Postmaster-General, MELBOURNE (Victoria), requires tenders by 3 p.m. June 27 for 18,551 Stalloy Telephone Receiver Diaphragms (schedule 1303). Specification, &c., from the Deputy Postmaster-General.

The Deputy Postmaster-General, Sydney (N.S.W.), invites tenders for the supply of the following plant and materials for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept.: Miscellaneous Switchboard Material and Additional Plates, &c., for accumulator battery in Petersham (N.S.W.) telephone exchange (schedule No. 544). Tenders by 3 p.m. June 29. Portable Direct-coupled Internal-combustion Engine and Dynamo, with Accessories, of an output of about 2½ kw. (schedule No. 497). Tenders by 2.30 p.m. Aug. 17. Supply and erection in City North Exchange, Sydney (N.S.W.), of Automatic Switchboards, with Accessories (schedule No. 511). Tenders by 3 p.m. Aug. 24. Specifications, &c., from the Deputy Postmaster-General, Sydney.

Coal Conveyors, Bunkers, &c.

SALFORD CORPORATION invite tenders by noon Monday, June 26, for Coal Conveyors and Bunkers. Particulars from the Borough electrical engineer, Mr. J. A. Robertson, Electricity Works, Frederick-road, Salford.

WARRINGTON Electricity and Tramways Committee require tenders by noon June 27 for (1) Coal Elevator and (2) Vertical Steam Boiler Feed Pump. Specifications, &c., from the Borough Electrical and Tramways Engineer.

Tramway Material.

SALFORD Corporation require tenders for Manganese Steel Tramway Crossings and Tramway Poles. Forms of tender, &c., from the General Manager, Tramways Department, 32, Blackfriars-street, Salford.

Electrical and General Stores, &c.

SALFORD Corporation require tenders by noon June 26 for supply of Cable Accessories, Carbon Brushes, Demand Indicators, Castings, Tools, Steam Tubes, Oils, &c. Specifications from Borough Electrical Engineer, Frederick-road, Salford.

ROTHERHAM Corporation require tenders by July 3 for 12 months' supply of Tramway Stores and Materials, Cables, Trolley Wire, &c. Specifications from the Engineer and Manager, Electricity Works, Rotherham.

Tenders are invited for 12 months' supply of Electrical Appliances, &c., to the Devon County Lunatic Asylum, EXMINSTER. Forms of tender from the Clerk. Tenders to Mr. E. H. Harbottle, County-chambers, Queen-street, Exeter, to whom tenders by June 28.

TENDERS RECEIVED AND ACCEPTED.

WOLVERHAMPTON.—The Electricity Committee recommends the acceptance of the following tenders :—

Stirling Boiler Co., two water-tube boilers and superheaters, £6,406; Underfeed Stoker Co., two sets mechanical stokers, £1,907; Crompton & Co., electric motor, £136. 15s.; H. Gough & Son, extension of electricity station building, £3,620.

An order has also been placed with Willans & Robinson for the supply of one turbo-alternator with condensing and auxiliary plant for £19,000.

AYLESBURY.—The Council have accepted the tender of the Chloride Electrical Storage Co. for an extension of the storage battery.

WEST HARTLEPOOL.—The Corporation have placed an order with the Stirling Boiler Co. for a water-tube boiler.

KEIGHLEY.—The tender of the Craven & District Private Telephone & Electric Co. has been accepted for wiring the temporary war hospital buildings, at £120.

LEYTON.—The Council have placed orders for the supply of meters with the Electrical Apparatus Co., the Reason Manufacturing Co., Chamberlain & Hookham (Ltd.) and the British Insulated & Helsby Cables (Ltd.).

MILE END (LONDON).—The Guardians have placed an order with Penrose & Co. for a new electric lift at the institution at £395.

Government Contracts.—The following tenders were accepted by the British Government Departments during May :—

War Office.—British Insulated & Helsby Cables, Connolly Bros., W. T. Glover & Co., Hooper's Telegraph & India Rubber Works and St. Helen's Cable & Rubber Co., electric cable and wire; Butters Bros. & Co., Ransomes & Rapier and T. Smith & Sons, cranes; India Rubber, Gutta Percha and Telegraph Works Co. and Peel-Conner Telephone Works, ebonite; Browett, Lindley & Co., Coventry Simplex Engines, W. H. Dorman & Co. and Norris, Henty & Gardners, generating sets; Craigpark Electric Cable Co., gutta percha; British Thomson-Houston Co. and Cryselco (Ltd.), electric lamps; Clegg Bros., Cook, White & Co., J. Glanville, E. Morley & Sons, Waring & Gillow and F. J. Weary & Co., wood telegraph poles; Renton & Fisher, trolley wheels.

India Office.—Callender's Cable & Construction Co. and W. T. Glover & Co., cable; Chloride Electric Storage Co., battery plates; F. Smith & Co., wire.

Post Office.—Automatic Telephone Mfg. Co., telephone apparatus; Siemens Bros. & Co., iron telegraph arms; F. W. Hollway & Bros., wood arms; New Gutta Percha Co., Siemens Bros. & Co. and Western Electric Co., telephone cable; India Rubber, Gutta Percha and Telegraph Works Co., porous cells; J. Bourne & Son, Bullers (Ltd.), Doulton & Co., J. Macintyre & Co. and Taylor, Tunnicliff & Co., insulators; Bayliss, Jones & Bayliss, Bullers (Ltd.), T. W. Lench (Ltd.), and Portland Bolt and Nut Co., telegraph ironwork; British Insulated & Helsby Cables, F. Smith & Co. (inc. in London Electric Wire Co. & Smith's), bronze wire; British Insulated & Helsby Cables, annealed and tinned copper wire; Rylands Bros., Shropshire Iron Co., F. Smith & Co., Wire Manufacturers, Ltd. and Whitecross Co., g.i. wire.

Furnace Contracts.—The Monometer Mfg. Co.'s specialities continue to be appreciated by the leading engineering firms, and over 50 orders have been recently booked by the company, which is also exporting monometer aluminium melting furnaces to Italy and other types of its furnaces to the United States and Australia. The Monometer tilting furnace is now constructed for coke firing, as well as oil and gas. Among the firms who recently ordered furnaces are:

Crompton & Co., India Rubber, Gutta Percha & Telegraph Works Co., Werner, Pfeiderer & Perkins, Siemens Bros. & Co., London Bronze & Metal Foundry, Interlock Metal Hose Co., Sam Whiteley & Son, Ing. A. Musso (Milan), National Galvanisers (Ltd.), Boulton & Paul, Birmingham Small Arms Co., Wolseley Motors (Ltd.), Aerators (Ltd.), Blackwell's Metallurgical Works, Navaltum (Ltd.), Mellowes & Co., Williams, Harvey & Co., Nobel's Explosives Co., Lead Wool Co. (Ltd.), Piston Rings (Ltd.), White & Poppe (Ltd.), Thos. Firth & Sons, Joseph Lucas (Ltd.), Smith & Davis, James Upton (Ltd.), Motor Stamping Co., Burlington Free Press Association (Vermont, U.S.A.), Darlington Wire Mills, John Swain & Son, Beldam Packing & Rubber Co., Metal Smelters Co., Greenwood & Batley, Simmons (Ltd.) (Sydney, N.S.W.), &c.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Chester.—The accounts of the municipal electricity department for the year ended March 25 show total capital expenditure £162,380 (increase £2,647), of which £91,927 is outstanding. £19,439 has been contribnted out of revenue for capital expenditure.

From the whole undertaking (including the steam and the hydro-electric works) revenue was £23,961 (compared with £24,102 in previous year), working expenses were £11,262 (£11,020), and after providing £215 (£128) for pay of employés in H.M. Forces and £112 (£460) for alterations to public lamps, gross profit was £12,370 (£12,484). Interest required £1,562, sinking fund £1,787 and bank interest and commission £64, leaving net profit £2,956 (against £3,194). Coal cost 0·285d. (0·211d.) per unit sold, works costs were 0·583d. (0·550d.), and total costs, other than capital charges, 0·877d. (0·825d.). Units generated were 3,467,323 and sold 2,668,058 (2,531,709). Total maximum supply demanded was 1,599 kw. Consumers increased from 1,667 to 1,749, and equivalent 8 c.p. lamps connected from 165,730 to 177,233.

With regard to the hydro works, Mr. S. E. Britton (city electrical engineer) says 1,567,300 units were generated, of which 16,062 were used for pumping sewage, 1,600 for lighting the works, 42,310 by exciation and feeder booster, 128,122 in the distribution cables, and 1,379,206 sold to consumers. The cost of operating these works included oil and stores, £28; wages, £242; repairs and maintenance, £64; rent, £100; rates and taxes and insurance, £138; total, £572 = 0·0995d. per unit sold. Capital charges were; interest £490 and sinking fund £524; total £1,014 = 0·1765d. per unit sold, making in all 0·276d.

Oldham.—The electricity department's accounts for the past year show a net profit of £5,107 (compared with £3,550 in previous year).

Revenue was £63,920 (against £52,293), and total costs were £37,222 (£27,006), leaving gross profit £26,698 (£25,287), and after meeting capital charges, &c., the net profit was as stated above. Working costs were equal to 0·852d. (0·812d.) per unit, and average price obtained was 1·441d. (1·545d.). Units sold were 10,487,235 (7,985,859). The joint engineers and managers state that, although the output increased by 2½ million units, it was from three to four millions less than would have been the case if the cotton mills under contract to take current could have obtained the necessary plant.

Salford.—At the last meeting of the Corporation the chairman of the Electric Supply Committee (Councillor Bellington) made a statement with regard to the working of the electricity undertaking during the past year.

He said that the electricity department, like other revenue-earning departments, had been suffering during the year from adverse conditions arising out of the war, and it would be considered very satisfactory that the financial results were the best which had been obtained in the history of the department. The electricity sold had increased since the end of last financial year from 20,650,000 units to 24,856,000 units, an increase of 20 per cent. The revenue had been raised from £115,847 to £133,764, the gross profit from £50,807 to £63,625, and the net profit from £8,406 to £16,598 this year. That was the largest net profit ever earned by the department in one year, the nearest amount being the profit in 1906, when it was £14,800. In that year, however, the cost of coal was 7s. 9d.

per ton, compared with an average cost of 15s. 1d. per ton during last year, while the average price received for current was 27 per cent. more than last year. The principal cause contributing to that favourable result was the introduction of modern plant and the consequent economies in operation. If they made a comparison with two years ago they found that the amount of coal consumed had been reduced from 4·8 lb. to 3·2 lb. per unit generated, which was equivalent to a total saving of 15,000 tons of coal per annum. All other heads of working expenditure, including repairs, wages, distribution, oils and stores, had been reduced. On the other hand, they had had an increase in taxes, compared with two years ago of £2,700, an increase in sinking fund and interest charges of £4,500, partly due to having scrapped obsolete plant, while the increased price of fuel represented nearly £7,000 and payments to dependents of men on active service and increased wages and bonus amounted to £3,000. They made an increase of 7½ per cent. on the ordinary rates for a part of the year, which brought in £4,700, but after making allowance for that item it would be found that with normal conditions the net profit, instead of being £16,500 would have been nearly £28,000. It might be pointed out also that while they only increased their rates last year by 7½ per cent., Manchester increased their lighting rates by 10 per cent. and their power rates by 15 per cent. Nearly all the increased output had been for power users at low prices, so that the average rate per unit received last year was exactly the same as the previous year. It was important to note that increased output and the modernisation of the works was being carried out without any increase in the amount of their capital indebtedness. During the last two years the amount of capital expended was actually less than the amount of their sinking-fund contributions. Last year the capital expended was about £14,500, while the sinking fund amounted to £30,940. They purchased last year a new 5,000 kw. steam turbo-alternator at £19,500. The whole of that amount was being paid for from renewals fund, and they were now engaged in erecting a sub-station in Blackfriars-road and laying high-tension mains at an estimated cost of £22,000, which would also be paid for from renewals fund. On the other hand, by adopting a modern system of distribution they had been able to withdraw portions of the original low-tension cables which were laid 14 years ago, and owing to the high price of metals the amount received for those cables was nearly equal to the amount paid. Last year they recovered cables to the extent of £14,500, which, by permission of the L. G. Board, were credited to renewals fund. A further amount of cable, valued at £25,000, would be released when the Blackfriars sub-station was completed. They were thus able to carry out those improvements, which increased the capacity and efficiency of their system, without increasing their capital indebtedness, which was a most important matter in view of national necessity for conserving all unnecessary capital expenditure at present. The gross profit had increased during the last two years from £44,180 to £63,625, and the latter sum was equal to nearly 9 per cent. on the total capital expenditure (£728,000), or if the amounts redeemed and written off be deducted the capital indebtedness was £451,000, and the gross profit was equal to 14 per cent. of that amount, a figure which would be considered quite satisfactory in any commercial undertaking. The department had released fully 35 per cent. of its employés for active service, and female labour was now largely employed for clerical work and also to some extent for other duties. The Committee will shortly be called on to consider a scheme for interconnecting electrical undertakings in that part of the country which it was hoped would prove of mutual advantage by reducing the necessity for additional capital expenditure and also improving the efficiency of the works as regards the coal consumption and the employment of labour.

Sunderland—The accounts of the electricity department for the year ended March 31, 1915, show gross capital expenditure £491,027 (increase £7,272), of which £254,770 is outstanding.

Revenue was £71,103 (compared with £73,517 in previous year), works costs were £29,632 (£25,216), and standing costs £10,835 (£14,875), leaving gross profit £30,636 (£33,426). Interest required £11,111 (£11,023), and sinking fund £17,726 (£16,751), and after providing £767 (£999) for renewals and special expenditure, net profit was £1,032 (£4,653). Works and standing costs per kelvin sold were 0·60d. (0·54d.), and total costs, including capital charges, special expenditure and attending public lamps, 1·08d. (1·04d.). Connections are equal to 20,906 kw. (19,868 kw.), maximum load was 5,495 kw. (6,300 kw.), and load factor 31·2 (26·27) per cent. Kelvins generated were 19,820,364 (18,013,911), and sold 15,056,376 (14,499,124).

COMPANIES' MEETINGS AND REPORTS.

ALUMINIUM CORPORATION (LTD.)—The net profit for 1915, after providing for debenture interest and other charges, is £14,257, to which is added £3,286 from 1914, making £17,543. The directors recommend a dividend of 7 per cent. (less tax) upon the preference stock, leaving to carry forward £4,559. The driving of the Dulyn Tunnel was completed early in the year, and has already fully justified its construction. Arrangements have been made to increase considerably the water power, and the Treasury has consented to the issue of another £100,000 of first mortgage debentures.

MARCONI INTERNATIONAL MARINE COMMUNICATION CO. (LTD.)—Mr. G. C. Isaacs presided over the annual meeting last week in the absence of the chairman (Senatore Marconi) in Italy. After giving an analysis of the accounts, he said that they could congratulate themselves upon the result of the past year's working, especially when they bore in mind that their business was necessarily being conducted in very difficult and abnormal circumstances, and that the whole of their losses incurred through the submarine warfare had been debited to profit and loss account. It would be interesting to note the regular growth of their gross receipts during recent years: In 1911 they amounted to £64,166, in 1912 to £100,325, in 1913 to £146,325, in 1914 to £175,105, and in 1915 to £208,927. For the year under review the available balance was £75,602. 1s. 1d. They had paid an interim dividend of 5 per cent. in February, and they proposed to pay a final dividend of 7½ per cent., making 12½ per cent. for the year, and after placing a further £3,500 to reserve for repayment of debentures, they carried forward (subject to excess profits duty) £33,841. 11s. 1d. The last year had given greater proof than in any previous time of the extreme utility, if not the absolute necessity, of a wireless telegraph installation on board every merchant ship, and he thought he could go yet a step further and say that, not only was it essential that every ship should be equipped with wireless telegraphy, but overwhelming evidence had been afforded of the importance of a world-wide organisation such as the company has built up. The Navy, the Army and the whole nation could be thankful that such an organisation existed, and that it was in the hands of a British company. The number of telegraph stations owned and worked by the company as public telegraph stations on the high seas—which had reference to merchant ships only—had increased at the end of December, 1915, to 1,008. At present time it was between 1,100 and 1,200, and that number was increasing as fast as it was possible to turn out and fit the installations. He was sorry that Mr. Marconi was not present to tell them of his new work. His recent developments would dispose of one more peril of the seas. He had authorised him to inform them that in the very near future he would introduce a new, independent and very simple apparatus, to be worked from the bridge of a ship and by one of the ship's officers, which should put an end to all danger of collision in darkness or fog. He had described that new work to him (Mr. Isaacs) and he had little doubt that every seagoing vessel would be equipped with that further great invention of Mr. Marconi, and, turning to the practical business side of the question, that should prove of no small value to the company. They had in their employ in these perilous times some 2,000 young men almost continuously upon the seas, and it spoke volumes for the great inherent qualities of their young men from the moment they were given serious occupation and responsibility that in no single instance had one of them been found wanting in the moment of peril. The chairman gave many striking instances of devotion to duty by wireless operators, and said they would all agree with him in being proud of such men. They vied with the Navy and the Army in proving that there had been no decline in the spirit of our race. 82 of their operators were employed on mercantile ships which had been sunk by the enemy. Three were drowned, two seriously injured, and seven had been slightly injured; of the operators transferred to the Admiralty service he was sorry to say that seven had already lost their lives.

UNITED ELECTRIC TRAMWAYS OF MONTEVIDEO (LTD.)—The chairman (Mr. G. A. Touche, M.P.) said that the European war was still a dominating factor in the River Plate. The company, in common with others doing business in Monte Video, suffered in the past year from the abnormal conditions in the shipping world, and would suffer still more in the current year. Practically all the materials required by the company had to be shipped to Monte Video. The coal situation had occasioned much anxiety and was continuing to do so. In addition to high freights there was a very serious shortage of Welsh coal for export. All coal required in Uruguay had to be imported. There were, however, fairly extensive peat deposits, with which experiments were being made for fuel purposes. Failing British coal, it became necessary to rely on American, although it was not of the same steaming qualities as Welsh. The cost of that coal, delivered in Monte Video, would be approximately 105s. per ton (of which 85s. represented freight), compared with an average pre-war price of 40s. 6d. The fuel difficulty had not reached its acutest stage during the period covered by the accounts, but during the year now current it must represent a serious charge on the company's receipts. Climatic and business conditions in Monte Video had also been unfavourable. Having referred to the political and economic situation in Monte Video he expressed regret that the directors were unable to recommend payment of any dividend on the ordinary shares. With regard to the current year, weather conditions during the past summer season showed some improvement, with the result that the traffics had shown increases when compared with the corresponding months in the previous year. It was, however, to be regretted that practically all the increase in gross receipts had been absorbed by heavier operating expenses. Those expenses were bound to go on increasing while fuel and freight costs continued on the up-grade. For some time past it had been part of the policy of the Government of Uruguay to municipalise businesses of public utility. With that object in view they acquired recently a controlling interest in the Norte Tramway Company, which still operated a system of trams in Monte Video by animal traction. He believed it to be the intention of the State to electrify that system, and extend it in various directions—probably in competition with existing electric tramways. Experience showed that co-operation was better than competition. If the municipality was to enter upon the tramway business it would clearly be better that they should control the largest system in the city instead of being in competition with it. The directors recognised that, although the object of the proprietors had not been to sell the undertaking, the position created by the war and the desire of the Government that British investments in North and South America should, when opportunity offered, be realised, were factors which ought to be taken into account. They therefore caused the authorities to be informed that if the Government were prepared to make a definite offer on a fair and reasonable basis of valuation, the directors would be pleased to give such an offer their serious consideration. Although, owing to temporary causes, the

net receipts this year were only £120,220, they had been steadily progressive from the inauguration of electric traction in 1906 to 1913, when they reached £150,985. It was to the development of potential value that the directors looked mainly for the reward of their enterprise, and if the municipality purchased they would have the benefit of the development. Since the report was issued, a cablegram had been received from Monte Video stating that the Government had made a proposal, and that information was being sent forward by mail as to its terms and conditions.

CITY NOTES.

MEMORANDA (June 21).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 59. Consols Pay Day, July 5. Stocks and Shares Ticket Days, June 28 and July 12. Pay Days, June 29 and July 13. Price of silver, 30 11/16d.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—The directors have decided not to pay an interim dividend on the second preference shares.

BULLERS (LTD.)—An interim dividend at rate of 5 per cent. per annum (5s. per share) tax free for the past half-year.

EASTERN TELEGRAPH CO. (LTD.)—The company announce the payment on July 15 next of dividend at rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending June 30, 1916, and a first quarterly interim dividend of 1½ per cent. on the ordinary stock (tax free), in respect of profits for the year ending Dec. 31, 1916. The transfer books of the ordinary stock of the company will be closed from July 7 to 14 inclusive.

VERITYS (LTD.)—A final dividend at rate of 6 per cent. per annum on the ordinary shares, making 6 per cent. for the past year, and carrying forward £1,084.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date June 20, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	17d.
Solid Drawn Copper Tubes	19½d.
Brazed Copper Tubes	19½d.
Brazed Brass Tubes	19d.
Brass Wire	16½d.
Copper Wire	19½d.
Rolled Brass	16½d.
Brass Sheets	17½d.

	per ton.
Copper Sheets	£160 0 0
Spelter	£68 0 0

	per ton.
English Lead	£33 0 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£90 0 0
Clean Brass Scrap	£60 0 0
Braziery Copper Scrap	£80 0 0
Old Lead	£26 10 0
Old Zinc	£43 0 0
Hollow Pewter	£125 0 0
Black Pewter	£85 0 0
Gun Metal	£72 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date June 20, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£100 0 0
Clean Mixed Brass	£60 0 0
Clean Cooper	£88 0 0
Braziery Copper	£78 0 0
Gun Metal	£76 0 0

	per ton.
Old Lead	£23 0 0
Tea Lead	£26 0 0
Old Zinc	£50 0 0
Hollow Pewter	£130 0 0
Shaped Black Pewter	£90 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £86; Commercial Tinman's Solder, £112; Blowpipe Solder, £122.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, June 20. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs	Last Dividend	Name	Price, Tues., June 20.	Rate per cent. Yielded.	Dividend Due
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9 5/8	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	8	5 12 6	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	10 1/8	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6 3/4	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. C. Deb. St	81½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 8	Jan, July
5	2/3	Do. 4½% Pref.	3 1/8	7 3 3	..
5	5%	Do. Ord.	3 1/8	7 0 4	Aug, Feb
5	4½%	Do. City Pref.	3	7 10 0	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	2 3/4	7 2 3	Mar, Sept
St.	4½%	Do. do. Deb.	97	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12	6 12 4	Feb, Aug
10	6/0	Do. 6% Pref.	10 1/8	5 16 4	Mar, July
St.	5%	Do. 5% Deb. St.	99½	5 0 6	Jun, Dec
St.	4½%	Do. 4½% Debs.	80	5 12 6	Jun, Dec
10	7%	County of London Ord.	10 1/8	6 12 7	Mar, Sept
10	6%	Do. 6% Pref.	10½	5 15 8	Feb, Aug
St.	4½%	Do. 1st Deb.	8	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	83	5 8 5	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	75½	5 18 10	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6/5	London Elec. Supp. 6% Pref.	4½	6 13 4	..
St.	4%	Do. 4% Mort. Debs.	80½	4 19 9	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2 1/8	6 [illegible] 2	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db St	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	2½	7 5 5	Mar, Sept

† Ex dividend or Interest

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs	Last Dividend	Name	Price, Tues., June 20.	Rate per cent. Yielded.	Dividend Due
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5 11/16	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5 11/16	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	71½	6 5 10	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1 3/16	6 14 9	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	5 1/16	5 17 11	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4½	5 5 11	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	80	6 5 0	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	79½	7 10 6	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	74	5 8 1	..
St.	4%	Do. do. Assented Def. Ord.	71½	5 11 6	..
St.	4½%	Do. 4½% Pref.	80½	5 11 10	Jan, July
St	4%	Do 4% Deb. St.	76½	5 4 7	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	70½	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2 3/16	5 16 1	Jan, July
St.	4%	Do. 4% Pref.	67½	5 18 6	Mar, Sept
St.	4%	Do. 4% Debs.	74†	5 7 6	Jan, July
St	1%	Metropolitan Ry. Con. Ord.	27½	3 13 5	Feb, Aug
St.	3½%	Do. 3½% Pref.	64½	5 8 6	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	61	5 14 9	Feb, Aug
St	3½%	Do. 3½% A Debs	67	5 5 1	Jan, July
St	3½%	Do. 3½% Debs.	69½	5 1 4	Jan, July
St	..	Metropolitan Dist. Ry. Ord.	19⅜	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75	5 6 8	May, Nov
St.	4½%	Do. 4½% First Pref.	72½	6 4 7	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	110†	5 9 1	Jan, July
St.	4%	Do. 4% Debs.	73½†	5 8 10	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	71†	5 8 1	Jan, July
St.	4%	Do. 4% Guar. Stock	69⅞	5 14 6	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2¾	5 9 1	Apl, Oct
1	6%	Do. 6% Pref.	1 3/16	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1½	5 12 0	Mar
100	5%	Do. Prior Lien Debs.	95	5 5 3	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	15%	Brit. Insulated & Helsby Ord.	10¾	6 19 6	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5 3/16	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref	⅝	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2 1/16	6 9 9	April
100	6%	Do. 6% Prior Lien Debs.	100½	5 19 5	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	68	5 17 8	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12 1/16	8 5 10	Jan, July
5	5%	Do. 5% Pref.	4½	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	98	4 11 10	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	1/16	8 14 7	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	1/16	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	⅛	10 0 0	May
1	7%	Do. 7% Cum. Pref.	1/16	7 9 4	Jan, July
St.	4%	Do. 4% Debs	7 1/16	5 11 6	Jan, July
10	10%	General Electric Ord.	11 1/16	8 11 1	July
10	6%	Do. 6% Pref.	9 1/16	6 2 8	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15½	6 12 3	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4½	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	12	8 6 8	Feb, Aug
10	5%	Do. Pref.	8 1/16	6 2 2	Apl, Oct
12	20%	Telegh. Con & Main. Co.	40	6 0 0	Mar, July
100	4%	Do. 4% Debt.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	1 1/16	4 1 4	May, Aug
1	6d.	Do. 5% Pref.	1/16	5 6 8	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 11	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	Jan, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40½	10 2 6	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	103½	5 16 3	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23½	6 17 2	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	70½	5 13 6	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7½	6 15 7	May, Nov
10	10%	Do. 10% Pref.	13½	7 7 10	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6½	7 16 10	Ja,Ap,Jly,O
St.	8%	Eastern Tel. Co. Ord., x d & bonus	145½	5 10 0	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	65	5 7 8	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	77½	5 3 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78½	5 2 3	Feb, Aug
10	8%	Do. Ord.	14½	5 12 3	Ja, Ap,Jly,O
10	22%	Gt. Northern Tel. Co.	36½	6 0 7	Ja, My, Jly
25	13%	Indo-European	48½	6 13 4	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2 1/16	3 14 5	April
1	7%	Do. 7% Pref.	2⅛	2 18 11	July
10	1%	West India & Panama Ord.	1	10 0 0	May Nov
10	6%	Do. 1st Pref.	7½	8 5 6	May, Nov
10	8%	Western Telegh. Co.	14 1/16	5 18 0	Mr, Jly,O,Dc
St.	4%	Do. 4% Deb. St.	78½	5 1 11	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99	4 10 11	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅝	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	1 1/16	5 3 3	Apl, Oct
St.	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6½	6 6 1	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4½	5 10 4	Jan, July
St.	4½%	Do Deb. Stk.	95½	5 5 7	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12 1/16	4 17 6	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10 1/16	5 13 7	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	83½	5 19 9	Ja, Apl,Jly,O
..	4%	Do. $100 Pref	70½	5 15 10	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅝	6 5 2	Mar, Sept
St.	5%	Do. 5% Deb.	95½	5 4 9	Jun, Dec
10	6/-	Bombay E. S. & T. 6% Pref.	10 1/16	5 16 4	..
St.	4½%	Do. 4½% Deb.	85	5 5 11	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6½	7 6 11	May, Nov
5	5%	Do. 5% Pref.	4½	5 11 1	Mar, Sept

† Ex dividend or Interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,989. [Vol. LXXVII. No. 13.] **FRIDAY, JUNE 30, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 417
Arrangements for the Week .. 420
Electric Power in Slate Quarries. By G. K. Paton. Illustrated 421
Rural Development of Transmission Lines in Eastern Pennsylvania. By J. W. Price 424
Electric Wiring Practice in Germany Under War Conditions 426
Notes on Design of Electromagnetic Machines. By Stanley Parker Smith, D.Sc. Illustrated. — *Continued* 427
Annual General Meeting of the I.M.E.A. 430
Report of the Electric Vehicle Committee of the Incorporated Municipal Electrical Association 433
Breakdowns of Electrical Machinery 433
REFLECTIONS ON TRADE AND TRADERS 434
The Work of S. P. Thompson. By Alexander Russell 435
Physical Society 437
CORRESPONDENCE 438
The Electricity Supply of Great Britain (Ernest T. Williams).
LEGAL INTELLIGENCE 439
PARLIAMENTARY INTELLIGENCE 440
The "Electrician" Commercial and Industrial Section .. 441-450

NOTES.

Zinc Conductors.

MANY years ago there was some talk of using zinc as a substitute for copper for electric conductors, but it was left to the present war to force this idea into actual practice. As will be seen by an article which we publish on another page, zinc is now being used somewhat extensively in Germany owing to the scarcity of copper, and the authorities have issued special rules in regard to cables, wiring and electrical machines, in which it is proposed to use this metal. In making use of zinc it must be remembered that there are mechanical difficulties, apart from the electrical properties, which render it rather unfit for certain uses. Some of these seem to have been eliminated by suitable purification of the metal; but, even so, the fact remains that weakness may be introduced by large crystalline structure, which is always liable to arise if the temperature exceeds a certain value for a considerable time. For this reason it is stated that temperatures above 100°C. should be avoided. This being so, we should be afraid that trouble might result from armatures in which zinc conductors were used, owing to the combined action of vibration and continued high temperature, even though this does not reach 100°C. With regard to cables, it is stated that the cost of these as compared with copper is from 100 to 150 per cent. greater when of the same section. This, however, does not give the final comparative cost, for the conductivity of zinc is much lower than that of copper, and even lower than that of aluminium; in fact, the ratios are given as 100 for copper, 58·4 for aluminium, 28·5 for zinc and 12·5 for iron. The object in using zinc at the present moment is to avoid the substitution of iron, which is manifestly unsuitable for many purposes, more particularly when it is a question of carrying alternating currents. Even for commutators the idea of using iron does not strike one as being very happy. Undoubtedly the use of zinc as a substitute for copper gives rise to a number of interesting questions, but we do not think that this substitution can be regarded as anything more than a purely temporary expedient adopted of necessity.

Electric Lighting Charges.

THERE has been a good deal of idle correspondence in the daily Press during the last week or two on the raising of prices by electrical undertakings to meet the smaller consumption of electrical energy on account of the Summer Time Act, and some correspondents have discovered for the first time that such undertakings have the right to charge a minimum quarterly sum. We do not suppose that it occurs to those correspondents to work out the cost per telephone call in the two cases when they make merely 50 calls and when they make 500 in a quarter, nor do we suppose that we can expect the general public to realise the principles upon which either electrical energy or the telephone service is supplied. So long as our legislators realise the position we must be content. So far, Mr. HARCOURT, in replying to a question in the House of Commons, has fortunately not seen his way to interfere in the matter, but has stated that the chief object of the Summer Time Act was to effect economy in the use of coal. In regard to action by the Board of Trade we notice that a suggestion has been put forward that the users of gas and electric light should be charged double rates on any excess over 75 per cent. on their accounts of the corresponding quarter of last year. This will surely operate in a direction which will not be approved by the correspondents to whom we have referred, and we are inclined to think that a good deal of hardship may result. The small consumer at least does not use more gas or electricity than is necessary, and he will find it extremely difficult to economise to the extent of 25 per cent. Moreover, it may lead to his using coal instead of cooking and heating by electricity or gas.

Double Income Tax.

AT the general meeting of the British Electric Traction Co. last week the Chairman stated that the Bombay Electric Supply & Tramways Co. had been formed as a separate organisation, so as to avoid the payment of income tax in both India and in England. By complying with certain formalities which became evident through a legal decision some little time ago, it is now possible to avoid this payment of double income tax, which is a great hardship in cases where most of the shareholders happen to be people belonging to the locality in which the business of the particular company is carried on. There is something obviously unsound in the levying of income tax in both of two countries, and we trust that among the many matters which will be set right after the war the payment of double income tax will be one, and that this grievance will be removed in cases where the business is of a local foreign character. Under the present high rates of income tax the double taxation of companies working within the British Empire may have a serious effect on commercial enterprise.

The Agricultural Load.

ELSEWHERE we give a short article describing the rural development of electricity supply in a part of Pennsylvania, which is of some interest in the light of Mr. W. T. KERR'S Paper, read last week before the Incorporated Municipal Electrical Association. In Pennsylvania it is noticeable that light seems to be the first consideration of the farmer, and that power is only taken as the result of education. For example, in the case of one company, out of 125 farmers only 30 are taking power. The average revenue from light is £3. 12s. per annum, whereas the average for light and power is £16. These figures do not seem to be so good as those obtained at Hereford, where 19 agricultural consumers averaged £25 per annum. The tariff for power at Hereford is 2½d. per unit; that in Pennsylvania is 2½d., less a discount of 10 per cent.; but the tariff for light in Pennsylvania is higher than at Hereford On the whole, it looks as if the farmers in the neighbourhood of Hereford take more readily to electric power than those in Pennsylvania, which is satisfactory from the point of view of development in this country.

Royal Visit to Bedford College.—On the 26th inst. Queen Alexandra, the Princess Royal, Princess Maud, the Grand Duchess George and Princess Nina paid a surprise visit to Bedford College. Her Majesty inspected the chemistry and physiology laboratories, the dining hall, kitchen, students' room and lecture room.

Mine Hoist Calculations.—The "Iron Age" has recently given examples of mine hoist calculations. The latest article deals with a balanced slope haulage engine operating "gunboats." The determination of the correct size of electric motor is given in detail. These articles should be useful to students and to designers of mine hoists.

Experience and Teachers.—"Engineering Record," referring to the decline in the number of engineering students at some colleges, considers it a mistake to have young graduates brought back to teach with little or no practical experience. The question is asked whether the low engineering standard reached may not be due to teachers who have never had to work under business standards of accomplishment.

American Engineers Prepared.—"Engineering Record" refers to the great civilian parade in New York recently. About 125,000 people took part in it, upwards of 6,000 engineers marched in the engineers' division, the Engineers' Club training battalion, and sections from civil, mechanical and electrical engineering. The parade, it is stated, shows how strongly the feeling of military preparedness pervades all classes.

Belt Dressing.—Mr. F. B. Prescott, in the "Iron Age," considers belt dressings should be abolished, because they are unnecessary and wasteful. The first waste is the cost; when put on belts the dressing picks up dirt and builds up on pulleys, changing its cone, and so is wasteful from the efficiency point of view. Clean belting, and pulleys free from all dressings are recommended for efficient working.

Massachusetts Institute of Technology.—It is stated in the "Electrical World" that the new group of buildings were to be dedicated on the 14th inst., when a distinguished company of scientific men and leaders of industry were to be present. The cost of these buildings was £1,400,000, and they contain extensive engineering and chemical laboratories. The floor space is 730,000 sq. ft., and the buildings face the Charles River Basin the dominant feature being a large dome surmounting the library.

Finsbury Technical College.—The "Old Students' Association and College Magazine" for May has been delayed in publication and has just come to hand. It contains official and editorial notes, and obituary notice of Prof. Raphael Meldola, F.R.S., in addition to an excellent photograph of him. There is also an excellent article on the "Humphrey Pumps," by Mr. James G. Bulger, and a section dealing with "The College and the War." Finally there is a list of names of those serving with the Colours.

Depreciation Rates at Glasgow.—Glasgow Corporation have adopted a recommendation by the Tramways Committee that in making up the annual accounts of the department depreciation for the current year shall be at the following rates:

Permanent way		£350 per mile.
Electric equipment of line	Average	2·9 per cent.
Ground		— ,,
Buildings and fixtures		2½ ,,
Power station and sub-stations plant		5 ,,
Workshop tools and sundry plant		5 ,,
Cars	Average	8·2 ,,
Electric equipment of cars		6 ,,
Other rolling stock	Average	16·4 ,,
Miscellaneous equipment		5 ,,

Technical Education.—Dr. William Garnett gave an address on "Technical Education After the War," at a recent conference of the Association of Teachers in Technical Institutions.

Dr. Garnett said we could never reform the schools, except through the examinations. He referred to Eton, and said that parents were the greatest hindrance to any change in the curriculum. Dr. Garnett laid down 14 principal points from which we select the following: Leaders of industry to place a higher value on research; teachers in technical institutions to be more closely connected with industrial leaders; and time to be given to teachers to enable them to carry on research. Trade associations and technical institutions should combine. It was pointed out that the war had shown people that our universities and technical schools are able to do work which very few people would have believed possible a short time ago. He considered that much of the school equipment would be altered, and methods of instruction modified, owing to experience gained through the war, and teachers should be prepared for changes. No sacrifice was too great in the way of market price to make this country independent, industrially, in regard to essentials of life and efficiency.

South African Possibilities.—The "Financial Times" refers to the value of the imports in South Africa, over £3,000,000 during March; and the exports, £1,420,000 for the same period. The mining and agricultural industries require together more than £2,000,000 worth of chemicals. A report has been issued by the Resources Committee of the Institution of Electrical Engineers in South Africa dealing with the possibilities of establishing there some electrochemical industries, such as calcium carbide, cyanamide and its derivatives, and concludes that, provided the necessary raw materials can be obtained, these can be profitably manufactured in South Africa. The high cost of transport as well as the protective duties and the fact that there is abundant coal and limestone and cheap electrical energy, are all in favour of South Africa manufacturing its own requirements in these respects.

The Gravitational Constant.—We referred in our issue of Dec. 24, 1915, to a Royal Society Paper by Mr. P. E. Shaw, in which the author concluded that the Newtonian constant is affected by temperature. In this connection there is an interesting letter in the current issue of 'Nature," signed "J.L." It is pointed out that the pendulum experiments of Bessel and more recent determinations by Eötvös, seem to establish proportionality between gravitational mass and mass of inertia irrespective of temperature, beyond the limits of the Paper in question. If the variation existed it is pointed out that comets like Halley's, which are amenable to astronomical calculation, would be accelerated on leaving the sun and retarded on approaching it, and this does not appear to have been noticed in any way. Electrodynamic theory shows that a gain of thermal energy causes an increase of the inertia of a body by the amount $\delta E/c^2$, where δE is the gain of energy, and c is the velocity of radiation, so that it is extremely minute and quite beyond detection. The question whether there is an equivalent increase in gravitational mass evades discussion, as at present no link between gravitative and electric forces has been established.

Positive Emission Currents From Platinum.—Prof. O. W. Richardson, F.R.S., and Prof. C. Sheard contribute a Paper to the "Philosophical Magazine" on "The Variation of the Positive Emission Currents from Hot Platinum with the

Applied Potential Difference." It had been observed previously by one of the authors that when a fresh metal wire is positively charged and heated in a vacuum, the relation between current and E.M.F., when due allowance is made for the decay of the current with time, is approximately linear. Yet no measurable quantity of negative ions is emitted by the wire at the temperature of the experiment. Since one would expect saturation to occur with quite a small potential, under the circumstances this phenomena required investigation.

Experiments were made with two forms of testing vessel: (*a*) A glass tube in which the electrodes are a loop of heated platinum wire and a plate; (*b*) a brass cylinder with an axial platinum wire. The wires were heated electrically, the temperature being controlled and regulated by placing the wires in one arm of a Wheatstone bridge, which was actuated by the main heating current in the usual way. A series of curves is given illustrating the results obtained. The authors considered two methods of accounting for the phenomenon: (*a*) By effect of electric field on emission from the hot wire; (*b*) an indirect effect by impact of ions on the negative electrode. Their results were inconclusive, but further investigations are being carried on.

Transmission of Electric Waves Around the Earth's Surface.—At a recent meeting of the Royal Society Prof. H. M. Macdonald, F.R.S., read a Paper on this subject. A formula is obtained for the magnetic force at any point of the earth's surface supposed imperfectly conducting when the source is a simple oscillator normal to its surface. If $\eta=\sigma(/2\lambda V)^{\frac{1}{2}}$, where σ is the specific resistance of the earth at its surface, V is the velocity of radiation in the space outside the earth, λ is the wave-length of the oscillations, and $z=(2\pi a/\lambda)$, where a is the earth's radius, it appears that, when ηz is a small quantity, the effect of imperfect conduction is to increase the magnetic force at a distance from the oscillator, the ratio of the magnetic force in this case to the magnetic force when the conduction is perfect, increasing with the distance from the oscillator and diminishing with increasing wave-length. When squares and higher powers of $\eta z^{\frac{1}{2}}$ are neglected, the results at angular distances from the oscillator of 6, 9, 12, 15, 18 deg. for a wave-length of 5 km. agree with those derived from Love's results when the square of k/m is neglected. The effect of the terms involving squares of $\eta z^{\frac{1}{2}}$ is opposite to that of the first order terms. Values of the ratio are calculated from the general formula for wave-lengths of 5 km. and 2 km., for a wave-length of 5 km. the ratio increases almost uniformly from 1·004 at an angular distance of 6 deg. to 1·027 at 18 deg., and for a wave-length of 2 km. from 1·106 at 6 deg. to 1·082 at 18 deg.

Reconnecting Induction Motors.—Mr. A. N. Dudley has an instructive article on this subject in a recent number of the "Electric Journal." After an examination of typical diagrams, the following changes are discussed: (*a*) Changes in phase and voltage of supply; (*b*) change in frequency of supply; (*c*) changes in the number of poles of the motor. Practically all commercial motors are arranged so that they can be connected for two voltages, say, 110 and 220 or 220 and 440. This is managed by joining the polar groups of windings in series for the higher voltage and in parallel for the lower. Tables are given for three-phase, star and mesh winding, and it is shown how a 2,200-volt motor may be reconnected to work at 440 volts, although it is not possible on account of insulation to reverse the procedure. For phase changes, on the other hand, it is remarked that theoretically there are 25 per cent. more total turns on a two-phase winding than in a three-phase one. If a three-phase motor is to be reconnected as a two-phase motor at the same voltage and with the same coils it will exhibit all the symptoms of a motor operating at 25 per cent. over voltage and would heat to a dangerous extent. When using two-phase as three-phase 80 per cent. only of the coils should be used, and the remainder distributed as evenly as possible around the rotor. Another arrangement shown is the Scott method for operating a two-phase motor on a three-phase circuit. One change which works very well is that where 550 volts three-phase is to run as 440 volts two phase. In this case the ratio of the voltages being in the ratio of $\sqrt{3}$ to $\sqrt{2}$ all the turns are utilised and the machine will give practically identical performance in each case. Regarding frequency changes the best rule to remember is to vary the applied volts on the coils, in the same way as the frequency, so as to keep the magnetic field, current in stator and rotor, the same if the torque is the same. For instance, if changing from 25 cycles to 60 cycles a 220-volt 25-cycle motor will run on a 440-volt 60-cycle circuit, at about double the power. The article referred to contains several diagrams and should be useful to those who are interested in the subject.

Emergency Employment of Women in Industry.—The substitution of women for enlisted men in the various occupations and industries of the country has for some time past been the subject of a vigorous campaign by the Home Office and the Board of Trade. The following special measures have recently been taken by the two departments to deal with the question:—

1. *Appeal to Employers.*—An appeal, signed by the Home Secretary and the President of the Board of Trade, has been issued to employers urging them to take immediate steps to extend as far as possible the employment of women in their works.

2. *Advisory Committee on Women's War Employment (Industrial).*—(*a*) A Central Advisory Committee on Women's War Employment (Industrial) has been appointed by the Board of Trade, in consultation with the Home Office, to advise the two departments on questions arising out of the action taken by them to facilitate the substitution of women for men and to watch the progress of this substitution in various localities and industries. (*b*) The Board have also appointed in a number of important centres local committees under the Labour Exchanges Act, 1909, to assist the two departments in dealing with the various questions that arise locally. The work undertaken by these Committees includes the collection of information as to the labour requirements of employers in their area, the organisation of a supply of women workers, the making of arrangements for housing accommodation for women brought in from other districts, and the initiation of schemes for the welfare of the women employed in their area.

3. *Conferences with Employers and Operatives.*—In most of the great industries (outside munitions industries) conferences have been arranged by the Home Office and the Board of Trade. In almost all cases a formal agreement has been concluded whereby the operatives' unions have undertaken, subject to certain conditions, to relax their trade rules in regard to the employment of women on processes hitherto regarded as men's processes. Among the industries in which such agreements have been reached are the following: Boots and shoes, bread and pastry baking (Scotland), china and earthenware, clay pipes, wholesale clothing, cotton, electroplate and silver (Sheffield), gloves (Somerset), hosiery manufacture, hosiery finishing, textile bleaching, dyeing and printing, woollen and worsted. These conferences are still proceeding, and it is hoped that similar agreements may shortly be concluded in a number of other industries, *e.g.*, cutlery, baking (England and Wales), brush making, printing and bookbinding.

4. *Pamphlets on Substitution.*—A series of pamphlets, setting out the processes in each industry in which women have been or can be introduced to replace or assist male operatives, with notes of any trade agreements or other relevant points of interest, are being issued by the two departments and brought to the notice of employers in the trades concerned.

5. *Information Bureau.*—With a view to enabling employers and others interested in the question of substitution to obtain information as to the developments which are taking place in this connection, an information bureau has been established at the Employment Department of the Board of Trade for the collection of particulars as to the occupations and processes in which women are replacing men in different parts of the country.

Inquiries on this subject addressed to the Information Bureau, Board of Trade, Victoria and Albert Museum, South Kensington, will receive prompt attention. Information may also be obtained from the Home Office, from the Board of Trade Divisional Officers for Labour Exchanges, or from the Home Office Inspectors of Factories.

PERSONAL.

Mr. A. B. Mountain has resigned his position as borough electrical engineer at Huddersfield, but the Corporation have retained his services as consulting engineer until the end of 1919. Mr. Mountain, who hopes to have more time for his consulting work, has been for 25 years at Huddersfield, where he designed and erected the original power station, and has since carried out various extensions of same. He has also acted as consultant to many Corporations and District Councils, having been responsible for the supply works at Worksop, Mirfield, Honley and Ravensthorpe, and he is now completing the Holmfirth supply scheme.

Second Lieut. Walter J. Cridge, of the 15th Sherwood Foresters, was wounded in the face recently in France, and is now in the 4th

Northern General Hospital, Lincoln, where he is (we are glad to learn) making good progress.

Prof. J. H. Dobson, general manager of the gas, electric supply and tramways department of Johannesburg municipality, has left on active service with the forces for the German East African campaign. He has been appointed officer commanding, Sonth African Pioneer Battalion, with the rank of major.

We understand that Mr. W. H. Allen has been offered and has accepted an appointment, and has consequently resigned his position of engineer and manager of the Loughborough electricity department, which he has held since its inception 12 years ago.

Mr. Donald Clark, chief inspector of Technical Schools in Victoria, recently went to South Australia to advise the Government on the subject of technical education.

Royal Engineers (T.F.)—The following appointments have been made :—

London Electrical Engineers : Sapper H. Nimmo, to be Second Lieutenant (on probation).

Tyne Electrical Engineers : Temporary Lieut. R. B. T. Pinkney (from Northumberland Fusiliers), to be Lieutenant (temporary).

APPOINTMENTS VACANT AND FILLED.

Two switchboard attendants with h.t. three-phase station experience are wanted for Government factory in South of Scotland. Salary from 45s. per 63 hours, seven shift week. *See advertisement.*

The Council of the Nottingham Society of Engineers invite applications for the position of secretary of the society, in succession to Mr. Price, at a salary of £25 per annum. Applications to the Chairman, Mr. C. J. Fox, The Limes, Beeston, by July 5.

Leek Urban Council require a junior assistant for their direct-current power station. Salary 30s. per week. Applications to the Manager.

Junior engineers-in-charge are required for Newport (Mon.) electricity department. Wages commencing at £2. 5s. per week. Applications to the Engineer.

Mr. J. W. Turner has been appointed borough electrical engineer at Huddersfield in succession to Mr. A. B. Mountain, resigned. Mr. Phillips has also been appointed mains foreman to the electricity department.

INSTITUTIONS AND SOCIETIES.

Royal Society.—Amongst the Papers read at last Thursday's meeting we notice the following : "On the Determination of Gravity at Sea," by Prof. Arthur Schuster, Sec., R.S. ; "The Genesis of Pleochroic Haloes," by Prof. J. Joly, F.R.S. ; "On Some Determinations of the Sign and Magnitude of Electric Discharges in Lightning Flashes," by Mr. C. T. R. Wilson, F.R.S. ; "On the Kinetic Theory of a Composite Monoatomic Gas : Diffusion, Viscosity and Thermal Conduction," by Mr. S. Chapman.

New Headquarters for the Engineering Department of the Post Office.—The Right Hon. J. A. Pease, M.P., Postmaster-General, opened the new offices in Denman-street, London Bridge, on the 22nd inst.

The premises provide accommodation for 350 members. The Mayor of Bermondsey and Southwark and other visitors were present. Sir W. Slingo, engineer-in-chief to the Post Office, in his opening remarks, referred to the expansion of the department, which expended £6,000,000 during 1914-15. Mr. Cropper, the architect, stated that the building cost £26,000, and as the site had 8,000 sq. ft. the problem was to get 45,000 sq. ft. of floor space. This was accomplished by means of seven floors, two underground and five above.

The Postmaster General, in his remarks referred to the work done during the war by the Post Office, and gave statistics as to progress. Overhead wires to the extent of 14,000 miles have been removed since 1912, and 36,000 subscribers have been added to the London telephone service. There are 53 telephone exchanges and 12,000 private branch exchanges. In the London district 251,142 telephones are maintained, and the total length of cables is 70,849 miles. Under normal conditions the annual extensions cost about a million pounds a year. When the National Telephone Co.'s system was taken over the complaints averaged 1·25 per 1,000 per day. It now only averages 0·5 per day. Special arrangements have been made for warning munition factories in the event of Zeppelin raids.

A suitable key was presented to the Postmaster General, who then declared the building open, after which the formal proceedings terminated. Amongst the visitors who afterwards took tea with the Postmaster-General, Mrs. Pease and the district staff were Mr. G. E. P. Murray, C.B. (secretary, G.P.O.), Sir Robert Bruce, C.B. (controller, L.P.S.), Sir William Slingo (engineer-in-chief), Mr. H. S. Carey, C.B. (joint second secretary, G.P.O.), Colonel Ogilvie, C.B. (joint second secretary, G.P.O., Director of Army Signals, Home Defence), Dr. Sinclair (chief medical officer, G.P.O.), the Mayor of Bermondsey, the Mayor of Southwark, Messrs. A. B. Walkley, A. G. Ferard and E. Raven (asst. secretaries, G.P.O.), Mr. J. Newlands, C.I.E. (controller, Central Telegraph Office), Mr. G. Morgan, I. S.O. (controller, Stores Dept., G.P.O.), Mr. G. F. Preston (controller, London Telephone Service), Messrs. A. J. Stubbs and W. Noble (asst. engineers-in-chief, G.P.O.), Mr. J. M. G. Trezise (superintending engineer, London Power District, G.P.O.) and Commander Sladen, R.N. (chief officer, London Fire Brigade).

Diesel Engine Users' Association.—At the last meeting of the Association Mr. A. J. C. De Renzi (Corporation of Newcastle-under-Lyme) made a suggestion that the Association should hold one meeting in each year in an important centre outside London, such as Manchester, Birmingham, &c., so that engineers in those parts who took an interest in the work of the Association might take the opportunity of attending its deliberations and discussions. A motion by Mr. H. Leslie Dixon (Leatherhead), seconded by Mr. C. O. Milton (Maidenhead), that the Association should support the application of the Suffolk Electricity Supply Co. (Ltd.), to the Board of Trade for the voiding or suspension during the war of the German patent in regard to "Improvements in internal combustion engines," to enable tar oils to be used as fuel, was discussed. It was pointed out that although at present any royalties would be paid to the Public Trustee, the Germans might eventually benefit as a direct result of the war in consequence of the increased price of crude petroleum oil which led to the present demand for tar oils as fuel for Diesel engines. Further, on public and patriotic grounds the Association should support any movement which would tend to the preservation and most economical use of the coal reserves of the country. The motion was carried unanimously. The President, Mr. Geoffrey Porter, then read a Paper on "Oil Engines and Steam Engines in Combination." We hope to deal with this Paper in a future issue.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 30th (to-day).

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

2.30 p.m. At Westminster Palace Hotel, S.W. Eighth Annual Congress.

3 p.m. Paper and Discussion on "Tramway Transit and Comfort : a Plea for the Passenger," by Mr. W. Tuke Robson, General Manager, Southampton Corporation Tramways.

4 p.m. Visit by Motor 'Bus to London General Omnibus Co.'s Training School at Milman-street, Chelsea. Inspection of Class Rooms, Drivers' and Conductors' Courses and Cinematograph Hall. This will be followed by Tea, after which Mr. Blain will give a Short Address on "The Safety Movement."

7.30 for 7.45 p.m. Dinner at Trocadero.

PHYSICAL SOCIETY.

5 p.m. At Imperial College of Science, Exhibition-road, S.W. Papers on "A Sensitive Magnetometer," by Dr. P. E. Shaw and Mr. C. Hayes, B.Sc. ; "The Latent Heat of Fusion of a Metal and the Quantum-Theory," by Dr. H. S. Allen : "Experiments on the Thermo-electric Properties of Fused Metals," by Mr. C. R. Darling, A.R.C.S., and on "Cohesion, Part 2," by Prof. H. Chatley, D.Sc.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding—Lieut.-Col. C. B. Clay, V.D.

Orders for the Week.

Officer for the Week.—Platoon Commander J. O. Cheadle.

Next for Duty.—Platoon Commander L. C. Hughes-Hallett.

Monday, July 3rd.—Technical for Platoon No. 9, 46, Regency-street, S.W. Squad and Platoon Drill Platoon No. 10. Signalling Class and Recruits.

Tuesday, July 4th.—Officers' Instruction Class 6 to 7. Recruits 7 to 8. Lecture, 7.15 "Constitution and Duties of a Field Company, Company Commander Bentley.

Wednesday, July 5th.—Platoon Drill, No. 2 Platoon.

Thursday, July 6th.—Platoon Drill, No. 6 Platoon. Recruits, 5.45 to 7.45. Instructional Class, 5.45.

Friday, July 7th. Technical for No. 10 Platoon, 46, Regency-street, S.W. Squad and Platoon Drill, No. 9 Platoon.

Saturday, July 8th.—Instruction Class, 2.30, Company Commander Fleming.

Sunday, July 9th.—Entrenching at Otford, parade Victoria (S.E. & C. Railway Booking Office) 8.35 a.m. Uniform, haversack, water bottles. Midday rations to be carried. Railway Vouchers will be provided.

Otford Camp.—On and after Saturday, June 3rd, there will be a standing Camp at Otford. See monthly orders.

Musketry.—For all Companies, see Notice and Tables A and B at Headquarters.

NOTE.—Unless otherwise indicated, all Drill, &c., will take place at Chester House.

ELECTRIC POWER IN SLATE QUARRIES.*

BY G. K. PATON.

It is only within the last 10 years that electric power has been introduced to any extent in the slate quarries of North Wales, some of which have been in active operation for a century or more. Under the terms of the North Wales Electric Power Act of 1904 the company is authorised to supply power in bulk to power consumers with an equivalent amount for lighting purposes.

The transmission lines of the power company now extend to the principal quarrying districts in an area of nearly 400 sq. miles, supplying slate and granite quarries, aluminium works, and also the new Carnarvon transmitting station of Marconi's Wireless Telegraph Co. (Ltd.). It may not be out of place to briefly describe the system of the power company before discussing in detail the electrical equipment of quarries.

The generating station is situated at Cwm Dyli, near Penygwryd, in the Gwynant Valley. Water-power is the prime mover, and Llyn Llydaw, into which the upper catchment area of the Snowdon range is drained, forms a natural reservoir at 1,416 ft. O.D. above sea level, giving an effective head of 1,150 ft., with a water pressure of 500 lb. per square inch at the power station.

The pipe line, which is in duplicate, is built of riveted mild steel pipes 30 in. internal diameter on the upper section, and 27 in. internal diameter lap-welded steel pipes on the lower section. Expansion joints are provided, and the pipes are anchored by means of concrete blocks, tie rods and clamps. Lead joints are used throughout.

Four Pelton wheels, each of 1,600 B.H.P., are installed, coupled to 1,500 k.v.a. alternators with direct-coupled exciters, generating three-phase current at 10,000 volts 50 periods when running at a speed of 500 revs. per min.

The voltage at the power house is regulated within 1 per cent. by means of Tirrill regulators. Power is transmitted to the various consumers by overhead transmission lines, and each consumer has one or more sub-stations, built to the requirements of the power company, equipped with two three-phase oil-insulated static transformers, varying in size from 100 k.v.a. and 750 k.v.a. capacity, according to requirements, to reduce the line pressure to 500-550 volts or whichever pressure is desired. The extra-high-tension equipment and transformers are the property of the power company. All consumers are in communication with the power house by telephone. The secondary equipment from the low-tension terminals of the transformers is supplied by the consumer.

The sub-station switchgear includes two transformer panels controlling the supply from the main transformers, and the necessary feeder panels, equipped with triple-pole oil-break switches with instantaneous or time limit trip-gear. It is advisable in all cases that the feeder switches should operate before the transformer switches.

Lightning arresters and kick coils should be fixed on all outgoing feeder circuits. For metering the supply, two double-element integrating three-phase watt-hour meters are installed coupled in series, so that one is a check on the other, the mean of the readings being taken as the net consumption.

The questions of metering, earthing, low-tension distribution and overhead lines are next dealt with.

Overhead Lines.—A simple and effective design for a 1,000-volt single-circuit line is given on Fig. 1, which is self-explanatory.

Double-circuit lines with channel arms are arranged with two insulators per conductor, to one of which the line wire is bound and to the other is attached the anchor wires.

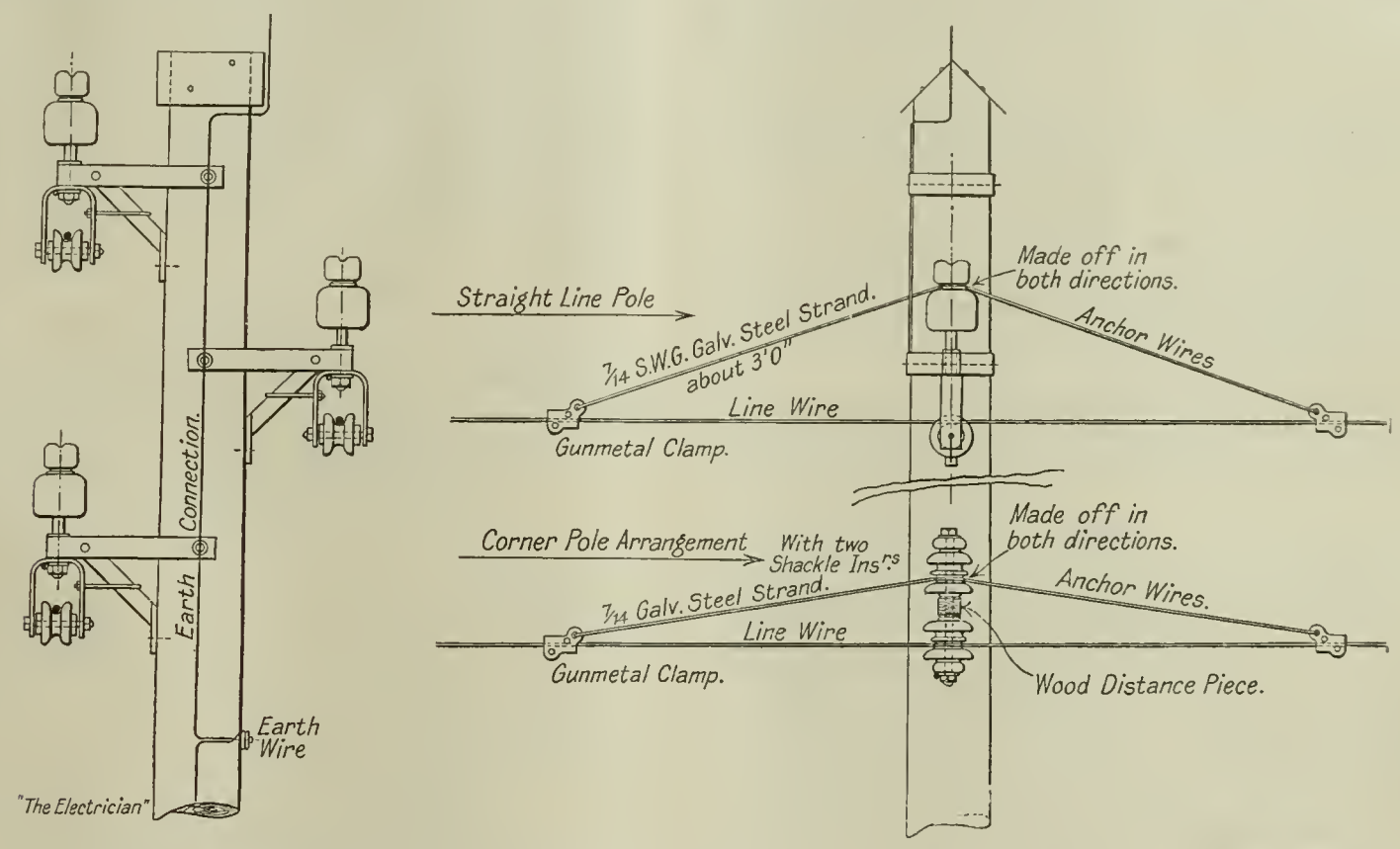
An earth bar is fixed as an additional protection, to effectively earth the live wire should it fall.

Both designs are based on the fact that the insulator is the weak point of a line, and should it fail the wire may fuse or break at this point. The second insulator and anchor wires then prevent the conductor from falling.

A continuous earth wire should be run throughout, and all ironwork, motor frames, switch ironwork and the neutral point of the secondary efficiently connected thereto.

Application of electric power in slate quarries is limited to the following purposes at present in operating :—

(*a*) Slate saws, guillotines, planing and drilling machinery in sheds. (*b*) Haulage and winding gears, including hoists, cableways and inclines. (*c*) Air compressors for rock drills. (*d*) Pumps.



OVERHEAD LINE CONSTRUCTION IN QUARRIES FOR CROSSING RAILS, FOOTPATHS. SINGLE CIRCUIT, 500-1,000.

For convenience, each will be considered *ad seriatim* :—

Slate-sawing Machinery.—The necessity for slate saws in a quarry is to avoid wastage and obtain the maximum size of roofing slate possible from the slate blocks.

1. The ragged end is sawn off, and facilitates splitting into what are commonly called "slates."

2. In large blocks, a fault, or what it is called in Welsh "crych," in the block is sufficient to prevent saleable slate being produced ; but by cutting the crych out, leaving two smaller blocks, good saleable slate is obtained.

3. The blocks are cut to a suitable size for splitting by hand, an operation for which no machinery has yet been designed. Generally, the provision of slate-sawing machinery prevents wastage of considerable quantities of rock ; enables the production of saleable slate from blocks which would otherwise be thrown away, and of larger size slates, which are more valuable and marketable : reduces debris, and gives a higher production at a reduced cost.

Slate sheds should be erected as near as possible to that part of the quarry from which the blocks are obtained.

Advantage should be taken of the electrical supply to install units of 15 B.H.P. to 20 B.H.P., driving 12 to 15 saw tables, instead of the older method of concentrating all the saw tables in one large shed.

When conversion is made to electric drive in these large sheds it is better to subdivide into groups of 12 to 15 tables, each group being driven by separate motor.

A convenient arrangement, recently laid down in Penrhyn quarry, is a shed 162 ft. by 58 ft., containing 12 saw tables, each driven by belt from a main shaft, 4 in. diameter at the centre and tapering to 3 in. at the extreme ends, driven from the centre by means of a

* Abstract of a Paper read before the Liverpool Engineering Society.

squirrel-cage three-phase induction motor of 20 B.H.P., coupled to a worm gear with a speed ratio of 960-45 revs. per min., the secondary shaft being direct coupled to the main shaft. An outline of this type of motor and worm gear is given on Fig. 2. The slate tables are arranged six on each side of the motor equipment. The tables, which measure 8 ft. by 4 ft., are carried on rollers, and a continuous feed motion is given by means of worm, worm wheel, pinion and rack gearing. The ratio of the gear can be arranged for any speed, according to the hardness of the slate rock to be sawn, varying from 1½ in. to 6 in. per minute.

Slate dressing machines are used to dress the slates to size, a gauge on the machine providing the necessary guide to obtain the maximum size possible. The revolving cutters are driven from the main shaft by fast and loose pulleys, or by pulley and clutch as desired. No slate-sawing shed is complete without a saw sharpening machine for sharpening the circular saws, and a saw punching and setting machine.

In some quarries, where very heavy blocks are dealt with in the sheds, lifting tackle is necessary; but in other quarries the blocks are reduced in size at the quarry before being sent to the sheds, and the men prefer to lift these smaller blocks by hand.

Lighting.

A shed with 12 tables requires about 1,250 watts per hour for 25 lamps, and costs 1¼d. per hour at a 1d. per unit, yet, to the author's knowledge, only one quarry has installed electric lighting in saw sheds.

Steel circular saws about 2 ft. in diameter, running at a speed of 26 to 36 revs. per min., are used for cutting the blocks of slate, the feed varying from 1½ in. to 6 in. per minute. The saw runs in a water bath.

Carborundum saws, although satisfactory for some special purposes, are not generally used. For very large slabs a circular disc with projecting cutters is used. The slow speed of these saws necessitates a main shaft running from 45 to 60 revs. per min., and four methods are available with an electric drive:—

(*a*) Worm gear coupled direct to line shaft; (*b*) single reduction gear with belt drive from secondary shaft; (*c*) double reduction gear with belt drive or geared to line shaft; (*d*) belt drive from slow-speed motor.

(*a*) For a new shed, where it is possible to arrange a centre drive, a worm gear, coupled to line shaft and driven by high-speed squirrel-cage three-phase induction motor is a convenient arrangement. A star delta starter is all that is required for starting purposes, but, on account of the low starting torque of these motors, an auto-transformer starter is sometimes an advantage if it is necessary to start against more than 25 per cent. starting torque. The efficiency of the worm gear is stated by the makers to be 95 to 96 per cent. This arrangement takes up very little space, and is very satisfactory in operation. An outline drawing of a combined set is shown in the Paper. The motor is 20 B.H.P. when running at 960 revs. per min. The worm gear ratio is 960-45.

(*b*) A belt drive is employed from the secondary shaft on the motor, running about 240 revs. per min. to the main shaft at 45 or 60 revs. per min., as may be required. For the 4 : 1 gear reduction 960-240 revs. per min., it is a vexed question whether straight or helical cut teeth should be used, and steel or iron, paper or raw hide pinions. Slate dust causes considerable wear on paper or hide pinions, and it is nearly impossible to prevent dust getting about, as it is carried by the belt, even when the motor is fixed in a different compartment. A helical cut gear gives better results than the other types mentioned. This arrangement of motor with single reduction gear is shown in the Paper.

(*c*) The double reduction geared drive is not used, so far as the author is aware, in any of the quarries, and it is higher in cost than the other types.

(*d*) It is always preferable to use a belt drive, but when a speed reduction to 45-60 revolutions is required this is only possible by means of a slow-speed motor. The "cascade" motor is suitable for this purpose, a 15 B.H.P. motor running at 320 revs. per min., synchronous speed 333 revs. per min. The pulley ratio is about 7 to 1, and consequently the motor pulley is of necessity small in diameter.

The power factor and efficiency of the cascade motor is lower than that of higher speed motors, and it is interesting to compare the cost and efficiency of each method. These are given in the following table, based on actual quotations for each type. The figures are comparative only and the prices include starters and slide rails where necessary.

Each type has its advocates, and that chosen will depend on local conditions, especially in converted sheds. There is no necessity for using slip-ring type motors, and squirrel-cage type will be found to give the best results.

Comparative Data for 15 B.H.P. Three-phase 50 ~ 500-volt Motor Equipment.

Type of motor.	Speed reduction.	Drive.	Price (approx.)	Motor. Load.	Effic.	P.F.	Kw.
				%	%		
Cascade	320:60	Belt	£95	1/1	83·0	0·77	13·5
				3/4	82·0	0·75	...
				1/2	78·0	0·70	7·2
Squirrel cage	960:60	Worm reduction gear	£80	1/1	85·0	0·87	13·2
				3/4	84·5	0·82	...
				1/2	83·5	0·75	6·7
Squirrel cage	960:60	Double reduction gear	£105	1/1	...	...	...
				3/4	...	...	...
				1/2	...	...	...
Squirrel	960:60	Double reduction helical cut gear	£115	...	...	...	...
Squirrel cage	960:60	Single reduction gear and belt helical cut gears	£60	1/1	87·0	0·88	12·9
				3/4	86·0	0·84	...
				1/2	84·0	0·76	6·7

From the power company's view it is better to use high-speed motors giving a higher power factor at half to three-quarter load which is about the average over the running periods of the day. The lower efficiency and power factor of the cascade motor adds over 14 per cent. to the total kilovolt-amperes taken from the power supply.

The following average working results have been obtained in modern saw sheds driven by 20 B.H.P. three-phase squirrel-cage motors coupled to worm reduction gears with a ratio of 960-60 or 45 revs. per min., each equipment driving 12 to 14 saw tables. In one shed there were 12 saw tables, 1 B.H.P. motor and 28 men employed.

Slate output—

200 tons in the proportion of bests ..... 62·5 per cent.
" " " seconds ..... 19·0 "
" " " thirds ..... 18·5 "

Hard quality. Cutting speed=3 in. per minute.

Power consumption—

=1,400 units.
=7 units per ton of saleable slate produced.
=at 1d. per unit, 7d. per ton.

In another shed there were 28 saw tables, two 20 B.H.P. motors, 80 men employed.

Slate output—

460 tons in the proportion of bests ..... 72 per cent.
" " " seconds ..... 14 "
" " " thirds ..... 11 "

Cutting speed=6 in. per minute.

Power consumption

=2,470 units.
=5·37 units per ton of saleable slate produced.
=at 1d. per unit, 5·37d. per ton.

In a third shed, over a shorter period of time, the power used was equal to 5 units per ton of slate output. The cost of power in slate saw sheds may, therefore, be taken at 5d. to 7d. per ton of output, depending on the quality of rock, hard or soft, at 1d. per unit. The running load factor varies from 45 to 55 per cent. over 9½ working hours per diem. The average load is not more than 15 B.H.P., and this gives approximately an average of 4 units per brake-horse-power per diem. The actual power required per table (8 ft. by 4 ft.) is on an average 1·1 kw.=1·475 H.P., or 1·25 B.H.P. at 85 per cent. motor efficiency. From tests taken, the actual cutting power per table is approximately 1 H.P., giving an overall efficiency of 68 per cent.

Haulage Systems.

North Wales is famed for its hills and valleys, and the slate quarries might well be known by the debris tips and the inclines by which the slate wagons are taken to otherwise inaccessible places. The majority of these inclines are operated by gravity, full wagons descending pulling up the empties, a hand-operated brake strap on the rope drum being the only control. In the Blaenau Festiniog district, slate and debris from the mine is hauled up from the lower workings to the shed levels. The majority of these inclines are operated electrically and vary in size according to the number of roads or drums operated. In the Nantlle district, where the quarries are of the open pit type, the slate blocks and debris require to be lifted out of the pit. Aerial suspension cable ways and inclined ropeway hoists are used for this work, and these types in particular are described with a view of showing the relative costs and work done by each. Undoubtedly, the simple incline with rails on which the wagons travel is cheapest and best; but in an open quarry cableways must be used, although some people call them a necessary evil.

Inclined Ropeway Hoists.

Two main cables are carried over a suitable mast at the landing stage, and anchored in such a position that they are suspended over the desired lifting point. Each heaving rope is doubled through a carriage which travels on the main cable. A stop is fixed on the cable directly above the lower landing point, and the slope of the main cable must be such that the carriage is not drawn up the inclined rope until the block collides with the carriage, this being arranged for in the design without causing injury to either block or carriage.

The minimum slope of the cable must be such that the resistance to drawing the carriage up the incline is greater than the effort involved in hoisting the load. When the load has been drawn up to the mast at the upper landing stage a stop is placed behind the carriage while the load is lowered.

Two heaving ropes are employed on one drum, one paying out as the other is pulled in, and the wagon and rope weight is balanced during most of the travel. In practice, however, it is found that the empty wagon descending is actually landed before the full wagon reaches the top of the mast at the upper landing stage. Consequently the power required at the end of the lift is that required for the gross weight of wagon and load. When the load is lowered, owing to the other wagon being already landed at the bottom, the heaving rops sags, but this does not matter.

The single hoist, with two main ropes, lifts a gross weight of about 50 cwt. to 60 cwt., one empty wagon descending while the other load is lifted. The double hoist is arranged with four main ropes, and is used to lift one or two full loads at a time, as may be required. The single hoist is driven by a 70 b.h.p. motor and the double hoist by a 150 b.h.p. motor. In order that a comparison may be made with the aerial suspension cableways, the following results are given from actual readings taken during working hours :—

Aerial Hoist.

Single, with two main ropes of 90-ton plough steel, 2 in. diameter ; heaving ropes, $\frac{3}{4}$ in. diameter ; rope drum, 4 ft. diameter ; rope speed, 600 ft. per minute ; lifting speed, through blocks, 200 ft. per minute ; hauling speed, up incline, 600 ft. per minute maximum ; actual height lifted=five galleries=300 ft., plus height of mast ; length of travel on main rope=approximately 460 ft.

Electrical Equipment.

Motor, 70 b.h.p., 500 volts, 50 periods, 570 revs. per min., three-phase, slip ring, reversing type. Tramway type reversing controllers, 11 steps forward and reverse, five minutes rated cast grid resistances. Gear ratio, first motion, 3 : 1 ; gear ratio, second motion, 4 : 1. Machined brake wheel on drum, with brake band and levers for foot control. An integrating watt-hour meter was put in circuit with the motor, and note taken of the number of loads hoisted, each of which weighs on an average 42 cwt. net and 51 cwt. gross.

The power required varies during the lifting operation as given in the following table of operations.

Aerial Hoist. Lifting Operations.

Operation.	Power taken from supply.	Drum revs.	Time.
Lifting empty wagon to mast head ; release carriage ready to lower.....	30 kw.	3	...
Lower empty wagon by gravity, pull-in slack in rope	...	4½	*
Lift load from bottom landing stage to stop on carriage (wagon balanced) ...	30 kw.	9½	20 seconds.
Pull up load on inclined rope to mast-head, empty wagon descending, and landed before full wagon reaches masthead, when maximum power is required	55-60 kw.	46	1¼ minutes.
Carriage held at masthead by stop while load lowered by gravity	...	...	...

The total net weight lifted with 1,135 loads during the period was 2,380 tons, and the corresponding units registered were 1,140 units, which gives per net ton lifted 0·48 unit and approximately 1 unit per journey or load. Although a maximum rope speed of 600 ft. per minute is provided for, it is used only while heaving between the stops on the main ropes from the time the carriage begins to pull up until the descending carriage with empty wagon reaches the other stop.

The speed is momentarily slowed down at these points to avoid damage to the ropes, an indicator being provided for the purpose in full view of the driver. The following table gives the actual power readings :—

——	Kw.	B.H.P.	Motor efficiency.	Load.
Lifting load	30	33 (a)	82 %	42 cwt. net
Lifting load	60	70 (a)	87 %	51 cwt. gross
Hoisting load average	45	52 (a)	86 %	...

The kilowatts were measured on a special indicating wattmeter.

The theoretical power required to haul the net load up the incline at 600 ft. per minute is 38·5 kw., which, with an actual average of 45 kw. recorded, gives an overall efficiency of 85 per cent.

To lift the gross load of 51 cwt. an input of 46·5 kw. is necessary, against 60 kw. recorded, an apparent overall efficiency of about 77·5 per cent. It is difficult to arrive at an accurate figure, but it is evident that the overall efficiency is 75 per cent. with unbalanced load and about 85 per cent. with the wagon weight balanced, a result which may well be considered satisfactory. The time taken for each complete operation is about 1¾ minutes, so that it is not impossible, if the wagons are to hand, to do one journey every 2½ minutes, equal to about 200 loads per day, or approximately 400 tons net.

Under these conditions the motor would take 200 units per diem, although actually about 100 units per diem would be a good average under normal conditions.

One hundred units per diem represents a load factor of 18·5 per cent. over nine working hours per diem, but taken over longer periods, when other conditions, weather, &c., interfere with outdoor work, the load factor averages from 12 to 15 per cent. only. In other words, to the power company, a winding motor taking a maximum demand of 60 kw. intermittently, consumes in a day from 60 to 100 units, representing from 0·9 to 1·43 units per horse-power per diem, and which at 1d. per unit brings in a revenue of from 5s. to 8s. 4d. per diem.

Aerial Suspension Cableways.

The following particulars relate to three such cableways in operation at Penrhyn Quarry :—

Span.—(1) 965 ft. ; (2) 1,010 ft. ; (3) 1,015ft.
Gross load, each 60 cwt.
Hoisting speed, 300 ft. per minute.
Travelling speed, 900 ft. per minute.
Winding drums, 5 ft. diameter, giving maximum rope speed of 900 ft. per minute.

Motor speed (syn. 600)	570 r.p.m.	pinion 19	ratio 2·53 : 1
Secondary shaft	225 ,,	spur 48	helical steel gears.
,, ,,	225 ,,	pinion 27	ratio 4 : 1
Drum speed	56·5 ,,	drum spur 108	cast-iron gear.

Motor.—70 b.h.p. three-phase, 50 periods, 500 volts, 570 revs. per min. Slip ring, reversing, enclosed ventilated type, with extended shaft and third bearing. Westinghouse F. 12A drum-type reversing controller, with 11 steps forward and reverse, arc shields, five-minute rated open type, cast grid resistance. *Switch Panel.*—Totally enclosed, oil break automatic circuit-breaker with no volt, and overload releases fitted with adjustable time lags.

Telegraph.—As the driver is not in full view of the landing points in the bottom of the quarry, an electric signalling system is used, with luminous signal receiver fitted in the driver's room. The signals are given by operator from a signal box in full view of the workings under the cableway.

The following average results have been obtained in actual operation :—

1. Over a definite period 423 complete journeys were made (in and out), when the net tonnage lifted amounted to 887 tons. During this period the power used amounted to 650 units, equal to 0·733 units per ton, or 1·54 units per load of 42 cwt.

No.	Operation.	Power in kw.	Distance.	Time.
1	Empty wagon lifted at mast	22	...	Short lift, 20 ft.
2	Empty wagon lifted from pit	25	150 ft.	30 seconds
3	Running out empty wagon	10	...	...
4	Lifting full wagon	55-60	165 ft.	35 seconds
5	Travelling in.....	10-15-20-30-40	900 ft.	60 seconds

2. In another cableway the tonnage noted in 255 journeys was 574 tons, when the power consumed amounted to 516 units, giving 0·9 unit per ton lifted, or 1·89 units per load of 42 cwt. net.

These figures include journeys made with empty wagons, which must be taken into account in arriving at an average cost. The

* Getting ready while hooking on load at bottom.

actual power in kilowatts for the various operations are given in the above table. A series of power readings were taken and the load weight checked to arrive at some idea of the general efficiency of a cableway. These are given in the following table :—

——	Kw.	Lifting Speed.	Overall effic.	Motor effic.	Cableway effic.
Lifting empty wagon ...	21	300 ft.	32·5	...	...
Lifting full wagon	60	300 ft.	70·0 %	87·0 %	80·5 %
Lifting load of blocks ...	70	300 ft.	65·0 %	86·0 %	76·0 %
Motor running alone ...	10	...	...	...	...

The loads being 9, 55 and 60 cwt. in each case.

Taking 200 tons per diem as a maximum, the consumption of power at an average of 0·8 unit per ton would be 160 units.

The average load requires a maximum power of 60 kw., or 70 B.H.P., which gives an average of 2·28 units per horse-power per diem. Over a longer period the average would amount to only about 50 units per diem, equal to only 0·715 unit per horse-power per diem. This is equivalent to a load factor of, say, 9 per cent. to a possible maximum of 28 per cent. over a 10-hour day, and under normal working conditions 10 to 15 per cent. would be a fair average.

From these results, which have been obtained under actual working conditions, it is now possible to tabulate and compare the costs and tonnage handled by each type. These are given below :—

Type of cableway.	Cost of equipment.	Tonnage per diem. Max.	Tonnage per diem. Av.	Kw.	Units per ton.
Single incline hoist.....	£600	400	130-200	60	0·48
Double hoist	£1,000	800	...	120	0·48
Aerial suspension cableway	£900	200	50-100	60	0·733-0·9

Type of cableway.	Load factor. Max.	Load factor. Av.	Overall efficiency.	Remarks.
Single incline hoist.....	35 %	12·18%	76%	Diagonal lift 300 ft. Travel 400 ft.
Double hoist	...	...	...	.....
Aerial suspension cableway	28%	10·15%	65-70%	Vertical lift 165 ft. Travel 900 ft.

The approximate cost given in column 2 includes complete electrical equipment, ropes, masts, buildings, foundations and anchorages. The electrical equipment of the single hoist and aerial cableway is similar with 70 B.H.P. motors and controllers.

From the figures given it will be noted that the actual tonnage handled by the inclined hoist is practically double that of the aerial suspension cableway.

The advantage of a cableway is that a wagon may be hoisted or landed at any point along the span of the main cable, whereas with an inclined hoist the landing places are fixed.

Both types are taken advantage of in Penrhyn Quarry, the cableways spanning the open workings, and landing the wagons on rails on which they are taken under the inclined hoist. The hoist then lifts the wagons another 300 ft. to the level of the debris tips. One hoist deals comfortably with the tonnage handled by two aerial cableways. In this way 200 to 300 tons of debris per diem are removed from one part of the quarry workings, lifted a height of 400 ft. to 500 ft., and a distance of over 1,500 ft., at a power cost of about 1½d. per ton.

The author next deals with air compressors and pumping.

Bulk Supply.

As already stated, with the exception of a pumping load, a quarry demand is for 10 hours per diem, and this is reduced in winter to eight hours per diem.

It may be interesting to summarise the results obtaining from the different types of demand on the power company, and to indicate the proportion of each.

This particular plant may be taken to give average working conditions, although there is a preponderance of winding, and consequently peak load. The load factor taken over a day of nine hours is 43·5 per cent.

The load factor taken over a month and 24 hours per diem is 12 per cent.

$$\text{The plant diversity factors} = \frac{\text{Total H.P. installed in kw.}}{\text{Average max. load on chart}} = 2.$$

In other words, a demand of 250 kw. on the power plant will supply a quarry plant totalling 500 kw.

The ratio is still further increased by totalling the individual quarry horse-power connected against the actual maximum demand on the power station, which gives a diversity factor of about three.

There are many advantages resulting from a bulk supply, and these may be enumerated briefly as follows : (1) The supply is available whenever required, night and day. (2) The supply is given within guaranteed limits of voltage and frequency. (3) Power used is directly proportional to work done; there are no stand-by losses. (4) Only one skilled man is required to supervise the secondary plant. (5) The power consumer can obtain from the meter readings his costs over any period, and know exactly what these costs are. (6) In this particular supply, from an hydro-electric power company, he is independent of coal, oil or other fuel costs, which vary according to market and other conditions. (7) His immediate capital cost is low, and only includes the secondary equipment; the plant invariably increases owing to the facilities afforded for putting down new plant without considering cost of generating machinery. (8) He obtains his power at a price unobtainable under other circumstances.

In pre-electric days the lost time due to want of steam pressure was also noticeable, especially in the mornings. In one steam-driven slate saw shed, the cyclic variation on the main shaft is quite noticeable, and it is not unusual to find the speed about 50 per cent. of normal, varying with the load and steam pressure. With electric power, however, the supply is available when the men start work, and no time is lost. Power is used only when useful work is done ; and in slate sheds the cutting speed is constant within a few per cent., according to the slip on the motors.

In conclusion, while the present state of the slate trade may not warrant further capital expenditure, and each particular quarry must be considered by itself, the actual working costs with modern machinery are so small compared with the additional revenue from increased output and reduced working costs, that no quarry manager should be content to work under conditions which prevailed in the past. The cost of electric power and machinery is only one item, small when compared with other expenditure in a quarry ; but it is one which will give a quick return and enable a manager to devote his energies to other problems in the production of slate.

RURAL DEVELOPMENT OF TRANSMISSION LINES IN EASTERN PENNSYLVANIA.*

BY J. W. PRICE.

Summary.—The author gives some data on the experience of two power companies in the U.S.A. regarding the development of rural loads. As these data are specific they should be of much value to other companies.

The class of station referred to was that which has assumed fair proportions, principally on account of being located in an industrial centre of reasonable size and which has grown along with the place, at the same time branching out here and there as business seemed to warrant, or as the pioneer idea found temporary favour. Such a station is herein designated as Company No. 1.

The other class of station was that which has been installed in a small community having little or no manufactures, making the station practically dependent upon farms and farmers for its existence. This type is well exemplified in Company No. 2.

Company No. 1.

This company has acquired its rural customers incidentally, as it were, and is frank to say that up to the present it has not established any definite policy for acquiring the rural load. Recent investigation into what this load consisted of brought out interesting and valuable data. The result will undoubtedly be the establishing of a definite policy for the acquiring of farm loads at a fair profit. This does not mean that the load so far obtained has not shown a profit, but from a monetary point of view the company has just succeeded in clearing expenses. It was pointed out that the company had heretofore taken farmers on its lines upon the same basis as a city customer, so far as running lines were concerned, except in a few special cases. If, under such conditions, the income from these rural customers allows the company to cover expenses it was fair to assume that if it had made charges for lines and transformers then the result would show the undertaking to be a paying proposition.

In writing this article the first desire was to show the cost of the line construction, of maintenance and general overhead charges. These data were not available for several reasons : The majority of the farms are connected to lines which could not properly be charged against them, as they were originally put up for connecting towns or

* Abstract of an article in the "General Electric Review."

to supply some large industrial plant. The farmers close enough to the line were taken on incidentally, and in fact, one of the most satisfactory farm loads is connected to a line which was run from one plant to another as a tie line. There were, at the time this was written, 125 farm customers. Only 12 miles of special lines have been put up. These 12 miles are made up of small sections here and there, averaging from $\frac{1}{4}$ to $\frac{1}{2}$ mile in length. Further, a number of the farm customers were inherited en masse, when lines formerly owned by separate companies were merged with the present company, and statistics of the costs of these lines are not at hand. As previously mentioned, it was not until very recently that attention has been given to the farm load, so that up to this time no careful statistics have been kept.

Of the 125 farmers above mentioned there are, to date, 30 users of power. All are users of light. A conservative average yearly revenue for the 95 customers who use current for light only is given as £3. 12s. per year, or a total of £342. In some cases, on large farms, there are two separate lighting circuits, one for house and nearby buildings and one for barn, stables and outbuildings. Separate meters are used for each circuit, and a separate meter is also used for the power circuit.

A table of the revenue for lighting and power is given in the article, and the average from 30 farms amounts to about £16 a year.

This company had a uniform lighting rate of 6·25d. (less 20 per cent. for prompt payment), and a power rate of 5 cents per kilowatt-hour (less 10 per cent. for prompt payment). This very reasonable power rate was given to the farmer the same as to the city user, and in the case of some farmers the rates are based on consumption. The monthly minimum is 5s. One had a line connected up and motor installed, but has the meter taken out for 9 or 10 months of the year, simply using the motor in August and September. This, of course, was very liberal treatment and certainly not a paying one for the power company so far as direct revenue from this particular power line was concerned. There was, however, some advantage gained from an advertising standpoint.

Another farm has a small motor-generator set installed for battery charging. One farm was the largest single user of electricity shown in the table, and this was explained by the fact that, in addition to operating a general business, this farmer also operates an ice-making plant. His brother farmers were thus kept supplied with this much needed commodity during the summer months. This is a good example not only for other central stations but for isolated farm communities as well.

A table is given of the number of machines installed. These include: milking, pumping and ice-making machines, in addition to bottle washers.

Two customers were gentlemen farmers with large main dwellings as well as a number of smaller buildings, all electrically lighted. Light is used, and both parties said they were well satisfied with the amount of their bills. In another the owner of the farm has been operating his own plant driven by a petrol engine, and was induced to change over to the central station service. He has been on the lines for only a few months, but was very much pleased, and claims his present cost for power is only half of what it was under the former system. Company No. 1 states that this is not an unusual experience among its customers.

The total connected farm power load was 412 H.P. or 307·35 kw. The total farm lighting load was 125 kw. The total load was 432·35 kw. The average connected load per rural customer was 3·46 kw. Total yearly kilowatt-hours for power 26,940. Total yearly kilowatt-hours for light 28,150. Total revenue £828. 10s. Average income per kilowatt-hour 4½d. The average horse power installed was 13·7. The average yearly revenue per power customer is £16. 4s. This includes the income for lighting for the same customers. The average yearly income per customer on the basis of 125 customers, including all power and light used, is £6. 12s. One writer in the West has stated that a rural customer is not a paying proposition until he averages nearly 15s. per month. From all the data obtainable in the present case, 15s. 9d. per month is the average minimum revenue per customer, and a fair profit did not show until the figure was close to 15s.

Company No. 2.

This company owns and operates two water-power plants, and has an agreement at the present time with Company No. 1 for emergency current.

Some of the present officers became interested in a local telephone company, the lines of which they constructed with great pains, using the same poles that belonged to the power company. This telephone company was later taken over by the Bell system, and one of the stipulations of the merger was that the power company should have the privilege of continuing and extending its lines on the poles of the telephone company in this section. It will readily be seen how impossible it was to charge up to the farmers the entire 32 miles of lines of this company. As a matter of fact, since it began operating, seven years ago, there have been constructed only 4¼ miles of pole lines, and this has been done to accommodate seven customers. It was fully expected, however, that more customers would be put on these lines very shortly. Current was also furnished for street and road lighting in the several boroughs through which the lines are run.

The company realised at once that the load would consist principally of farms; to make a success of its enterprise, it must make a fair profit; that the farmers wanted electricity and were willing to pay a reasonable rate for it. Therefore, the company arranged a special contract for farm customers, and when submitting this contract to prospective clients pointed out that farmers living in scattered communities could hardly expect to obtain first-class electric service at city rates without sharing part or all of the cost of the line if conditions warranted.

This contract provided that any service connections beyond 100 ft. should be paid for by the customer unless business warranted the power company assuming the cost. Several changes were made in the original contract, until it now provides that where the prospective business is not sufficient to warrant an extension at the company's expense, such extension will be installed by the company, but the customer guarantees revenues within two years to cover th cost of the extension. The customer must pay for and maintain his own transformer and disconnecting switch. The idea of this was that the farm load is very intermittent, and the load occasioned by the core loss in the idle transformers would be considerable. The disconnecting switch was conveniently mounted, and the customer kept this open when not using current, thus reducing the load on the station and protecting his transformer.

The base rate for lighting is 6·25d. per kilowatt-hour with a discount of 10 per cent. for prompt payment. Further discounts were available for bills amounting to £1 and over. The minimum charge for 1 to 15 lamps installed is 4s. 6d. per month; for 16 lamps or more 5s. 6d. per month, subject to 10 per cent. discount for prompt payment. Motors 1 H.P. and smaller were classed as lighting.

Cooking, heating, charging batteries and general motor service in excess of 1 H.P. were classed as power. The rates for power were as follows:—

1-H.P. to 6-H.P. motor	5s. 7d. per month	Or equivalent.
6-H.P. to 16-H.P. motor	11s. 1d. ,,	
16-H.P. to 31-H.P. motor	16s. 7d. ,,	

For prompt payment a discount of 10 per cent. was allowed.

There were 40 farm customers on the lines of this company. 30 of these used both light and power. The total motor load on the station is 325 H.P. of which 225 H.P. was distributed among these 30 customers, averaging 7½ H.P. each. This load would be 300 H.P. and the average 10 H.P. each, but for the fact that in the early stages of its work the company permitted the installation of a number of 5 H.P. and 7½ H.P. motors for general farm use. Later they adopted a standard of 10 H.P.

A table was next given showing the revenue per month and year.

For 40 farms, therefore, the total would be £578. The total average income per horse power (above 1 H.P. sizes) installed on the 30 farms is 22s. The total income for power (above 1 H.P.) alone would be £248. The farms on the lines of Company No. 2 are of the same class as those of Company No. 1; in fact, some of the farms on the separate lines adjoin each other. Three farms on No. 2 have their motors mounted on portable trucks. There were also about 200 flat irons, 100 vacuum cleaners and 50 washing machines, besides a large number of the different types of heating devices, distributed among the farm customers on the lines of No. 2.

Conclusion.

The experiences of these two stations should be of assistance to other central stations in so far as indicating that the farm load has its own special features and must be handled accordingly.

There was a question as to the size of motor to recommend for general farm purposes. The tendency was to keep the horse-power rating down, making the farmer operate his machines at lighter loads but for longer periods, instead of trying to cram all his work through the machine at one time.

The 15 H.P. motor seemed the favourite, with the 10 H.P. a close second, but as education progressed this latter size will doubtless become the most popular. Another point which should be borne in mind was, while a customer may start out using current for light only, and the revenue at first may be lower than the required average, experience showed it to be a question of but a short time before this customer added new devices and took power for driving his machines.

Attention was called to the fact that none of these customers employ irrigation, and it was considered that if electricity can pay without irrigation, it should be still more profitable where pumping was used.

ELECTRIC WIRING PRACTICE IN GERMANY UNDER WAR CONDITIONS.

The necessity for substituting other material for copper is receiving much attention in electrical circles in Germany as a result of the war, and the discussion of this subject has occupied considerable space in recent issues of the journal of the Society of Electrical Works. The substance of these discussions, from our contemporary the "Electrical world," is given below.

The difficulties both of a mechanical and an electrical nature associated with the employment of iron conductors in insulated wires and cables suggested the importance of finding a non-magnetic material of greater conductivity and increased flexibility. Of the available metals, zinc was the most promising electrically. Although in sheet form it is a common building material, zinc wire has scarcely ever been produced in large quantities, and there existed from the very start a fear that, in view of the great brittleness of the crystalline zinc, the production of wire would meet with difficulties. These were soon overcome sufficiently to enable wires to be produced from this material which, as regards mechanical quality, are only slightly inferior to copper wire. This has induced the Society of German Electrical Engineers to standardise, in addition to jacketed wires, which were frequently found to be too stiff, the so-called KGZ wires (zinc conductor with rubber insulation), which above all were to meet the lack of a material which could be drawn into conduit.

The use of zinc conductors was also permitted for jacketed wires (class MPZ), and was even recommended in the case of lead-covered cables. The great advantage of zinc as compared with iron consists in the carrying capacity of the former, which is more than double that of the latter; moreover, the zinc is non-magnetic, essentially more flexible and eliminates the problem of rust. In view of the novelty of the use of zinc wire, and because of the lack of experience in its treatment, wrong impressions were frequently formed among consumers as to the qualities of such material, especially as the zinc wire products first marketed were found deficient in certain cases.

It was first thought possible to manufacture zinc wire from the unworked pig zinc, but special treatment was soon found to be necessary in order to secure wire of sufficient tensile and bending strength. These manufacturing difficulties have now been overcome. Zinc wires are being produced and laid in large quantities, so that the wire and cable commissions consider it suitable to tabulate the special qualities of zinc, the way in which it differs from copper and its advantages over iron in the manner shown in Table II.

It is also noteworthy that the actual resistance of iron wire to alternating current is essentially greater than would be calculated from the conductivity.

The mechanical qualities of zinc wire depend upon the crystalline structure of the metal. The coarser the latter the more brittle and less resisting to bending action will be the wire, while an increase in the fineness of the structure will cause the metal to be more refined. If zinc wire is exposed for a fairly long time to temperatures exceeding 100°C., under certain circumstances changes in the structure can take place and the mechanical qualities of the wire can become deteriorated. Hence it is necessary to be cautious when heating zinc for any length of time to a higher temperature. So far nothing has been observed which would prove that changes in structure have a disadvantageous influence upon the electrical qualities of the zinc. Even if the solidity and bending strength are reduced, the electrical conductivity is not diminished. Local defects in the way of hollow and brittle places cannot wholly be avoided. It is well to keep in mind that corrosion may result in the use of zinc under unfavourable conditions.

Overhead Lines and 'Bus Bars.—German engineers hold that zinc wires or cables are not suitable for overhead lines, since mechanically weak places already existing, or which might be formed under atmospheric influence, might bring about breakage in view of the constant strain in overhead circuits. As a substitute for copper, only iron can be considered here for the time being.

'Bus bars, connecting lines and switching devices with bare conductors of zinc require little consideration, except that bending in 'bus bars should be effected with moderate warming of the bar to at most 100°C., and in case of a small radius a special segment is desirable. The connection of the various lengths can be effected by iron screws. Where moisture or fumes are liable to occur, varnishing with oil paint, paying special attention to points of connection, is essential.

The commission on installation and service regulations has decided, in agreement with the wire and cable commission, in view of the shortage of insulated wire of 1 sq. mm. section, to allow the use of insulated strand wire of 0·75 mm. section for stationary installations during the war, provided that the thickness of the insulation wall is at least 0·6 mm. and that the insulation consists of standard rubber.

Replacement of Copper in Electrical Machinery.—The machine standardising commission has taken up the question in what apparatus and to what extent copper can be replaced by zinc or iron. Mr. G. Dettmar, secretary-general of the society, has prepared preliminary notes upon this subject. He states that in many electrical machines the windings can be made entirely or partly of zinc wire and the commutators and collector rings of iron without fear of difficulties arising from this cause. Inasmuch as little operating experience is as yet available, such apparatus cannot receive guarantees of safe running applying to equipment of standard construction. Machines with zinc-wire windings should, therefore, be debarred from installations where failure in service must be absolutely excluded, as in plants used in military operations. Machines of special design are also not suitable for the application of substituting metals, including equipment exposed to particularly low or high temperatures as in open-air service. Careful provision for oversight in operation must be made in designing machines with iron commutators. The capacity of apparatus is reduced by the zinc winding, so that for machines with such construction higher prices will as a rule have to be charged for a given capacity than for the standard construction.

In Table III. data compiled by the wire and cable commission covering the loading of zinc cables are given. When laying cables in the open air, or when installing them in conduits or other unfavourable circumstances, it is recommended that the highest load be reduced to three-fourths of the values indicated in the table. Installation in places subjected to severe concussion must be avoided. The table is based on an excess temperature of 25°C., with permanent load and a laying depth of about 70 cm. The table applies

Table I.—*Limits of Capacity for Apparatus with Zinc Windings. Three-phase Transformers.*

Tension in volts.	Rating in k.v.a.	Tension in volts.	Rating in k.v.a.
Up to 130	0·10 to 250	3,000 to 5,000	3·50 to 250
130 to 260	0·15 to 250	5,000 to 10,000	7·50 to 250
260 to 550	0·35 to 250	10,000 to 15,000	10·00 to 250
550 to 1,000	0·75 to 250	15,000 to 20,000	15·00 to 250
1,000 to 3,000	2·00 to 250	20,000 to 30,000	30·00 to 250

From the above figures the German engineer decides for each case whether each wire, whether for primary or secondary winding or both, should be made of zinc. Single-phase transformers can be produced with zinc-wire windings for two-thirds the above rating limits.

Three-phase Generators and Synchronous Motors, with Rotating Field Windings of Zinc Wire.

Speeds from 375 to 1,000 revs. per min.

Output up to 150 k.v.a. for three-phase current and to 100 k.v.a. for single-phase current.

Direct-connected exciters must, on the whole, be given copper windings, as otherwise their output is not sufficient.

Induction Motors for 50 Cycles, with Stator and Rotor Windings of Zinc.

Speeds from 375 to 1,500 revs. per min. Potentials up to 5,000 volts.

For outputs of 3·7 kw. to 100 kw.

For outputs above 50 kw. it may at times be necessary to use copper windings in the rotor.

Direct-current Machines, above 100 volts. Armature Windings of Copper, Commutators of Iron, Field Windings of Zinc.

Tension in volts.	Kw. rating (calc. for 1,000 r.p.m.)
100 to 260	2 to 250
260 to 550	6 to 100

For other speeds the output changes in proportion to the number of revolutions. The maximum speeds are: Up to 50 kw., 2,000 revs. per min.; above 50 kw. to 100 kw., 1,500 revs. per min.; above 100 kw., 1,000 revs. per min.

In some cases, particularly in heavy current work or at high speeds, the commutator must be of copper for the above output.

Rotary Converters for 50 cycles, with Field Windings of Zinc, otherwise Copper (also for Damping Winding).

Tension, 100 to 550 volts.

Outputs of 10 kw. to 250 kw.

Table II.—*Electrical Properties of Wire Materials.*

	Copper wire.	Aluminium.	Zinc.	Iron.
Specific resistance at 20°C. in ohm mm^2/m.	0·0178	0·0306	0·0625	0·143
Conductivity at 20°C. in Siemens m/mm^2	56·2	32·7	16·0	7·0
Conductivity calculated for copper in per cent.	100	58·4	28·5	12·5
Coefficient of temperature for 1°C.	0·004	0·004	0·0039	0·0057

Table III.—*Loading Table for Zinc Cables.—Highest Permanently Admissible Current in Amperes when Lying in Ground.*

Cross-section mm².	Single conductor to 750 volts.	Twisted two-conductor cable to		Twisted three-conductor cable to		Twisted four-conductor cable to		Concentric two-conductor three-conductor to	
		3,000 volts.	10,000 volts.	3,000 volts.	10,000 volts.	3,000 volts.	10,000 volts.	3,000 volts.	3,000 volts.
1·0	12	10	...	9	...	8	...	...	...
1·5	16	13	...	12	...	10	...	...	...
2·5	22	17	...	15	...	14	...	...	...
4·0	29	22	...	19	...	18	...	...	...
6·0	37	28	...	25	...	23	...	...	...
10	50	37	34	35	32	30	29	37	29
16	70	50	48	45	42	40	37	48	40
25	90	65	60	59	56	53	50	65	53
35·0	110	80	75	70	65	65	60	75	65
50·0	135	100	95	90	85	80	75	95	80
70·0	170	120	115	105	100	100	90	115	100
95·0	205	145	135	125	120	115	110	145	115
120·0	240	165	155	145	135	130	125	165	135
150·0	270	190	175	165	160	155	145	190	155
185·0	305	215	200	190	180	175	165	215	175
240·0	355	250	...	225	...	205	...	250	205
310·0	420	290	...	260	...	235	...	295	240
400·0	485	340	...	305	...	...	...	345	380
500·0	555	...	...	...	...	...	...	...	...
625·0	635	...	...	...	...	...	...	...	...
800·0	740	...	...	...	...	...	...	...	...
1000·0	850	...	...	...	...	...	...	...	...

so long as no more than two cables are laid side by side in the same ditch. Central conductors which are laid separately are not taken into consideration in this connection.

As regards prices, representatives of the cable factories stated in a recent conference that the elaboration of zinc from the raw pig zinc to the wire represents an expense of 125 marks to 150 marks per 100 kg., while the same cost for copper amounts to 15 marks. If one takes into consideration the increased prices of raw materials required for cable manufacture, and assumes that the refined zinc costs about 70 marks per 100 kg., then the cable with the zinc conductors costs from 100 to 150 per cent. more than copper cable of the same section used to cost prior to the war, and it must be expected that these prices will rise still further in the future. The lead used for cables is already being requisitioned in part, and it is feared that it will not be available in a very short time. The use of zinc cables is not considered desirable except where absolutely necessary.

Dwelling-house Installations.—Upon the suggestion of Mr. Schlebach, of the Society of Middle-Rhenish Electrical Works, the regulations covering dwelling-house installations to be carried out during war time have been revised by a committee of the society. Particular attention is called to the novel points of view concerning the calculations of mains covered by the regulations.

1. Only line material standardised or approved by the Society of German Electrical Engineers is to be used.

2. Higher losses of voltage than allowed so far are to be permitted in the installations as follows: Up to 5 per cent. in lighting installations and up to 6 per cent. in power installations. The cross-sections of mains are to be calculated, taking into consideration the voltage drop so far admitted, and the cross-sections thus obtained are to be multiplied by 2·5 for iron mains and by 1·5 for zinc.

3. In calculating the cross-section of the mains the following loading proportions are to be used as a basis :—

(*a*) For lighting installations—

Feeder.—For one circuit, 6 amperes. For dwelling houses with several circuits, 6 amperes for each circuit ; as load for the feeder, however, only 75 per cent. of the total connecting rating. For business houses and stores, for each circuit 6 amperes. High-candle-power lamps—*i.e.*, over 50 c.p.—must be calculated at their actual watt consumption.

Distributing Lines.—For dwelling and business houses, each lamp provided shall be calculated at 40 watts, but high candle-power lamps shall be accurately figured.

(*b*) For power installations—

In the case of motors, the power of the working current shall be calculated in lieu of the power of the starting current.

Submitting of plans—

These are to be simplified as much as possible, and for otherwise clearly defined and comparatively small installations in lieu of ground plans only switching diagrams or sketches should be required.

It has been agreed between the Society of Electrical Works and the manufacturers of insulated wires that hereafter all zinc wires insulated with rubber regenerate shall be identified with a special light-green standard thread.

NOTES ON DESIGN OF ELECTROMAGNETIC MACHINES.

I. CONTINUOUS-CURRENT MACHINES.

BY STANLEY PARKER SMITH, D.Sc.

(*Continued from page 362.*)

Summary.—In the first part of the article the author deals with the principles underlying the design of continuous-current machines, and in the second part he applies these principles to the design of a 350 kw., 500-volt generator running at 200 revs. per min.

5. Conversion of Energy in the Continuous-current Machine.

We now pass on to the second underlying principle on which all electromagnetic machines are based, namely, the mechanical force exerted by a magnetic field on a conductor traversed by an electric current. In all machines built according to the heteropolar arrangement the expression for this force assumes a very simple form, namely,

$$F = B \,.\, I \,.\, L \,.\, 10^{-1} \text{ dynes per conductor,} \quad . \quad . \quad (12)$$

where I denotes the current in amperes flowing in the conductor of length L cm. lying in the magnetic field of density B lines per square centimetre. The direction of the field is perpendicular to that of the conductors, and the direction of the force due to the interaction is perpendicular to both. Thus, if the field and the conductors lie in the planes X and Y respectively, then the force F acts along the plane Z. This is illustrated in Fig. 8.

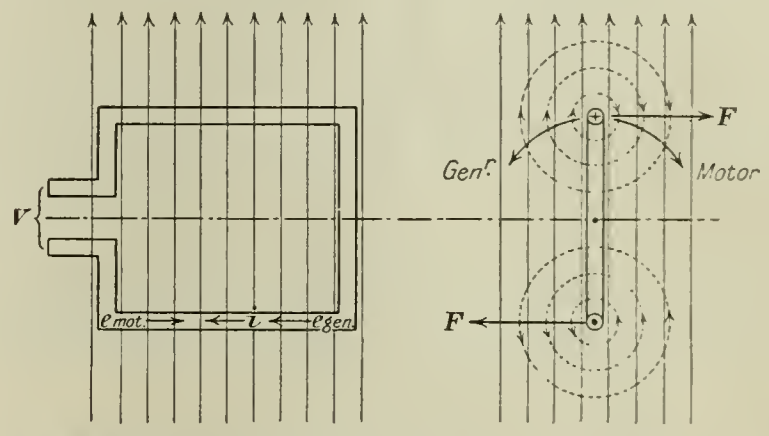


Fig. 8.—Mechanical Force Exerted on a Coil Carrying Current. Illustrating Principle of Generator and Motor.
(+ and • denote current.)

If the current and field are varying, the force F will be the instantaneous value, and to find the mean value—on which the power depends—the law of variation must be known. In the case of a continuous-current machine, however, each conductor carries the steady current $I_a = I/2a$, where I is the total current and $2a$ is the number of armature circuits in parallel. If the brushes are fixed in the neutral zone, so that the conductors lie in a field of mean density B_{mean} = flux per pole/area of pole-pitch $= \Phi/YL$, then the total pull on the Z conductors in the winding is

$$F = ZB_{mean} I_a L 10^{-1} \text{ dynes.} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

This is constant, since both B_{mean} and I_a are constant, and is independent of the speed of the machine.

The power is then

$$\begin{aligned} P &= F \,.\, v = F \,.\, \pi D n \text{ ergs per second} \\ &= Z\, B_{mean} I_a L 10^{-1} \,.\, 2pYn \,.\, 10^{-7} \text{ watts} \\ &= Y\, L\, B_{mean} \,.\, Zn \,.\, 2p \,.\, \frac{I}{2a} 10^{-8} \\ &= \frac{p}{a} n\, Z \Phi 10^{-8} . I \\ &= E \,.\, I \text{ watts.} \quad [\textit{See} \text{ equation (7).}] \quad . \quad . \quad (14) \end{aligned}$$

We thus see the relation between the mechanical power Fv and the electric power EI. When the pressure E produces the current I the direction of rotation is against the force F (*see* Fig. 8), and the mechanical power Fv is converted into the electrical power EI. This is the case of an electric generator. When the force F produces the motion, the induced pressure E opposes the current I, which is maintained by an externally

applied pressure V. The electrical energy VI is then converted into the mechanical work Fv, and we have an electric motor.

Another way of writing this relation, which is of more service to the designer, is as follows :—

$$\begin{aligned} P &= F \,.\, v \\ &= B_{\text{mean}} Z I_a L \pi D n 10^{-8} \text{ watts} \\ &= B_{\text{mean}}\, \pi D a c L \pi D n 10^{-8} \\ &= \pi^2 B_{\text{mean}} a c \,.\, D^2 L n 10^{-11} \text{ kw.}, \quad . \quad . \quad . \quad (15) \end{aligned}$$

where $ac = ZI_a/\pi D$ = ampere-conductors per centimetre of armature periphery.

B_{mean} and ac can be called the specific magnetic and electric loadings respectively. These are just as useful to the designer of the electrical parts as a knowledge of stresses and strains is to the designer of the mechanical parts. In large machines ac may be as high as 400, whilst B_{mean} sometimes reaches values of the order of 7,000, but experience is the only safe guide in fixing these specific quantities to conform with the permissible limits of heating, sparking, &c. A knowledge of ac and B_{mean} is also extremely useful in comparing machines of different makers, and they are very easily found when the leading dimensions of the machines in question are known.

Equation (15) is often used in the form

$$\frac{P \,.\, 10^5}{D^2 L n} = \pi^2 a c B_{\text{mean}} 10^{-6} = C. \quad . \quad . \quad . \quad . \quad . \quad (16)$$

C is frequently called the output coefficient, but can logically be called the torque coefficient, as suggested by Hawkins, since P/n denotes the torque for any given D^2L.

For each type of electromagnetic machine an expression similar to that in equation (15) can be deduced, the only difference being in the value of the constant. The advantage of designing machines in this way is that we start directly from first principles, and only need to know the permissible values of B_{mean} and ac in order to find the output obtainable from any given armature.

Since $B_{\text{mean}} = k_f \,.\, B_{\text{max.}}$, where the factor k_f depends on the ratio pole-arc : pole-pitch and the shape of the B-curve, B_{mean} in equation (16) can be replaced by $k_f B_{\text{max.}}$, a form preferred by many designers.

6. Commutation and Commutating Poles.

From a theoretical point of view the subject of commutation is one of the most difficult that the engineer has to deal with. One of the chief sources of trouble in dealing with the problem of commutation analytically arises from our ignorance of, or our inability to take into account, the rapid fluctuations occurring at the sliding contact between carbon and commutator and the magnetic pulsations due to the teeth. In consequence of this it is practically impossible to predict the shape of the current curve during reversal, and we have to rely very largely on practical experience when designing the parts of a machine which affect commutation ; indeed, it is not too much to say that most of the progress made is due to the good experience obtained with the carbon brush. At the same time it must not be concluded that theoretical investigations of this subject lead to entirely futile results ; such a view is at once dispelled by following the careful studies that have been made on commutation by Arnold, Hawkins and many other writers. Nevertheless, it is quite probable that the mode of attack adopted in future investigations will be materially different, and will rely much more on experiment to determine involved and intricate relations. For our present purpose we shall confine ourselves to a brief discussion of the practical side of the question.

Ideal commutation is said to occur when the current in a coil changes from its steady value in one direction to its steady value in the other direction at a constant rate during the period of reversal. This ideal reversal of the current is called straight-line commutation. It does not follow that straight-line commutation is necessary for satisfactory working, but it is clear that when the current does reverse in this manner the reversal is completed by the time the coil is about to leave the brush, so that no spark can be produced by a sudden change of current. Whilst the current is changing its direction the coil is short-circuited by a brush, and since E.M.F.s are generally induced in the coil during the period of commutation it is possible and usual for circulating currents to flow through the path provided by the coil and the brush, thus causing the curve of current in the coils undergoing commutation to deviate from a straight line. The reversal of the current is delayed by two causes.

Effect of Inductance.—The first cause retarding the reversal of the current is the inductance of the coil, which sets up a back E.M.F. opposing any change in the value of the current. This can be overcome by an opposing E.M.F. induced by rotation in a commutating field of suitable sign and strength. The necessary sign of the commutating field is easily seen from the following consideration. Imagine a coil-side about to leave a north pole and enter the commutating zone. Taking the case of a generator, the current in the coil-side at this instant is due to the influence of a north pole. When commutation commences, therefore, the E.M.F. of self-induction will tend to maintain the current in this direction, so that to neutralise it the coil-side must move in a south pole field to induce an opposing pressure by rotation. Similarly, a coil-side leaving a south pole must move under the influence of north pole flux to produce an E.M.F. to counteract the E.M.F. of self-induction. The auxiliary pressure produced by the commutating flux to assist commutation is called the commutating E.M.F.

We thus see that in a generator the coils undergoing commutation should move in a field of the same sign as the main pole following. In a motor, where the current is reversed, the sign of the commutating flux must be reversed.

The action of the commutating flux in assisting the reversal of the current can be compared with cushioning in a steam engine.

Effect of Armature Field.—The other cause tending to retard commutation arises from the E.M.F. induced in the short-circuited coils by rotation in the field due to the armature current. If we consider the fluxes in a generator on load, Fig. 9, we see that the armature current produces a flux in the brush axis, the direction of which, with respect to the armature, is the same as the flux in the preceding pole. This is just the opposite from what is needed for the commutating flux to neutralise the E.M.F. of self-induction, and indeed aggravates matters, for now, in addition to the back E.M.F. of self-induction, the short-circuited conductors move in a field of the wrong sign. Thus both inductance and the armature field retard the reversal of the current.

The Retarding Pressure.—Let e_s denote the instantaneous value of the E.M.F. of self-induction, and e_a that of the E.M.F. induced in the short-circuited coils by rotation in the armature flux, then ignoring all other effects, the pressure retarding commutation, or in short, the retarding E.M.F will be

$$e_r = e_s + e_a. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

Both these counter pressures are obviously dependent upon the load or current, and can be expressed as follows :

$$e_s = -L_s \frac{di}{dt}$$

and

$$e_a = 2 T_c v L B_a 10^{-8},$$

where L_s denotes the apparent inductance of the short-circuited coil (including mutual induction) and B_a the strength of the armature flux at the place where the coil is moving at the instant considered. A full-pitch coil is assumed.

If only one coil had to be considered, e_s and e_a might be estimated without difficulty, as shown by Hawkins in "The Dynamo," but actually a brush must cover 2 to 3 segments, so that 3 to 4 coils are short-circuited simultaneously by a brush. This makes the problem very complicated to deal with analytically, and it is only possible to attack it indirectly.

The usual way of treating the problem of several coils short-circuited together is to estimate the difference of potential set up between the brush tips, because the currents circulating in the coils undergoing commutation are dependent upon this

potential difference. It is most likely that the release of the energy due to the circulating currents and the retarding pressure is the cause of sparking; for when a coil leaves the brush, the current in it must instantly assume its steady value.

A simple, rough and ready means of checking the commutation conditions of the machine is to calculate what is called the reactance pressure E_s, or the mean value of the E.M.F. of self-induction, the calculation of the actual pressure e_s not being possible owing to our ignorance of the function the current i obeys.

If the current changes from $+I_a$ to $-I_a$ in time T, the mean E.M.F. of self-induction E_s will be

$$E_s = L_s \frac{2I_a}{T} 10^{-8}.$$

For the inductance L_s we can write $L_s = T_c \Sigma L_x \lambda_x = T_c L \lambda'$, where λ' is the fictitious specific permeance taken over the core-length L.

We then get
$$E_s = 2T_c L \lambda' \frac{I_a}{T} 10^{-8}. \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Now time T = distance/velocity = s/v, and if for I_a/s we substitute ac, the amperes per unit length of armature periphery, we shall have

$$E_s = 2T_c v L \lambda ac 10^{-8}, \quad . \quad . \quad . \quad . \quad . \quad (19)$$

where λ is the corresponding specific permeance.

The attention of designers was directed to the great importance of the reactance pressure by Hobart, who also gave simple approximate methods of finding $\Sigma L_x \lambda_x$.

It is doubtless the simplicity and handiness of this method, combined with the absence of a simple, better method, that makes it so popular among designers, despite its incompleteness.

To take e_a into account a suitable addition can be made to λ.

Calculated in this way it is possible to give certain limiting values for E_s in equation (18) or (19), for definite grades of carbon brushes when used on certain types of machines; but the utmost caution must be exercised in the use of this method, which at its best should be regarded rather as a comparison between machines of like constants than an actual determination.

Regarding the value of λ in equation (19), it can be said to lie between 4 and 9, depending largely on the number of bars covered by a brush. With a brush-width equal to two to three segments, a common value for λ is 6 to 8.

The Commutating Pressure.—To obtain ideal commutation, if the resistance of the short-circuit were negligible, it would be necessary to have $e_c = -e_r$ at every instant during the period of commutation. Actually, the best that can be hoped for is to make the mean values E_r and E_c approximately equal and trust to the carbon brushes to keep the circulating currents within permissible limits.

To produce the commutating pressure E_c, the short-circuited coils must move in a field

$$E_c = 2T_c v L_c B_c 10^{-8}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

where L_c is the length over which the commutating field of density B_c extends. Since E_r depends mainly on the load or ac, the commutating flux should be practically proportional to the current.

There are two common ways of obtaining the requisite commutating flux. The older and simpler method is to shift the brushes out of the geometrical neutral zone into the region where the main flux has the needful sign and strength. In accordance with the rule just established, therefore, the brushes must be rocked in the direction of rotation in the case of a generator, and backwards in the case of a motor. The other way—better, but more expensive—of obtaining the commutating field, is to provide a commutating or interpole. This is situated in the geometrical neutral zone and excited to give a field of the right direction and strength.

Where the commutating field is obtained by shifting the brushes, the field M.M.F. must overcome the armature M.M.F. To get the required value of B_c, therefore, the brushes must be rocked further and further from the geometrical zone as the load or armature M.M.F. increases, to bring them under a stronger field M.M.F. Nowadays, however, fixed brush position is almost invariably called for, so that the machine usually works with the brushes clamped in the best position for the mean load. The parts must then be designed so that the pressure induced in the short-circuited coils will never be sufficient to send strong enough circulating currents through the brushes to cause sparking under any working conditions. To attain this, it is needful to keep down as far as possible everything that tends to increase e_r—thus the number of turns per coil must be kept small, the field ampere-turns must be large compared with the armature ampere-turns, and the magnetic loading high compared with the electric loading; also suitable carbons must be used. These restrictions often necessitate a reduction in the rating, and it is common experience that the sparking limit in a continuous-current machine is reached earlier than the heating limit. It is this fact that often leads to the adoption of interpoles, which remove most of the restrictions enumerated.

In the case of reversible motors (such as traction and crane motors) without interpoles, the conditions become still more stringent, because here the brushes must be fixed in the geometrical neutral zone, and the resistance of the carbons alone must be relied upon to suppress sparking.

The tendency of modern practice leads more and more to the use of interpoles, for in addition to the removal of numerous limitations in the design, interpoles are a great commercial

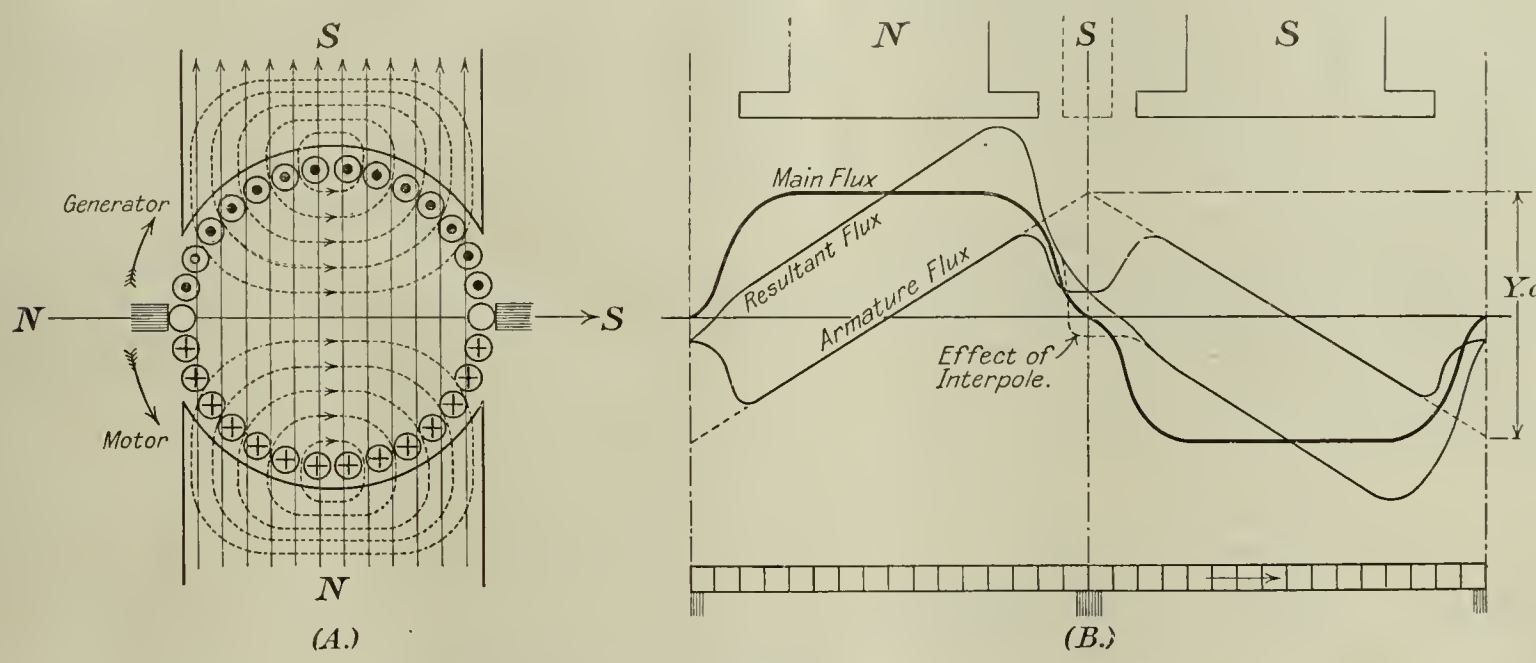


FIG. 9.—ARMATURE REACTION IN CONTINUOUS-CURRENT MACHINE.

(A) Full lines denote flux due to field current.
Dotted ,, ,, ,, ,, armature current.
(B) Resultant flux in generator and effect of interpole.

asset and often help the machine to pass the test unhindered, thereby improving a firm's deliveries and reputation. Compared with the advantages of increased output, reliable working, &c., the extra cost and poorer ventilation due to the interpoles is seldom important.

In the case of an interpole design, it is possible to make B_c fairly well proportional to the load by exciting the commutating poles by means of a series winding, if care is taken to avoid saturation within the working range. By adjusting λ suitably to make $E_s=E_r$, we get from equations (19) and (20), $B_cL_c=ac\lambda L$,

or $$B_c=ac\lambda L/L_c \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

Design of Commutating Poles.—To find the requisite ampere-turns for the interpoles, it is seen from Fig. 9 that the total armature ampere-turns must be neutralised before the commutating flux can be produced In addition to this, ampere-turns are needed to drive the commutating flux through the magnetic circuit, so that the total ampere-turns for a complete magnetic path or pair of the interpoles will be

$$AT_{cp}=Y\,.\,ac+AT_c \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

The ampere-turns, AT_c, needed for the flux are about 20 to 30 per cent. of the total ampere-turns AT_{cp}, and some firms make a practice of adding 25 per cent. to the armature reaction $Y\,.\,ac$, whilst others ignore the iron and merely calculate AT_c as the ampere-turns required to send B_c through the air-gap.

Regarding the width of the interpole, much depends on the shape of the curve we wish the current in the short-circuited coils to follow. For example, Miles Walker prefers this to be a sine curve, so that the rate of reversal of the current is much lower at the start and finish of the period of commutation than in the middle of this period, and for this purpose makes the coil-span one slot-pitch shorter than the pole-pitch and the width of the interpole equal to a slot-pitch.* The author has had no experience with this method, and prefers to design the interpoles to give straight-line commutation—a method which he has found always to yield satisfactory results. In this case, it is necessary for the coil to move in the commutating field of density B_c so long as it is short-circuited.

The time of short-circuit of a coil is as follows (*see* Hawkins, "The Dynamo," Vol. II.):

$$T=\frac{b_1+y_1\left(1-\frac{a}{p}\right)}{v_c}$$

where b_1=brush-width, y_1=segment-pitch and v_c=peripheral speed of the commutator. Hence the distance passed through by a coil during the reversal of the current is

$$T\,.\,v_c=b_1+y_1\left(1-\frac{a}{p}\right).$$

This refers to the commutator surface, and for the coil-side on the armature surface, the distance traversed during short-circuit is

$$T\,.\,v=\frac{D}{D_c}\left\{b_1+y_1\left(1-\frac{a}{p}\right)\right\}.$$

Since, however, there are usually several coil-sides concentrated in a slot, the coil-sides are displaced from the mean position they would occupy if they were distributed uniformly over the circumference. To prevent coil-sides leaving the commutating zone, therefore, before they leave the brush, it is usual to add a slot-pitch y_s to the width $T\,.\,v$, so that the width for the commutating pole-shoe becomes

$$b_c=\frac{D}{D_c}\left\{b_1+y_1\left(1-\frac{a}{p}\right)\right\}+y_s. \quad . \quad . \quad . \quad . \quad . \quad (23)$$

The value for b_c given by this formula is usually somewhat less than two slot-pitches, and if it be remarked that this is on the large side, we may reply that it is on the safe side and less likely to be influenced by magnetic oscillations due to the teeth. Of course, the pole need not be so wide as b_c' if a shoe is used.

(To be continued.)

* *See* Walker, "The Design and Specification of Dynamo-electric Machinery," p. 481.

ANNUAL GENERAL MEETING OF THE I.M.E.A.

The annual meeting of the Incorporated Municipal Electrical Association was held at the Institution of Electrical Engineers, London, on Friday last, Mr. A. C. Cramb, borough electrical engineer, Croydon, presiding.

Mr. R. A. Chattock (Birmingham), referring to the Model General Conditions of Contract, said the Council were instructed to lay this matter before the Association of Municipal Corporations, and to report the result. The four B.E.A.M.A. clauses were discussed, but although they had been pressing ever since they could get nothing definite from the Association of Municipal Associations. Three years had passed, and he thought it inadvisable to let the matter go on unsettled. The Model Conditions of the Institution of Electrical Engineers had since been published and accepted by the B.E.A.M.A.; the I.M.E.A. was the only body holding out, purely on instructions received from the members. He thought they now should rescind this instruction and accept the conditions adopted by the Institution of Electrical Engineers. Individual buyers could vary the conditions to suit their own cases; therefore, he could see no objection to trying them for, at any rate, a year or two. Many Corporations were already working to them, without difficulty so far as could be ascertained. He, therefore, moved that they be accepted provisionally and tried for a year or two.

Mr. H. Faraday Proctor (Bristol), seconding, said Bristol had accepted the conditions and worked to them. It was open for engineers to depart from them if desired. Considerable time and expense in framing conditions were saved by having only one form.

Mr. A. Blackman (Sunderland) said he regretted he could not see eye to eye with many of his fellow members of the Council in advising these conditions. A great deal was taken out of the engineers' or purchasers' hands. Buying intricate electrical machinery was very different to dealing in bricks and mortar, and a great deal depended upon tests which could not be undertaken until the machinery was erected. The plant was delivered in pieces, and a large proportion of the contract price then paid. Developments in turbo-electric machinery were still very rapid. What would be the position if, after paying 80 per cent. of its value, the machine did not comply with the tests? He did not agree that individual buyers could vary the conditions. The contractor would immediately argue that they were unreasonable persons to deal with, and that the reasonableness of the conditions was shown by the fact that their own Municipal Association accepted them.

Mr. C. C. Atchison (Rochdale) said that he understood that the matter had been attended to by the Association of Municipal Corporations, who were mainly concerned with the legal aspect. He understood that the general conditions had been knocked into shape, and that a sub-committee of the Law Committee of the Association of Municipal Corporations was dealing with them. He did not think the members of the I.M.E.A. should pass any resolution at that meeting.

Mr. F. W. Purse (Carlisle) associated himself with the two previous speakers, and

Mr. A. Nichols Moore (Newport, Mon.) remarked that he could find nothing in the annual report to lead them to suppose that such a resolution would be brought forward. It ought not to have been sprung upon the members. Now that German and Austrian competition had been removed, it was more than ever necessary that there should be some conditions different if possible to those put forward to enable the small undertaking men to hold their own. The big undertakings could get what they wanted, but the small ones had to take what they could get. He submitted that the matter be postponed to the end of the war.

Mr. T. Roles (Bradford) said the matter had been sprung upon the committee five minutes before the meeting. He did not agree with them, and voted against them on the Council.

Mr. J. A. Robertson (Salford) said they were living in abnormal times, and just now had to take pretty well the conditions imposed upon them by the war. While the matter had been remitted to the Association of Municipal Corporations, he did not think they would take them even if recommended to do so by that body.

In deference to the opinions which had been expressed, the resolution was then withdrawn on the motion of Mr. R. A. Chattock.

The question of coal supplies was then dealt with.

Mr. R. A. Chattock (Birmingham) said the steamer traffic was now easier, but so far the local committees appointed by the Board of Trade had no authority to commandeer and distribute coal where it was wanted. There was still anxiety and difficulty in entering into contracts and ensuring a proper supply for public utility undertakings. The sub-committee was still considering the matter with the idea of again approaching the Government to urge that further steps be taken. They had a meeting 10 days previously on the subject, and communications had been sent in to the Government.

Ald. Sinclair (Swansea) said that at the last meeting previous to the Convention he mentioned the question of running contracts, and Bailie Smith pressed the point, with the result that in the Limitations of Coal Bill a clause was inserted which had saved the Swansea undertaking £1,000. He desired to thank the Council for the action they had taken in the matter, especially mentioning Bailie Smith's name.

Mr. F. W. Purse, referring to the constitution of the Council, contended that the smaller undertakings should have a larger representation. In 1913 the Council reported that they were of opinion that a scheme should be evolved which would bring in a continuous flow of fresh blood. He had nothing to say against the individual members of Council, but thought the honours should go round. They had heard the previous day

of super-stations and supermen; he supposed the small stations were likely to be superimposed and their engineers superseded. (Laughter.)

Mr. A. Nichols Moore, speaking as engineer of a small undertaking, or, as he preferred to put it, of the general body of members, supported Mr. Purse's views. If the Association was to progress, no doubt, increased subscriptions would be asked for; 70 per cent. of these subscriptions came from the general body of members. To ensure progress and retain status as an official body it was essential to have the larger men, who formed a very powerful minority, but let there be a reasonable proportion on the Council representative of the majority.

Mr. C. Turnbull (Tynemouth) deprecated any bitterness in the question, and said the Council had served them very well and deserved their gratitude. He felt that the majority should be from large stations, in order that the Association should have status. At the same time, many of the small stations were now getting as big as the big stations used to be, and the council would do well to follow the method of the Institution, and apportion the representation to some extent amongst stations according to size.

Mr. Faraday Proctor pointed out that the Council were in the hands of the members. The smaller undertakings predominated, and every member had an equal vote.

Mr. S. J. Watson (Bury) said that as he understood Mr. Purse the smaller undertakings felt they had a grievance, inasmuch as, by reason of their smallness, they were little known, and consequently had little chance of being elected to the council, and further, by reason of their being unable to become council members, they were unable to go forward to any of the higher positions. He felt they had something of a grievance. On the other hand, the matter appealed to him in a different way. A small undertaking might next year become of moderate size, and the change of output from year to year would make it difficult to put a scheme into operation. The membership was roughly split up into three or four types of authorities—cities, county boroughs, boroughs and urban district councils—each of which had to deal with any given point on rather different lines. If any change were made in the method of election he suggested it should be somewhat on these lines.

Other members having spoken, Mr. Atchison moved: "That the Council be requested to reconsider the constitution of the council with a view to giving proportionate representation to cities, county boroughs, non-county boroughs, urban district councils and rural district councils."

Mr. H. R. Burnett (Barrow-in-Furness) moved as an amendment: "That one-third of the new engineer members of council elected annually shall be members who have not previously served on the council." This was lost, and

Mr. E. E. Hoadley (Maidstone) moved a further amendment: "That the council be requested to sympathetically consider the representation of the smaller undertakings on the lines of giving representation to undertakings with less than 50,000 inhabitants."

Mr. G. Wilkinson (Harrogate) suggested that as the council had heard the views of the members the matter should now be left in their hands to be dealt with. This course was adopted.

A resolution instructing the Council to make the necessary alterations in the articles to provide for a postal ballot, proposed by Mr. Purse, was carried.

Mr. Atchison, on the subject of British trade after the war, regretted the action of the council, and said that the Congress in Paris had practically cut the ground from under their feet.

The President: We say that local authorities should not be compelled to do something for the protection of manufacturers which private concerns are not compelled to do; we want to be in the same position as the private company.

Mr. T. Roles (Bradford) said the matter affected our Allies as much as our enemies. Everyone would try to get all they could from British manufacturers, but if it were made a close trade, with Government departments and municipalities especially and with the proposed conditions of contract, they all knew what would happen.

Ald. Walker (Manchester) moved: "That this Convention of the I.M.E.A. urges the Government to take adequate steps to deal with the industrial situation which will arise immediately peace is declared. The members attending the Convention represent the electricity supply departments of public authorities in which many millions of public money is invested, and the prosperity of these departments is dependent upon the prosperity of the manufacturing and commercial sections of the community." They did not want to drift into peace in the same way as they had drifted into war, and the Convention should lend its weight and influence to get the Government to take the necessary steps.

Mr. R. A. Chattock seconded the resolution.

Ald. Smith (Liverpool) asked: Why the Government? Why not do something themselves? They did not drift into the war; they were shoved into it, and would be shoved into peace. (Laughter.) If they did not mind they would be shoved into a most unsatisfactory peace. (Hear, hear.) They had through their council an enormous weight of public opinion, and ought to make representations to the Government, but he did not believe in resting upon anyone else. They must themselves put heart and soul into the job, so as to be ready for peace when it came.

Mr. H. Dickinson (Liverpool) agreed with Ald. Smith, who he thought, however, did not go far enough. The association ought to do what it could to encourage trade after the war. It was necessary to educate the Government to change its attitude towards trade questions. The Government possessed enormous power, and could do anything within the bounds of practical politics. If that power were used to encourage trade, they would see a great advancement in the trade of the country. Under the old conditions the municipalities had been under a pall, which had created an over-cautiousness. This had gone on for so long that it had become almost a habit. Government encouragement would be of enormous benefit to the country, and if the matter were taken up quickly there would be no slackness after the war, but rather a boom in trade. (Hear, hear.)

Ald. Jones (Kilmarnock) said, unfortunately, they were pushed into the war an unorganised nation. They had had to set their house in order, and had been nearly two years getting ready to oppose forces which had been organising for over 30 years. They had assisted in organising Germany by their trade with that country. If the Government did not act, buyers would again be after the best bargains, whether from Germany or elsewhere. It was their business to support the Government, and get them to take action. We had plenty of friends in the colonies and our Allies, and he wished to support the resolution.

The resolution was carried unanimously, and it was decided that copies be sent to the Board of Trade and to the Premier.

Mr. W. Wyld (Hampstead), on the subject of financial organisation, moved: "That this association views with concern the repeated attempts made by the financial departments of various municipalities to encroach upon the work of the trading departments, and is of opinion that it is necessary that the books and accounts should be kept by the departments concerned if the work is to be efficiently and economically carried out, and that any proposed legislation in a contrary direction should be strenuously opposed."—Carried.

Mr. Faraday Proctor said the Hackney undertaking had corresponded with reference to the alleged preferential charging brought against them by the local gas company. The case was the exact converse to that of Long Eaton. It was alleged that the undertaking showed preference by allowing lighting consumers a lower rate of charge when power was taken as well; Long Eaton reduced the charge for power when lighting was also taken. If the case was fought it was desirable that the association in general meeting should promise their moral support to Hackney, and also, if need be, financial support. He proposed a resolution in these terms, which Mr. J. E. Edgcome (Kingston-upon-Thames) seconded, and it was carried.

The matter of the extension of loan periods, on account of the condition arising owing to the war, was also discussed, but a resolution on the subject was defeated.

The following Council were elected:—

I.M.E.A. Council, 1916-17.

President.—Mr. F. M. Long (Norwich).
Senior Vice-President.—Mr. S. J. Watson (Bury).
Junior Vice-President.—Mr. F. Ayton (Ipswich).
Immediate Past Presidents.—Messrs. G. Wilkinson (Harrogate), R. A. Chattock (Birmingham), H. Richardson (Dundee), A. C. Cramb (Croydon).
Hon. Solicitor.—Ald. G. Pearson (Bristol).
Hon. Secretary.—Mr. H. Faraday Proctor (Bristol).
Hon. Treasurer.—Mr. J. E. Edgcome (Kingston-upon-Thames).
Members of Council.—Engineers: Messrs. J. W. Beauchamp (West Ham), A. S. Blackman (Sunderland), W. A. Vignoles (Grimsby), W. W. Lackie (Glasgow), S. L. Pearce (Manchester), S. E. Britton (Chester), J. Christie (Brighton), S. T. Allen (Wolverhampton), H. W. Bowden (Poplar). *Committee Representatives:* Councillor Crowther (Sheffield), Bailie W. B. Smith (Glasgow), Councillor H. R. Barge (Poplar), Ald. Sir J. Beecham (St. Helens), Councillor Sinclair (Swansea), Ald. Walker (Manchester).

In regard to the place of meeting for 1917, owing to the war, it was decided to leave this matter in the hands of the President and Council.

The report of the Electric Vehicle Committee, abstracted on p. 433, was not discussed, probably owing to so much time having been given to other important matters and the members wishing to bring the Convention to a close without the necessity of extending it to another meeting after the adjournment for lunch.

Votes of thanks to the retiring President and to the Institution for again allowing the members to meet in their building brought a very successful Convention to a close.

ANNUAL REPORT.

Model General Conditions of Contract.—The British Electrical & Allied Manufacturers' Association have expressed the hope that the Association would now recognise the Institution of Electrical Engineers' conditions as standard. The Council have, however, been unable to take any further steps in the matter pending the receipt of the report of the Association of Municipal Corporations.

I.M.E.A. Bill.—At the suggestion of the B.E.A.M.A., joint meetings of representatives of the Association, the B.E.A.M.A. and the Electrical Contractors' Association have been held, at which it was believed that a completed settlement agreeable to all parties had been arrived at. After reference to the full Councils of the respective Associations, however, the E.C.A. finally declined to continue negotiations and decided to oppose the Bill so long as powers to sell are retained therein.

Engineering Standards Committee.—At the last annual meeting an appeal was made to representatives of the Committees present to contribute more liberally to the funds of the Engineering Standards Committee, and shortly afterwards the Association issued an appeal to its members, the result of which was a substantial addition to the subscriptions from municipalities to that Committee. The Association also renewed its donation of £21.

The Association is represented on the following sectional Committees, Sub-committees and panels of the Engineering Standards Committee :—

Sectional Committee and B.N.C. Standardisation of Rules for Electrical Machinery	R. A. Chattock and A. H. Seabrook J. Christie.
Electric Lamps	S. E. Fedden and G. Wilkinson.
Electric Power Cables	A. C. Cramb and W. Wyld.
Electrical Accessories	A. C. Cramb and A. H. Seabrook.
Prime Movers	F. M. Long & H. Faraday Proctor.
Panels of the Sub-committee on Electrical Accessories :—	
(*a*) Plugs	A. C. Cramb and A. H. Seabrook.
(*b*) Switches	A. C. Cramb.
(*c*) Fuses	W. Wyld.
(*d*) Heating and Cooking	A. H. Seabrook.
(*e*) Carbon brushes, control gear and electric vehicle accessories	F. Ayton.
(*i*) Meter Panel	J. W. Beauchamp.

Eastbourne Accident and the Board of Trade.—The Council have had under consideration the report of the Electrical Adviser to the Board of Trade on the subject of the fatal accident which occurred on Dec. 26th last, arising out of the collision of a motor car with a switch pillar. At the request of the Eastbourne Electricity Committee, the Council received Mr. Fovargue, the town clerk, and Mr. Brydges, the electrical engineer, who, after laying before the Council certain information with regard to the matter, expressed a desire that the Council should approach the Board of Trade with a view to getting the recommendations contained in the above-mentioned report modified. The question is still engaging the attention of the Council.

Coal Supplies.—On the invitation of the Institution of Electrical Engineers the Association appointed Mr. Chattock as their representative to attend a national conference of representatives of the gas and electrical industries for the purpose of considering the question of coal supplies on May 6, 1915.

As a result of the deliberation a deputation of 34 representatives was appointed to present the case to Members of Parliament, asking for their assistance in urging the Government to give effect to the recommendations passed at the meeting, calling for increased output, railway transit facilities and proper regard to the requirements of public utility undertakings dependent upon their supplies on sea-borne coal, when requisitioning coal steamers. At a further meeting of the members of the deputation a sub-committee was appointed on which the Association was represented by Mr. R. A. Chattock. Bailie Smith, a member of the I.M.E.A. Council, took a prominent part in the negotiations with the Coal Export Committee, and subsequently he was successful in getting an amendment made to the Price of Coal (Limitation) Bill, giving power to public utility undertakings to have the Bill made retrospective to include already placed contracts.

The whole question of coal supply was referred to a sub-committee, and in March, 1916, a summary of the report and recommendations of the sub-committee, which had been adopted by the Council, was communicated to the members. This was to the effect :—

(*a*) That a stated case was being considered by the Board of Trade on the question of price under the Price of Coal (Limitation) Act, 1915, but no decision had then been received.

(*b*) That the response to the circular letter sent out by the secretary with regard to the supply of coal, showed that while there had been, in many cases, serious difficulty in getting the necessary supply, there was a serious shortage in connection with a few undertakings only.

(*c*) That the Board of Trade had, on Feb. 7, 1916, instituted Committees on Coal and Coke Supplies in 11 districts throughout the country as follows :—

(1) Scotland ; (2) Northumberland ; (3) Durham ; (4) Cumberland ; (5) Lancashire, Cheshire and North Wales ; (6) West Yorkshire ; (7) South Yorkshire ; (8) Nottingham, Derby and Leicester ; (9) Staffordshire, Warwickshire and Shropshire ; (10) South Wales ; (11) Somersetshire, Forest of Dean and Bristol Coalfield.

(*d*) That the business of these Committees is to see that the resources of their respective districts are used to the best advantage, and that the requirements of important industries are fully met. A parent Committee was formed by the Right Hon. Walter Runciman, President of the Board of Trade, to consider all questions relating to the distribution of coal and coke that may be referred to it from time to time by the Board of Trade, or submitted by the Coal and Coke Committee of any district.

(*e*) That the Committee recommended that local authorities should approach their local Committee on the supply of coal and coke.

(*f*) That the Association had approached the Board of Trade, urging them to restrict the exportation of small coal and to limit exportation to large bunker coal, and the Board of Trade state that they were bringing the communication before the District Committees on the Supply of Coal and Coke.

Since the District Committees have got to work it has become evident that they have very little power to obtain coal for public utility undertakings, and this appears to be due to the fact that there are no legal powers for this conferred upon the Board of Trade. Steps have therefore been taken to urge upon the Government the desirability of giving the Board of Trade powers to distribute coal where it is required, and to organise local coal for local use as far as possible, and so relieve congestion on the railways. It was also urged that more steamers should be provided to bring coal down from the North to the South of England.

The Sub-committee is continuing its work and dealing with inquiries from members.

The Council.—The Council elected Ald. Miller, of Croydon, a member of their body for the current year, and appointed Councillor S. Evans, of Sheffield, to fill a vacancy caused by the death of the late Councillor Crowther, of Sheffield. The Council have had under consideration a communication from Mr. Purse (member), of Carlisle, making observations on the constitution of the Council, and some suggestions having for their object more particularly a definite representation of the smaller undertakings on the Council, and the substitution of a postal ballot for the present procedure.

The Council believe that satisfactory representation is gained under the existing articles of association. The opinion of members will be taken at the annual meeting upon the question of the suggested postal ballot.

Institution of Electrical Engineers' Wiring Rules.—The Institution Wiring Rules Committee, on which the Association has two representatives, have again revised the Rules and invited the Council of the Association to give their adhesion thereto. This the Council have done, but with the recommendation that the Rules should be re-arranged, so as to distinguish regulations from recommendations. At the same time the Council made suggestions or amendments for further revision.

British Trade after the War.—The Council have had before them the report of the Sub-committee of the Advisory Committee of the Board of Trade on Commercial Intelligence, with respect to measures for securing the position, after the war, of certain branches of British industry, and after having given the report careful consideration unanimously passed the following resolution :—

> "That this Council, while being anxious in every way to encourage British Trade and the purchase of home manufactures, and being prepared heartily to support measures taken to this end by legislation or otherwise, view with deep concern recommendation 6 (*b*) of the Sub-committee of the Advisory Committee of the Board of Trade to the effect that :
>
> "'All Government departments, local authorities and statutory bodies entrusted with the control of monies raised by taxes or rates, should be under legal obligation to purchase, so far as possible, only goods produced within the British Empire.'
>
> "The Council is strongly of the opinion that in the event of this recommendation being adopted, the interests of municipal electrical undertakings and their consumers—which latter embrace some of the largest manufacturing concerns in the country—will be seriously jeopardised, and that municipalities should in no way be subjected to any restrictions with regard to the purchase of plant and materials other than those imposed on private concerns."

Copies of this resolution were sent to the Institution of Electrical Engineers, the Association of Municipal Corporations and other interested bodies.

Honorary Treasurer's Report.—The chief features of the accounts are a reduction in the cost of postages, printing and stationery, and in general expenses. The income from subscriptions remains stationary, and there is a decrease in the income from sales and advertisements derived from the "Proceedings." The net result is a surplus for the year of £77, as against £62 last year. The balance-sheet shows a slight decrease in the liabilities and a surplus of assets over liabilities of £926.

In regard to the Parliamentary expenses, applications are being made to those municipalities who have promised financial support with a view to the amount already expended being refunded to the Association.

Development Committee.—Owing to circumstances caused by the war, the Development Committee have for the time being suspended their activities.

National Association of Local Government Officers.—The Association was represented at the annual general meeting by Mr. Edgcome and Mr. Wyld. The question of the Superannuation Bill upon which the National Association of Local Government Officers were in communication with the Local Government Board, was discussed, but little progress can be made unless the larger municipalities support the proposal.

Financial Organisation.—As a result of the Council having received a number of communications from engineer members intimating that difficulties were being experienced by them in efficiently managing the undertakings for which they are responsible, by reason of the systems of financial control adopted by the local authorities owning such undertakings, it was decided that the matter was of such importance as to warrant the appointment of a Special Sub-committee to consider the whole question and to report thereon.

The Sub-Committee came to the conclusion that the difficulties experienced were common to all municipally-owned trading departments, and that the matter could better be dealt with by a joint Committee composed of members of various interests concerned. To this end the co-operation of the Municipal Tramways Association, the Municipal Waterworks Association and the Institution of Gas Engineers was invited, with the result that these bodies have appointed representatives to serve on a joint Committee, and meetings of the Committee so formed are being held.

A request has been forwarded to all engineer members of the Incorporated Municipal Electrical Association to submit to the Honorary Secretary of the Sub-Committee particulars of troubles which are being experienced by them in connection with the financial control of the undertakings with which they are connected. A considerable number of replies have been received, and will be considered by the joint Committee at an early date. The matter being one of equal importance to the chairmen and members of Electricity Committees as to the engineer members, the Council have recently strengthened the Sub-Committee by the addition of three "Chairmen" members.

REPORT OF THE ELECTRIC VEHICLE COMMITTEE OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

Five meetings of the Committee have been held, all of them in London. The Committee elected the following as its officers for the year :—

Chairman, R. A. Chattock ; Hon. Secretary, F. Ayton ; Hon. Treasurer, J. Christie ; Chairman of the Technical Sub-Committee, R. A. Chattock ; Acting Hon. Secretary of the Technical Sub-Committee, J. Christie ; Chairman of the Commercial Sub-Committee, A. H. Seabrook ; Hon. Editor of the "Electric Vehicle," A. H. Seabrook.

The secretary of the Association, Mr. McArthur Butler, attends the meetings of the Committee officially on behalf of the Association, and the Committee are indebted to him for much valuable assistance. The work of the Committee during the period dealt with by this report has covered the following :—

Publication of the "Electric Vehicle."—The "Electric Vehicle" has been regularly brought out quarterly, and the Committee feel satisfied that it is proving a valuable means of educating the public as to the advantages of the electric vehicle for the different purposes for which it is specially recommended. Its success seems to be clearly proved by the fact that the circulation is increasing among regular subscribers who are now numbered in all parts of the world.

Lamps on Electric Vehicles.—The Committee jointly with representatives of the Tungsten Lamp Association, have considered the question of the sizes of bulbs, and the voltage of incandescent lamps for use on electric vehicles. The result of the joint deliberation was the issuing of a recommendation that the standard voltage should be considered as 12 volts, the lamps to be coupled across a section of six cells in a lead-plate battery or the equivalent number in a nickel-iron-alkali battery. It was recommended that the sizes of bulbs should be those fixed by the British Engineering Standards Committee in their report, No. 69.

Equipments for Charging Electric Vehicles.—The Committee gave considerable attention to the preparation of a pamphlet in which their recommendations as to the most suitable plant to use were embodied. This pamphlet was issued with the September number of the "Electric Vehicle."

Standardisation in Relation to Lead-Acid Accumulators.—At the suggestion of the Committee this matter was gone into by the Accumulator Makers' Section of the B.E.A.M.A., with the result that the accumulator makers have agreed to the following as the maximum overall sizes. These sizes will be known as "E.V.C." Standards : For all sizes the maximum width of the cell shall be $6\frac{5}{16}$ in. (163 mm.) and the maximum overall height, including connector, $14\frac{7}{8}$ in. (378 mm.). The maximum length of the smallest size, *i.e.*, that with seven plates, shall be $2\frac{7}{16}$ in. (62 mm.) with the addition of $\frac{5}{8}$ in. (16 mm.) for each pair of plates above seven plates. An exception is in the case of the Chloride Accumulator Co.'s "Ironclad-Exide" type of cell in connection with which the length of the seven-plate size is $2\frac{3}{4}$ in. (70 mm.) with the addition of $\frac{3}{4}$ in. (19 mm.) for each pair of plates above seven plates.

A Standard rating for lead-acid electric vehicle cells known as "E.V.C." Standard Rating has also been agreed to and is as follows : "E.V.C." Standard Rating shall be the capacity in ampere-hours obtained by a continuous discharge at a uniform rate for a period of five hours until the voltage of the cell falls to 1·7. Example : If a battery is specified to have an "E.V.C." Standard Rating of 180 ampere-hours, it means that the battery will give this capacity when discharged at a continuous rate of 36 amperes for a period of five hours, at the end of which time the voltage per cell shall not have fallen below 1·7 volts.

It is desirable to add that other points that have been standardised in relation to lead-acid accumulators, some of them being in the Committee's previous report, are as follows :—

"*E.V.C.*" *Standard Plates.*—Height, $8\frac{5}{8}$ in. (219 mm.) ; width, $5\frac{3}{4}$ in. (146 mm.) ; lug centres, $4\frac{3}{8}$ in. (111 mm.).

"*E.V.C.*" *Standard Inspection Plug.*—Shall be that which will fit a hole in the cover of the cell, 1 in. (25·4 mm.) in diameter.

"*E.V.C.*" *Standard Charging Voltage.*—Shall be that which is suitable for charging 44 lead-acid cells, *i.e.*, 85 to 120 volts. This voltage is also suitable for charging 60 cells of the nickel-iron-alkali type.

Standard Charging Plug and Receptacle.—This design, so far as the dimensions of the contacts are concerned, has now been adopted as a standard by the British Engineering Standards Committee and the specification of same has been published and can be obtained from the Secretary of that Committee, 28, Victoria-street, Westminster, S.W.

The Committee has been in communication with representative electrical engineers in our Colonies with a view to the British Electric Vehicle Standards being adopted throughout the British Empire.

Tyre and Road Wear Research Committee of the Motor Manufacturers and Traders' Society.—The Committee received an invitation during the year to elect a representative to sit on this Committee and the invitation was accepted. The Committee place on record their appreciation of the courtesy of the Society in inviting their co-operation in this important work.

Financial Support.—The Committee are again deeply indebted to municipalities, electric supply companies, manufacturing firms and others for financial assistance (£141. 17s.) given during this year.

The Electric Vehicle Association of America.—This Association has now ceased to exist as a separate body. Its members have been absorbed into the National Electric Light Association of America, which has a membership of about 14,000. The N.E.L.A. has formed an Electric Vehicle Section and this Committee is affiliated with that section through the membership of the secretary. The Committee desire to place on record their indebtedness for the amount of useful information which has been so courteously supplied to it during the past year by the energetic secretary of the Electric Vehicle Association of America, Mr. A. Jackson Marshall.

Accounts.—Attached to the report was the audited statement of accounts and balance-sheet.

During the year the following additional bodies have become represented on the Committee :—

Garage Proprietors ; Institution of Municipal and County Engineers ; Municipal Tramways Association ; Light Railways and Tramways Association ; British Electrical Federation (Ltd.).

It is satisfactory to note that many new vehicles have been put into commission during the year so that at the present time, the estimate of vehicles in use in the United Kingdom is in the neighbourhood of about 680. This number includes 48 electric warehouse or works trucks, the use of which is likely to considerably extend in the near future. It is noteworthy that 33 municipalities operate between them, or have on order 78 vehicles. The total number of vehicles quoted above shows an increase during the 12 months of 197 vehicles.

The Committee take the opportunity of expressing their thanks to the hon. secretary, Mr. F. Ayton, for the very able and efficient manner in which he has handled the work of the Committee.

BREAKDOWNS OF ELECTRICAL MACHINERY.

We give below an abstract from a Paper on this subject, which was read recently by Mr. C. S. Buyers before the Scientific Society of the Royal Technical College, Glasgow. The Paper deals with faults due to faulty design or materials, unsuitable conditions of working, and failures due to external causes such as lightning, flooding or fires. Seventy-five per cent. of the breakdowns are stated to be due to unsuitable conditions of working. With regard to faulty manufacture the necessity for ample clearance between the rotors of induction motors and the stator is pointed out. In steel works with overhead wires it is stated that during thunderstorms it is advisable to shut down the electric plant, as lightning arresters are unreliable, the 'bus bars being connected to earth. The necessity for having a motor accessible and well lighted is insisted upon quite rightly, and back-geared motors are not considered satisfactory on account of vibration and oil throwing. It is considered a wise plan to run direct-current machinery at 10 to 20 per cent. below full load, as the "wear and tear" is then considerably reduced. With induction motors, however, these should be run at approximately full load. The various types of "dirts" which cause breakdowns are given as moisture, oil, carbon dust, metal, chips, filings or turnings, sawdust, wool or cotton fluff, cement and coal dust, and acids, chemical fumes and exhaust gases. The effect of moisture on insulators, such as presspahn, is next discussed, and the necessity for dryness in such cases indicated. This is particularly important in shipyards, collieries and iron works where motors work in exposed positions. A too liberal use of oil is considered as likely to cause trouble, and a case is referred to where the bearings were lubricated three times a day and the overflow being plugged up ; a breakdown quickly ensued in the armature coils and two bottom field coils of the motor. To prevent overfilling of the bearings a snag should be cast on the outside of the bearing housing at the proper oil level. This should be filled with a small hinged lid and have a $\frac{3}{8}$ in. diameter hole to prevent it getting easily choked with dirt. Air filters dry and wet are dealt with, and the use is recommended of a small blower for cleaning. The trouble caused by ventilating fans drawing dust into enclosed motors is referred to ; open motors without fans in such cases are to be preferred.

In order to prevent fine particles of copper flying off from the tools and getting on to the commutator lugs when trueing the commutator, it is advisable to cut a piece of millboard the same diameter as the armature coil. A circular hole the same diameter as the commutator is then cut in it, and it is pushed tightly up against the front of the lugs. After turning, the main segments should be carefully examined and any copper particles removed, the windings should also be blown through with compressed air, or by a pair of bellows.

With regard to bearings the oil should be renewed and the sludge in the oil chamber cleared out. The life of an open-type motor in a sulphuric acid factory is stated to be a very short one, and the author recommends totally-enclosed motors with tightly fitting doors closed by sheds and wing nets. The armature windings and field coils should receive three coats of anti-sulphuric enamel. Other exposed parts should receive one coat. Alternating-current motors should be treated similarly, and switches should preferably be enclosed in a wooden case with glass front and operated from outside.

In gas engine installations tarry matter is stated to deposit on the back of the commutator and cause trouble. In such cases the generator should be so designed as to afford no collecting places for dirt of this description. Finally regular inspection and insurance of plant is recommended.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*

Advertisement Rates, &c., forwarded on application.

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Nearly Ready.* 15s. nett, post free 15s. 6d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

"THE ELECTRICIAN" PRIMERS (84 Primers in all, and a GLOSSARY). Single Primers 3d. each post free. *In One Complete Vol., 10s. 6d. nett, or Three Separate Vols. (Vol. I. 3s. 6d. nett ; Vol. II., 6s. nett ; Vol. III., 4s. 6d. nett).* Prospectus free. The Primers are revised or re-written as new printings are called for, and new Primers are added from time to time. Five New Primers: Gas Engines (No. 52), Oil Engines (No. 52A), Common Battery Telegraphs (No. 60A), Electric Clocks (No. 79), Electric Impulse Dials (No. 79A), now ready. Revised Primers, 1914 and 1915: No. 29 (Management of Dynamos and Electric Machinery); No. 46 (House Wiring for Electric Light) ; No. 63 (Repairing Submarine Telegraph Cables); No. 42 (Electric Ignition) ; No. 49 (Steam Engines) ; No. 54 (Comparative Advantages of Steam and Producer Gas for Power Production) ; No. 59 (Diplex and Quadruplex Telegraphy) ; No. 61 (Automatic Telegraphic Apparatus).

ELECTRIC TRACTION ON RAILWAYS. By Philip Dawson, M.I.C.E., M.I.E.E., &c. Handsomely bound ; fully illustrated. Price 25s. nett, postage 6d. U.K., abroad, 1s. 6d.

SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson. M.I.E.E. *New Edition in preparation.*

ELECTRICAL LABORATORY NOTES AND FORMS. Arranged by Dr. J. A. Fleming, M.A., F.R.S. Single copies 4d. nett, or in dozens at 3s. 6d. nett. Complete Sets of 50 Notes and Forms, 12s. 6d. nett, or in strong portfolio, 14s. nett ; or bound in strong cloth, 15s. nett. Spare Copies of Tabular Sheets, 1s. per dozen. Portfolios, 1s. 6d. each. Sectional paper, 1s. per dozen sheets. *Complete Prospectus post free on request.* These Notes and Forms are kept revised as new printings are required.

HANDBOOK OF THE ELECTRICAL LABORATORY & TESTING ROOM. Very fully illustrated. By Dr. J. A. Fleming. *Revised Editions.* Vol. I., 12s. 6d. nett. Vol. II., 14s. nett.

SECONDARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.

THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.

INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903). Full Report of Proceedings at, 8s. 6d. ; post free, 8s. 9d. ; abroad, 9s.

INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.

BRAKES FOR TRAMWAY CARS. By H. M. Sayers. Price 2s. 6d. nett.

A RELIABLE WORK OF REFERENCE.

THE LOCALIZATION OF FAULTS IN ELECTRIC LIGHT AND POWER MAINS.
By F. C. RAPHAEL.

THIRD EDITION: *Now Ready.* Price **8s. 6d.** nett, post free **9s.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

REFLECTIONS ON TRADE AND TRADERS.

If the passing of resolutions entitled us to the bulk of the trade of our enemies, the latter, long ere this, would have been anxious to secure peace on any conditions we cared to impose in order to make certain of a few of the crumbs which fall from the rich man's table ; but the passing of resolutions, the holding of Paris Conferences and the like, neither entitle us to a share of the trade of the enemy nor ensure that our people will be as prosperous after the war as they were before.

The ostracising of a neighbour who has put himself outside the pale of civilisation is only beneficial to us as long as we are able to provide for ourselves. Experience shows that if our neighbour be powerful enough and clever enough we submit to all sorts of indignities in order to enjoy the fruits of his cleverness. The fact that it is necessary for the State to impose a heavy tax on war profits leads one to the conclusion that the so-called holy fire of patriotism, about which so much is said in these days, takes a poor second place in some cases in comparison with the desire to become rich quickly and *at any cost.* For at what greater cost can a man become rich than at the expense of his country ? To such an extent are patriotism and profit synonymous with some that we fear our people, particularly those who were prosperous under the old "Made in Germany" conditions, will not be content in the future with the kind of patriotism which demands rigid frugality and necessitates more laborious toil. That those who were prosperous under the old conditions will find fault with the recommendations made at the Paris Conference in regard to trade with the enemy powers during the war and after peace is proclaimed will become evident during the next few months.

Although we deny that such conferences alone will bring about a much to be desired result, we are strongly of the opinion that lasting good will result from an immediate attempt to test the soundness of the recommendations by preparing to put them into practice. By so doing we shall discover the weak places in our organisations in time to strengthen them sufficiently to withstand the pressure of the oncoming economic struggle. Our manufacturers and merchants have been subjected to the pressure of economic struggle long enough to know the meaning of such pressure, and they, for the most part, are aware that it is not within the power of the State to relieve them to any appreciable extent. Not only must the desire for reform come from the manufacturer, but he must also make the reforms for himself in order to derive, to the full, the benefits which the recommendations made at the Paris Conference are intended to confer. Even if reforms mean the making of temporary sacrifice, this should act more as an incentive than as a deterrent, seeing that countless thousands of our people and of the people of our Allies have made the greatest sacrifice of all without thought or hope of monetary gain.

We doubt whether it is yet fully realised to what extent we have depended in the past on Germany and friendly neutrals for the tools and raw materials of our industries. It is highly discreditable to us as a nation of engineers that we have relied upon these countries to meet the ever-increasing demand for automatic machinery of all kinds, and precision tools in particular. It is cruel irony that machines of enemy manufacture should be working day and night on shells, and other engines of war, intended to

annihilate the enemy; that chemical processes of enemy origin should be worked with the same object in view; that the clothing of our soldiers and sailors should be dyed with enemy dyestuffs and manufactured in machines of enemy design and construction; that heavy cranes should have been erected in our steel works and shipyards by our enemies, and should now be working for the destruction of the enemy; and that after nearly two years of war the enemy should still be in our midst and should be allowed to live at our expense, and work to the detriment of our own people.

Our readers will remember that we recently referred to the haste shown by the Americans in regard to preparedness. Our contemporary, the "Electrical World," under the heading "Preparedness Propaganda," describes part of the anatomy of the preparedness programme in the following terms:—

"American industry, around which all preparedness talk should centre, is . . . often lost sight of. Defence propaganda, while it kindles the slumbering fires of patriotism and calls for pure and unalloyed Americanism, is not the entire spinal column of the preparedness programme. Industrial self-reliance, opportunity for American genius, American products and American workmen are important vertebræ. Any programme for national defence in time of war that does not involve social and economic security in time of peace is sadly deficient in meeting the nation's needs, and it is well that the two political parties in convention this week should ask that the American shield protect against destruction by foreign competition as well as from the raiders, political or otherwise, at home. We need preparedness not so much from European armies and navies as from European manufacturers, and we should also be on the look-out for wider markets."

Beyond expressing the pious wish that the American shield shall be more successful in protecting American trade in the future than it has been in the past in protecting American traders, we do not propose to play the part of surgeon by dissecting the programme.

It is to be hoped that the Allies, working in concert, will be able to devise some scheme which will enable them to keep out not only the Germans, but also the Americans. Seeing that the United States have received such enormous financial benefits by the war, it will be difficult to frame a scheme that will prevent the American underselling us in our own markets by a process vulgarly known as dumping, but the position is becoming more hopeful, as our manufacturers are beginning to show signs that they are alive to the danger. If the German finds that he can get no footing in this country for his goods he will invest his capital in America, and the American, priding himself on what he pleases to call his "smartness," will do the German's work for him at a price. Fortunately, the British Empire of itself is a very considerable market, and the countries over which the Allies have control represent a large part of the earth's surface. To supply these markets will keep us and our Allies busy till such time as our manufacturers and merchants are prepared to enter wider markets.

THE WORK OF S. P. THOMPSON.

The writer has been asked to say something on the scientific work of Silvanus Thompson. To one who has been associated with him for many years and who reveres his memory, the first feeling is that of strong disinclination. He would rather confine himself to reminiscences of the youthful professor—for Thompson was always young—who was kind as a fairy godmother, and who made all his contemporaries love him by the spell of that very kindness. There was a time—not so very long ago—when professors were not *personæ gratæ* at the Institution of Electrical Engineers, but Thompson was always a notable exception. He lived a life full of varied interests, and the many columns of the catalogue of the British Museum library enumerating his works are an excellent testimony to his well-spent life. To discuss his life's work fully in a brief article is impossible, and so the writer will confine himself to those aspects of his work with which he is familiar.

Electricians are in the habit of referring to Prof. Thompson as Silvanus Thompson, partly as a term of endearment, and partly to distinguish him from those other great pioneers of the electrical industry Sir William Thomson (Lord Kelvin) and Prof. Elihu Thomson. The first letter the writer ever got from Prof. Thompson began in this way:—

"*Imprimis*, why do you Professor me? Is not Thompson good enough?" In what follows, therefore, he will drop the title.

The best or at least that part of Thompson's work which was of most immediate value in his lifetime was done in connection with electrical engineering. The publication in 1884 of "Dynamo-electric Machinery: a Manual for Students of Electrotechnics," marks an important epoch in the history of the electrical industry. We wonder whether there is a single designer of electrical machines who has not gleaned his first information in the subject from this work. In the numerous editions and expansions of the book which have appeared Thompson improved and amplified much of the first edition. Still the first edition contains nearly all that matters, and the theorems and ideas incorporated in it are still to be found in all the recently published books on design.

The success of the book was instantaneous. It was much appreciated in the universities, and many young men were first attracted to engineering studies by reading this work. In the preface the author carefully pointed out that the mathematical theory of the dynamo could only be written when the true basis on which it should be founded is discovered. This basis is the exact law of the induction of magnetism in the core of an electromagnet. To many writers this had proved an insuperable obstacle. But Thompson proved that notwithstanding this limitation an approximate theory could be given which was of the greatest value in practical design. The theory is limited and so it is not exact in the same way that many theorems in astronomy are exact. Hence, doubtless in the old days it came under the ban of the Board of Mathematical Studies at Cambridge.

In his early years Thompson fully appreciated the experimentalists, but he was not unnaturally prejudiced against some of the mathematical electricians who thought that no one had the right to express an opinion on electrical matters unless he had studied the difficult theories advanced by Clerk Maxwell in his wonderful book on "Electricity and Magnetism." In other words, unless one had spent years in studying higher mathematics he was not supposed to be qualified to discuss electrical matters. This preposterous claim Thompson would not admit, and so for some time two schools arose whose work proceeded in parallel lines, but without the benefit of mutual co-operation. In later years, however, happier relations were established and mutual concessions led to more harmonious working. On the one side, it was admitted that the mathematicians were in the main right, and that some modern theories of ions were built, as Thompson humorously said, on "facty as opposed to fictitious foundations." On the other side, the mathematicians admitted that the experimental discoveries were a long way in advance of their theories.

The work of Thompson's which had the greatest success was his "Elementary Lessons in Electricity and Magnetism," published in 1881. The writer remembers using it as a text book for first year medical students at Cambridge in 1887, and how admirably it answered its purpose. The almost unrivalled demand there has been for this work all over the world is strong evidence of its excellence.

In 1890 Thompson delivered the Cantor Lectures to the Society of Arts, the subject being the electromagnet and electromagnetic mechanisms. He subsequently expanded the lectures into a book, which was published in 1891. It also contains a chapter on the use of the electromagnet in surgery, by his brother, Dr. J. Tatham Thompson, of Cardiff. The book is admirably lucid, and many difficult problems are successfully attacked. In several cases also his conclusions have

formed the starting point for other investigators, and the good seed he sowed has borne abundant fruit.

In 1898 Thompson read a very valuable Paper to the Institution of Electrical Engineers on "Rotatory Converters." The writer never heard anyone expound a difficult subject in a more lucid way, and no small part of our present knowledge of the subject was first given in this Paper. In 1899 he was elected President of the Institution, a post which he most worthily filled. Much of the advice which he gave in his Presidential Address has been adopted by the Institution. He advocated both the mutual co-operation of scientific workers and the combination of electrical engineers in active union. "When we speak," he said, "in the name of the united profession, with the weight of the whole industry to emphasise our views" we can accomplish much for the good of the profession and also for the country.

At the Glasgow meeting of the Institution in 1912 Thompson read a very valuable Paper on "The Magnetism of Permanent Magnets." He pointed out that the production of magnet steel was a branch of business which even more than the manufacture of tool steel depends on the co-operation of science with industry, and gave a most excellent *resume* of the work that had previously been done. As chairman of the Research Committee of the Institution he had the pleasure of initiating many researches, some of which have proved most useful to the industry.

In the battle of continuous-current versus alternating-current systems Thompson was the protagonist. He felt most strongly on the way the managers of the Metropolitan Railway decided on whether they should use continuous or alternating current. He was most scornful about the so-called experiments on electric traction on this railway. In his opinion it was simply a throwing away of £30,000. When one can predict absolutely what is going to happen, surely it is pure waste to go to the cost of making the experiment.

In 1887 Oliver Heaviside published a Paper on "Electromagnetic Induction and its Propagation" in THE ELECTRICIAN (Vol. XIX., p. 79). Thompson was most interested in the methods described in this Paper for annulling distributed capacity by means of inductance and leakage. He thoroughly appreciated the importance of the problem Heaviside had solved, and set about perfecting methods for diminishing the distortion of the electromagnetic waves in cables. One of these methods—the Thompson method—consists in inserting inductive shunt circuits or leaks either across the two lines of the cable or between the line and the earth. It undoubtedly equalises the "attenuation" at different frequencies, and so improves the clearness of the articulation. Unfortunately, however it greatly diminishes the loudness of the sound. The method is a perfectly valid one, and may be useful in certain cases. Pupin's method, however, perfected some years later, is the one now usually adopted in practice. In this method inductive or "loading" coils are inserted at intervals in series in the line. Thompson was the earliest pioneer of ocean telephony, and his Paper read to the Electrical Congress meeting at Chicago in 1893 attracted world-wide attention.

Thompson's ingenious system of electric traction by surface contact studs was described by Miles Walker in a Paper to the Institution in 1899. If this country had proved more inimical to overhead wires, doubtless this system would have been largely used. He had entirely obviated the danger of the studs being left alive after the car had passed over them.

Thompson had strong views on the supreme importance of technical education to the welfare of the nation. In 1879 he published a pamphlet on "Apprenticeship: Scientific and Unscientific," which embodies much of what now has become common practice. The success of his teaching is proved by the many eminent electricians who were educated at Finsbury. Nothing gave Thompson greater pleasure than the success of his old pupils.

The writer has had the pleasure of sitting on many committees with Thompson, but one in which Thompson took the foremost part stands out pre-eminently—namely, the Committee on Nomenclature—of which Mr. Trotter was chairman. Surely never did a committee work harder. Mr. Trotter, Mr. Duddell and Prof. Thompson seemed untrammelled by conventional ideas about time, and worked unremittingly in making lists of definitions and sifting all the numerous foreign lists, taking care to lose nothing that was good. Yet Thompson said that in the early days of the Physical Society they would have regarded this as mere child's play. In those strenuous times week-ends had not been invented, and they used to work all Saturday afternoons. From his point of view, I am afraid he must have thought many of us slackers.

As a popular lecturer Silvanus Thompson was unrivalled. Some 20 years ago he gave a lecture in the Carpenter's Hall on the future of electricity, in which he described in a most entrancing way the industrial revolution that would ensue when electricity was used universally. The hygienic factories, the workpeople conveyed rapidly to their suburban homes, the small manufacturer, with the aid of cheap power and assisted by his family, well able to compete successfully with the factory, the absence of smoke, the roof gardens, &c., were all described in the most realistic and convincing way. One felt that electricity was on the point of revolutionising the world.

In optics, more particularly in photometry, Thompson took the greatest delight. Some years ago he had to give expert evidence at the Law Courts as to the relative merits of various types of reflectors. The writer remembers him coming to the Faraday House laboratories to check the numbers obtained by the various experts. It was an education in itself to see how he verified their figures and tested them in every possible way. He also showed at the Physical Society on more than one occasion ingenious and novel laboratory methods of making optical measurements. His Christmas lectures at the Royal Institution in 1896 were published in book form under the title "Light Visible and Invisible," and have given pleasure to a very wide circle of readers. He translated Lummer's "Contributions to Photographic Optics" and Huygen's "Treatise on Light."

Silvanus Thompson loved music and had a very accurate musical ear. He translated the "Physical Foundations of Music," by Koenig, and was always pleased to discuss problems in sound. The valuable Paper on "Hysteresis Loops and Lissajous' Figures" which he read to the Physical Society in 1910, was a happy mixture of magnetism, sound and mathematical theorems.

In solving mathematical problems and inventing new mathematical methods he took the keenest delight. He was highly pleased when he had simplified some abstruse mathematical theorem until it could be comprehended by everybody. He could instruct and keep an unmathematical class interested even when discussing higher mathematics. He did most excellent work in simplifying "Practical Harmonic Analysis." At first he adopted Runge's method, and made some notable improvements on it; but he was dissatisfied with the accuracy obtainable. He then perfected the "series method" of harmonic analysis with which his name will always be associated. I remember how pleased he was when he first discovered it, and with what mutual pleasure we discussed it. He made most careful and elaborate calculations to test its accuracy and find out its limitations. He has left the method to us as a finished and polished tool well capable of doing its work and needing no special skill in its application. In hyperbolic trigonometry he took a keen interest, and I think that at one time he meditated writing a little treatise on the subject. He much appreciated the lectures which Dr. Kennelly of Harvard gave at the Institution some years ago. In proposing a vote of thanks to him he expressed himself as usual, most happily. He said that he felt constrained to exclaim "Great is the Hyperbolic Angle and Kennelly is its prophet."

As a biographer of scientific men Thompson will always be in the highest rank. The "Life of William Thomson, Baron Kelvin of Largs," is a model of painstaking accuracy and lucidity. The writer having had the fortune to be an old pupil of Kelvin's, and to be in full sympathy with his work, naturally

read this life with a severely critical eye. Before, however, he had got very far with the first volume he had been completely won over, and read the remainder with pure delight. In "Michael Faraday: His Life and Work," we have another excellent biography. In the preface he says: "In the recollection of such as have survived him, his image lives and moves, surrounded with gracious memories. a vivid personality instinct with rare and unselfish kindness." Surely we can apply these words also to Silvanus Thompson.

As an antiquarian he loved rare manuscripts and books, of which he possessed about 900. He had an unbounded admiration for Gilbert, of Colchester, the Elizabethan magnetiser. As he happily said, there were dramatists before Shakespeare, but there were no magnetisers before Gilbert. William Sturgeon, the electrician, Petrus Peregrinus and the Hon. R. Boyle were also favourite authors.

As a past-president of the "Sette of Odd Volumes," he took a great interest in general antiquarian literature. A most interesting Paper on "The Rose and the Winds: the Origin and Development of the Compass Card," he contributed to the "Proceedings" of the British Academy in 1914. "La Quaestio de Aqua et Terra, Dante Alighieri," "Peter Short, Printer, and his Marks," and the "Pied Piper of Hamelin" were other of his writings.

As a poet he attained some distinction. His monodies on Matthew Arnold and Tennyson were excellent. The following lines from the former may be quoted appropriately :—

> "The eager spirit pent within thy breast
> Hath passed from doubt to sight ;
> Hath found the awaited spark from heaven descend ;
> The light thou soughtest shining clear in view
> When strange and vain the earthly turmoil grew,
> And night has fallen as welcome as a friend."

In work connected with wireless, Thompson was a pioneer. As far back as 1876 he worked at experiments on oscillating sparks and their properties. He was a great admirer of Sir Oliver Lodge's work on wireless, and gave impartial and valuable evidence in the great wireless case in the law courts.

To the Institution of Electrical Engineers the loss of Prof. Silvanus Thompson in the full plenitude of his powers is most grievous. He has not only left us heavily in his debt, but he had started work on many valuable researches, and had laid down plans for many future theoretical investigations, when the call came. His work on the corona he has alas left unfinished. Yet we can rejoice that it has been given to him to complete so much valuable work. His work lives and will continue to live. As the years roll on we shall ever remember his enthusiasm and kindly sympathy. Our indebtedness to him is a precious possession.

ALEXANDER RUSSELL.

PHYSICAL SOCIETY.

At the meeting of this Society on the 16th inst., Prof. G. W. O. HOWE, D.Sc., in the Chair, a Paper, entitled

"Experiments With Mercury Jet Interrupters,"

was read by Capt. C. E. S. PHILLIPS.

The Paper describes an experimental attempt to ascertain the form of the mercury column issuing from a hole in the side of a rotating drum that is continuously supplied with mercury by centrifugal action

Incidentally a new form of interrupter is introduced, in which the interior is visible through a window in the lid. The arrangement forms a suitable apparatus for experiments with various forms of orifices and metallic contact segments, and the Paper gives an account of work in that direction. As it is important to ensure the cleanliness of the mercury in interrupters of this type, the usual copper segments are replaced by ones made of tantalum, which, for many reasons is preferable. It is not "wetted" by mercury, it remains clean and bright indefinitely, and its high melting point renders it lasting.

Experiments with various forms of orifice are described, and it is pointed out that the issuing stream is only slightly affected by this means. An explanation is given of the fact that a vertical slit orifice will not produce a ribbon of mercury, and that no matter how much the diameter of the orifice is increased beyond about 2 mm., the cross-section of the mercury column remains unaltered. A method is described, however, by which a much larger stream of mercury can be obtained from the rotating drum, if necessary.

Brief reference is made to experiments with various volatile liquids in suppressing the flare which occurs when the mercury columns leave the contact segments. The three well-known substances which are most effective in this respect are coal gas, hydrogen and ether.

It is pointed out that experiments of this nature are necessary, in view of the wide use now made of mercury interrupters in X-ray work.

Capt. REID thought the instrument described by the author was of considerable importance. In practice it would be a great advantage to see the interior of the instrument when anything went wrong.

Dr. R. S. WILLOWS congratulated Capt. Phillips on having broken new ground in his experiments. Mercury interrupters had not been very scientifically investigated so far. He thought experiments on the thickness and resistance of the jet, on the resistance at the contact with the tantalum vane, and on the effect of varying the inductance of the primary circuit on the performance of the interrupter, would yield results of importance. Had the best shape and inclination of the plate on which the jet impinged been worked out ? With regard to the effect of different gases in quenching the flare, he thought the specific inductive capacities were the determining factor rather than the specific heats. The same problem was met with in running a singing arc.

Mr. G. L. ADDENBROOKE mentioned that one firm he knew of made interrupters with an electrode of variable inclination.

Capt. PHILLIPS, in reply, said that some of the points raised by Dr. Willows were dealt with more fully in the Paper than in his description. The resistance of the jet was a very interesting point, and he had some experiments in progress on the matter. He was not quite clear whether the seat of the resistance was the mercury column or the junction of the column with the electrode. The position of the electrodes was also dealt with in the Paper.

A Paper, entitled

"A Method of Measuring the Pressure of Light by Means of Thin Metal Foil,"

Part II., was read by Mr. G. D. WEST.

The pressure of the radiation emitted by a carbon filament lamp at a distance of a few centimetres, is sufficient to cause a microscopically measurable deflection of the end of a strip of gold or aluminium foil, suspended in a closed test tube. By this means the radiation pressure may be measured, and the results may be checked by a comparison with the energy density of the radiation, as deduced from the initial rate of rise of temperature of an exposed blackened copper plate.

In a previous Paper experiments were carried out in atmospheres of air and hydrogen, and at pressures extending from 76 cm. to 1 cm. of mercury. Under certain conditions it was found possible to obtain satisfactory results. The present Paper deals with experiments at pressures from 1 cm. of mercury down to the highest exhaustions that could be reached.

As the pressure is lowered, certain gas-action effects make their appearance, but, inasmuch as there is no appreciable difference of temperature on the two sides of the strip, the effects are somewhat different from those that occur in the ordinary type of Crookes' radiometer.

When the surface of the strip is closer to one side of the containing vessel than to the opposite side, a deflection away from the closer side occurs, and the direction of this deflection is independent of the side of the strip on which the radiation falls. With a symmetrically-placed strip the deflection should be negligibly small. An explanation of these effects is suggested in the Paper, and a special type of radiometer is described.

The nature of the residual gas in the tube does not seem to be very important material, but it is found that the repulsive force acting on the strip increases with decreasing pressure, until a maximum is reached at about 0·002 cm. of mercury. With further reduction of pressure a progressive decrease takes place.

By symmetrical suspension, and by the use of liquid air and charcoal, it is possible so to reduce the gas action effect that measurements of the pressure of light of reasonable accuracy are again possible.

Experiments on the pressure of light may thus be advantageously carried out at the highest vacua obtainable, or at pressures as far above 0·002 cm. of mercury as convection currents will permit. The latter alternative is the easier, and leads to more consistent results.

A Paper, entitled

"The Viscosity of Suspensions of Rigid Particles at Different Rates of Shear,"

by Edith Humphrey, B.Sc., Ph.D., and Emil Hatschek, was read by the former.

This investigation was undertaken with a view to testing the Einstein-Hatschek formula at variable rates of shear. According to this formula the viscosity of a suspension of rigid spherical particles grows in linear ratio with the aggregate volume of suspended particles, and is independent of their size as long as the latter conforms to Stokes's formula.

The suspension chosen was one of rice starch of 0·003 mm., and less diameter in a mixture of carbon tetrachloride and toluene having the same specific gravity. The measurements were carried out in a modification of Couette's apparatus, in which the deflection of a cylinder, suspended coaxially in another cylinder filled with the liquid and rotated at different speeds, is measured. All measurements were carried out at speeds below that at which turbulence sets in, so that the deflection was proportional to the product of viscosity × angular velocity.

The results of the investigation are: (1) The viscosity of a suspension is a function of the rate of shear, and increases as the latter decreases, the difference being more marked at higher concentrations; (2) for all rates of shear the viscosity of the suspension increases more rapidly than the aggregate volume of suspended matter; (3) for any one rate of shear the relative viscosity of a suspension, *i.e*, its absolute viscosity divided by the absolute viscosity of the medium at the same rate of shear, also increases more rapidly than the percentage of suspended matter, the divergence from the linear increase demanded by the formula becoming less as the rate of shear becomes greater, so that a linear law may possibly hold good at rates of shear higher than those attainable in the present apparatus without turbulence.

The general conclusion is that the assumption on which the Einstein-Hatschek formula is based, viz., non-interference between adjoining particles, is not tenable in the case of suspensions containing between 2 and 6 per cent. of suspended matter.

A Paper, entitled

"A Correction of Some Work on Diffusion by Dr. A. Griffiths and Others,"

by Dr. A. Griffiths, was taken as read on account of the lateness of the hour.

When salt diffuses through water, in general there must be a movement of the water due to volume-changes associated with variations in concentration. In the Papers to which the recalculation refers reference was made to the velocity of the liquid or solution; but what was meant by the velocity of the liquid was not explained. The author now deals with the velocity of the water-component of the solution to which a clear mathematical meaning can be given. When salt leaves a given section of the vessel containing the solution, the diminution in volume of the contained liquid is prevented by the automatic addition of water, and of water only. In the Papers to which the recalculation refers, the error was made of assuming that the diminution of volume was prevented by the automatic addition of solution. The results by the method of diffusive convection require no recalculation, and agree with Mr. Clack's recalculated values to less than 1 per cent. There is no doubt that the results, as recalculated, given by the three methods employed in the author's laboratory agree within the limits of experimental error; and the author's opinion is that the true value of the coefficient of diffusion lies close to those given by his convective method and by Mr. Clack's gravitational method.

CORRESPONDENCE.

THE ELECTRICITY SUPPLY OF GREAT BRITAIN.

TO THE EDITORS OF THE ELECTRICIAN.

1. Some remarks made by me during the discussion on Mr. Harry Ellis's Paper at the I.M.E.A. Convention on Thursday, June 22nd, having, in one instance at least, been given an interpretation not intended by me, may I briefly state the present position with reference to electricity supply as I understand it?

2. The fact that the moment was ripe for dealing with this subject is proved by the remarkable advance which has been made since April 13th when the subject was discussed at the I.E.E., and much credit is due to those gentlemen who have been responsible for this exemplary progress; also to the responsible officials in the Board of Trade who strengthened their hands by issuing the circular on "Linking Up," and not least to the technical press which grasped the importance of the subject at the outset and gave its powerful support. Any contribution to the subject made by me since the Paper was read on April 13th will I trust, be taken as an appreciation of the work of others and as an effort further to assist in these practical steps to progress.

3. The "linking-up" of power stations was an important part of the original scheme, *but only a part;* the possible development of separate districts until the whole country is organised for electricity supply was pointed out in the original Paper. The "linking-up" of existing stations, however, requires to be carried out as a part of the whole scheme and not as a number of separate schemes in themselves. I suggest the dangers we must avoid in connection with "linking-up" are:

(*a*) The temptation to extend existing stations which are *not* suitable for the complete scheme and thus perpetuate to some extent the present unsatisfactory conditions.

(*b*) The expenditure of capital on certain "linking-up" feeders which might not be necessary as part of the complete scheme.

(*c*) The temptation for the powerful industrial areas to be satisfied with the good results which will be attained and not take advantage of the opportunity which certainly exists for re-organising the control of electricity supply for the whole country.

4. As has been pointed out by several gentlemen, the supply industry at present suffers from legislation, the control of several Government departments and the costly machinery for passing new Bills. Some engineers have read into the proposal to establish an Electricity Board, a suggestion for even more legislation and more obstacles. The very reverse is intended, viz., to replace the present unsatisfactory system and put the necessary powers into the hands of a few practical engineers in intelligent sympathy with the industry. This Board would have the very valuable feature that each Board engineer would work and reside in the district he represented, and therefore would be in close association with the people of the district. Given a clear understanding of the meaning of the proposed Board and leaving out the question of its having operating powers to generate and supply electrical energy, it is considered the industry would be almost unanimous in promoting its establishment. This Board would be invaluable in co-ordinating all the various local efforts and shaping them into a homogeneous whole.

5. At the I.M.E.A. Convention I referred to the business policy of the Canadian Pacific Railway Co. Perhaps an illustration nearer home would be the Port of London Authority established by Act of Parliament to re-organise and co-ordinate the work of the Port of London. The justification for the step taken and for the enterprise and broad policy adopted, is the result attained. This is referred to in an instructive manner in "The Daily Telegraph," of June 24th, which deserves perusal. In electricity supply we can equally well have a broad policy with sound finance, and an electricity Board would assist in securing this. Sound finance sometimes means capital expenditure without an *immediate* return, and it is weak finance to withhold such justifiable expenditure which is necessary for a progressive industry.

6. The various discussions and practical advance made since the original Paper was written have but served to strengthen my conviction that if we will we may achieve great and early results. It would be regrettable for us to fall short in attainment because of a lack of imagination and appreciation of our exceptional opportunities. Scepticism, which before the war may have been justified, is now a brake to achievement and progress. As electrical engineers we are best serving our country, both now and for the future, in placing the electrical industry on the most satisfactory basis to serve that country's needs.

London, June 26. Ernest T. Williams.

LEGAL INTELLIGENCE.

A. E. Rickaby v. Plymouth Corporation.

At the Devon Assizes last week plaintiff sued for damages for injuries alleged to be due to the negligence of defendants' servants.

Mr. FOOTE, K.C. (for plaintiff) said that on Oct. 21 last his client was a passenger on the top of one of defendants' tramcars. The car was proceeding from Fore-street to Stuart-road, and when it was going down a hill en route the trolley arm slipped off the overhead wire and wobbled about loose. Plaintiff called to the conductor, but could not attract his attention, as the conductor was talking to someone on the footpath. After having left the wire the trolley arm hit the cross-piece of one of the standards supporting the overhead wires. Nothing broke off the arm, but the spring was destroyed by the blow and the arm fell on plaintiff's head, injuring him seriously and necessitating the operation of trepanning. Plaintiff alleged negligence against the Corporation in that they had provided no means of immediately apprising the driver of the fact that the trolley arm had left the wire. It was also alleged that the conductor, who was young and inexperienced, was not attending to his duties. In consequence the tram travelled for more than 60 yds. before being brought to a standstill.

The JUDGE, referring to a suggestion that a mechanical device to warn the driver should be provided, asked whether such a device was in use anywhere.

Mr. FOOTE: No; that is the point. Tramway companies have not fitted such a thing, but it is time they did. A further allegation by plaintiff was that the tramcar was negligently constructed in that there was no covering or protection over the top of the tram to prevent the arm from falling upon passengers. It would be easy to have an arch of wire or metal over a tramcar for that purpose. The Corporation had stated that they had applied to the Board of Trade for permission to cover their tramcars, but it had been refused on account of the fact that the additional weight and wind pressure would be dangerous on the hills and gradients; but the Corporation had not applied for permission to place on the cars such a protection as he had suggested.

PLAINTIFF, in evidence, said the conductor was talking to a boy who was running alongside the car. As a result of the injury he received he was confined to bed for some time, and still suffered with his head. He had to give up his business, which he had sold. Previously, his business brought him in a profit of about £200 a year.

Mr. HAWKE (for defendants) intimated that he did not dispute items of special damage totalling £42. 18s., bu the did not accept the claim to £26 for loss of profit on business.

Sergt. J. V. STEPHENS, R.A.M.C., spoke as to seeing the trolley arm swinging. He then heard a "smack," from which he judged that the arm hit a standard. Afterwards the arm lay helpless on the top of the car, and plaintiff was huddled up on the back seat. It was a common sight in Devonport to see trolley arms come off the wire. He had seen it happen seven or eight times since the accident. He did not hear the tram bell ring.

A passenger who was riding inside the car said she did not see the conductor ring the bell. Two days after the accident she saw a trolley arm leave the wire near the same spot.

Medical evidence was then given as to the nature and extent of plaintiff's injuries.

Mr. R. H. WORTH, engineer, said it was not infrequent for trolley arms to leave the wire on the Plymouth system. He had seen it occur four times in one week. On the occasion of the accident the car would be going downhill, and as the current would be turned off, the driver would not be aware that the arm had left the wire. On that gradient the tramcar could be stopped in between one and two lengths—probably in one. It would be simple to provide some automatic means by which the driver could be made aware that the arm had left the wire. It could be done by an electrical circuit which, when the arm came off, would ring a bell. Such a device was not in operation anywhere.

The JUDGE: The non-adoption of a particular device is not negligence.

Replying to Mr. Foote, WITNESS said there was a Board of Trade regulation that there should be such a signal in case the trolley standard on the top of the car became charged with electricity—a red lamp or, preferably, an audible signal.

The JUDGE: This is a tramcar authorised by the Legislature to go without any such provision. It is quite another thing to say defendants are guilty of negligence.

In the course of argument concerning the suggested signal the Judge asked the witness: "Why haven't you brought out such a device? You might have been a millionaire at this moment." (Laughter.)

Mr. FOOTE: Tramway companies have been solicited to adopt such a device, but they won't because it costs money, and because if one adopted it all the others would have to do so.

WITNESS: A red lamp that would go out when the arm left the wire would be sufficient. It would cost 10s. or 15s. per car. An audible signal would cost 30s. or £2 per car. It was practicable for a light metal arch to be fixed 6 ft. 6 in. above the upper deck of the car to protect passengers from a falling trolley arm.

Mr. HAWKE, K.C. (for the Corporation), said defendants did not believe the man's skull was fractured, and the X-ray photograph showed it was not. It was not denied that plaintiff had had a severe blow, and that he was still suffering to some extent; but he was able to do light work. As to the suggestion that tramway companies were regardless of the safety of their passengers so long as they could save money, the tramway system at Plymouth was inspected from time to time by the Board of Trade, and every known device was used for the safety of the travelling public that could be used. All the suggestions made by Mr. Worth had been thought out years ago, and were discarded because they gave a false security. There was a risk of trolley arms coming off, but if the jury found that that was a risk that there was no known means of avoiding, there was no negligence. He argued that the law was that it was sufficient for a tramway company to adopt the best known apparatus, kept in perfect order, and worked without negligence by the men employed. The conductor was 17 years of age and old enough to look after a tramcar. The conductor rang the bell on seeing that the arm was off the wire, and there was no negligence on his part.

Medical witnesses were called to prove that they could find no evidence of injury to or pressure on plaintiff's brain. Plaintiff would be all right again in two or three months without an operation.

GEORGE HERBERT AMOS, driver of the tramcar, said it was by means of a signal from the conductor that he knew anything was wrong. The signal was four rings of the bell, which was the emergency signal. He pulled up the car in half its length. He afterwards found that the arm was off the wire, and bent at an angle of about 45 deg. He denied having said that the accident would not have happened if the conductor had been looking out or that it was a pity the conductor did not ring the bell before.

Mr. FOOTE reminded the Court that at Exeter there was an excellent and simple device by which the driver could be notified when the trolley arm left the wire.

The JUDGE: Upon this matter of invention I do not think that an action for negligence is the method for introducing new means of notification. I shall express my view upon it, and Mr. Foote will be able to pull it to pieces in the Court of Appeal.

FREDK. JAMES FRY, the conductor, stated that he did not hear plaintiff call to him, and he denied that he was speaking to someone running beside the car. As soon as he became aware that the trolley arm had left the wire he gave the driver the emergency signal by ringing the bell four times.

Mr. C. R. EVERSON, manager of Plymouth Corporation tramways, stated that the car in question was overhauled and refitted, new trucks being fitted and the wheel base extended. Since then it had been running regularly and had given no trouble.

In cross-examination, he said it was a fact that sometimes the trolley pole would leave the wire for some unexplained reason; that fact was quite unaccountable.

At this point Mr. HAWKE said he was told there was no such device on the Exeter tramways as had been suggested.

Mr. FOOTE: Why, I pulled it myself this morning.

WITNESS said he knew that particular method. It was called a trolley catcher. At Exeter the system was a centre running one; theirs was a side running one, and that appliance was not effective for side running (where the wires were not immediately above the car). Their trolley arms ran at angles varying from 15 deg. to 35 deg. He was not aware that the Exeter method rang a gong when the trolley arm came off the wire.

The JUDGE asked whether the witness could suggest any practical object to having a cord fixed taut from the end of the trolley arm to a gong on the conductor's platform, so that the gong would ring when the arm left the wire.

Mr. EVERSON replied that no such recommendation had ever been made by the Board of Trade. As far as he could see there could be no objection to it.

Re-examined, Mr. EVERSON stated that if the rope were made taut in the manner suggested when the wire was immediately over the car it would pull the trolley wheel off the wire when the arm moved outwards at an angle.

Mr. J. B. HAMILTON, of Leeds, stated that he knew of no device in practical use on a system similar to Plymouth which the Plymouth system had not got. There was no known method which ensured that a trolley arm should not come off the wire at times. An apparatus such as that in use at Exeter was tried, and found wanting 17 years ago. All the apparatus did was to wind up the slack of the rope. It did not prevent the arm leaving the wire, and did not give warning when it came off. It would not be adaptable to the Plymouth system because of the range of the trolley arms. The rope would possibly catch other vehicles, and the arrangement would not be suitable for giving any signal. Mr. Worth's suggestion was not practicable.

In cross-examination, Mr. HAMILTON said that owing to the high voltage it would not be possible to have a single lamp by the driver which would go out when the arm left the wire. There would have to be a series of five lamps.

Mr. E. M. MUNRO, consulting engineer, described Mr. Worth's suggestion for an audible signal to the driver as impracticable. He could not suggest any device that would improve the Plymouth tramway system.

Mr. P. J. BAKER, electrical engineer in the Plymouth tramway department, said the tramcar was inspected before it went out on the day of the accident.

Mr. J. H. ELLIS, town clerk, said the Board of Trade had refused to sanction the running of covered cars on the old Plymouth system.

Counsel, having addressed the Court, his LORDSHIP summed up, and said Counsel for plaintiff had asked the jury to say there was an absence of due care if a tramway company did not introduce some device or appliance that could be suggested as obviating the particular danger that arose in the case. He thought that was not the fact; that was not what "due care" meant. "Due care" meant what a prudent, reasonable and ordinary tramway manager would do. Mr. Worth suggested what sounded a very ingenious and admirable device, but, as witnesses for defendants pointed out, it would not ensure safety, for it would leave many possibilities of passengers being hit. The answer of defendants was that they did not know of any tramway system on which any one of the suggested devices was adopted and was successful. Exeter seemed to have adopted an unusual precaution, but Plymouth was not negligent

because Exeter was in advance of the times. If plaintiff had shown that on half, or a quarter, of the tramway systems of England a device was adopted which would have prevented this accident, but that the device was not in operation at Plymouth, he would have made some case for saying that the Corporation were negligent. That applied alike to the suggested gong, lamp and arch. Nobody heard of an arch until Mr. Worth went into the witness box. How could it be negligent for a person not to have obtained all the ideas that Mr. Worth had in his head? The tramcar was a properly appointed tramcar. The question was whether the tramcar was used at the time of the accident with due care. If the jury came to the conclusion that there was no absence of due care on the part of the conductor, they should find a verdict for defendants. It seemed to him that, in the absence of an automatic arrangement for warning the driver that the trolley arm had left the wire, it seemed a proper thing that when a tram was "coasting" down hill the conductor should stand where he could see the trolley arm and warn the driver immediately it came off.

The jury found for plaintiff, awarding him £250 damages.

D. Davis & Son (Ltd.) v. Assessment Committee of Pontypridd Union, Overseers of Rhondda and Rhondda Urban Council.

Last week the Court of Appeal (Lords Justices Swinfen Eady, Phillimore and Bankes) heard this appeal of the respondent Assessment Committee, Overseers and Urban Council, from a judgment of a Divisional Court.

It appeared that Messrs. D. Davis & Sons, owners and occupiers of certain mines, made, in 1904, an agreement with the Assessment Committee by which, for the purposes of rates, assessment of the property was to be calculated on the output of coal, the agreement being determinable by one year's notice. Some small electric stations were attached to appellant's pits, and for some years they purchased a large amount of power from an electric power company. In 1907 they erected an electric power station of their own, and from that time the small stations went out of use, and the company reduced the amount of power that they purchased. Down to April, 1913, the assessments on the company's property were made in accordance with the agreement, the electric power station not being assessed separately from the rest of the colliery. In April, 1913, the Assessment Committee, having given previous notice determining the agreement, assessed the electric power station separately from the rest of the colliery, but still assessed the latter in accordance with the agreement. The Divisional Court held that upon the question of the company's appeal against the poor rate, that although the Assessment Committee of 1904 had no power to bind subsequent Assessment Committees, yet as the Assessment Committee of 1913 could not repudiate the agreement, so far as concerned the power station, since they had affirmed it as regarded the rest of the company's property, there was no power to rate the power station separately, as long as the rest of the property was rated in accordance with the agreement. The Court, therefore, held that the rate was bad and remitted the matter back to Quarter Sessions, with an intimation to that effect. Hence the present appeal.

At the conclusion of the arguments of Counsel their lordships affirmed the decision of the Divisional Court, and dismissed the appeal with costs.

Re Magneta Time Co. (Ltd.)—Last week an application in a debenholder's action—The Magneta Fabrique d'Horloges Electric *v.* Magneta Time Co. (Ltd.)— to confirm a provisional contract for the sale of the undertaking of defendant company to a Mr. Molden, one of the co-plaintiffs in the action, came before Mr. Justice Astbury.

Mr. VANNECK said the application had been before Mr. Justice Neville, when the contract was strenuously opposed, and his lordship adjourned the application with the intimation that the provisional contract would be sanctioned at the adjourned hearing, unless in the meantime a better offer was brought forward. The opposition of the company was that the price the applicants were to get for certain of the assets was not sufficient, and that the company would be able to realise to better advantage and save something for themselves, whereas under the provisional contract they would get nothing. Defendants did not now appear.

Mr. Justice ASTBURY sanctioned the contract.

PARLIAMENTARY INTELLIGENCE.

ELECTRICITY SUPPLY CHARGES.

In the House of Commons on Monday, Mr. L. V. HARCOURT stated, in reply to a question, that he was aware that certain electric lighting companies as well as local authorities were increasing their charges to consumers, and that the operation of the Summer Time Act was given as one of the reasons for the increase. The Acts and Orders authorising the supply of electric light fixed the maximum charges which might be made to consumers, and undertakers were acting within their statutory powers in increasing their prices so long as the prescribed maximum was not exceeded. The chief object of the Summer Time Act was to effect economy in the use of coal by public utility bodies, and he did not see his way to promote legislation to prevent electric lighting undertakers from increasing their prices for current actually used to compensate them for the reduced consumption.

Sir F. LOWE: Will the right hon. gentleman undertake to see that the increased charge is not continued during that portion of the year when the Summer Time Act will not be in operation?

Mr. HARCOURT: I should like to see exactly what my powers of preventing it are.

EXCESS PROFITS TAXATION.

In the House of Commons on Monday the Committee stage of the Finance Bill was considered.

Mr. S. ROBERTS moved an amendment to exempt controlled establishments from the operation of clause 29, which continues and increases the rate of excess profits duty.

Sir A. MOND called attention to the complication of accounts involved and the immense difficulty of dealing with two Government departments. On the question of the duty itself, he thought the controlled firms would prefer rather to pay excess profits duty than to work under the present arrangement.

The Chancellor of the Exchequer (Mr. R. MCKENNA) said the whole argument was that the taxation which affected all firms must not fall less heavily upon controlled firms than upon other firms. All he asked was that the joint effect of the munitions levy and the excess profits duty should be such that controlled firms should not escape more lightly than other firms. He did not desire to get at cross purposes with those great firms who had done such magnificent work for the State and whom they rightly looked upon as the best friends of the State. Cases had been cited of firms who had put up new buildings, erected new plant and introduced new capital with the object of increasing their output, and it was said that in all those cases an arrangement had been made with the Minister of Munitions that depreciation of these buildings, plant, &c., should be at such a rate as would reduce the value of the capital in the books of the companies after the war to the post-war value. He was prepared to go further than that, and was prepared to accept, in every such case, for the determination of excess profits duty, the rules of the Munitions Act, and not in accordance with the rules of the excess profits duty. Then there were cases of firms who had been turned off their original businesses, and who might at the end of the war have lost the whole of their goodwill. He was perfectly prepared to allow such firms to write off such loss of goodwill as might be shown to have taken place after the war. When he had met all such cases as those cited, how were controlled firms hit in a manner other firms were not hit? It was impossible at present to say what the return of the munition levy would be. The Minister of Munitions had large discretionary powers in regard to this levy, but no Minister ought to have discretionary powers in regard to taxation. He had made inquiries regarding what would be the charge to the revenue if the excess profits duty was so amended that no one would have to pay more duty than would leave him a balance of 20 per cent. in excess of the standard. The loss to the Treasury would be about ten millions, and he should hesitate to ask the House to accept it.

Ultimately the amendment was rejected.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 SPECIFICATIONS.

4,808 THOMAS CROSBEE & SONS (LTD.) & SPICER. Sparking plugs and the manufacture of the same. (Cognate applications, 11,123/15 and 12,240/15.)

2,197 B.T.-H. Co. (G.E. Co.) Controlling-mechanism for automobiles.

6,340 WOOLLISCROFT. Electric resistance regulating arrangements.

7,909 WESTWOOD. Battery cases for electric cycle lamps.

8,106 BERRY. Protective arrangements for alternating-current apparatus.

8,305 WALKER. Method of and means for separating metals by electrolysis.

8,318 MURRAY. Mechanism for operating electrically-worked tramway and railway track points.

8,417 MASCHINENFABRIK OERLIKON. Casing for the stators of dynamo-electrical machines. (30/6/14.)

9,408 CHINN & BUTLER. Cases for ammeters and voltmeters.

11,224 BETHENOD. Magnetos applicable for the lighting of vehicles. (27/6/14.)

11,473 B.T.-H. Co. (G.E. Co.) Alternating-current motors.

An induction motor having a secondary member whose magnetic core is provided with relatively deep slots in each of which a conductor of considerably less thickness than the slot width is located with adjacent less conductive material for filling the slot.

11,684 GOSS PRINTING PRESS CO. OF ENGLAND. (Goss Printing Press Co.) Controlling-mechanism for printing presses operated by electric motors.

12,228 THOMPSON. Actuating signals on and communicating with trains. (Patent of addition not granted. Cognate application, 14,844/15.)

12,702 CHESHIRE. Electrical heating elements.

12,772 WYNNE. Electrical switches.

Consists in improved operating mechanism for plug and like switches, comprising a sliding and detachable pin or plunger member and an angularly-displaceable sleeve or tubular member, which is mechanically connected with the contact arm, one of said members being formed with a helical slot groove or recess, which is open at one end, whilst the other member has a stud or lateral projection which, on the insertion of the detachable pin or plunger into the sleeve, engages and co-operates with the helical slot or groove, and imparts movement to the said sleeve for closing the switch, whilst on withdrawal of the said pin or plunger the co-operation of the stud and slot or groove positively brings about the opening of the said switch.

14,164 COLLINSON. Electrical resistances.

14,273 HUNT & GIDDEN. Process for the electrolysis and treatment of sulphate liquors. (Addition to 11,634/13.)

14,499 YATES, GAMBLING & PARKER. Guards for the cords or wires of telephone sets.

15,563 MARKT. Construction of electric switch.

16,452 CLEMENS. Electric soldering-irons. (21/11/14.)

1916 SPECIFICATIONS.

831 MCLACHLAN, R. W. Shade-holders for gas or electric-light fittings. (18/1/16.) 100,525.

955 DEVENTER, H. R. VAN. Electrical condensers. (15/2/15.) 100,081.

3,389 WAYGOOD-OTIS (LTD.). (Otis Elevator Co.) Alternating-current electromagnets. (7/3/16.) 100,519.

3,533 SIGNAL GES. Multiple-contact microphones. (19/1/15.) 100,156.

3,658 BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. Starting mechanism for internal-combustion engines. (6/4/15.) (100,246.)

3,659 BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. Starting mechanism for internal-combustion engines. (24/3/15.) 100,197.

4,109 TANNER, A. E., & CLAREMONT, E. A. Joint for an electric cable. (20/3/16. Addition to 6,980/15.) 100,511.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	441	"Universal" Table Utensils. Illustrated	86
Imports and Exports of Electrical Manufactures	442	Ironclad Switch Fuses. Illus.	87
Educational	442	The Second-Hand Motor	88
Business Notices	442	Broadbent C.C. Generators. Illustrated	88
Liquidations, Bankruptcies, &c.	442	"Ediswan Hosgood Utensils." Illustrated	89
Electricity Supply	442	New T.L.A. Discount Scheme	90
Traction Notes	443		
Telegraph and Telephone Notes	444	Tenders Received & Accepted	446
Empire Notes	444	Municipal Accounts	446
Foreign Notes	444	Companies' Meetings and Reports	447
Miscellaneous Notes	444	New Companies, &c.	449
Tenders Invited	445	City Notes	450
		Electrical Companies' Share List	450
The Round Table	85		

COMMERCIAL TOPICS.

Stock Transfers and Trading with the Enemy. Notice has been issued to companies, municipal authorities and bankers as to transfers of stock, &c.

The notice requires them, before registering or allowing any transfer of any annuities, debenture stock, debentures, stocks, shares or other securities to obtain from both transferor and transferee (or from the brokers acting for them), or from a solicitor or banker on their behalf, declarations to the effect that neither the transferor(s) nor transferee(s), nor one of them, is a person resident or carrying on business in any country at war with Great Britain, or treated as an enemy under any proclamation relating to trading with the enemy, or mentioned, or a member of a body of persons mentioned, in the statutory list under the Trading with the Enemy (Statutory List) Proclamation, 1916, No. 3, and that the within written transfer is not made on behalf of any such person as aforesaid.

* * * *

Trade After the War. Some time ago we gave an abstract of the report of the Sub-committee of the Board of Trade's Advisory Committee on Commercial Intelligence, as to the measures to be adopted for securing the position after the war.

The report was on certain branches of industry, including electrical apparatus, china and earthenware glass, toys, stationery, &c. The Board have now issued summaries of the evidence taken in respect of each branch of trade covered by the inquiry, and of the suggestions made to the Sub-committee as to the directions in which Government action for their assistance might be taken. Among the collective proposals submitted to the Sub-committee were several touching matters of general interest to the commercial community. Stress was laid on the need for the promotion of scientific research in relation to industry and on the importance of technical schools. It was admitted that employers had not properly appreciated the value of technical education, and that difficulty was experienced in inducing employés to avail themselves of the opportunities afforded them of increasing their technical knowledge. The suggestions put forward in this connection included :—

Appointment of "travelling scientists," to be lent to industrial enterprise in turn.
Organisation of a committee to collect and classify samples from all parts of the world of articles manufactured from various raw materials.
Compilation of a list of substitutes for well-known raw materials.
Formation of a bureau of consulting scientists, chemists, engineers, &c.
Increased attention to the growing of timber.
Offer of rewards for valuable discoveries.

In regard to transport facilities, complaint was made of preferential treatment of foreign goods by British railway companies, and it was suggested that the system of rating should be altered so as to favour the home instead of the foreign manufacturer. Representatives of various trades attached importance to the development and modernisation of our canal system. It was urged that this reform would be of immense advantage to export trade, and relieve the railways of much slow traffic.

Reform of the banking system on German lines, and the formation of trust companies to sell goods for groups of manufacturers were among the suggestions made under the head of financial assistance. There was a fairly general expression of opinion to the effect that in granting loans to foreign countries we should make it a condition that some of the money raised should be spent in this country ; and some witnesses proposed that British industries should receive preferential treatment in connection with money raised for local loans or by taxation.

The value of the trade exhibition organised by the Board of Trade was fully recognised, and it was suggested that future exhibitions should be on a larger scale and be better advertised, and that only real manufacturers should be allowed to exhibit. The establishment of a great annual trade fair in London was recommended.

Representatives of practically all the industries urged the necessity, in the interest of British trade, of amending the law relating to copyright, patents and trade-marks, and also the Merchandise Marks Act. It was contended that every article made in Germany or Austria-Hungary (or every foreign-made article) imported into the United Kingdom should bear a mark showing the country of its origin.

Most of the witnesses expressed the opinion that import duties would be needed after the war if British industry was to be protected against unfair competition, especially from Germany.

* * * *

British Industries and the War. The directors of the Glasgow Chamber of Commerce have decided to begin the collection of information from various industries which will be at the disposal of the Government in devising its fiscal policy for the safeguarding of British industries.

On Exports and Shortage of Labour the Home Affairs Committee of the Chamber recently presented a statement setting forth the result of inquiries made with regard to the shortage of labour.

It was stated that there was a serious shortage of labour for industrial work in Glasgow and the west of Scotland. The Committee did not know of any single industry which was not affected by the shortage. It was particularly serious in the textile industries, and was contributed to largely by the competition of munition works for female labour. A large amount of plant was at present lying idle for want of workers. The productive power of one company was now only equal to about one-third of the pre-war standard. With regard to the Board of Trade returns, which showed that apparently the export trade of the country was now only about 25 per cent. less than it was immediately before the war, the Committee desired to state that if that related to value—and they understood it did—they considered that the statement was fallacious, as prices of exported commodities showed an increase in value of from 75 per cent. to 100 per cent. over the pre-war standard, and that the export in quantity had declined at least 50 to 60 per cent. The export trade had undoubtedly been very seriously affected by the withdrawal of men from all industries, the substitution of women for the men taken, and the consequent shortage of women. Employers expected that the difficulties experienced by the shortage of labour would increase from day to day as the war progressed. Certain recommendations as to lowering the school-leaving age, &c., were adopted.

* * * *

Commercial Museums. Sir Geo. Foster, the Dominion Minister of Trade and Commerce, recently announced that he would establish, in the near future, probably at Ottawa, a commercial museum for the purpose of affording practical hints to those contemplating the launching of new industries in Canada. Plans for the project were nearing completion. Samples of products of other nations, with a history of each, would be shown, the idea being to enable prospective manufacturers to investigate and decide whether the articles could be successfully manufactured in the Dominion. He also suggested a yearly convention of practical financial and commercial men and a commission representative of business interests, and he invited co-operation in the project from commercial and financial interests.

* * * *

War Time Profits in Australia. The Commonwealth Treasurer recently stated that the Government had decided to ask Parliament to pass a bill for the taxation of profits of trades and businesses which are enjoying extra profits during the war.

The tax will be at the rate of 50 per cent. on excess profits accruing after June 30, 1915. The Act will apply to all trades or businesses carried on in the Commonwealth, or owned or carried on in any other place by persons ordinarily resident in the Commonwealth ; but will exempt trades or businesses carried on by a municipal corporation or other public authority ; or by a society registered under a Friendly Societies' Act of the Commonwealth, or a State, and not carried on for pecuniary profits ; or by a religious, charitable, or public educational institution. Agriculture will be exempted ; also any profession, the profits of which are dependent mainly on the personal qualifications of the person by whom the profession is carried on ; but the Act will apply to the business of any person taking commission ; and of any agent of any description not being a commercial traveller or any agent whose remuneration consists of a fixed sum not dependent on the amount of business

done. An exemption will also be allowed to the extent of £200 excess profits in one year.

* * * *

The Cash on Delivery System. The London Chamber of Commerce has instructed its Post and Telegraph Committee to consider and report upon the desirability of advocating the extension of the cash on delivery system in connection with the Parcel Post service with foreign countries, in view of the great importance of the matter at the present time, when Germany is shut out from markets to which the United Kingdom has access.

* * * *

Prohibition of Imports. As from July 6th the importation of the following goods into the United Kingdom will be prohibited :—

Such motor cars, chassis, parts and accessories (other than tyres) as were expressly exempted from the prohibition on the importation of motor cars, chassis, motor cycles and parts and accessories thereof which was imposed by the Prohibition of Import (No. 3) Proclamation, 1916, and also vacuum cleaners.

The Board of Trade states that licences to import will be granted in cases where the goods were either en route for the United Kingdom or actually paid for at the date of the Proclamation. Licences will also be given where it can be shown that the importation is desirable in the national interests, or is urgently required for any of the purposes specified in Class A of the Order of Priority for the distribution of motor spirit, or for agricultural purposes, or for the conveyance of essential goods.

As regards vacuum cleaners, licences will not, in general, be granted except where it can be shown that the goods were either en route for this country or actually paid for at the date of the Proclamation.

* * * *

Import Duties in Russia. It is announced that, according to the official "Trade Gazette" of Petrograd for April 29th/May 12th, the Minister of Commerce has submitted to the Council of Ministers proposals for the duty-free admission into Russia, for a period of 10 years, of various articles for the needs of the Siberian and Ural gold mining industries, including dredges and excavators and parts of dredges and excavators (as specified in special lists to be drawn up by the Ministers of Finance and Commerce, whether imported with them or separately; appurtenances and apparatus for crushing gold ores and for extracting gold by chemical processes, apparatus for exploring dredging areas, &c., whether imported with them or separately, according to special lists to be drawn up by the above-mentioned Ministers.

The "Trade Gazette" states that it is also proposed that the privilege of duty-free admission shall be accorded to dredges, excavators, apparatus, appurtenances and their parts imported for the Siberian and Ural gold mining industries since the 1st/14th January, 1916, and that the Customs duties paid on such importations since that date shall be reimbursed.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From June 19, 1916, *to* June 24, 1916.

IMPORTS.

GRIMSBY. *France:* Unenumerated, 2 pkgs.

SOUTHAMPTON. *France:* Unenumerated, cases, £13.

LIVERPOOL. *S. Africa:* Elec. motor.

LONDON. *U.S.A.:* Elec. lamps, £300; carbon candles, £231; wire and cable, £169; unenumerated, £19,138 68 pkgs.; telephone material, £256. *Holland:* Elec. lamps, £2,686 1,212 pkgs.; elec. bulbs, 55 cases. *Japan:* Unenumerated, £677. *France:* Unenumerated, £1,142. *Switzerland:* Carbon candles, £300; unenumerated, £429 *Canada:* Unenumerated, £495.

MANCHESTER. *U.S.A.:* Elec. motor parts, 6 pkgs.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Elec. machinery, £93; unenumerated, £1,910. *Melbourne:* Wire and cable, £4,226; unenumerated, £501. *Sydney:* Elec. machinery, £30; wire and cable, £4,114; elec. glow lamps, 3,050 no.; unenumerated, £95. *Wellington:* Elec. machinery, £56; elec. lamps, 1,800 no.; unenumerated, £61. *Christchurch:* Wire and cable, £33; telegraph material, £30; unenumerated, £85. *Lyttelton:* Elec. machinery, £222. *Dunedin:* Elec. machinery, £524; unenumerated, £48. *Adelaide.* Unenumerated, £2,731. *Fremantle:* Unenumerated, £249. *Hobart:* Elec. machinery £165. *Brisbane:* Unenumerated, £2,205. *Townsville:* Elec machinery, £2,096.

AFRICA.—*Durban:* Unenumerated, £227. *Cape Town.* Unenumerated, £128. *Port Elizabeth:* Wire and cable £1,680; unenumerated, £237. *Mauritius.* Unenumerated, £35. *East London:* Unenumerated, £50.

EGYPT. *Alexandria:* Unenumerated, £649. *Port Said:* Wire and cable, £29; unenumerated, £33. *Port Sudan:* Unenumerated, £31.

MOROCCO. *Casablanca:* Wire and cable, £1,049.

ST. HELENA. Wire and cable, £10; unenumerated, £32.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Wire and cable, £2,620; unenumerated, £2,443. *Penang:* Unenumerated, £26. *Singapore:* Elec. machinery, £62; unenumerated, £42. *Calcutta:* Elec. machinery, £667; wire and cable, £8,074; unenumerated, £2,536. *Madras:* Unenumerated, £535. *Karachi:* Elec. machinery, £694; unenumerated, £78. *Colombo:* Elec. machinery, £62; unenumerated, £148.

CHINA. *Shanghai:* Elec. machinery, £83; elec. glow lamps, 1,840 no.; unenumerated, £184. *Hong Kong:* Wire and cable, £397; elec. machinery, £310; unenumerated, £97. *Hankow:* Unenumerated, £167.

U.S.A. *New York:* Telegraph material, £190; unenumerated, £72.

CANADA. *Montreal:* Unenumerated, £31. *Toronto:* Elec. machinery, £12. *Halifax:* Submarine telegraph cable, £96,000.

SOUTH AND CENTRAL AMERICA. *Buenos Aires:* Wire and cable, £1,843; unenumerated, £196. *Valparaiso:* Unenumerated, £405. *Punta Arenas:* Unenumerated, £237.

HOLLAND.—*Amsterdam:* Wire and cable, £11,957; unenumerated, £1,591. *Rotterdam:* Elec. machinery, £190; wire and cable, £238; telegraph material, £1,200; unenumerated, £47. *Haarlem:* Wire and cable, £269.

FRANCE.—*Paris:* Unenumerated. £564. *Dieppe:* Unenumerated, £64. *Havre:* Wire and cable, £594. *Bordeaux:* Unenumerated, £99. *Calais:* Unenumerated, £67. *Boulogne:* Unenumerated, £539.

JAVA.—*Sourabaya:* Elec. machinery, £86; unenumerated, £86.

SWEDEN.—*Stockholm:* Unenumerated, £95.

NORWAY.—*Christiana:* Wire and cable, £384.

GIBRALTAR.—Telegraph material, £105; unenumerated, £14.

CYPRUS.—Unenumerated, £96.

MALTA.—Telegraph material, £10.

DENMARK.—*Copenhagen:* Wire and cable, £3,813; telegraph material, £30; unenumerated, £76.

SPAIN.—*Malaga:* Wire and cable, £283; unenumerated, £35.

PORTUGAL.—*Lisbon:* Elec. machinery, £273; wire and cable, £442 · unenumerated £39.

FOREIGN GOODS (duty paid and free).

Port Elizabeth: Unenumerated, £13. *Durban:* Unenumerated, £417. *Calcutta:* Unenumerated, £11. *Cape Town:* Unenumerated, £20. *Christchurch:* Unenumerated, £69. *East London:* Unenumerated, £180. *Lisbon:* Unenumerated, £525. *Melbourne:* Unenumerated, £143. *Saigon:* Unenumerated, £10. *Bombay:* Unenumerated, £44. *Bordeaux:* Unenumerated, £280. *Buenos Aires:* Unenumerated, £12.

IN TRANSIT.

Shanghai: Elec. glow lamps, £239.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

EDUCATIONAL.

Manchester School of Technology.—The session 1916-17 will open on October 5th, and the matriculation and entrance examinations will be held in July and September. In the Faculty of Technology there are complete courses of instruction in mechanical, electrical and sanitary engineering, the chemical and textile industries, mining, architecture, &c. First-year courses will be specially adapted to the requirements of students who may wish to take commissions in H.M. Forces. Prospectuses (free) and particulars will be forwarded on application.

Huddersfield Technical College.—A new department for specialised study and research in coal tar colour chemistry (aniline and alizarine dyes) is to be established under the headship of Dr. A. E. Everest.

BUSINESS NOTICES.

Messrs. John C. Fuller & Son (Ltd.), The Fuller Accumulator Co. (Ltd.) and Fullers Wire & Cable Co. (Ltd.) have transferred their offices and works to new and larger premises at Grove-road, Chadwell Heath, Essex. Telephone No. Ilford 173.

Claims against the Coke Ovens & By-Products Co. (Ltd.) are to be sent by July 24 to the liquidator Mr. Wm. Hutton 95, Gresham-street, London, E.C.

Plant Wanted.—An advertiser requires three 200 kw. generating sets, 450 to 550 volts a.c., coupled to up-to-date high-speed engines.

Water Power for Sale.—An advertiser has for disposal water power (up to 190,000 H.P.) in Western Norway.

Patent Development.—The proprietors of patents Nos. 15,951/1913 and 10,868/1914, for "Improvements in safety devices for electric conductors" and "Improvements in and relating to electrical condensers and a process of manufacture thereof," desire to enter into arrangements for exploiting same in this country. Particulars from Messrs. Haseltine, Lake & Co., Patent Agents, 28, Southampton-buildings, Chancery-lane, London, W.C.

LIQUIDATIONS, BANKRUPTCIES, &c.

A meeting to receive an account of the winding-up of Economisers (Ltd.) will be held on July 28 at 18, Theobald's-road, London, W.C.

A meeting to receive an account of the winding-up of the Hobart Electric Tramways (Ltd.) (in vol. liq.) will take place on Aug. 3 at 5, Bucklersbury, London, E.C.

ELECTRICITY SUPPLY.

EXTENSIONS.

West Ham.—The electrical engineer (Mr. J. W. Beauchamp) has been authorised to proceed with the work of extending the supply of current to the works of the India Rubber, Gutta Percha & Telegraph Co.

Stalybridge.—The Stalybridge, Hyde, Mossley & Dukinfield Joint Tramways and Electricity Board have received sanction to borrow £30,000 for additional generating plant, &c.

GENERAL.

Beckenham.—Owing to the increased price of coal, &c., the charge for electric current for private lighting has been increased to 7d. per unit.

Bolton.—Despite the Summer Time Act the electrical engineer (Mr. W. J. Wood) reports that there is no appreciable decrease in the consumption of electricity.

A war bonus of 3s. per week has been granted to fitters of the electric supply department.

Hiram Hart, an electrical fitter, formerly in the employ of the Electricity Committee, has been killed on active service, and the Electricity Committee have expressed their condolence with the relatives.

Colwyn Bay.—The Council has increased the price of electrical energy for private lighting from 5d. to 5½d. per unit.

Coventry.—The Electric Supply Committee recommends an increase of the scale of charges for the supply of energy for power proportionately to the increased cost of coal.

Gillingham.—The question of employing tar oil as fuel is under consideration. The cost of altering the two engines at the electricity works is estimated at £515.

Gosport.—The Gosport & Alverstoke Electric Light Supply Co. has notified its customers that, owing to the impossibility of retaining the services of trained men, and the practical impossibility, under present circumstances, of replacing them, it is feared that it may be necessary in the near future to restrict, if not entirely cancel, the supply of electricity for power, lighting and heating, also for the service of tramcars.

Hampstead (London).—The Borough Council have decided, owing to the heavy cost of coal, to increase the charge for electric current by 23⅓ per cent., making with the 10 per cent. increase made in January last a total advance of 33⅓ per cent. on the pre-war charges.

Hornsey.—The Council has again found it necessary to increase the prices for current and meter rent, this time by a further 15 per cent., provided they do not exceed the authorised maximum rates.

Huddersfield.—Mr. A. B. Mountain has resigned his position as borough electrical engineer, and the Council have, therefore, made the following arrangements for carrying on the work of the electric supply department as from Sept. 1 next :—

Mr. A. B. Mountain to be consulting engineer, up to Dec. 31, 1919, at £200 per annum and expenses : Mr. J. W. Turner to be borough electrical engineer at £400 per annum ; Mr. E. Lunn, station superintendent, to have his salary increased from £240 to £265 ; Mr. J. A. Swift, commercial assistant, to have his salary increased from £200 to £225 ; and Mr. Phillips to be appointed mains foreman at £182 per annum.

Ripon.—The City Council have decided to apply for a provisional electric lighting order.

St. Pancras.—The Electricity Committee has had under consideration the question of revising the charges for current in view of the serious loss falling upon the undertaking owing to the additional expenditure for generation and capital charges arising from the growing cost of coal, stores, &c., and as a consequence of the shorter periods during which current is now in use.

From reports of the chief electrical engineer (Mr. S. W. Baynes) and the chief clerk of the department (Mr. A. E. Pycraft) it appears to the Committee that these extra charges represent about £16,000, which must be met by increased revenue. Having due regard to the continuance of the 10 per cent. at present added to all accounts, the Committee recommends the following revision of charges, which they estimate will produce an additional income of £18,000 during the year : (1) Present charge of 1d. per unit for power, heating and cooking to be increased to 1½d. ; (2) present rebate of 20 per cent. allowed for "factory" lighting (exclusive of offices, showrooms, &c.) to be abolished, and a flat rate of 3d. per unit charged in lieu thereof ; (3) present two-rate system of 6d. per unit between 4.30 p.m. and 8.30 p.m., and 1d. per unit afterwards to be abolished ; (4) present maximum demand system of charge of 6d. and 1½d. per unit to be increased to 6d. and 2d., and the introduction of a flat rate of 2d. per unit for cinema theatre supplies ; (5) the kilowatt demand system of charge of £4 per annum plus ½d. per unit to be abolished ; (6) meter rents to be charged on a sliding scale in regard to all supplies instead of only, as at present, where a factory lighting rebate is allowed, and for cooking and heating purposes, &c., and where the maximum demand indicator is used.

The Finance Committee has reported that it is in full agreement with the above proposals of the Electricity Committee. The Finance Committee has had in view the fact that as a result of the agreement come to with the L.C.C. to accelerate the periods of repayment of certain electricity loans an additional sum of £1,454 a year will have to be paid from revenue during the next three years. Having regard to the heavy generation charges and other growing costs with which the undertaking is faced in these exceptional times, the Committee is of opinion that the interest of about £1,500 a year earned by the reserve fund account should be taken into revenue instead of accruing to the reserve fund, as the latter fund stands at an adequate amount without the addition of interest.

An e.h.t. main is to be laid in Gray's Inn-road to supply current for power. This work will necessitate the re-arrangement of the switchboard at Tavistock-place sub-station, and Mr. Baynes suggests that whilst the work is in progress it would be advisable for the switchboard to be extended (at a cost of about £462) to meet the growing demand for power.

Scarborough.—The Council is considering the advisability of substituting electric for gas lighting in the streets.

Slaithwaite Urban District Electric Lighting Order, 1914.—The Board of Trade has extended for one year from July 8, 1916, the periods of two years and 18 months respectively mentioned in sec. 21 of the schedule to the Electric Lighting Clauses Act as incorporated with the Slaithwaite Urban District Electric Lighting Order, 1914 (mains, &c., to be laid down in streets specified in special order and in remainder of area of supply).

Walthamstow.—The Lighting Committee has given instructions for the whole of the street lighting to be discontinued until the end of August.

The Committee recommends the installation of automatic switches for the public lamps, at a cost of about £150.

TRACTION NOTES.

Brentford.—The Council has decided to call the attention of the Board of Trade and the Commissioner of Police to the noise made by the tramcars owing to the worn-out state of the tracks.

Croydon.—The Corporation is purchasing from Edison Accumulators (Ltd.) a 4-ton electric vehicle for the use of the mains department and for coal cartage.

East Ham.—In consequence of the increased cost of tickets the Tramways Committee recommends the adoption of suggestions put forward by the engineer and manager and borough treasurer for the abolition of exchange tickets and for the provision of hand pliers for the cancellation of the return ticket on the return journey.

Huddersfield.—The salary of the tramways manager (Mr. R. H. Wilkinson) has been increased from £400 to £500 per annum.

Loughborough.—The Council have decided to purchase a 2-ton electrically-propelled truck, at a cost of £600, for the carting work of the electric supply department.

Middlesex Trailer Cars.—Hendon Urban Council will not raise any objection to the Metropolitan Tramway Co.'s proposal to run trailer cars through the district.

Southampton.—The tramways general manager (Mr. W. T. Robson) has reported on the inequality of the existing 1d. sections and as to the advisability of revising them.

Mr. Robson is of opinion that the department cannot afford to make any reduction in fares at present ; that in view of the difficulties caused by the war it is unlikely that an increased service could be run in order to meet the demand caused by cheaper fares and swell the receipts to the necessary amount ; that the adoption of 1d. fares to the junction would mean unworkable congestion at that point ; and that any future concession of this description should be shared equally by all passengers, irrespective of where they reside, either by the levelling-up of all stages to an equal length, or preferably, a universal 1d. fare, and the abolition of transfers. Mr. Robson also emphasises the fact that since his estimate for the current year was submitted an additional £2,000 had been added for increased electricity charges and also an increase of £1,000 on income tax. It was evident, therefore, that no surplus approaching that of last year could be looked for, and that brought up the question of the reserve and renewals fund, which now stood at a little more than £9,000. In an estimate of track work reconstruction required in the near future an expenditure of £9,400 during the next two years and a further expenditure of £24,000 during the next three to five years have been provided. Thus the sum standing to credit of renewals fund would have to be expended during the next two years, and without allowing for any extraordinary expenditure, it would be necessary to restore this fund to the highest possible amount in order to meet the heavy renewals in three to four years' time. That object could not be attained if any concession were made which would reduce the present income of the undertaking.

Having made an inspection of the permanent way, the Committee considered a revised list of 1d. sections prepared by the manager and arranged on the basis of equal stages throughout the various routes of the system, and approved the suggested alterations, which they desired should take effect as from July 1.

Mr. Robson reports that underneath the clips and brackets of the span poles on the Shirley route severe corrosion has occurred. The poles are rusted away to a little more than half their original thickness of metal, and in order to preserve them it will be necessary to remove all clips and scrolls and thoroughly scale the poles.

West Ham.—The Corporation is recommended to apply for sanction to a loan of £1,000 for doubling the tramway track at Connaught-road terminus.

The Tramways Committee, which has reconsidered the recommendation referred back at the last Council meeting in reference to the adoption of a revised list of ½d. stages and the substitution of 1½d. workmen's

return tickets for the existing 1d. returns, together with certain resolutions adopted by the Leyton Tramways Committee, now recommends that the following be adopted: (1) A universal 1d. fare for a continuous journey on any one car within the borough; (2) children's stages to remain in force as at present; (3) a 1½d. workmen's return fare for a continuous journey on any one car within the borough. Return tickets to be issued on all cars scheduled to arrive at a terminus before and up to 8 a.m.; (4) existing through fares (where necessary) to be adjusted to comply with the above scheme.

TELEGRAPH & TELEPHONE NOTES.

Growth of the London Telephone Service.—The new head office of the London Post Office engineering department at London Bridge was opened by the Postmaster-General on the 22nd inst.

Mr. PEASE said that when the war broke out there was a total number of all ranks in the London engineering district of 5,541, and of these 2,132 had joined the Colours, 25 had gained commissions, and 58 had fallen in the war, 68 had been invalided out of the Army and returned to their civil employment, seven had received the D.C.M., and others had been mentioned in despatches. The engineering staff had to maintain 53 telephone exchanges and 12,000 private branch exchanges. In addition 251,142 telephones were maintained in the district, which was equivalent to one-third of the telephone service of the United Kingdom. Over 300,000,000 calls originated in the metropolitan area last year. There were 600 telegraph offices, and the Central Telegraph Office was the largest in the world, and it dealt with one-third of the 91,000,000 messages which were sent out every year over cables 70,849 miles in length. Complaints regarding the telephone service had been reduced from 1·25 per thousand lines to 0·5, and investigation of these showed that the public were the sinners more often than the Post Office. The private branch exchanges had grown largely, and there were about 7,000 Government exchanges. The Ministry of Munitions had requested them to put up 1,500 telephones.

Telephone Installation.—The Union House Committee of Bradford Guardians is to obtain an estimate of the cost of installing an adequate telephone system at Bowling Park colony.

EMPIRE NOTES.

Australasia.—The "Australian Mining Standard" says the Progress Association of Helensburgh (N.S.W.) recently asked the Metropolitan Coal Co. if it could supply electricity for the lighting of the town. The company replied that at present they had no power to spare, but intends to install, shortly, a more powerful plant.

Melbourne Council has adopted a recommendation to reduce the tariff for electricity supply to Footscray, Port Melbourne, Brunswick and Williamstown, and the Brunswick and Coburg Tramway Trust. From November next the following reductions are to be made: Up to 500,000 units a reduction from the £5 per kilowatt to £4. 10s.; for any excesss above 500,000 units the charge will be £4 per kilowatt, plus present rate of 0·65d. a unit up to 1,000,000 units a year; 0·6d. per unit for next 1,000,000 units, and 0·55d. a unit for excess above 2,000,000.

The first section (about 2 miles in length) of the Melbourne, Brunswick and Coburg electric tramway, along Sydney-road from Moreland-road to Wilson-road, Coburg, was opened for traffic in April. The whole line will be completed by September. The cars are of the single truck, four-wheel combination saloon and open type, seating 40 passengers. The cars are fitted with two 65 h.p. motors, capable of driving them at 52 miles an hour, although, of course, such speeds will not be attempted.

The formal inauguration of the Tasmanian Government's Great Lake hydro-electric scheme connecting with Hobart, took place recently when Sir R. Munro Ferguson, Governor-General, performed the ceremony of switching on the current. The requirements of the State hydro-electric department run up to near 100,000 h.p., while several contracts are being negotiated. Hobart Council will be a considerable customer, and contracts have also been made with the Amalgamated Zinc (De Bavay's) Ltd., and the Mt. Lyell Mining and Railway Co (though the latter has its own Lake Margaret scheme in full operation). These two, as well as the vendor company, will employ the power supplies in metallurgical work, and their demand should soon amount to about 100,000 h.p. The Government is not yet in position to commence the general supply, and at the opening of the works only produced about 10,000 h.p. There is in contemplation a scheme to utilise water power in Lake St Clair, 30 miles west of the Great Lake.

India.—It is stated that the Mukhs and the leading Sind merchants of Hyderabad are combining to establish an electricity supply company for Hyderabad, on the lines of the Karachi Electric Corpn.

Messrs. Mukhi Hiran & Tarachand are to be managing agents of the proposed company. The engineers of Messrs. Tata & Sons' electricity works are to be consulted. It is proposed to utilise the water power of the river Indus for the generation of electrical energy.

FOREIGN NOTES.

Argentina.—The "Review of the River Plate" says the Government of the Province of Buenos Ayres have ordered a payment of $5,500 m/n. (about £500) for the installation of an electrical generating station for the lighting of the North Esplanade at Mar del Plata.

In their report for the year ended December last the directors of the Compañia Italo-Argentina de Electricidad say owing to the war progress has been retarded but the principal difficulties were already surmounted. Profits for the year, after applying $101,232 m/n. to amortisation fund, amount to $108,311 m/n., which has to be distributed as follows: 5 per cent. ($5,417) to reserve, 5 per cent. ($5,417) to directors and syndic, and balance ($97,507) plus $1,134 brought forward from previous year, making $98,642 to shareholders. This sum is carried forward.

British Trade With Italy.—The British Chamber of Commerce for Italy states that the new headquarters of the Chamber at 7, Via Carlo Felice, Genoa, are now ready.

The offices are situated in a very central position, in a main thoroughfare. The rooms are lofty and adapted for the sample exhibition of British goods (in showcases) suitable for import into Italy. The offices of the Chamber are in the same premises, and all callers will pass through the showrooms, which it is intended to keep open daily from 10–12 a.m. and 2–5 p.m. Firms desirous of exhibiting should apply at once to the Secretary General (Mr. E. B. Weatherhead), and it is also pointed out that exhibits should be selected with a special view to business after the war.

China.—H.M. Consul at Kiung-chow (Hoi-how) states that, generally speaking, the whole of the import business of Kiung-chow is done through importing firms in Hong Kong, the centre of supply for the South China market.

United Kingdom firms who are not in a position to send out agents of their own to push sales direct should endeavour to get into touch with importing firms in Hong Kong through the Chamber of Commerce there, or through the firms' own offices in London. There is a good demand in South China for tools, small lamps with fancy globes, electric hand lamps, and cheap novelties of every description.

St. Thomas (Danish W. Indies).—The "Syren and Shipping" says the first large section of the new harbour works at Long Bay has been completed, and comprises quayage 3,200 ft. in length. There is accommodation for 180,000 tons of coal, and steamers can be bunkered or discharged at the rate of 150 tons per hour each by two electric conveyors.

Venezuela.—The Ministerio de Fomento has granted General Gabriel A. Laclé, of Coro, permission to construct a telephone line about 12½ miles in length, in the Miranda district of the State of Falcon.

Wireless Telegraph Charges in Chili.—The Chilian State Telegraph Office has issued a circular stating that the tariff for radio-telegrams in any language, or in cipher, for vessels of any nationality sent from one of the coastal stations is $5.50 gold (of 18d.) for the first 10 words and 55 cents for every additional word.

For radio-telegrams sent from one wireless station to another, $4 (currency) will be charged for the first 10 words and 40 cents each additional word. If messages have to pass over the lines of other companies an additional charge will be made. Radio-telegrams for Port Stanley (Falkland Islands) will be charged $6.50 gold (of 18d.) and 65 cents gold for every additional word. Press telegrams will be taken at half tariff rates.

MISCELLANEOUS NOTES.

Automatic Telephony in Italy.—A proposal has been introduced in the Italian Parliament for converting all the telephone exchanges to the automatic system, the working of the 2,000 line automatic exchange which has been in operation in Rome for some years having proved satisfactory.

Coal Supplies for Electricity Works.—St. Pancras Electricity Committee has received a reply from the Board of Trade in reference to the representations made as to the necessity of action being taken to ensure an adequate supply of coal for the undertaking, forwarding a list of District Coal and Coke Supplies Committees appointed by the Board, and suggesting that in any case in which the Council are unable to renew a contract, they should communicate with the Committee for the district in which the colliery concerned is situated, and also suggesting that, if the Council have not already done so, immediate steps should be taken to renew contracts which will shortly expire. The Committee has also received a reply from the Admiralty Coasting Trade Office, stating that every effort will be made to assist the Council to secure supplies, and enquiring the

names of the Council's contractors, the class of coal, and the monthly quantities absolutely essential for the undertaking.

Alien Enemy Firms.—Messrs. Edward Le Bas & Co., sales agents for the Standard Underground Cable Co. (of Pittsburg and Perth Amboy, U.S.A., and Hamilton, Canada), whom they have represented in this country for many years, write to say that that company has no connection with the Standard Cable Mfg. Co., which is being wound up owing to its being an enemy concern.

Enemy Firms Wound Up.—The Board of Trade has ordered the winding up of 299 businesses controlled by alien enemies.

Included in the latest list are Eiermann & Tabor, 2, Lauderdale-bldgs., Aldersgate-street, London, E.C., bronze powder and metal leaf manufacturers. (Controller: P. W. Straus, 7, Great Winchester-street, E.C.) Bakelite Co. (Ltd.), Orb Works, Cowley, Middlesex, makers of insulating material. (Controller: Sir William B. Peat, 11, Ironmonger-lane, E.C.) Th. Goldschmidt (Ltd.), care of Messrs. Hudson, Smith, Briggs & Taylor, Thames House, Queen-street-place, London, E.C., purchasers of tin scrap. (Controller: Arthur Taylor, Thames House, Queen-street-place, E.C.) W. Wertens & Co. (Ltd.), Balfour House, Finsbury-pavement, London, E.C., purchasers of tin and timber properties. (Controller: J. D. Pattullo, 65, London Wall, E.C.) Griesheim-Elektron (Ltd.), 3, Thames House, Queen-street-place, London, E.C., and 119, Chapel-street, Salford, chemical merchants. (Controller: Wm. Eaves, 15, Fountain-street, Manchester.)

Claims against Ship Carbons (Ltd.), 5, Chancery-lane, London, W.C., are to be sent by Aug. 7 to the controller, Wm. Hancock, 90, Queen-street, Cheapside, E.C.

Claims against the Standard Cable Mfg. Co. (Ltd.), 18 and 19, Queenhithe, London, E.C., are to be sent by July 31 to the controller, J. S. Feather, 35, Great Tower-street, E.C.

Exports to Liberia.—The Foreign Trade Department of the Foreign Office announces that Cassius Ernest (Monravia) and the Liberian Government Departments have been added to the list of persons and bodies of persons to whom goods may be consigned from the United Kingdom.

New Zealand Trade.—In his report on the trade of New Zealand for 1915 the late Trade Commissioner in New Zealand (Mr. W. G. Wickham) says, speaking generally, the year was one of overwhelming prosperity for the Dominion.

Imports from the United Kingdom have declined somewhat seriously. Imports from Germany in previous years have been valued at £1,000,000, and from this source, as well as from Austria-Hungary, Turkey and France, practically nothing has reached New Zealand during 1915. On the other hand, the war has effectively stimulated trade with America and Japan. From America travellers in search of business have come to New Zealand in unusual numbers. Importers have made the acquaintance of new suppliers, and the leeway to be made up by British manufacturers will be serious. Mr. Wickham says firms occupied entirely with munition making, and who are precluded from exporting should make the fact known to their N.Z. customers, and if goods are still available, but at enhanced prices, an explanation of the cause of the enhanced prices should be given, and firms should spend more rather than less in advertising. Manufacturers should give the Trade Commissioner particulars of what goods he makes, and the name of the agent should also be given in order that the Commissioner can refer inquiries to him.

South African Patent Law.—The "Union of South Africa Government Gazette Extraordinary" of April 15 contains the text of an Act (No. 9 of 1916) to consolidate and amend the Laws in South Africa relating to the granting of letters patent and for the registration of patents, designs, trade marks and copyright.

South African Trade in 1915.—The Customs and Excise Department's review of the trade of South Africa in 1915 says the war brings prominently to the fore the extent and significance of South Africa's reliance upon intercourse with the outside world.

The shortage of tonnage and the frequent holding up of sea-borne traffic have not, however, imposed any conspicuous hardships upon the community at large. The demand for goods has been well maintained, though in a large number of instances orders could not be executed. Imports were valued at £33,833,542 (compared with £36,391,861 in previous year). Machinery, &c., imported was valued at £1,929,762 (against £2,555,331) and metal manufactures (not machinery) £1,358,499 (£1,875,338). There was a decrease in imports of motor vehicles, probably largely due to difficulty in obtaining supplies. Imports from the United States amounted to £4,413,148 (compared with £3,009,497 in 1914). There was an increase in exports of asbestos (6,180,000 lb.; value £44,500, compared with 2,614,000 lb., value £19,300). The United Kingdom has taken larger quantities than Germany during recent years, reversing the former position.

The Telephone in Canadian Farm Work.—It is reported that there is now in Canada one telephone installation for every 15 persons in the Dominion. The number of telephones reported as being in use in 1915 was 533,090, an increase of 11,946 over 1914. The principal growth was in rural districts.

The net earnings of the 1,396 companies in Canada totalled $4,764,957, or $350,091 better than in 1914. The total capitalisation of Canadian telephone companies amounts to $74,285,000. The growth of the system in the rural districts is remarkable as demonstrating the use that is being made of the telephone by the farming community. On the Canadian farm the telephone is no longer regarded as a luxury but as a necessary adjunct to business.

TENDERS INVITED.

Telegraph and Telephone Material.

Tenders are invited up to Aug. 16 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, PERTH (W. Australia), requires tenders by 3 p.m. June 28 for Paper-insulated Lead-covered Cable (schedule 489 W.A.), and until 3 p.m. July 19 for 96 Terminal Blocks (schedule 495 W.A.). Specifications from the Deputy Postmaster-General, Perth, W.A.

Tenders are also invited up to July 19 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of Insulators (schedule 510). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

The Deputy Paymaster-General, Perth (W. Australia), also requires tenders by 3 p.m. July 12 for supply of 3,000 Dry Cells for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy-Postmaster-General.

The Deputy Postmaster-General, Adelaide, requires tenders by 2 p.m. July 12 for 600 Accumulator Cells and Telegraph Power Board Apparatus (schedule 415) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Department. Specification, &c., from the Deputy Postmaster-General, Adelaide.

Telegraph and Telephone Material.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

Cables.

ABERDARE Urban Council require tenders for the supply and laying of Cables. Specifications from the General Manager, Electricity Works, Aberdare.

ROCHDALE Electricity Committee require tenders by noon July 12 for 12 months' supply of Paper-insulated Cables. Specification from Engineer and Manager, Dane-street, Rochdale.

Tramway Stores, &c.

ROTHERHAM Corporation require tenders by July 3 for 12 months' supply of Tramway Stores and Materials, Cables, Trolley Wire, &c. Specifications from the Engineer and Manager, Electricity Works, Rotherham.

Lift and Turntable, &c.

MANCHESTER Electricity Committee require tenders by noon July 11th for (*a*) Electric or Hydraulic Coal Wagon Lift and Turntable; and (*b*) Saddle Tank Steam Locomotive for their Stuart-street generating station. Specifications, &c., from the Secretary, Electricity Dept., Town Hall, Manchester.

Signal Lighting Transformers.

The VICTORIAN RAILWAY COMMISSIONERS want tenders by 11 a.m. July 26 for 400 Signal Lighting Transformers (contract No. 29,997). Specifications from the Commissioners' Offices, Spencer-street, Melbourne, Victoria.

Turbo-Alternator Surface Condenser and Auxiliaries.

The Corporation of ABERDEEN invite tenders for the supply, delivery and erection at their electricity works, Millburn-street, Aberdeen, of one 5,000 kw. Turbo-Alternator to run at a speed of either 1,500 or 3,000 revs. per min., together with surface condenser and auxiliaries. Specification, general conditions and form of tender from the city electrical engineer, Mr. J. Alex. Bell, to whom tenders are to be delivered by noon July 7.

Street Lighting, Generating Plant, Gas Engines, Dynamos, &c.

PAHIATUA (N.Z.) Borough Council requires tenders by noon July 10 for (contract No. 1) Overhead Wires, Poles and Street Lamps; (No. 2) Gas engines, Producers, Dynamos and Auxiliary Apparatus; (No. 3) Accumulators. Specifications and plans from the Town Clerk, Pahiatua.

TENDERS RECEIVED AND ACCEPTED.

ST. PANCRAS.—The Borough Council has received the following quotations for the supply of 1,000 yd. of c.h.t. three-core cable :—

Western Electric Co. (*accepted*)	£568	Siemens Bros. & Co.	594
Union Cable Co.	564	W. T. Henley's Telegraph Works Co.	597
Pirelli General Cable Works	579	W. T. Glover & Co.	608
Johnson & Phillips	590	Callender's Cable & Construction Co.	632
British Insulated & Helsby Cables	590	Macintosh Cable Co.	690

For the supply of coal the tender of Beattie & Co. has been accepted. The approximate estimated quantities are 16,125 tons beans; 5,375 tons nuts and 3,600 tons large hard steam. The prices quoted (£1. 6s. 5d. for hard steam, £1. 4s. 5d. for beans and £1. 5s. 8d. for nuts) are subject to any advance or reduction should same be authorised under any alteration of the Price of Coal (Limitation) Act, to the Coal Exchange Strike, &c., Clauses, the Official Government Clause, and to the increase or reduction in railway rates and charges.

GLASGOW.—The Corporation have accepted the tender of Babcock & Wilcox for four sets of water-tube boilers for St. Andrew's Cross electricity works at £10,632, and that of Waygood Otis (Ltd.) for an electric hoist for the Sauchiehall-street showrooms at £250.

SUNDERLAND.—The Council have accepted the tender of Ferranti Limited for extra-high-tension switchgear and meters; that of Stewarts & Lloyds for pipework; and that of P. A. Mudd & Co. for pipe and boiler lagging.

METROPOLITAN ASYLUMS BOARD.—The Board has accepted the tender of the General Electric Co. for annual supply of electrical stores.

MARYLEBONE (LONDON).—The Borough Council has accepted the tender of Oakes & Co. for renewing boiler house coal chutes, at £96, and that of the Cumberland Engineering Co. for the supply of electro-chemical apparatus for diverting corrosion from the economiser tubes to pieces of cast-iron placed in the economiser for that purpose, at £100.

BRENTFORD.—The Igranic Electric Co. has received an order to supply the automatic starters required by the Council for the pumping station.

SOUTHAMPTON.—The Electricity Committee has accepted the tender of Jenkins & Co. (at £147. 15s.) for the supply of a coal breaker.

WATFORD.—The Electricity Committee recommends the acceptance of the offer of the Tudor Accumulator Co. to renew their contract for battery maintenance for 10 years on the same terms as before, but that the engineer should, if possible, obtain the deletion of the condition that there shall be no option to terminate the contract before the 10 years have expired.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Brighton.—The accounts of the tramways department for the year ended March 31 show total capital expenditure £280,616 (including £5,723 for rail-less traction), of which £76,330 has been paid off.

Revenue was £57,974 (compared with £56,526), and working and general expenses were £37,163 (£41,148), leaving gross profit £16,935 (£13,541). Capital charges and income tax, less bank interest received required £14,704 (£13,990), and net profit was £2,230 (£18).

Revenue per car-mile was 13·202d. (12·24d.) and working expenses were 8·47d. (8·91d.). Passengers were 12,295,198 (11,837,828), car-miles run 1,053,285 (1,108,352), and units used 1,678,627 (1,676,770).

In his report the engineer and manager (Mr. Wm. Marsh) says, although much less was spent on repairs and renewals, power expenses and war allowances largely increased. War dependents' separation allowances absorbed £3,838, war bonus £222, and extra income tax amounted to £474, and bombardment and aircraft insurance £88, total £5,490. This additional expenditure does not include the extra cost of materials nor the interest on the rail less traction expenditure, from which no benefit has been derived yet. The female conductors have done extremely well, and at present 54 women and girls are employed.

During the 12 months 82 more men joined H.M. Forces, bringing the total up to 196. During the year 36 men were engaged who had left the forces, being incapacitated for further service, but who were able to be taught driving or conducting.

Up to date 491 rail joints have been welded by the Thermit process without a single one having broken, though some were done five years ago.

Burton-on-Trent.—The electricity department's accounts for the year ended March 30 show total capital expenditure £127,389 (increase £2,616), and the outstanding debt is £63,177.

Income was £20,310 (compared with 18,541 in 1914-15), and working expenses were £9,770 (£8,579), leaving gross profit £10,540 (£9,962), and the net balance, after meeting all charges, was £1,938 (£2,565), of which £1,308 has been applied to capital purposes, £520 to meet depreciation of Consols, and £110 carried to renewals fund. Units sold were 3,499,338 (compared with 2,914,828), the increase being chiefly in sales for power and heating. Total horse-power of motors connected is 3,360 (increase 357 h.p.). Total costs were 0·658d. (against 0·686d.) per unit. Maximum load was 1,751 kw. (increase 431 kw.).

In his report Mr. Thos. Hall (borough electrical and tramways engineer) says the gross profit of £10,540 represents 8·3 per cent. on the capital expenditure (against 8 per cent.). The revenue contribution to capital (£971) included meters £303, motors £343, radiators and cookers £182 and wiring circuits £141. There is an increase of nearly £1,000 in the fuel bill, and a further substantial increase must be expected this year. During the year under review the price of electricity was not increased. The ordinary capital charges were up £904, and £2,860 has been provided for capital and special expenditure incurred during the year. Units sold to power and heating consumers show an increase of 649,193, or 35 per cent. Tramway supply shows a decrease of 46,692 units. This has shown a continual decrease since 1910. Revenue from lighting shows a decrease of £346. This is the first year since the advent of the metal filament lamp that there has been a decrease in revenue from this class of supply, but the decrease is accounted for by the curtailing of the hours of public houses and restricted hours of shop lighting. Revenue from the sale of energy for power shows a record increase of £1,761. During the last three years the revenue from power consumers has increased by nearly £1,000. The heating and cooking demand is showing rapid progress. In the year previous to the opening of the showrooms this supply only yielded £213, whereas this year the revenue amounts to £827, which proves the usefulness of a showroom in developing sales of electricity for domestic purposes. Average price obtained was 1·34d. per unit (compared with 1·49d. in the previous year and 2·51d. in 1905-6). Total costs per unit are down, which is accounted for by there having been a substantial increase in the units sold. This is a strong point in favour of supplying large supplies at a low rate, and it proves that the average cost of production in any one year cannot be taken as the minimum at which it is possible to produce a unit. Although there was an increase of £940 on the cost of generation, there was a decrease in the cost per unit sold. The same applies to total costs, where there is an increase of £1,265 but a reduction in cost per unit sold of 0·028d. There is no doubt that a showroom is most beneficial to an electrical undertaking. The showrooms have been well patronised by consumers, and although the department is unable to deal with some inquiries at present, there is every possibility it will reap the benefit when the present national crisis is over. The profit-sharing scheme has again been a decided success, the bonus working out at 6·8 per cent., compared with 6·28 per cent. last year. The total amount payable to the employés on the wages bill was £227. 15s. 7d. This scheme has a good effect upon the men by making them take a keen interest in the welfare of the undertaking. The reserve should be built up to a sum approaching 10 per cent. on the capital outlay. To provide cheap electricity the department must be so placed financially that it can take advantage of any improvements introduced. It will be remembered how well the introduction of the new machinery in May, 1913, was justified. The cost of generation has dropped from 0·921d. to 0·64d. per unit, and the capital charges from 0·589d. to 0·51d. per unit. No. 2 turbine was put into commission in May, 1915, and has taken a very large proportion of the running hours of the station during the year.

The tramway accounts show gross capital expenditure £101,648 (increase £1,239). Revenue was £16,046 (against £16,493 in previous

year), working expenses were £12,019 (£12,962), leaving gross profit £4,027 (£3,531). Loan charges were £2,687 (£2,693), and net balance was £1,329 (£838), of which £1,239 has been transferred to capital account and £90 has been carried forward. £1,500 provided out of rates has been placed to renewals fund.

The report of the tramways manager (Mr. A. B. Slater) says the income per car-mile was 9·92d. (against 9d.). Though the traffic revenue shows a decrease, the figure per mile is higher, due to curtailment of the service during unremunerative periods of the day. Revenue from passengers' luggage was £197 (£198), the number of parcels carried being 47,408 (decrease 176). The profit on the parcels' express service was £92, the parcels carried being 76,795 (decrease 3,943). Car-miles run were 386,876 (against 440,021). Passengers carried were 3,223,559 (3,311,355). Operating expenses were 7·05d. (6·74d.). Power consumption increased from 1·04 to 1·07 units per car-mile, which is satisfactory, considering the large number of new motormen and conductors.

Hereford.—The accounts of the electricity department for the past year have been prepared, and it has been decided to increase the charges as from June 24.

All lighting units charged at 4½d. or 3d. per unit before the war are to be charged 6d. All other units 25 per cent. extra, making with the advance of 10 per cent. last year a total advance of 35 per cent. on previous prices. Discount will be allowed on same scale as before. The Lighting Committee state that as every item of expenditure has gone up, the chief item (fuel) by no less than 59 per cent., the increase seems unavoidable.

Poplar (London).—The accounts of the electricity department for the year ended March 31 show gross capital expenditure £451,164 (increase £22,873), of which £306,912 is outstanding.

The year's income was £88,992 (compared with £74,176 in 1914-15), or £88,489 (£73,438) after allowing discounts, &c. Total cost of production was £52,178 (£35,953), leaving gross profit £36,311 (£37,484), and net revenue charges were £24,742 (£22,961), leaving net profit £11,568 (£14,523), or £11,814 (£14,749) after adding income from property and profit from sales department. Cost per unit sold was 0·352d. (0·2532d.). Units generated were 26,244,494 (20,768,512), including units generated from coal 22,581,243, from dust destructor steam 1,250,212, and purchased 2,413,039; and sold 21,506,614 (16,899,548). Coal used per unit generated was 3·058 lb. (2·961 lb.). Plant capacity is 10,000 kw. (10,200 kw.). Maximum load (including works) was 8,750 kw. (7,250 kw.). Connections are equal to 21,857·669 kw. (19,793·73 kw.).

Mr. J. Horace Bowden, borough electrical engineer and manager, says in his report the agreement entered into with Stepney Council obviated the necessity for further extensions until the maximum demand upon the Poplar undertaking has reached 10,000 kw. This provision will allow for an output of 25,000,000 units per annum, which will probably meet all demands until the winter of next year. Average price of coal was 17s. 11½d. per ton, compared with 12s. 5½d., the difference amounting to £8,478 on a consumption of 30,829 tons. Reciprocal supply with Stepney is the dominating factor in the improvement of the efficiency of the system from 81·37 per cent. to 81·94 per cent., by saving works units when shut down. Working costs have risen from 0·51d. to 0·58d. per unit, which is probably the record for the metropolitan area for the past year, and average price obtained was 0·988d. per unit, which was also a record. If the supply to Stepney is deducted, the resultant figure for sales in Poplar (1·087d.) is still a record to date. Capital employed per kilowatt of plant installed (£30·7) appears to be about the lowest in the country, and the output (over 21½ million units) is the largest figure yet published for any metropolitan municipal undertaking. Load factor was 30·2 (against 28·8) per cent., the increase being probably accounted for by the restricted lighting during the past winter. Capital charges on account of new extensions were increased by £741, and as Stepney did not take a stand-by supply the net income was £1,200 less. The showrooms and commercial offices opened in July, 1911, have proved an unqualified success. In addition to the increased sale of current, the net profit from sale of lamps and fittings was £217 (against £189).

Rochdale.—The accounts of the tramways department for the year ended March 31 show gross capital expenditure £360,754 (increase £7,553), and the total amount placed to sinking fund is £120,868.

Revenue was £87,909 (against £83,401 in previous year), working expenses were £48,124 (£46,891), interest required £10,396 and sinking fund £9,398, leaving net balance £19,991, of which £6,309 was paid as rent for Littleborough, Whitworth, Bacup and Milnrow lines, £3,865 as income tax, £2,945 to Heywood Corporation and £3,263 as half wages to men on active service and as war bonus. The net profit was £3,608 (£4,284). Passengers carried were 14,632,646, car-miles run 1,698,504 and units used 2,777,673 (=1·729 per car-mile). Total revenue was 12·48d. per car-mile, and working expenses, including power, were 6·911d. Average fare charged per car-mile was 0·9d. The decrease in net profit is due to increases in costs, including £1,250 more for power, £1,826 for income tax and £2,074 paid to men on active service and as war bonus. Gross profit increased £4,506, contributed to by all sections except Littleborough.

Walsall.—In presenting the annual accounts of the electric supply department for the year ended March 31, the chairman of the Electricity Committee (Mr. Hayward) said that a loss of £900 on the year's trading was a serious matter.

Although the new electricity works were to have been completed 12 months ago they were not yet in use. In respect of the capital outlay involved, however, £950 had had to be provided, which more than accounted for the deficiency. The Committee had had to pay an additional £1,400 for coal, and the allowances to dependents of men on active service amounted to £427. Difficult problems had to be faced in the near future, as in the current year the capital charges on the new works would be increased to £2,450. It might be suggested that the charges to users of current should be increased, but such a course would be disastrous to the undertaking, which could meet the extra charges only by an increased output.

The MAYOR said as the charges for current locally were already in excess of the general average, the Committee felt that the only thing they could do was to go on and take the risk, hoping things would right themselves at a later stage. In the event of a loss taking place, the undertaking had no reserve fund, and it would be necessary to call upon the ratepayers to make good the loss.

Worcester.—At March 31 the total capital expenditure of the electric supply department was £174,385 (increase £257). Stock cancelled, redemption fund and sinking fund amount to £85,869, and debt redeemed to £9,915.

Revenue was £21,225 (against £20,860 in previous year), and total costs were £9,968 (£9,225), leaving gross profit £11,256 (£11,634), capital charges were £10,652 (£10,673), and the net result was a deficit of £121 (after paying £725 for work of capital nature and improvements), compared with a deficit of £81 in previous year (after payment of £879 for improvements). Total working expenses per unit sold were 0·89d. (0·84d.), of which coal cost 0·38d. (0·32d.), and total costs, including capital charges and improvements, were 1·996d. Average price obtained was 1·85d. per unit. Units generated were 2,853,492 (2,915,814) and sold 2,567,104 (2,506,875). Maximum load was 904 kw. (939 kw.) and load-factor 19·58 (23·26) per cent.

Mr. C. M. Shaw, city electrical engineer, says in his report 238,915 extra units were sold for power; motors equal to 323 H.P. and heating devices to 45 H.P. were connected during the year. Increased cost of production seemed to be about 50 per cent. in the case of persons producing their own power, and from 10 to 15 per cent. in the case of central stations, and this factor was working in their favour. Units generated by water power were 607,682 (509,422). Coal cost was the same per unit as in 1912-13, since which year the price per ton has increased more than 45 per cent. This improvement in cost of coal per unit is due to the new turbine and mechanical stoker and the increased power output. The prospects of further development of the power load are distinctly favourable.

COMPANIES' MEETINGS AND REPORTS.

ALUMINIUM CORPN. (LTD.)—At the meeting last week Mr. S. G. Bibby presided, and said that they were now reaping the benefit of the Dulyn water, and already it was making all the difference as regards their output, which had increased by approximately 30 per cent. during the five months of the current year compared with the same period of 1915. An ample water supply was absolutely vital to the company's success; the more water the company could control the greater the output. After paying debenture and loan interest, directors' fees, &c., the net profit was £14,257. 1s. 9d., which was fully £6,000 greater than in the previous year. The capital expended during the year was £24,034, and about half that was spent on the Dulyn tunnel. With balance forward, their available balance was £17,543. 4s. 2d. Having regard to the present position and the prospects of the company, the directors recommended that a start be made to reduce the accumulating preference stock dividend by a payment of 7 per cent., less tax, leaving £4,559. 16s. 2d. to carry forward. They would be pleased to know that the company had proved itself during the past year to be a national asset. Conditions were extremely abnormal in consequence of the demand for aluminium. Recent developments would have the effect of increasing the demand and consumption of aluminium when they returned to normal peaceful times. While the abnormal demand for the metal had created a much higher selling price than that ruling prior to the war, it must not be overlooked that the cost of production had very considerably increased. They had experienced serious difficulties as to supplies of raw materials, labour, freights, &c. The Treasury had permitted them to increase their debenture issue, and they were negotiating for placing a further £100,000 6 per cent. debentures, to rank pari passu with the existing issue. That would allow them to proceed with the erection of the Cowlyd and Trasbwll dams, which were essential to increased output they had in view. Arrangements had also been made for the installation of a new generator, and work had been commenced upon a bridge over the River Conway, which would enable them to bring the L. & N.W. Railway trucks into the works.

The report and accounts were adopted, and at an extraordinary general meeting immediately after the Conway and Colwyn Bay Joint Water Supply Board Bill, which provides for the joint use of the Cowlyd watershed by the company and the Cowlyd Water Board, was approved.

BRITISH ELECTRIC TRACTION CO. (LTD.)—Mr. Emile Garcke, who presided at the meeting last week, said that the enlistment of a large number of their men had caused a good deal of disturbance in their organisation, and in other respects changes had been brought about in consequence of the war which had in many ways altered the character of their business. They had had to pay higher wages, and there was great scarcity of material, which cost more. Their working expenses had increased considerably, but they were not able to charge correspondingly more for their services. Their tramway fares and the rates for the supply of electricity were fixed by acts of Parliament, and in most cases could not be increased. If, therefore, they showed larger profits, it was because they had done very much more work, for they had earned

less per passenger and per unit. They were making no so-called war profits. An Act had been passed taxing heavily all profits made during the war in excess of those of a pre-war period. There was no injustice in that, speaking generally, but tramway and electricity supply companies occupied a most exceptional position. Those businesses, if they were profitable, were taken over by local authorities on the expiration of specified periods, and the price paid was generally less than the capital expended. Therefore those companies were bound to make large reserves out of profits, and it was only after the undertakings had been developed for several years that they were able to do that. A tax on profits in those cases was thus also a tax on capital. They had suggested to the Chancellor of the Exchequer that special protection should be given to such companies, but the only concession they had been able to obtain was that those cases should receive special consideration by the referees. As regarded the results of the year's working, the revenue from their investments and sundry profits amounted to £244,000, or 8,500 more than in the preceding year, and their general expenses were £27,749, or £1,500 more. The average yield on all their investments for the past year represented 5·19 per cent., which was a little higher than the figure for the preceding year. The available balance was £209,000, or about £11,000 more than in the preceding year. After paying the debenture interest (£91,259) and the dividend of 6 per cent. for the year upon the cumulative participating preference stock (£42,764), they had a balance of £75,146, besides £71,398 brought forward. Last year nothing was placed to reserve, but the directors thought that an addition of £20,327 to reserve, raising it to £410,000, was the right thing to do this year. With regard to the dividend on the new ordinary stock, it might be remembered that when the scheme of rearrangement of capital was formulated he intimated that in the first year after the scheme had been carried through they would be in a position to pay on the new ordinary stock a dividend of 4 per cent., and that they might expect the dividend gradually to improve. The accounts showed that their estimates were well founded, and that they could easily pay this year a dividend on the ordinary stock of more than the 3 per cent. suggested. The estimate was made before the outbreak of war, and circumstances had since completely altered. It was important that they should keep in a liquid form some part of their profits, especially as the present was not a favourable moment for the realisation of their investments. After making the various appropriations mentioned, they were able to increase the carry forward by £15,030 to £86,428.

CIE FRANCAISE POUR L'EXPLOITATION DES PROCEDES THOMSON-HOUSTON.—The report for 1915 states that the net profits amounted to 4,821,778 francs, an increase of 272,000 francs. A dividend of 7 per cent. is proposed, leaving 197,614 francs to be carried forward.

CITY OF BRISBANE ELECTRIC LIGHT CO. (LTD.) The report for the year 1916 stated that, after making additions to the franchise and purchasing sinkingfund and renewal, replacement and contingencies account, and allowing for depreciation, the credit balance was £20,133 which, with balance brought forward, made £21,448. The directors paid an interim dividend in Sept. last (£8,987, 2s.), a further dividend was paid in March, 3 per cent. on the preference shares and 5 per cent. on the fully-paid ordinary shares, and 5 per cent. on the contributing shares. A balance of £1,569 was carried forward.

GLOBE TELEGRAPH & TRUST CO. (LTD.) The net revenue for the year ended May 31, after deduction of expenses, amounts to £226,085. 11s. 8d., and makes, with £27,655. 6s. 9d. brought forward, a total of £253,740. 18s. 5d. From this amount there has been distributed £122,932. 9s. 1d. in interim dividends, leaving an available blance of £130,808. 9s. 4d. The directors now recommend payment of the following final dividends, viz., 3s. per share (less tax) on the preference shares, making with previous distributions a total dividend for the year on those shares at rate of 6 per cent. per annum (less tax), and 8s. per share (tax free) on the ordinary shares, making with previous distributions a total dividend on these shares at the rate of 7 per cent. (tax free) for the year. These dividends will absorb £93,959. 12s. 8d., and leave £36,848. 16s. 8d. to be carried forward. During the year £3,700 Anglo American Telegraph Co.'s preferred stock has been sold, also nine certificates of the Submarine Cables Trust, belonging to this company, have been drawn and paid off at £120 per certificate. The proceeds have been re-invested in the Eastern Telegraph Co., the Telegraph Construction & Maintenance Co. and Indo-European Telegraph Co.

IMPERIAL TRAMWAYS CO. (LTD.) The report for 1915 states that the available balance is £25,769, and after payment of debenture and preference interest the directors propose a dividend for the year at rate of 2 per cent. on the ordinary capital (less tax), carrying forward £193. The gross receipts of the Middlesborough, Stockton and Thornaby electric tramways amount to £66,529, an increase of £2,967. The net profit is £15,431, compared with £17,604.

JAMES KEITH & BLACKMAN CO. (LTD.) The chairman (Mr. T. W. Alsop) announced at the meeting last week that the business done during the past year was a record; it was 18 per cent. more than in the previous year. The proposed dividend was 10 per cent. (tax free). The patents and goodwill they proposed to wipe out altogether.

Mr. James Keith (managing director), in seconding the adoption of the report and accounts, said that, notwithstanding the continued diminution at home in the lighting department of our business, owing to Government restrictions, the turnover has largely increased in other directions. Of course, they had to get a lot of new and special machinery to meet urgent requirements, but they had been careful only to obtain such machinery as would be necessary for their regular and special work long after the war would be over. Their principal trouble at present was the getting and retaining of skilled workmen.

KENT ELECTRIC POWER CO.—The directors' report states that the total revenue from the sale of electrical energy, &c., for the past year was £21,204, from which must be deducted working expenses (£15,601), leaving a profit of £5,603. From this has to be deducted interest on debenture stock, &c., and directors' and auditors' fees (£4,536), leaving £1,067, making, with amount brought forward (£565) a total of £1,632, which the directors propose to carry forward. Owing to the increased cost of production and to lighting restrictions the profits have not reached a sufficient amount to enable the first instalment of £1,500 Lloyds bonds to be redeemed, or to pay the dividend on the cumulative priority shares.

LANCASHIRE POWER CONSTRUCTION CO. (LTD.)—Dr. H. F. Parshall presided at the meeting on the 22nd inst. and stated that the progress made in 1915 had been very satisfactory, the profit on trading showing a substantial increase. The report was so late that it was ancient history to most of them, and, therefore, he might tell them something respecting the results of the first five months' trading of the present year. They were very satisfactory compared with those for 1915, as they were appreciably up, and if that progress were maintained during the whole of the year, it would mean that their profit on trading would be substantially more for 1916. From an engineering point of view the progress had been comparatively uneventful. No addition had been made to the power plant, which had worked economically and well throughout the year. They had extended the mains and the system generally had been reinforced and consolidated, and therefore there was no large capital expenditure for them to face in order to keep up a sufficient supply in the district they served. The outlook for future business was good, and on terms more consistent with the advantages given by the company and than those which had so far been obtained. There were several contracts of importance. The units sold during the year showed a substantial increase over those of 1914, as did also the revenue. The growth of business with local orders showed an increase, but not as great as might have been anticipated owing to the restricted lighting regulations. Still, the increase showed that their investment in those local orders would ultimately be a profitable one. The cost for fuel per unit sold was greater than in 1914, but the total operating costs had been reduced, although there had been an increase in the rates. While on the subject of generation he desired to point out that the Government appeared to be favourable now to a central supply system. In the past they had certainly not been given much consideration in that connection, and local authorities which could not generate as cheaply as the company had been allowed to go on with generating systems, when in the interests of the public or of economy they should have come to the company for a supply. They had most pleasing and satisfactory relations with some of their larger neighbours, but some of their smaller neighbours had been very anxious to go on with their own undertakings, even at a loss. Their undertaking was in a central district, where they could give a supply of current to a great number of local authorities, to the great advantage of the latter. It was satisfactory to know that the principle of centralisation, after all those years, was now being recognised in a practical way by the Government, for he thought it could be said without fear of dispute that generation in England was carried more wastefully on than in any country in the world; that was to say, the relative cost of fuel per unit generated was vastly greater than in any other country. That was due to the fact that almost every local authority had been allowed to set up its own undertaking. In London half a million tons of coal were wasted yearly. If the principle of centralisation became generally adopted, their Lancashire undertaking would become a very important one, because they were in the centre of the district, with every facility for extension and generating on the most economical lines—and they could attain to very much lower generating figures than smaller undertakings less favourably situated. Owing to the handicap of not being, he feared, as favoured as the local authorities, they had had to feel their way, going on with small generating units, and, as a result, their fuel economy had not been as low as it might have been if they could have gone ahead at full speed from the beginning. Their fuel consumption, however, was lower, considering the class of fuel they were using, than of most other similar undertakings in the kingdom. Although they might have been in a better position had they been allowed to go ahead with bigger units, yet, as they stood they were very favourably situated to give a proper supply if they became the nucleus for giving a general supply in their district. They were proposing to extend their power station by the addition of another large generating unit, in order to meet the general growth of their business and to give a safe margin for the continuity of the supply. The expenditure had been approved by the Government authorities, who had also approved the ordering of the machinery, and they were able to carry out the extension without asking for any new capital. When that unit was in working order they might expect an improvement in their cost of generation—at least, in their coal consumption; and they could also safely say that on the present basis of working, that unit would take them up to the point when they would be earning their fixed charges something like three times over. They had a considerable issue of profit-sharing notes, and those who held them were wondering when the happy day would come when they would receive a dividend on them. He thought he might say with some degree of accuracy that a dividend would be forthcoming when the new unit was fully employed, because they could then pay a fair dividend and at the same time have a sufficient margin over for carrying on the business. Having regard to the present general financial situation, he thought they must provide for necessary extensions out of earnings. He thought the fact that they were able to provide an important extension such as that mentioned largely out of earnings must be considered satisfactory; and such an extension really meant that the whole of the depreciation of the plant, when the extension was carried out, had been provided for by a very substantial renewal.

MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)—The gross profit for 1915 was £581,125. 8s. 2d., and the net profit £377,817. 12s. 1d. (an increase of net profit over 1914 of £145,101. 3s. 2d.), and with £69,497. 8s. 6d. brought forward the balance available is £447,315. 0s. 7d. The directors regret to report that they are still without an agreement as to the basis of remuneration and compensation from the Government for the use of the company's high-power stations since the beginning of the war and for the other services rendered in connection therewith. It has, therefore, been once more impossible to include any sum in respect of these matters in the accounts. There have been, however, a large number of contracts entered into by the company with Government departments, in respect of all of which payments have been regularly received. There are four heads under which considerable sums are payable by the Government to the company—viz., (1) the Post Office, for remuneration and compensation in respect of the use of the company's high-power stations since the beginning of the war, &c.; (2) the Admiralty, for the use of the company's patents since the expiration (on March 31, 1914) of the Admiralty agreement of 1903, no new agreement having yet been concluded; (3) the War Office, in respect of the use of the company's patents, without agreement, during the whole time wireless telegraphy has been used by the War Office; (4) the Post Office, for compensation in respect of their withdrawal from the contract for the Imperial chain of stations, with regard to which no agreement has been arrived at, and the company has, therefore, been obliged to leave the amount of compensation to which it is entitled to be settled by a court.

Shares in associated companies and patents are taken at their cost price (£1,383,657. 14s. 6d.), and show an increase of £23,531. 19s. 2d. The par value of the shares held in associated companies now stands at £2,484,369. 14s. 10d., exclusive of shares which have no capital denomination. After crediting £100,000 allocated from profit and loss account of the preceding year, the general reserve account now stands at £967,539. The Marconi International Marine Communication Co. has continued to show substantial development of its business. Dividends for the past year amounting to 12½ per cent. have been declared, and £33,841. 11s. 1d. has been carried forward. The Russian Company (Société Russe de Télégraphes et Téléphones sans Fil) has continued to do a large business, and a dividend at rate of 15 per cent. for 1915 has been declared. The French Company (La Compagnie Française Maritime et Coloniale de Télégraphie sans Fil) has declared a dividend for 1915 at rate of 10 per cent. on the ordinary shares and 31·25 francs on the founders' shares. The Amalgamated Wireless (Australasia) (Ltd.) has paid 6 per cent. for the year ended June 30, 1915. The Wireless Press (Ltd.) has paid 25 per cent. for the year ended Sept. 30, 1915. The Marconi Wireless Telegraph Co. of America has again earned increased profits for the past year, but their principal revenue is expected to be derived from the trans-Atlantic service, which, in consequence of this company's stations being in Government service, has been obliged to remain idle. It is apprehended that the compensation in respect of this company's Carnarvon stations will also embrace the loss incurred by the enforced idleness of the American stations. Owing to the unfavourable rates of exchange, large sums of money have had to be placed on deposit with foreign banks, principally in allied countries, until such time as the exchanges become normal. Had these moneys been remitted on Dec. 31 last there would have been a loss in exchange of £25,757. 2s. 5d. Temporary investments at the end of the year showed a depreciation of £27,606. 5s. 9d. It has, therefore, been deemed right to debit to profit and loss account both these sums, which amount to £53,363. 8s. 2d. In view of the state of war, and having regard to the large sums of money abroad, and to the uncertainty as to when any of the moneys due to the company from the Government will be received, the directors deem it prudent to husband their resources, and recommend the declaration of a final dividend upon the ordinary shares at rate of 5 per cent, which, together with the 5 per cent. interim dividend paid in February, 1916, will make 10 per cent. for the year. They will, however, further recommend that a substantial bonus shall be declared and paid out of the moneys due from the Government as soon as received.

TRAFFORD POWER & LIGHT SUPPLY (1902) (LTD).—At the annual meeting last week the chairman (Mr. A. L. Ormrod) pointed out that after providing for a larger amount for depreciation than in previous years, which was necessary owing to the increased work the station had been doing, the year's net profit was £8,665, compared with £4,601 for the preceding year. That was equivalent to at least 13 per cent. on the ordinary shares; but in view of necessary expenditure and the conserving of the resources of the company only a small proportion would be recommended to be devoted to payment of dividend. The report and accounts were adopted and dividends of 5 per cent on the preference and 2½ per cent. on the ordinary shares approved, leaving £12,950 (subject to possible liability to excess profits duty) to be carried forward.

WAYGOOD OTIS (LTD.)—The chairman (Mr. Henry C. Walker) stated at the recent meeting that, although the figures for the past year were disappointing, the result would not be a surprise to shareholders under existing conditions. While the company did not show a profit they had been able to meet all their difficulties. During a great part of the time under review they had been a controlled establishment. They had been carrying out contracts, but their position in relation to that work had not been a fortunate one, as only their machine shop was required. Consequently their other departments had suffered considerably because they had been unable to draw supplies from the machine shop as in normal times. It was also impossible to change a factory over from one class of manufacture to another without incurring considerable expense, or to obtain profitable results with new work until a considerable amount had been turned out. They had also had to face considerable difficulties in regard to labour. A large number of their skilled workmen had been called away, and to fill the vacancies they had employed women, who had had to be trained to do the work. They had made a loss on a number of contracts, some of large amounts, the orders for which were placed with them at pre-war prices, and owing to delay in building work generally these had been hung up and had had to be completed at the advanced costs of labour and material due to the war. The profit on trading was £12,287, and after adding dividends on investments, &c., the balance available was £14,531, from which had been deducted various amounts for depreciation, &c., which left £672. He did not regard the present state of affairs with any apprehension, and when they were able to resume normal business he felt satisfied that they would be able to do so with conspicuous success.

J. [illegible] WHITE & CO. (LTD.)—The profit for the year ended Feb. 29 after bringing in £29,559) was £46,939. The directors recommend a dividend of 6 per cent. (less tax) on the ordinary shares, leaving to be carried forward £34,939. The war still continues to affect the business adversely. Methods for broadening the scope of the company's work both at home and abroad, are, however, receiving careful consideration, and the prospects of satisfactory arrangements being concluded during the current year seem encouraging. In spite of the generally unfavourable business conditions prevailing, the profit earned of £17,389 during the past year is not unsatisfactory.

ZINC CORPORATION (LTD.)—The profit for 1915 after writing off £21,031 for depreciation, amounted to £140,639. The amount of £84,687 due by Messrs. Aron Hirsch & Sohn in respect of zinc concentrates delivered prior to the outbreak of the war (carried to suspense) has not yet been received. The first dividend of 2s. per share on the preference shares for the year 1915 was paid in January, and the second dividend of 2s. per share has been declared payable on July 1. This will leave a surplus of £65,274, out of which the directors recommend payment of a final participating dividend of 1s. per share upon both classes of shares on Sept. 30, leaving £20,332 to be carried forward. The Corporation was successful in its action against Messrs. Aron Hirsch & Sohn for the determination of the zinc contract. In view of the delay which was likely to be experienced before a decision could be obtained in the House of Lords, the directors applied to the Board of Trade for the determination of the contract under the powers conferred upon that body by the Trading with the Enemy Amendment Act, 1916, and an order was made on May 13 for the determination of the agreements.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

B.I. CO. (OF LONDON & BIRMINGHAM) (LTD.) (144,149)—Reg. June 22, capital £2,000 in £1 shares, to carry on the business of designers, manufacturers, exporters and importers of, contractors and factors for and dealers in electric light and other electrical apparatus, conduits, dynamo machines, lamps, fittings, &c. Private company. Cecil Douglas Falcke is permanent managing director. Reg. office: 410 and 411, Mansion House Chambers, Queen Victoria-street, E.C.

ELLIOTT BROTHERS (LONDON) (LTD.) (144,140)—Reg. June 21, capital £90,000 in £1 shares, to take over as a going concern the business carried on by W. O. Smith, W. S. Smith, G. K. B. Elphinstone and L. W. Smith at Century Works, Lewisham, and 1, Central Buildings, Westminster, or elsewhere, as Elliott Brothers, to carry on the business of mechanical and electrical engineers, electricians, contractors, instrument makers, constructors, manufacturers and suppliers of and dealers in all kinds of mechanical, mathematical, electrical and scientific apparatus, instruments, telegraphic and engineering appliances or accessories, nautical, aerial, motoring or other implements and machinery, tool makers, &c. Private company. First directors (to number not less than three nor more than 6) are W. O. Smith, G. K. B. Elphinstone and L. W. Smith, with power to appoint others. Secretary: R. O. Smith.

FULLER'S CARBON & ELECTRICAL CO. (LTD.) (144,168)—Reg. June 23, capital £25,000 in £1 shares, to carry on the business of manufacturers of and dealers in carbon, charcoal, graphite, lampblack, soot and all products which contain carbon, charcoal or graphite, carbon crucibles and carbon for electrical purposes, dynamo brushes, microphones, resistances, &c., mechanical and electrical engineers. Private company. First directors are G. Fuller, G. J. A. Fuller and L. Fuller. Secretary (pro tem.): F. King. Reg. office: Grove-road, Chadwell Heath, Essex.

SOUTH COAST KEARNEY HIGH-SPEED RAILWAY (LTD.) (144,019).—Reg. June 3 by E. W. C. Kearney. Capital £21,000 in 20,000 ordinary shares of £1 each and 20,000 founders' shares of 1s. each, to adopt agreements with Charles William Neville and with the Kearney High-speed Railway Co., whereby the said company shall grant to this company the exclusive use of the patents and other rights in connection with the Kearney high-speed system for constructing a line of railway on the south coast of England. First directors are E. W. C. Kearney (managing) C. B. Kearney and W. F. Paul. Reg. office: 100, Victoria-street, S.W.

TROUP, CURTIS & CO. (LTD.) (144,175)—Reg. June 23, capital £7,000 in £1 shares, to take over the business of electrical engineers carried on by C. L. Troup and A. Curtis as Troup, Curtis & Co., and to carry on same and the business of electricians, instrument makers, heating, ventilating and mechanical engineers, &c. Private company. First directors are C. L. Troup and A. Curtis (both permanent, subject to holding 2,000 shares each). Reg. office: 282, Victoria Dock-road, E.

MORTGAGES AND CHARGES.

BOURTON-ON-THE-WATER ELECTRIC LIGHT & POWER CO. (LTD.)—particulars of £600 2nd debentures, created Aug. 27, 1915, have been filed, amount of present issue being £530. Property charged: Company's undertaking and property, present and future. No trustees.

BRILLIANT ARC LAMP & ENGINEERING CO. (LTD.)—Memorandum of satisfaction to extent of £1,800 on May 13, 1916, of debentures dated June 18, 1915, securing £3,000, has been filed.

DURAM (LTD.)—Particulars of £20,000 debentures, created March 24 1916, have been filed, amount of present issue being £6,500. Property charged: Company's undertaking and property, present and future. No trustees.

RURAL ELECTRICITY SUPPLY CO. (LTD.)—Issue on June 6, 1916, of £100 debentures, part of series of which particulars have already been filed.

CITY NOTES.

MEMORANDA (June 28).—**Bank rate 5 per cent. (since Aug. 8, 1914). Consols 60⅛. Consols Pay Day, July 5. Stocks and Shares Ticket Days, July 12 and 27. Pay Days, July 13 and 28. Price of silver, 31⅝d.**

CHADBURN'S (SHIP) TELEGRAPH CO. (LTD.)—Though the accounts for the year ended March have not been published, the directors are satisfied that the result of the year's trading warrants them in paying the usual dividend at the rate of 10 per cent. per annum for the half-year.

CONSOLIDATED ELECTRICAL CO. (LTD.)—A dividend of 2½ per cent. (6d. per share) on the ordinary shares for the year, carrying forward £3,160, subject to directors' fees.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date June 27, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	16d.
Solid Drawn Copper Tubes	18½d.
Brazed Copper Tubes	18½d.
Brazed Brass Tubes	18d.
Brass Wire	16½d.
Copper Wire	19½d.
Rolled Brass	16¾d.
Brass Sheets	17⅛d.

	per ton.
Copper Sheets	£156 0 0
Spelter	£65 0 0

	per ton.
English Lead	£31 0 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£94 0 0
Clean Brass Scrap	£63 0 0
Braziery Copper Scrap	£80 0 0
Old Lead	£24 10 0
Old Zinc	£48 0 0
Hollow Pewter	£120 0 0
Black Pewter	£90 0 0
Gun Metal	£73 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date June 27, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£95 0 0
Clean Mixed Brass	£59 0 0
Clean Copper	£90 0 0
Braziery Copper	£80 0 0
Gun Metal	£78 0 0

	per ton.
Old Lead	£27 0 0
Tea Lead	£25 10 0
Old Zinc	£48 0 0
Hollow Pewter	£125 0 0
Shaped Black Pewter	£85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £76; Commercial Tinman's Solder, £108; Blowpipe Solder, £118.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, June 27. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., June 27.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4¼%	Do. 4¼% Cum. Pref.	8⅞	5 11 8	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	10⅞	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅞	7 12 5	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	91½	4 18 6	..
St.	4%	Charing Cross West End & City Debs.	79½†	5 0 8	Jan. July
5	2/3	Do. 4½% Pref.	3⅛	7 4 0	..
5	5%	Do. Ord.	3⅞	7 0 4	Aug, Feb
5	4¼%	Do. City Pref.	3⅛	7 4 0	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	2⅛	7 2 3	Mar, Sept
St.	4¼%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12½	6 12 0	Feb, Aug
10	6/0	Do. 6% Pref.	10⅜	5 15 8	Mar, July
St.	5%	Do. 5% Deb. St.	99½	5 0 6	Jun, Dec
St.	4½%	Do. 4½% Debs.	81	5 11 1	Jun, Dec
10	7%	County of London Ord.	10½	6 8 6	Mar. Sept
10	6%	Do. 6% Pref.	10⅜	5 15 8	Feb, Aug
St.	4¼%	Do. 1st Deb.	87½	5 4 2	Jan, July
St.	4¼%	Do. 2nd Deb.	83½	5 7 4	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	75½	5 18 10	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6%	London Elec. Supp. 6% Pref.	4½	6 13 4	..
St.	4%	Do. 4% Mort. Debs.	80½	4 19 9	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅞	6 6 2	Mar, Aug
St.	4¼%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	2½	7 5 5	Mar, Sept
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5⅜	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅜	6 0 5	Feb, Aug
St.	3½%	Do, do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	71½	6 5 10	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅞	6 14 9	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6½	5 11 3	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4½	5 5 11	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	82	6 1 11	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	79	7 11 11	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	74	5 8 1	..
St.	4%	Do. do. Assented Def. Ord.	72½	5 7 3	..
St.	4½%	Do. 4½% Pref.	82	5 9 9	Jan, July
St.	4%	Do. 4% Deb. St.	76½	5 4 7	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May. Nov
St.	5%	Do. Pref. 1896	70½	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅛	5 16 1	Jan, July
St.	4%	Do. 4% Pref.	68½	5 16 4	Mar. Sept.
St.	4%	Do. 4% Debs.	74†	5 7 6	Jan, July
St	1%	Metropolitan Ry. Con. Ord.	27½	3 13 5	Feb, Aug
St.	3½%	Do. 3½% Pref.	64½	5 8 6	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	61	5 14 9	Feb, Aug
St	3½%	Do. 3½% A Debs.	67½	5 4 7	Jan, July
St	3½%	Do. 3½% Debs.	70	5 1 1	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 7	May, Nov
St.	4½%	Do. 4½% First Pref.	72½	6 4 1	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	110†	5 9 1	Jan, July
St.	4%	Do. 4% Debs.	73½†	5 8 10	Jan, July
St.	4%	Do. 4% Debs. (1903-51	76½†	5 4 7	Jan, July
St.	4%	Do. 4% Guar. Stock	70	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	3⅜	4 18 0	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅝	5 9 3	Mar
100	5%	Do. Prior Lien Debs.	94½	5 5 9	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	11⅜	7 14 8	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅜	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref	⅝	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅜	6 6 4	April
100	6%	Do. 6% Prior Lien Debs.	100½	5 19 5	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	63	5 17 8	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅜	8 4 11	Jan, July
5	5%	Do. 5% Pref.	4½	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	84	5 7 2	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅝	7 7 8	Sept
5	..	Ellison & Swan U.Elec.Lt.A. £3 pd.	⅛	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	⅛	10 0 0	May
1	7%	Do. 7% Cum. Pref.	⅝	7 9 4	Jan, July
St.	4%	Do. 4% Debs	71⅝	5 11 6	Jan, July
10	10%	General Electric Ord.	11⅝	8 11 t	July
10	6%	Do. 6% Pref.	9⅛	6 2 8	Jun, Dec
5	20%	W. T. Henley's Teleph. Wks. Co. Ord.	15½	6 12 3	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4½	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	12⅜	8 1 7	Feb, Aug
10	5%	Do. Pref.	8⅛	6 4 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	40	6 0 0	Mar, July
100	4%	Do. 4% Debs.	95½	4 6 0	Jan, July
1	7½%	Vickers Ord.	11⅞	4 1 4	May, Aug
1	6%	Do. 5% Pref.	⅝	5 6 8	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 11	Jun, Dec
..	4½%	Do. 4½% 2nd Debs.	99½	4 10 8	Jan, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40	10 6 3	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	105½	5 13 7	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23⅛	6 17 6	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	71	5 12 8	Ja.Ap.Jly,O
10	5%	Cuba Submarine Ord.	7½	6 9 0	May, Nov
10	10%	Do. 10% Pref.	13½	7 7 10	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅛	7 16 10	Ja.Ap.Jly,O
St.	8%	Eastern Tel. Co. Ord.	148½	5 7 9	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	66½	5 5 8	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	77½	5 3 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78½	5 2 3	Feb, Aug
10	8%	Do. Ord.	14½	5 7 8	Ja, Ap.Jly,O
10	22%	Gt. Northern Tel. Co.	37⅛	5 16 9	Ja, My, Jly
25	13%	Indo-European	48	6 15 5	May, Nov
1	10%	Marconi's Wireless Tel. Co.	2⅜	3 8 10	April
1	7%	Do. 7% Pref.	2⅛	2 18 11	July
10	1%	West India & Panama Ord.	1	10 0 0	May Nov
10	6%	Do. 1st Pref.	7½	7 17 5	May, Nov
10	8%	Western Telegh. Co.	15⅞	5 5 5	Mr.Jly,O.Dec
St.	4%	Do. 4% Deb. St.	78½	5 1 11	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99	4 10 11	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅜	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	2	5 0 0	Apl, Oct
St.	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅞	6 1 11	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅛	5 6 8	Jan, July
St	4½%	Do. Deb. Stk.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	13	4 12 4	Sp.Dc,Mr,Jn
10	6%	Do. 6% Pf.	10⅛	5 9 9	Sp.Dc.Mr,Jn
100	5%	Mackay Companies' Common	83½	5 19 9	Ja,Apl,Jly,O
..	4%	Do. $100 Pref	67	5 19 5	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4⅞	6 5 2	Mar, Sept
St.	5%	Do. 5% Debs.	93½	5 6 11	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10⅜	5 16 4	..
St.	4½%	Do. 4½% Debs.	85½	5 4 11	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6½	7 6 11	May, Nov
5	5%	Do. 5% Pref	4½	5 11 1	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,990. [No. 14. Vol. LXXVII.] **FRIDAY, JULY 7, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 80pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 451
Arrangements for the Week .. 454
Motor Drive for Steel Mills. By F. B. Crosby. Illus. .. 455
Electricity Supply. By W. W. Lackie. Illustrated .. 458
Notes on Design of Electromagnetic Machines. By Stanley Parker Smith, D.Sc.—*Continued* 461
Tramways and Light Railways Association 463
Tramway Transit and Comfort. By W. Tuke Robson 464
A Ministry of Science. Suggestions by Prof. F. G. Donnan, F.R.S. 466
The Training of Our Captains of Industry. By Sir Robert Hadfield, F.R.S. 467
A MINISTRY OF SCIENCE 468
REVIEWS 469
Wireless Telegraphy and Telephony: A Handbook of Formulæ, Data and Information [Eccles]: Reviewed by L. B. Turner.
Experimental Physics: A Text-Book of Mechanics, Heat, Sound and Light [Wilson].
Engineering Education and Research 470
Electricity Regulations 472
CORRESPONDENCE 473
S. P. Thompson (Charles Bright).
PARLIAMENTARY INTELLIGENCE 473
The "Electrician" Commercial and Industrial Section .. 475-484

NOTES.

Enemy Controlled Companies.

WE desire to draw the attention of our readers to the judgment delivered last week in the House of Lords in the Continental Tyre & Rubber and Daimler case. We consider this judgment, which is reported in another column, to be the most important judicial pronouncement so far given on the question of enemy controlled companies. Briefly, the facts were as follows: The Continental Company was registered in this country, but all its shareholders (except one, who was naturalised), and all its directors were Germans and resident in that country. They sued the Daimler Company for money due for goods supplied, and in normal times there would probably have been no defence to the action. The defendants, however, raised the plea that the plaintiff company was an alien enemy and could not sue in an English court during the war. This plea was unsuccessful, though in the Court of Appeal Lord Justice BUCKLEY (now Lord WRENBURY) delivered a strong dissenting judgment, and defendants appealed to the House of Lords, who have now unanimously allowed the appeal. Though several points were raised in the course of the legal arguments, some of their lordships based their judgment on the narrow ground that the Secretary of the Continental Company had no authority from its directors to sue, and, therefore, the action could not be allowed to proceed. We have given a lengthy abstract of the luminous and clearly-reasoned judgment of Lord PARKER of Waddington, with whom Lord SUMNER, a great authority on commercial law, agreed, because we think it to be not only sound law and common sense, but also a good illustration of the manner in which English law is developed by judicial interpretation. We hope, therefore, that our readers will peruse the judgment, for it deals with many matters relating to enemy-controlled firms and trading with the enemy which, though not immediately revelant to the present case, come before us from day to day.

The Electric Drive in Steel Works.

IN little more than a decade the electric drive has become the established practice in steelworks, and the progress made during this time has been little short of phenomenal. Apart from the severity of the service, the conditions which obtain in steelworks are peculiar in so far as a stoppage, for a relatively short period, of any essential part of the equipment means a break in the manufacturing process. Since one process must immediately follow another, such stoppage would mean the closing down of the plant or would result in considerable waste of material. In either case the monetary loss would be considerable. The electric drive was first applied to cranes and charging machines, and the inherent weaknesses of the then existing motors and control apparatus, on being subjected to the exacting service, were exposed. The correction of these weaknesses, which were partly mechanical and partly electrical, was effected by the steelworks engineers and electrical engineers working in close co-operation, and motors and controllers of a robust character were evolved. Following on the application of the electric drive to cranes and allied machinery came the electric driving of rolling mills. The solution of the many and difficult problems connected with slow-speed drives of many thousand horse-power and the winning over of ironmasters, almost without exception, in less than 10 years is no mean achievement. Elsewhere will be found in abstract an article by Mr. F. B. CROSBY setting out the progress that has been made in the application of the polyphase alternating-current motor to the driving of rolling mills. Although for the driving of the reversing mill the continuous-current motor with Leonard control is unrivalled both as regards efficiency and simplicity, it would appear that there is a very strong case in favour of the alternating-current motor for continuous rolls, and apparently the several difficulties have been partly overcome by using variable-pole induction motors in cascade and more completely by the application of the ingenious system devised by SCHERBIUS, which is fully described by Mr. CROSBY.

Engineering Education.

ON another page we publish an interesting report upon Engineering Education and Research, by a Committee of the Council for Organising British Engineering Industry. This Council was formed at Manchester some time ago, and the report is signed by Mr. A. P. FLEMING, Mr. J. C. M. GARNETT and Prof. MILES WALKER. The report deals with the training of workmen, the training of the highly trained staff, and, lastly, with research. We are glad to see that the training of workmen receives a considerable amount of attention, for it seems to us that this part of the subject is quite as important as any other and should be approached from a very broad standpoint. It is suggested that a boy should enter works at the age of 15 as an apprentice, but need not necessarily be indentured, and that throughout the first years of his apprenticeship he should attend classes, for, say, eight hours a week, preferably during working

hours. This attendance should be made compulsory for all employed persons under 18 years of age, and employers should be required to grant the necessary facilities. It is also suggested that an apprentices' school should include as many as possible of the activities of a good boys' club, such as football, cricket and other recreations. We fully agree with this breadth of view. In regard to the highly trained staff, emphasis is laid upon the desirability of providing a larger amount of university training. In order that technical degrees shall be a guarantee of practical experience it is suggested that no more than a B.A. degree should be conferred upon students at the close of their three years' university course in engineering, specialised degrees, such as Bachelor of Technical Science, being reserved for students who have completed at least two years of satisfactory practical training in their profession. In regard to research, the idea of a central institution for industrial research is favoured. The report should carry weight with manufacturers, as it is signed by Mr. FLEMING, of the Westinghouse Co., and by Prof. MILES WALKER, who has commercial experience. It is of the highest importance that such matters should be considered by the manufacturers themselves, and it is indeed stated that many of the suggestions can only be effectively carried out by a federation of manufacturing engineers.

A Sinecure and a Suggestion.

THE following advertisement appeared last week in one of our contemporaries :—

> Wanted, early in September, a temporary full-time Assistant-Master for Engineering Subjects. Qualifications to include workshop, laboratory, and teaching experience. Graduate preferred. Salary £150 to well qualified man.
>
> Application, by letter, to—
>
> PRINCIPAL,
>
> Technical School, Bootle, Lancashire.

We give publicity to the modest requirements of the Principal of the Bootle Technical School, not because the conditions set out in the advertisement are peculiar to Bootle, but because they represent the views of many education authorities as to the value of the services of technically-trained men. The fact that local education committees—and such committees are composed largely of men who know neither the meaning nor purpose of technical education—value at something less than three pounds per week the services of a well-qualified graduate engineer skilled in workshop processes and laboratory methods and an experienced teacher to boot, will, we venture to think, serve to illustrate the sourdness of the advice urging technical teachers to combine with the sole object, in the first instance, of pursuing an aggressive policy. Of one of the most powerful teachers' associations in the country it has been said that its principal function is to put fear into the hearts of local education committees. We would have the same said of the National Union of Technical Teachers that we have in mind. A humble artisan whose training has cost him nothing can command a wage considerably higher than that offered to technical teachers at Bootle and elsewhere, and in these days boys, without *real* engineering experience, from technical schools are being taken into munition works at a commencing salary in excess of £150 a year. Our advice to well-qualified graduate engineers skilled in workshop processes and laboratory methods is to steer clear of such places as Bootle. By so doing, with industry and perseverance, they stand a fair chance of being able to provide against sickness and old age, and to live in that state of decency to which, as professional men, they are entitled.

Electric Steel Industry.—Dr. J. A. Mathews (president of the Halcolm Steel Co.) read a Paper recently before the American Iron and Steel Institute. He gave figures which seem to show that the United States in its second decade of this industry will greatly increase its output. The figures for 1909 were 13,762 tons, and for 1913 they were 30,180 tons, and 24,009 tons in 1914.

Electric Furnaces.—Dr. J. A. Mathews, in an informative Paper read before the American Iron and Steel Institute, stated that the furnaces already installed in the States represent the utilisation of 125,000 to 135,000 electrical horse-power. This represents an output of about a million tons of ingots or castings per annum. The Héroult system represents some 70 per cent. of the total tonnage.

Electric Ovens.—An article by Mr. W. S. Scott on "The Application of Electricity to Enamelling or Japanning" in the "Electric Journal" summarises the advantages of the electric oven. These are improved quality, less fire risk, increased production, better temperature control, and for central stations: opportunities for increased sales of power at steady load, excellent load factor, and equalising of load conditions.

Organisation of Gas Industry.—The "Gas World" refers to a conference of the Councils of the Institution of Gas Engineers and Society of British Gas Industries, the General Committee of the British Commercial Gas Association and Committee of the Gas Companies' Protection Association, to consider the question of the better organisation of the gas industry. There was a large and representative attendance, and the principle of co-ordination was approved.

Moisture in Coal.—Mr. T. F. Winmill, B.A., B.Sc., read a Paper on this subject before the Institution of Mining Engineers. Results of tests showed that dried coals have a considerable power of absorbing moisture, and a sample must be protected at once if it is to remain free from moisture. A vacuum method of drying the coal and estimating the moisture is described, an electric oven being used to raise the sample to the temperature required, viz., 105°C. to 110°C.

Steam Condensers.—The "Electric Journal" states that condenser development keeps pace with turbine and boiler progress, the theoretical limit being closely approached. Recently the Philadelphia Co. with a load of 30,000 kw. on the turbine had no difficulty in maintaining a vacuum of 29·4 in. (with barometer at 30 in.) In another case a jet condenser for a 45,000 kw. turbine was being used with highly satisfactory results, although until recently it was not considered feasible to use jet condensers with such large units.

Electric Steel Furnaces.—The "Iron and Coal Trades' Review" states that for some time the United States Steel Corporation has had a 15-ton Héroult electric steel furnace at its works in the Chicago district, and a similar one at its wire works at Worcester, Mass. The corporation is now building a 20-ton furnace at the Duquesne works, and two 20-ton and one 15-ton at the South works. The South works installation will represent about 800 tons of steel ingots daily, making this the largest electric steel department in the world.

German Trade and Copper.—"Le Génie Civil" states that although Germany may have enough copper for munitions, she is not able to employ it in industry. Consequently her dream of flooding foreign markets after the conclusion of peace with her produce cannot be realised, at least so far as products requiring copper are concerned. Amongst these, and in the first place, is electric apparatus, of which there has been so great a development in Germany. Finally Germany has stopped sending to foreign countries a certain number of technical journals, amongst which is the "Electrotechnische Zeitschrift," and papers relating to leather, rubber, dyes and chemical products. These measures indicate that there is considerable trouble with these industries, and exceptional measures are being taken in order to surmount it.

Middlesbrough Technical College.—"Nature" states that a combined meeting of the Cleveland Institution of Engineers and educational authorities of Middlesbrough and neighbouring localities has been held to hear of the munificent offer of Mr. Joseph Constantine to guarantee a sum of £40,000 for the erection of a technical college. It is to be erected on a

piece of ground which had already been purchased by the Town Council for this purpose. Further offers were made by Messrs. Bell Bros, and Messrs. Dorman, Long & Co. and their allied firms of £10,000, Sir Bernard Samuelson & Co. £5,000, and it is expected £100,000 will be raised without difficulty. The scheme of a metallurgical laboratory is being proceeded with, and at the end of the war the equipment is to be transferred to the new Constantine Technical College.

Education of Inventors.—"The Times" states that Mr. D. Ainslie read a Paper on "The Discovery of Discoverers" at the Royal Automobile Club on the 28th ult. There was an erroneous idea that Germany was the leader in literature and science. German literature was behind that of England, France and Italy. He thought Italy should take her forward place in our studies, and there ought to be schools for unlearning German and more schools for teaching Russian, French and Italian. England had not encouraged her inventions in the same way that Germany and America had done, and this was why Germany had proved her predominance in the war. A Ministry of Inventions ought to be formed in this country, and a board of experts should be allowed to enter schools and colleges in order to find scholars with inventive minds. They should then be trained at the cost of the State

Utilisation of Peat.—The "Bulletin" of the Imperial Institute refers to the above matter. All questions regarding the mechanical excavation, pulping, drying, briquetting and disposal of the fuel or of power produced from it in steam engines or producer gas plants, the recovery of the nitrogen, and reclamation of the peat bog for agricultural purposes must be considered in relation to local conditions.

It is pointed out that the open air drying of peat has many disadvantages, the process being dependent on weather conditions, and can only be carried on for a limited period each year. Artificial drying by pressure or heat, or a combination of both, was not a success, and increases the cost of production. Owing to the water forming a gelatinous compound with the hydrocellulose it cannot as a rule be reduced below 70 per cent. by pressure alone. At the Mond Gas Plant at Lucca, Italy, the peat is dried by hot air. The raw peat with 77 per cent. moisture is placed in trays mounted on trucks, which are rolled into the drying chambers. Air is forced through and round the trays of peat by a 40 H.P. electric fan. The waste gases from the boiler plant and gas engine exhaust with hot air from a pre-heater, are mixed with enough cold air to reduce the temperature of the mixture to about 150°C. In two hours this reduces the moisture content of the peat from 77 to about 30 per cent.

Exemption for Selected Science Students.—The Board of Education have issued a circular to local education authorities announcing the following arrangements which have been made between the Army Council and the Board of Education regarding the exemption of teachers and students: (1) Teachers, full-time students and educational officials who are not passed for general service are not to be called up without reference to the War Office, who will consult with the Board of Education. (2) The procedure now applicable in the case of attested teachers and officials fit for general service is to apply to attested and unattested alike, but in future reference is to be made to the War Office (not the Board of Education). (3) Full-time students fit for general service are for the present not to be called up until they attain the age of 18; but the Army Council may terminate this arrangement after July 31. (4) The Army Council, on grounds of public interest, is prepared to consider applications endorsed by the Board of Education for the postponement of military service in the case of a strictly limited number of specially selected students of science or technology. Applications on behalf of such students are to be made by the authorities of universities, technical institutions, &c., in the first instance to the Board of Education, who will submit them to the Army Council.

45,000 kw. Steam Turbine.—"Power" states that the Narragansett Electric Lighting Co., of Providence, R.I., has placed an order for a cross compound turbine of 45,000 kw. capacity, with the Westinghouse Co. At three-quarter load its steam consumption is to be 11·5 lb., which will increase to 11·9 lb. at full-load. There will be two generators driven by high pressure and low-pressure turbines. The steam pressure is 175 lb. and 100°F. superheat, the steam being received through a 24 in. inlet valve, and this exhausts to atmospheric pressure in the low-pressure turbine. The blades increase from 6 in. at the entrance to 18 in. in length finally. One generator is a four-pole machine, giving three-phase 60-cycle current at 1,800 revs. per min., the other runs at 1,200 revs. per min. six-pole; both give 12,000 volts. The exciters are 100 kw. each, and work at 250 volts. The dimensions overall are 46 ft. 9 in. in length, 37 ft. 2 in. in width, and 18 ft. 6 in. high, the weight being 1,300,000 lb. The Westinghouse-Le Blanc condenser deals with 18,000,000 lb. of circulating water per hour, condensing 500,000 lb. of steam per hour, with a vacuum of 28 in., and water at 70°F. A double suction centrifugal pump receives the mixture of steam and water. The air pump draws from the top cone the steam inlet to each condenswer is 29 sq. ft. in area, and the discharge pipe 30 in. in diameter, the discharge pipe from the air pump being 14 in. in diameter.

Factories and Workshops.—The annual report of the Chief Inspector of Factories and Workshops for 1915 deals with the duties that have arisen owing to the war. Besides taking a census of machinery suitable for munition work, arrangements were made for transferring munition workers from one factory to another, and assistance was given to the Army Contracts Department in various ways. Trade conferences were also arranged in order to facilitate recruiting. Details are given of the arrangements made in each trade as to the employment of women and learners. Something has been done to introduce men over military age into works, and by the earlier promotion of stronger boys; also the use of female labour. It is stated, however, that the extent to which the replacement of men of military age has taken place is probably much less than is generally supposed; much of the labour lost has not yet been replaced, and businesses have been carried on with reduced staffs. Women were first employed in shell turning, but are now employed in many other departments of the engineering trade, such as grinding, milling, fitting and bench work, brazing and welding. They have been specially successful in all kinds of repetition work. A special report is attached on the "Effect of the Second Year of War on Industrial Employment of Women and Girls," by Miss Anderson, H.M. Principal Lady Inspector of Factories. From all quarters the reports by managers and foremen alike regarding the employment of women are astonishingly satisfactory.

Coal Supplies.—A deputation of representatives of gas and electricity undertakings, consisting of the following gentlemen—Mr. A. E. Broadberry (president of the Institution of Gas Engineers), Mr. H. E. Jones (president of the Gas Companies' Protection Association), Mr. Alderman Phillips (chairman of the Salford Corporation Gas dept.), Mr. D. Milne Watson (managing director of the Gas Light & Coke Company), Mr. A. Wilson (manager and engineer of the Glasgow Corporation Gas Dept.), representing the gas industry; and Mr. R. A. Chattock (city electrical engineer, Birmingham), Mr. C. P. Sparks (president of the Institution of Electrical Engineers), representing electricity—waited on Mr. Marwood, of the Board of Trade, on June 28, 1916, and laid before him the various difficulties which were being encountered by the above industries at the present moment, more especially those with regard to the making of new contracts for coal for the next 12 months, both as regards quantities and prices. The deputation was most courteously received by Mr. Marwood and Mr. Carlill, who, after the various members of the deputation had stated their case, informed them that the Board of Trade were prepared, if approached by gas, electricity or water undertakings, to use their influence through the medium of the District Coal Committees which had been established in the various colliery areas to procure the necessary quantities of coal required by the above-named undertakings. With regard to prices, it was further stated that if any undertaking which had cause to complain of the prices proposed to be charged for new contracts would bring such cases before the Board of Trade, the Board would be prepared to take steps, if thought necessary, so that the prices charged should be justified by the provisions of the Price of Coal (Limitation) Act.

OBITUARY.

KILLED IN ACTION.—We regret to record the death of Second-Lieut. Eric E. F. Beatty, who has fallen in action. Deceased, who was 22 years of age, was the eldest son of Mr. A. H. Beatty, of Messrs. Balfour, Beatty & Co., electrical engineers, of Queen-street, E.C.

Lieut. Sydney Wm. Bell was killed on June 14th. He volunteered for service in the South African War and was with the electrical engineers. He was a mining engineer on the Rand.

Second-Lieut. F. W. Caton, R.E., at one time senior science master at Taunton School, was killed on June 28.

PERSONAL.

We understand that Capt. F. C. Austin, of Messrs. Pooley & Austin, was wounded by a shell explosion on June 15. After two days in hospital he returned to duty, and was later wounded in the foot. He is now in hospital making good progress.

Battery Scout Cyril F. Barrow, formerly an assistant engineer at the Bolton electricity works, and who joined the Army in 1914, has been gazetted second-lieutenant in the Royal Engineers.

On June 28, Mr. T. H. Nutter, chief assistant electrical engineer at Burnley, was married to Miss Clara Haythornthwaite.

ROYAL ENGINEERS (T.F.).—The following appointments have been made :—

London Electrical Engineers.—L.-Corp. F. C. Baumann, L.-Corp. E. G. Conzens and Sec. Corp. S. R. Squire to be Second Lieutenants (on probation).

Second-Lieut. (temporary Lieutenant) H. F. G. Roose is restored to the establishment.

Tyne Electrical Engineers.—Sergt. L. Bird and Sergt. H. Hutchinson to be Second Lieutenants.

APPOINTMENTS VACANT AND FILLED.

The Hydro-Electric Department of Tasmania invite applications for the position of chief assistant electrical engineer to the Department. Salary £500 per annum, with three years' engagement and first-class return passage. Applications to the Agent-General for Tasmania, 56, Victoria-street, London, S.W. *See also an advertisement.*

A chief assistant engineer and manager is required for Leek Urban Council's electricity undertaking. Salary £160. Applications (on forms supplied) to the Chairman of the Lighting Committee by 10 a.m. July 14.

Mr. R. H. Ginman has been appointed engineer and manager of the Leek Urban Council's electricity and gas works, in succession to Mr. Benrose, resigned.

Mr. B. Moynagh has been appointed assistant electrical engineer at Dundalk electricity works.

INSTITUTIONS AND SOCIETIES.

Present and Future Position of Electricity Supply in Great Britain.—The Council of the Institution of Electrical Engineers appointed on June 8 last a Committee to consider the suggestions made in Mr. E. T. Williams' recent Paper, and in the discussion on "The Present Position of Electricity Supply in the United Kingdom." After consultation with the Incorporated Municipal Electrical Association and other similar bodies connected with electricity supply, the Committee will embody their recommendations in a Report to the Council. The Chairman of the Committee is Mr. R. A. Chattock, and the other members are Mr. C. P. Sparks (President I.E.E.), Mr. C. H. Merz, Mr. G. W. Partridge, Mr. S. L. Pearce, Mr. T. Roles and Mr. W. B. Woodhouse.

Institute of Radio Engineers.—A meeting of this Institute was held on Wednesday evening, June 7, when a Paper on "Are Oscillations in Coupled Circuits," by Prof. Hidetsugu Yagi, of the College of Engineering at Sendai, Japan, was read. The efficient transfer of energy from the primary to the secondary and the production of overtones were fully considered. The Paper was illustrated by many interesting experimentally determined curves.

Society of Arts.—At the recent annual general meeting of this society the chairman declared that the following had been elected to fill the several offices :—

President.—H.R.H. the Duke of Connaught and Strathearn, K.G.

Vice-Presidents.—Sir George Ranken Askwith, K.C.B., K.C., D.C.L., Right Hon. Arthur James Balfour, O.M., LL.D., D.C.L., M.P., F.R.S., Sir Steuart Colvin Bayley, G.C.S.I., C.I.E., Sir George Birdwood, K.C.I.E., C.S.I., M.D., LL.D., Lord Blyth, Sir William Duke, K.C.S.I., K.C.I.E., Lord Faringdon, Lord Inchcape, G.C.M.G., K.C.S.I., K.C.I.E., Edwin Landseer Lutyens, A.R.A., F.R.I.B.A., Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., Sir Philip Magnus, M.P., Right Hon. Lord Moulton, K.C.B., M.A., LL.D., F.R.S., Lord Newlands, LL.D., Duke of Norfolk, K.G., G.C.V.O., Lord Northcliffe, Hon. Richard Clere Parsons, M.A., Ernest H. Pooley, M.A., LL.B., Lord Sanderson, G.C.B., K.C.M.G., Alan A. Campbell Swinton, F.R.S., Prof. J. M. Thomson, LL.D., F.R.S., Sir John Wolfe-Barry, K.C.B., LL.D., F.R.S.

Ordinary Members of Council.—Sir George Thomas Beilby, LL.D., F.R.S., F.I.C., F.C.S., Dugald Clerk, D.Sc., F.R.S., Alan S. Cole, C.B., Edward Dent, M.A., Peter MacIntyre Evans, M.A., Sir Robert Abbott Hadfield, D.Sc., D.Met., F.R.S., Col. Sir Henry Capel Lofft Holden, R.A., K.C.B., F.R.S., Major Francis Grant Ogilvie, C.B., LL.D., Sir Robert William Perks, Bart., Sir Boverton Redwood, Bart., D.Sc., F.R.S.E., John Slater, F.R.I.B.A., James Swinburne, F.R.S.

Treasurers.—Carmichael Thomas, William Henry Davison, M.A.

Secretary.—Sir Henry Trueman Wood, M.A.

Electric Vehicle Committee.—At the last meeting of this Committee, held in London on June 16, 1916, it was announced that, for the present year the following had been nominated by their respective Associations to act as their representatives on the Committee : The Society of Motor Manufacturers and Traders : Mr. T. C. Pullinger, of Arrol Johnston, Ltd. The Tramway & Light Railways Association : Mr. W. T. Robson, General Manager, Corporation Tramways, Southampton. The Incorporated Association of Electric Power Companies : Mr. J. S. Highfield, Chief Engineer, Metropolitan Electric Supply Co. It was decided to issue an invitation to the Royal Automobile Club of Great Britain to nominate a representative.

Association of British Chemical Manufacturers.—This Association has now been definitely formed. Its objects are to promote co-operation, to place the views of manufacturers before Government, to develop technical organisation and promote research. To facilitate the development of new British industries, and to extend the existing industries. The minimum annual subscription is 25 guineas in respect of a subscribed capital of £50,000, or less, rising by 2½ guineas for each additional £10,000 to 250 guineas. The provisional committee holding office for three months is as follows :—

Dr. E. F. Armstrong (Messrs. Joseph Crosfield & Sons), Mr. F. W. Brock (Messrs. Brunner, Mond & Co.), Dr. Charles Carpenter (South Metropolitan Gas Company), Dr. M. O. Forster (British Dyes, Ltd.), Mr. John Gray (Messrs. Lever Brothers), Mr. Norman Holden (Messrs. Hardman & Holden), Mr. C. A. Hill (British Drug Houses, Ltd.), Mr. C. P. Merriam (British Xylonite Co.), Sir Alfred Mond, M.P. (Mond Nickel Co.), Mr. Max Muspratt (United Alkali Co.), Sir William Pearce, M.P. (Messrs. Spencer, Chapman & Messel), Mr. R. G. Perry (Messrs. Chance & Hunt), Mr. R. D. Pullar (Pullar's Dye Works), Dr. Alfred Ree (Society of Dyers and Colorists), Mr. A. T. Smith (Castner-Kellner Alkali Co.), and Mr. John W. Wilson, M.P. (Messrs. Albright & Wilson).

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Commanding Officer, Lieut.-Col. C. B. Clay, V.D.

Orders for the Week.

Officer for the Week.—Platoon Commander L. C. Hughes-Hallett.

Next for Duty.—Platoon Commander J. R. G. Williamson.

Appointment.—Platoon Commander A. Girard to be Instructor of Musketry.

Saturday, July 8.—Instructional Class, 2.30, Company Commander Fleming.

Monday, July 10.—Technical for Platoon No. 9, 46, Regency-street, S.W. Squad and Platoon Drill, Platoon No. 10. Signalling Class and Recruits.

Tuesday, July 11.—Officers' Instructional Class, 6 to 7. Recruits, 7 to 8. Lecture, 7.15, "The System of Command," Company Commander W. Hynam.

Wednesday, July 12.—Platoon Drill for No. 3 Platoon.

Thursday, July 13.—Platoon Drill, No. 7 Platoon. Recruits, 5.45 to 7.15. Instructional Class, 5.45.

Friday, July 14.—Technical for No. 10 Platoon, 46, Regency-street, S.W. Squad and Platoon Drill, No. 9 Platoon.

Saturday, July 15.—Parade Golder's Green Station, 3.0 sharp, uniform.

Sunday, July 16.—Entrenching at Otford. Parade Victoria (S.E. & C. Railway Booking Office), 8.35 a.m. Uniform, haversacks, water bottles. Midday rations to be carried. Railway vouchers will be provided. Otford Camp.—For the standing camp at Otford, see monthly orders.

Musketry.—For all companies, see Notice and Tables A and B at Headquarters.

Note.—Unless otherwise indicated, all drills, &c., will take place at Chester House.

MOTOR DRIVE FOR STEEL MILLS*.

BY F. B. CROSBY.

Summary.—The early installations were of direct-current motors, but the more recent ones have usually been of induction motors, because of the ability of the latter type machines to stand excessive abuse. The employment of the induction motor introduced the problem of developing a satisfactory variable-speed control. The methods attempted in solving the problem are treated in this article.

Just as the advent of a practical steam engine made possible the development of industrial centres apart from natural sources of energy such as water-powers, so in even greater measure has the practical application of electric power increased the scope of human activity. Certainly, without the electric motor the steel industry could never have reached its present magnitude and marvellous efficiency.

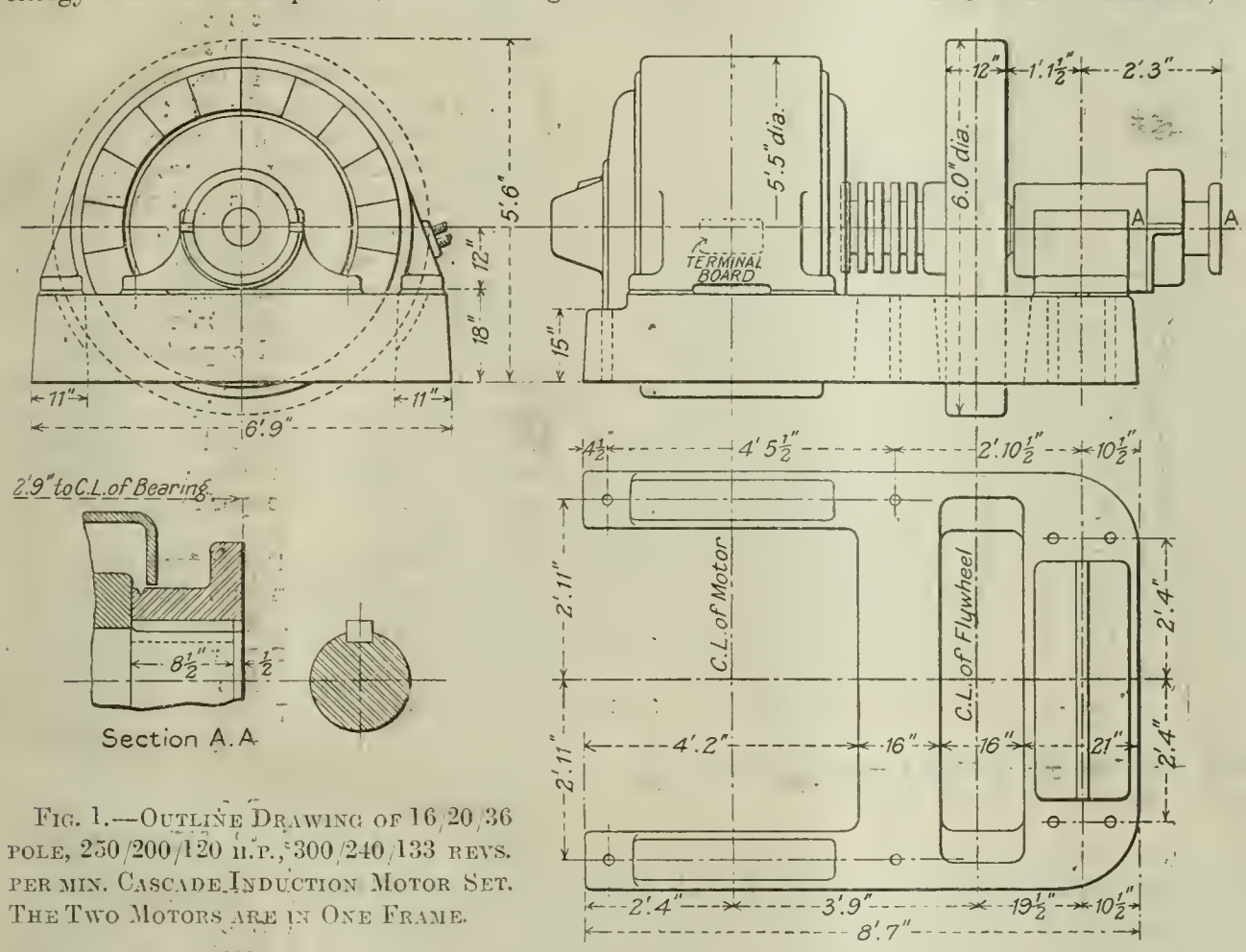


FIG. 1.—OUTLINE DRAWING OF 16/20/36 POLE, 250/200/120 H.P., 300/240/133 REVS. PER MIN. CASCADE INDUCTION MOTOR SET. THE TWO MOTORS ARE IN ONE FRAME.

Several schemes, each a compromise, have been suggested and tried in actual service where more than one speed was required. The most common arrangement is perhaps the multi-speed motor with one or two windings. Two speeds with a 2 : 1 ratio can be readily obtained with a single winding or a maximum of four speeds with two independent windings, each winding having leads brought out for two 2 : 1 speeds. In steel mill work it is rarely possible to select four synchronous speeds bearing the right relation to one another and to the mill requirements. Furthermore, while the efficiency of such a machine is good, the power-factor at the lower speeds, particularly for 60-cycle motors, is very poor and the cost very high.

A second method employs what is known as operation in cascade. Two induction motors, one of which must have a phase-wound rotor, are arranged on a common shaft and base. One or both of these machines may have either a double or a single winding, and either may be operated independently of the other at its respective synchronous speed or speeds. Other speeds in cascade may be obtained by connecting the secondary windings of the first motor to the primary of the second motor while the primary of the first is connected to the power circuits. The cascade speed can be readily determined from the effective number of poles, $\frac{P_1 \pm P_2}{2}$, where P_1 equals the number of poles in the first motor and P_2 the number of poles in the second.

A figure in the Paper shows a 600 H.P. set of this type installed by the Oliver Iron & Steel Co. Each motor has two independent windings, the machine at the right having a phase-wound rotor and that on the left a squirrel-cage rotor. Six synchronous speeds are arranged for by the control.

The master controller, main and pole-changing oil switches, the air-break primary reversing contactors, accelerating contactors, current-limit relays and starting resistance are all clearly shown in the Paper. This equipment can be started or stopped by reversing at full speed from the master controller.

Fig. 1 shows the outline drawing of a 250 H.P. three-speed cascade set installed by the Ludlum Steel Spring Co., in which the two motors are combined in a single frame. As with the multi-speed motor, this method of obtaining adjustable speeds is open to the objections of high cost, complicated control, limited choice of speeds and low power-factor at low speeds.

Fig. 2 shows schematically the connection of a multi-speed motor and also of a cascade set.

The third and simplest method of obtaining speed control is indicated in the sketch at the left of Fig. 2. It consists merely of inserting an adjustable resistance (B) in the secondary circuit of the induction motor (A). So long as the load remains constant the speed will remain constant for any given setting of the controller.

Unfortunately, however, the average steel mill load is made up of a series of peaks interspersed with periods of friction load only. It should be obvious, therefore, that the series speed characteristic obtained with rheostatic control is entirely unsuitable for main roll drives.

Fig. 3 shows typical speed torque curves of a phase-wound rotor induction motor with external resistance in the secondary, plotted

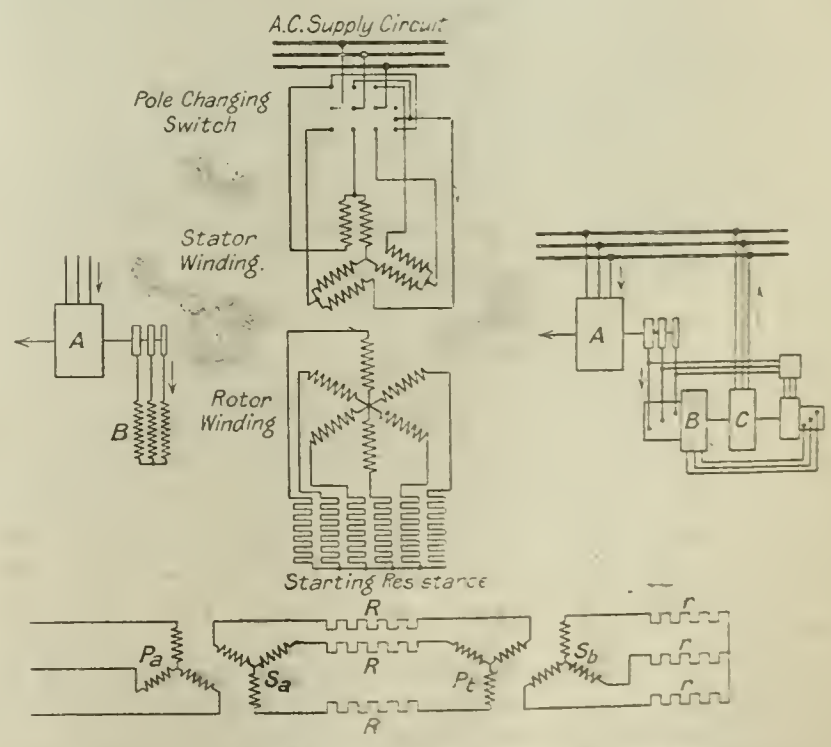


FIG. 2.—WIRING DIAGRAM OF A MULTI-SPEED MOTOR AND ALSO OF A CASCADE SET.

from 100 per cent. backward rotation to 100 per cent. above synchronism. The similarity of the curves above and below synchronism will be referred to later. Assuming that sufficient external secondary resistance is in circuit to maintain 40 per cent. speed with

* Abstracted from the "General Electric Review."

full load torque of 800 lb. at 1 ft. radius, as shown on curve No. 2, it follows that if this torque suddenly drops to 200 lb., corresponding to the friction load on the mill, the motor will accelerate along curve No. 2 to 85 per cent. speed, unless a prohibitive amount of resistance were cut in simultaneously with the change in load. In view of this fact, it is astonishing to note how frequently motor manufacturers are requested to quote rheostatic control for main line drives.

A second serious objection to rheostatic control for mill drives lies

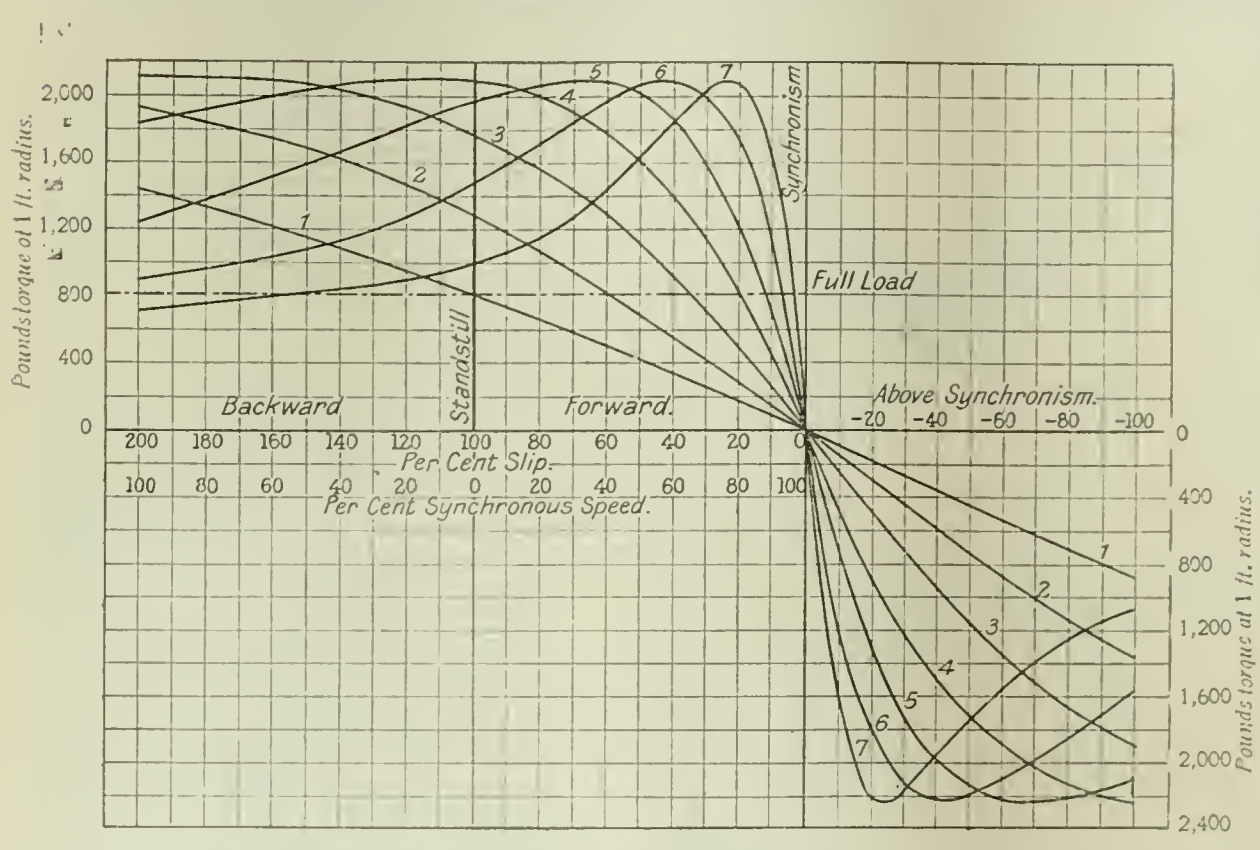


Fig. 3.—Typical Speed-torque Curves for Induction Motor with Phase-wound Secondary and 7-point Current Limit Control.

in the fact that for constant torque the input to an induction motor is constant irrespective of speed. To keep this point clearly in mind it is well to consider the machine under normal operation as combining two functions (Fig. 4); first, a pure motor action transforming electrical to mechanical energy, and, second, a simple transformation of electrical energy of primary frequency and voltage to a secondary frequency and voltage. At standstill the motor acts as a crude static transformer with maximum potential and line frequency at the slip rings. As the motor accelerates, the slip-ring frequency decreases or remains constant with change of speed, the secondary losses are always equal to

$$\frac{\text{slip}}{1-\text{slip}} \times \text{shaft horse-power.}$$

It is evident therefore that, both from the standpoint of speed characteristics and efficiency, rheostatic control is not desirable for rolling mill drives.

The first practical application of the adjustable speed alternating-current drive was made in Europe. Out of a very considerable number of methods, more or less experimental, two, the so-called Kraemer and Scherbius systems, emerged on a commercial basis. In the early part of 1911 the General Electric Co. began a careful and exhaustive study of the relative advantages and commercial possibilities of these and other systems. For reasons mentioned later, the Scherbius system received more favourable consideration, and the first American speed-regulating set was built similar to, but not identical with, the Scherbius motor. The results obtained with this first set so far exceeded expectations that negotiations were opened to secure the American rights to the Scherbius motor, which, by the way, permitted with standard induction motor design a somewhat simpler control than did the experimental set as first built.

In 1912 the first *bona-fide* proposition to build a speed-regulating set was made to the U.S. Steel Corpn. in connection with the two-speed 6,500 h.p. universal plate mill motor at Gary. This motor, rated I-28 56-6,500 h.p. 107 53·5-M-6,600 volts, is the largest induction motor yet built for steel mill service. It has a continuous overload capacity of 8,150 h.p. and a maximum torque corresponding to approximately 24,000 h.p.

Many of the features incorporated in the Gary motors have since become recognised standard requirements in alternating-current mill motor design. The massive frame and bearings, the steel rotor spider, end thrust device and provision for sliding the stator parallel to the shaft to clear the rotor for examination, are all standard features.

Since this installation was completed, alternating-current contactors have been developed and are now almost universally used for large mill motor control.

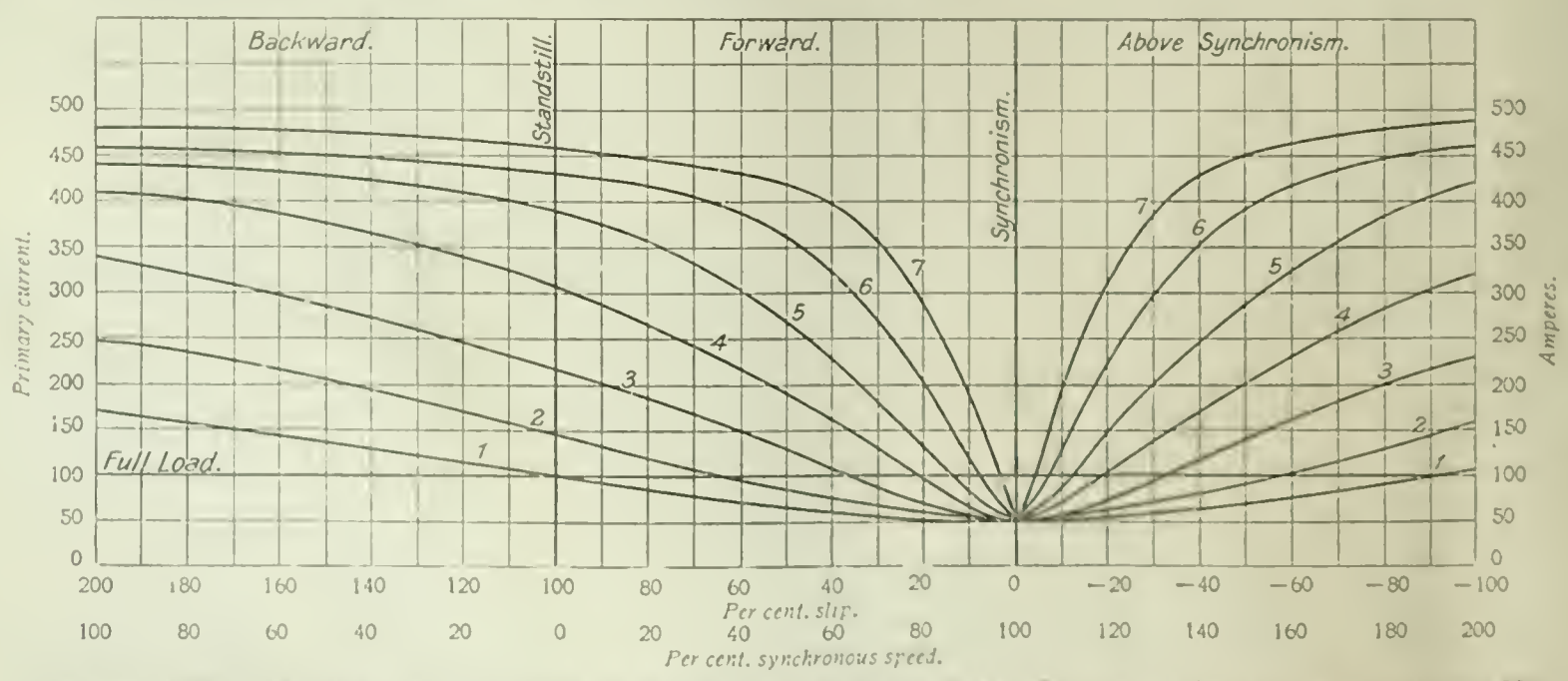


Fig. 4.—Curve Prepared to Show the Objection to Rheostatic Speed Control of Induction Motors for Mill Drive. For Constant Torque the Input is Constant Irrespective of Speed, and hence Efficiency is Reduced in Proportion to the Reduction in Speed.

and voltage approach zero at synchronism with constant torque; therefore, at half speed, neglecting losses, 50 per cent. of the input becomes useful work at the shaft and 50 per cent. is dissipated as heat in the external secondary resistance. In other words, with rheostatic control the efficiency is reduced in proportion to the reduction in speed. No matter whether the torque increases,

Fig. 5 shows a diagrammatic arrangement of connections with distribution of losses as calculated for a definite condition.

A—800 h.p. induction motor at 1,200 revs. per min.
B—160 h.p. kilowatt rotary.
C—208 h.p. direct-current motor.
D—150 kw. induction generator.

With 254 kw. at shaft and 422 kw. input to the motor at 720 revs. per min. there are 3·7 kw. loss in main motor, 10·8 kw. loss in rotary, and 29·3 kw. loss in motor-generator, leaving 125·2 kw. of slip energy to be returned to the system, and showing an efficiency of 80 per cent. with rotary regulating set, as compared with 57·5 per cent. for rheostatic control. This also shows the original Kraemer idea of connecting the auxiliary direct-current motor to the shaft of the main motor and returning the slip energy mechanically.

Where the minimum speed of the main motor is sufficiently high, and where constant power or increasing torque at reduced speed is required, this arrangement is sometimes used. Generally speaking, however, the slow speed direct-connected direct-current motor will cost quite as much as or more than the higher speed direct-current motor and induction generator, since when forming a part of the mill unit it must be built sufficiently rugged to meet mill service, whereas if a separate set is employed the standard industrial construction is satisfactory. Furthermore, the separate set can often be placed in a room apart from the mill along with the control and better operating conditions can be maintained.

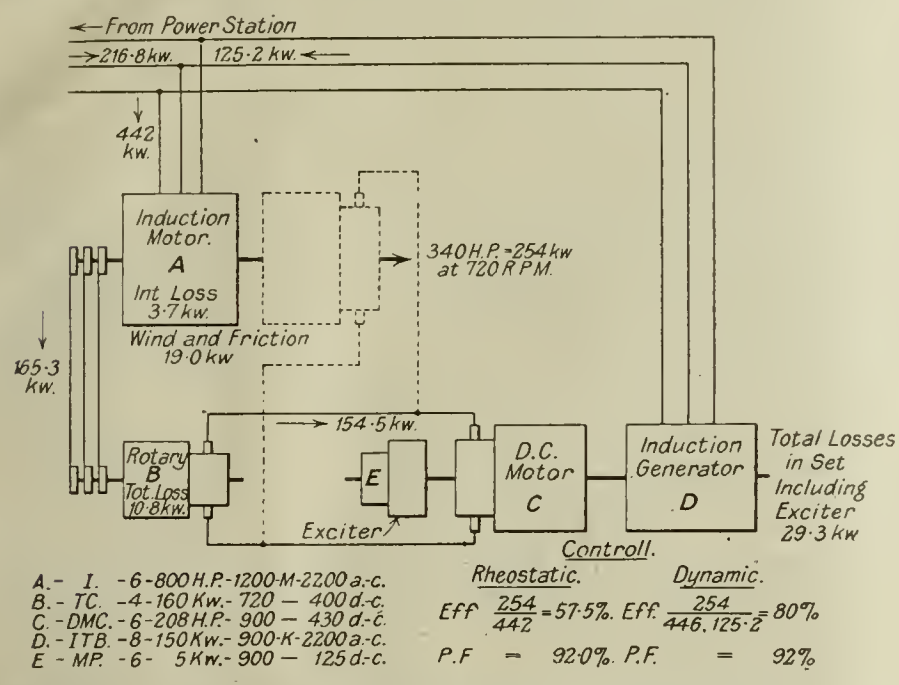


Fig. 5.—A Rotary Converter Method of Speed Control for Induction Motors.

phases is used, speed control being obtained by connecting different taps to the field winding of the polyphase commutator regulating unit. This arrangement has been used here in one or two instances, but in such a transformer for seven running points the complexity of taps encountered if a large number of running points is required is very great.

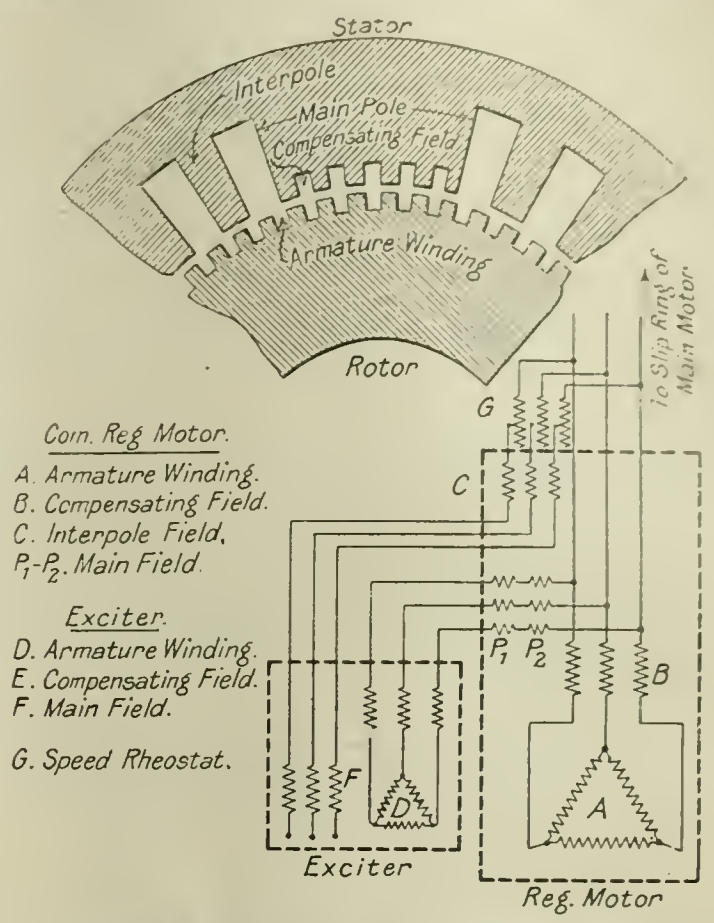
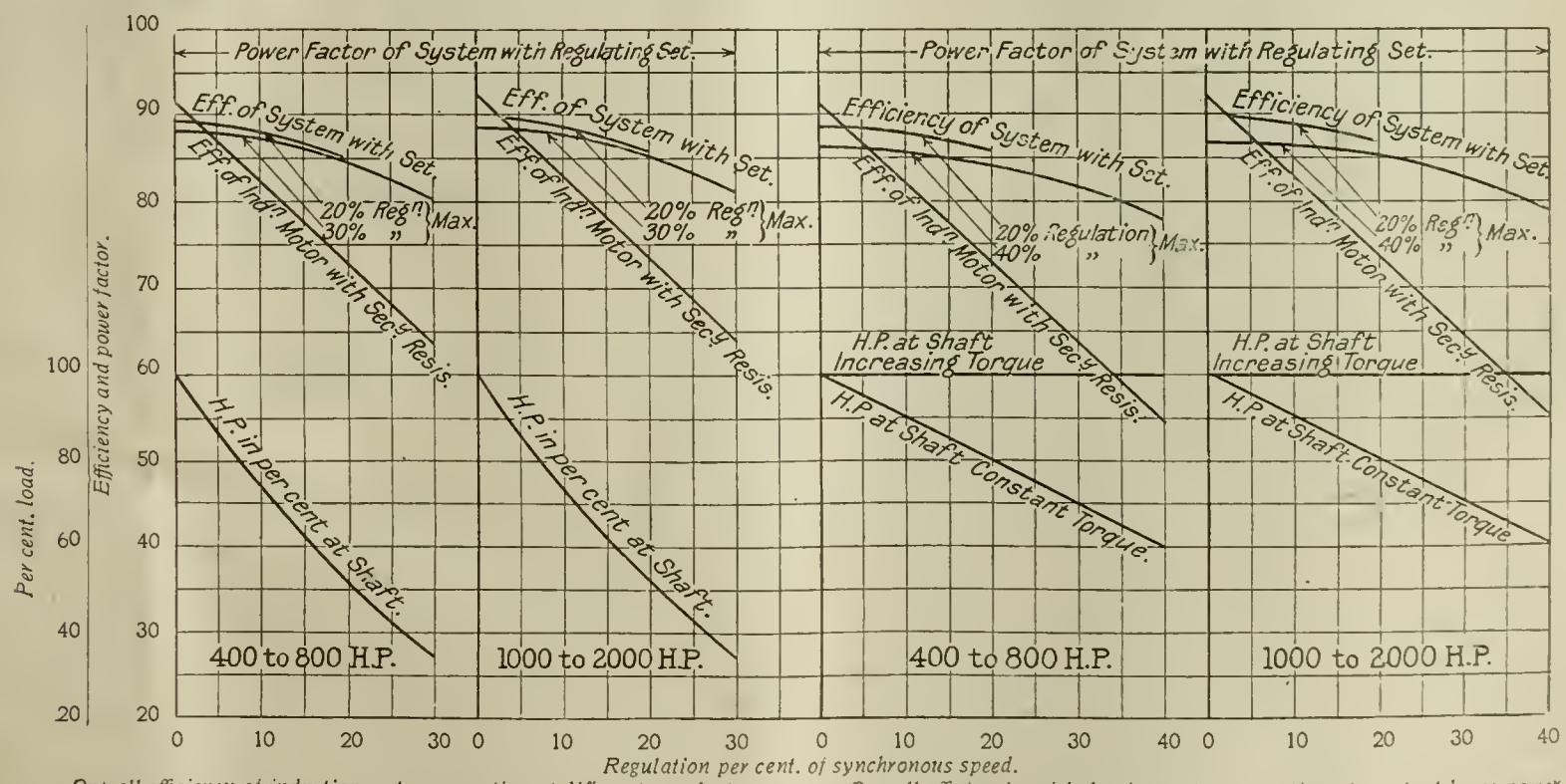


Fig. 6.—Diagram of Punchings and Connections of Polyphase Commutator Regulating Set.

The standard three-phase exciter field rheostat used with the polyphase exciter are easily made to give as many as 125 running points. These rheostats are usually operated by means of a vertical lever very similar to the usual throttle control for engine drives, the full speed range being obtained by a single movement of the lever.

In view of the apprehension which has been expressed in certain



Overall efficiency of induction motors operating at different speeds, torque decreasing with speed (fan service). Speed control obtained by speed regulating set and by rotor resistance.

Overall efficiencies of induction motors operating at constant horse-power or constant torque at different speeds. Speed control obtained by speed regulating set and by rotor resistance.

Fig. 7.—Typical Power-factor and Efficiency Curves for Decreasing, Increasing and Constant Torque, with Regulation by Means of Polyphase Commutator Regulating Set and by Rheostatic Control.

Shortly after the Gary universal plate mill proposition was submitted, the American patent rights to the Scherbius system were secured, and an order taken from the Forged Steel Wheel Co. for one 1,300 h.p. and one 600 h.p. motor, each with speed regulating sets of this type.

In European practice a special transformer with three independent

The problem is much simpler with the three-phase compensated winding of the Scherbius design. In the second place, unless sparking is very severe, it is much less

injurious with alternating current than with direct current, due to the potential dying away to zero twice during each cycle. It may also be of interest to note that with the 600 H.P. motor driving a direct-current generator connected to a water box load of 900 kw., or practically 100 per cent. overload on the motor, absolutely *no* sparking could be detected at any brush on the polyphase commutator regulating motor when the load was suddenly relieved by a circuit-breaker or thrown on by closing a knife switch.

Fig. 6 shows schematically the general character of punchings and connection of windings. The main interpole compensating and armature windings are clearly indicated. The secret of perfect commutation lies largely in the proper design of the compensating winding, which is fully covered by the Scherbius patents. The polyphase commutator regulating motor is in effect a shunt-wound machine with a series speed characteristic, due to the effect of increasing the armature voltage while maintaining constant excitation. It is this series speed characteristic which renders possible the induction generator action of the squirrel-cage motor referred to above.

Seven of these polyphase commutator regulating sets were sold on one order to the American Iron & Steel Co., all of which were put into operation without difficulties of any sort. This installation is of especial interest, in that the motors replaced old steam engines, and it was put into service by men accustomed to engine characteristics. Production has been increased fully 25 per cent. over that obtained with engine-driven units, and now it is proposed to obtain a further 25 per cent. increase by increasing the length of the cooling beds to permit handling larger billets.

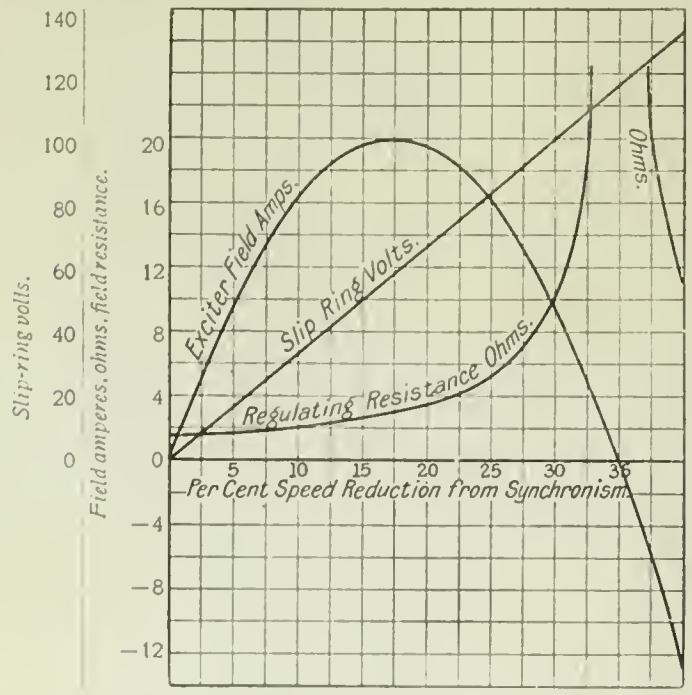


Fig. 8.—Typical Excitation Curve for Polyphase Commutator Regulating Set.

In making the change from steam to electrical drive the American Iron & Steel Co. made a clean sweep, and have put in a strictly up-to-date equipment in every respect.

A shop view of the automatic controller for one of these sets, showing the primary reversing contactors, accelerating contactors, current-limit relays and the notching back relay for producing the automatic slip of the flywheel is shown in the Paper. By opening the three-pole switch and throwing the five-pole switch down, the polyphase commutator regulating set is cut out and the motor runs as a normal induction motor with or without rheostatic control.

The regulating set is started first by means of a standard hand-operated compensator. The main motor is then started, and the polyphase commutator regulator set put into commission by a single movement of the master controller. Necessary interlocks ensure the proper sequence of action and prevent possible mistakes on the part of the operator. The motor may be plugged in emergency by simply throwing the master controller to full reverse position, the polyphase commutator regulating set being automatically cut out. The desired speed reduction is secured by means of the three-phase rheostat shown in the preceding view (Fig. 6).

Fig. 7 shows power-factor and efficiency curves for the general case with torque decreasing, increasing and constant. As the total required regulation increases the efficiency curve becomes slightly lower.

Fig. 8 shows a typical excitation curve for the PCR exciter. While the slip-ring potential varies uniformly, the field resistance increases slowly at first with increasing field current, and then more rapidly until at a point corresponding to about five-sixths of the total range the resistance becomes infinite, the exciter current zero, and the polyphase commutator regulator is excited directly from the slip rings of the main motor. Beyond this point the exciter current is reversed and the field resistance rapidly reduced.

A type of relay actuated by the line current for automatically reducing the speed of the motor and flywheel as the load comes on, thus making available a portion of its stored energy for reducing the peaks is shown in the Paper. This same relay works equally well with the motor on rheostatic or dynamic control.

It is of interest to note that the speed may be automatically increased instead of reduced where it is essential that the inherent tendency of any asynchronous machine to drop slightly in speed under load be strictly neutralised. Two 2,000 H.P. equipments are under construction at the present time for the Jones & Laughlin Co., which contemplate this arrangement in order to ensure absolutely constant speed under varying load.

Seven of these polyphase commutator regulating sets have been installed for controlling the speed of mine fans, and have shown very material savings over the old method of rheostatic control.

Referring again to this curve shown in Fig. 3, it is evident that the speed torque current curves of an induction motor are practically the same above or below synchronism. Furthermore, the slip-ring voltage and frequency increase uniformly above synchronism just as they do below, although, of course, the phase rotation is reversed. It is apparent, therefore, that the standard polyphase commutator regulating set will function equally well above and below synchronism. The difficulty has been to develop a practical commercial method of operation at and near synchronism *without sacrificing continuous speed control, torque efficiency* or *other desirable characteristics* obtained below synchronism.

As compared with the polyphase commutator regulating motor, the rotary converter system will always involve one more machine when the two systems are laid out on the same basis. If the separate motor-generator set is used the rotary converter system require four machines, as against three.

It is the established policy that the use of regulating sets shall in no wise handicap the desirable characteristics of the mill type induction motor as regards torque, heating or efficiency, and shall in every case improve the normal power-factor. The customary guarantee of 250 per cent. maximum torque can readily be met with the polyphase commutator regulating set from maximum regulation to within a slip frequency of about one cycle, whereas with the rotary converter the tendency to fall out of step at low frequency limits the 250 per cent. torque guarantee to about 8 cycles slip frequency, which on a 25-cycle circuit means that 250 per cent. torque cannot be guaranteed at regulation less than about 30 per cent. In many cases, therefore, the maximum torque throughout the entire speed range required is greatly reduced except at prohibitive expense.

ELECTRICITY SUPPLY.*

BY W. W. LACKIE.

Summary.—The author sketches the supply of electric energy and its progress during the last 18 years. The more recent work done at Glasgow is detailed, and coal consumption is discussed fully and comparisons made. An electrical scheme to supply the whole of Scotland with energy is outlined, and the economies of large stations clearly indicated.

After referring to the growth of the Institution and the effect of the war on engineering, the generation and distribution of electrical energy is discussed as follows :—

A public supply of electrical energy is now a necessity. Eighteen years ago in this country there were only 38 electricity supply companies, with a capital of £6,000,000, and 33 municipalities owned electricity works, with a capital of £2,000,000. Eighteen years ago there were 17 privately owned electric traction schemes in this country, with a capital of £7,000,000. This gives a total of 88 concerns, with a capital of £15,000,000.

To-day there are 276 companies owning electricity works, having a capital of £61,000,000 ; 328 municipalities own electricity works, with a capital of £52,000,000 ; besides 172 traction companies, with a capital of £183,000,000 ; and 175 municipalities have electrically operated tramway systems, with a capital of £53,000,000. These figures represent a total of 951 concerns and a capital of £349,000,000, and they show conclusively that the production and distribution of electrical energy is now a huge industry.

With regard to electricity supply in Glasgow, the plant at Port

* Abstract of a Presidential Address to the Institution of Engineers and Shipbuilders, Glasgow.

Dundas at first consisted of reciprocating engines and dynamos of approximately 1,000 H.P. each. Five such sets and the necessary water-tube boilers were installed. Later two sets of 2,000 H.P. each were added. In 1906 three turbo-alternators of 4,000 H.P. each were installed, and later two turbines of 5,300 H.P. each. This was followed by a 9,000 H.P. turbo-alternator in 1914. The total power now in Port Dundas amounts to 28,000 kw., or 37,000 H.P. Similar plant has been installed at St. Andrew's Cross, and the total power there is now 17,000 kw., or 22,500 H.P.

Three years ago the Corporation purchased 14 acres of land in the east end of the city, near Dalmarnock Bridge, for a new generating station. The southern boundary of the site is the Clyde, from which an abundant supply of water for condensing purposes is available. Railway lines are already laid into the site, and had it not been for the war the buildings would have been in progress of erection.

The lay-out of a power station is complicated by the fact that, whereas the power per square foot of engine room has increased enormously in recent years, there has not been a corresponding increase in the boiler house.

Coming to the boiler house and boiler-house design, notwithstanding all the work that has been done on fuel consumption and on the transformation of coal to steam in boilers, and giving full credit to such improvements as have been made, it has to be confessed that during the period under review no outstanding advance has been effected in the design and operation of boilers and boiler-house plant.

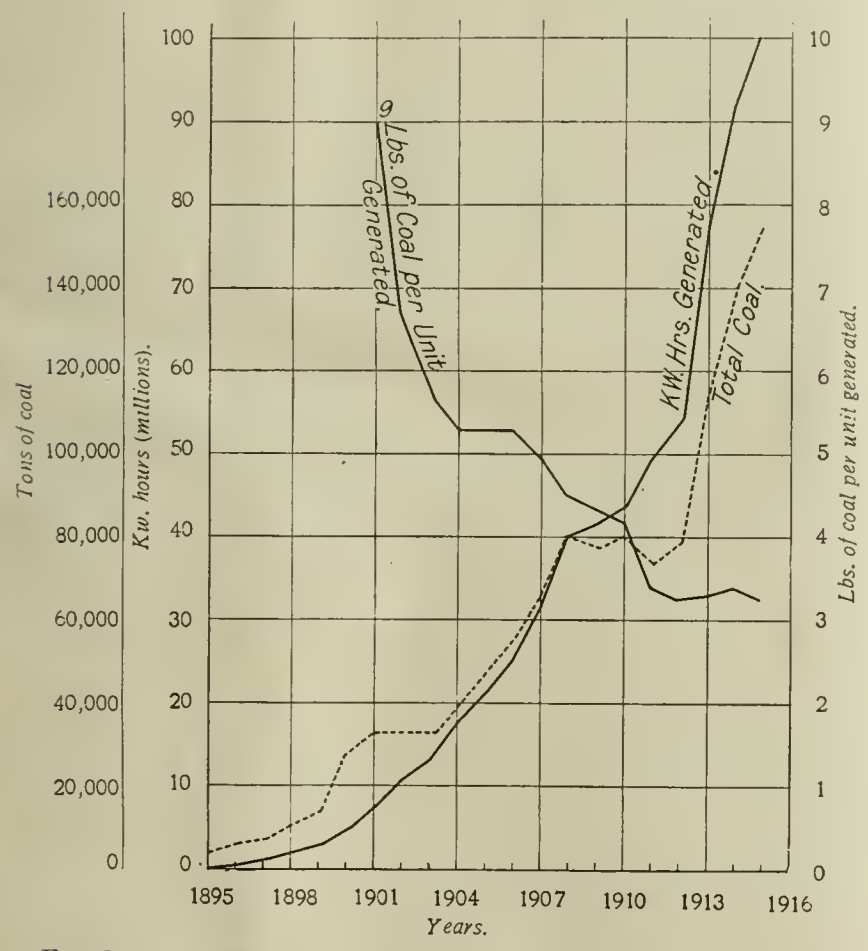


FIG. 1.—COAL, KILOWATT-HOURS GENERATED, AND COAL USED PER UNIT FOR 20 YEARS.

This need not be a matter for surprise, as 18 years ago boilers already had an efficiency of 75 per cent. expressed as the ratio of the thermal units in the steam to the thermal units in the coal fired, and the margin of 25 per cent. was made up of losses that could not be avoided. It would be doing negative work to discharge the gases from a boiler at a temperature lower than that of the water in the boiler; a certain amount of radiation must take place, and there is always some heat lost in ashes.

The chief improvements in the boiler house have been the increase in size of the steam unit, the raising of the steam pressure, and the use of highly superheated steam. The first boilers put down in Waterloo-street station 23 years ago had a heating surface of 800 sq. ft., and a grate area of 46 sq. ft., the nominal steaming capacity being 3,400 lb. of steam per hour. The most recent boilers installed at Port Dundas have a heating surface of 6,000 sq. ft., and a grate area of 150 sq. ft., the nominal steaming capacity being 30,000 lb. of steam per hour. The boilers in the new Dalmarnock works will have a steaming capacity of 50,000 lb. each. In the Detroit electricity works five boilers have been installed, each having an effective heating surface of 23,654 sq. ft., the nominal steaming capacity being of the order of 88,000 lb. of steam per hour. The increase in the size of the boiler unit, when water-tube boilers only are under consideration, has not seriously diminished the floor space occupied, for, after all, it resolves itself into the rate of combustion per square foot of grate area. This can be increased, but generally only at the sacrifice of efficiency. In the Detroit boilers, with an evaporation of 3 lb. per square foot of heating surface, the efficiency was 80 per cent., with an evaporation of 7 lb. per square foot the efficiency was 76 per cent., and with 14·7 lb. per square foot the efficiency was 60 per cent. The rate of combustion per square foot of grate area varied from 16 lb. to 36 lb. per square foot. For many years, under ordinary circumstances, Scotch coal has shown the best results with a draught of 0·5 in. at the back of the boiler, and a rate of combustion of 25 lb. per square foot of grate area.

Recently an American stoker was installed in the Port Dundas electricity works, and a rate of combustion of 56 lb. per square foot of grate area has been obtained with forced and induced draught. The reason for installing this stoker was to meet the exceptional conditions we have in Glasgow, arising from the rapid descent of fog and accompanying darkness, which causes sudden demands for large quantities of steam. It is no uncommon occurrence for a normal demand of 500,000 lb. of steam to be increased in 10 minutes to 750,000 lb. If the stoker, just described, enables us to get rid of the expensive necessity of the banked boiler—and we confidently anticipate that it will—it will be a welcome addition to boiler-house equipment.

After referring to the various types of steam turbines in use, the author passes on to the question of steam consumption. Eighteen years ago little attention was paid to steam consumption of plant purchased. The chief consideration was price. This was due to the fact that, in those days, electric lighting was the chief use to which the supply was put. The load-factor was between 10 and 15 per cent.; or, in other words, the output corresponded to from $2\frac{1}{2}$ to $3\frac{1}{2}$ hours per day of the maximum load on the plant. Interest, sinking fund and depreciation represented by far the largest charge

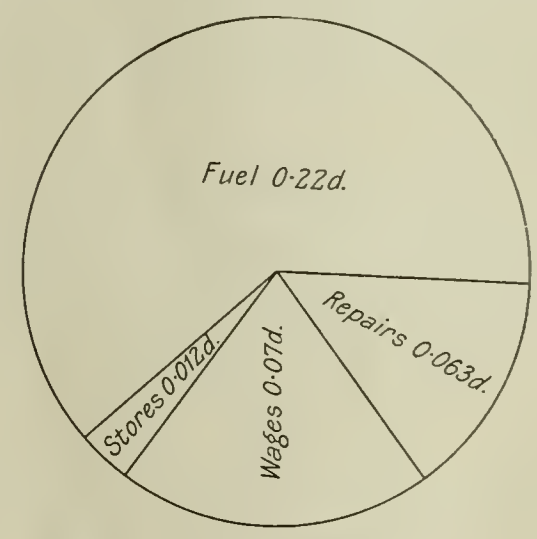


FIG. 2.—ALLOCATION OF WORKS COST.

against revenue in the annual balance-sheet. The coal bill represented only 10 per cent. of the revenue. The load-factor now obtained in most large power stations, due to the use of electrical energy for power purposes, has been raised to 25 and 30 per cent., and we look forward to a load-factor of 50 per cent. The price of plant is, therefore, not now the first consideration, and steam consumption has to be seriously taken into account. As an illustration of this the Glasgow Corporation recently issued a specification for a 6,000 kw. turbine, and the following clause was inserted: "Should the contractor fail to meet the guaranteed steam consumption, the contractor shall pay to the Corporation the sum of £750 for every $\frac{1}{4}$ lb., or part of $\frac{1}{4}$ lb. consumed, over and above the figure of guaranteed steam consumption per kilowatt-hour."

All branches of engineering are under a debt of gratitude to the Engineering Standards Committee. This Committee has rendered most valuable service in connection with the standardisation of electrical machinery and appliances. Similarly important work has also been carried out by the British Electric & Allied Manufacturers' Association in standardising rules for electrical machinery. In the latest publication of this Association the term "tolerance" is introduced as representing the permissible amount of deviation in observed results from guaranteed results, in connection with new plant. In steam consumption this Association has fixed on a $2\frac{1}{2}$ per cent. tolerance to be allowed before any penalty or bonus is exacted.

The improvement that has taken place in coal consumption in the Glasgow stations, due to larger generating sets, and the introduction of the steam turbine, is shown in Fig. 1. It is interesting to look back on a Paper, read before this Institution by Mr. William Arnot in 1894, in which he gave the results of tests on a 350 H.P. Willans-Siemens set in the original Waterloo-street station. The steam

conditions were: Boiler pressure 150 lb. per square inch, saturated steam and exhaust to atmosphere. A figure of 22 lb. per indicated horse-power, or 29 lb. per kilowatt-hour, was obtained at full load, and 25 lb. per indicated horse-power, or 31 lb. per kilowatt-hour at half load.

In 1901 three engines in the Port Dundas works were tested, viz., a marine engine of 900 H.P. by Messrs. Matthew Paul, of Dumbarton, coupled to a Siemens generator; an American Ball & Wood vertical engine of 800 H.P.; and a Willans & Robinson high-speed central-valve enclosed engine of 1,100 H.P. The steam conditions were 180 lb. per square inch dry steam at the stop valve, vacuum 23 in., and the steam consumption obtained varied from 13 lb. to 17 lb. per indicated horse-power, or from 20 lb. to 24 lb. per kilowatt-hour. In 1902 tests were made on two Musgrave engines and two Allis-Chalmers engines, installed in the Pinkston power station, belonging to the tramways department. The engines were each tested at or about 3,000 H.P. At the time (1902) these sets were supposed to be the last word in steam generating sets. The steam conditions were 160 lb. per square inch in dry steam, and vacuum 24 in. The steam consumption was from 12·2 lb. to 12·4 lb. per indicated horse-power, which corresponded to 18 lb. per kilowatt-hour. For the first seven years' running of these engines the consumption of coal per kilowatt-hour generated was practically 3 lb. Since 1909 three steam turbo-alternators have been installed at the Pinkston station, viz., one 3,000 kw. set, one 4,000 kw. set, and one 6,000 kw. set; and these meet the whole load of the tramways department, the reciprocating engines being used as a stand-by. The steam consumption of these turbines was given as 14 lb. per kilowatt-hour, which would correspond to 9·6 lb. per indicated horse-power, and the coal consumption last year had fallen to 2·74 lb., showing a saving of 8½ per cent. It has to be noted that the saving is not proportionate to the steam consumption, for the reason that the steam conditions for the turbo-alternator sets are very different, being as follows: Steam pressure 160 lb. per square inch, 100°F. superheat, vacuum 29 in. In other words, although the steam consumption has fallen from 18 lb. per kilowatt-hour to 14 lb., or 22 per cent., the coal consumption has only fallen 8½ per cent.

The most recent tests on a turbo-alternator were made on a 6,000 kw. set at Port Dundas last year. The conditions were as follows: Steam pressure 190 lb. per square inch, steam temperature 550°F. (150°F. superheat), vacuum 27·45 in. The steam consumption per kilowatt-hour was 13·7 lb. That is to say, that since 1901 the actual steam consumption has been improved by the use of turbines and larger units, from 20 lb. to 13·7 lb. Although the saving in coal has not been in proportion to this reduction in pounds of steam, the coal consumption in the Glasgow stations has fallen from 9 lb. in 1901, to 5 lb. in 1907, and to 3·3 lb. in 1914. The thermo-dynamic efficiency (*i.e.*, the ratio between the kilowatt-hour and the heat units available to do the work in steam, between the range of temperature of inlet steam and the outlet to condenser) in a well-designed turbo-alternator is between 65 and 70 per cent., representing a possible steam consumption of 11 lb. to 12 lb. per kilowatt-hour. The thermo-dynamic efficiency of the Pinkston engines appears to have been as high as 65 per cent.

The electrical part of the generating plant has kept pace with the development effected in the turbine. A 10,000 kw. alternator driven by a steam turbine takes up no more space than a 1,000 kw. alternator driven by a reciprocating engine, and what is of much greater importance, the capital cost per kilowatt for a turbo-alternator is £4, as against £8. 10s. per kilowatt for a reciprocating engine and alternator.

The efficiency of the electric generator has all along been of a very high order. The original generators installed in Waterloo-street in 1894 had an efficiency expressed by the ratio of output to indicated horse-power of 88 per cent. The efficiency of the present-day alternator expressed in the same way is 97 per cent. This improvement is partly due to the increase in the size of the unit, but it also owes much to design.

For many years it has been a fashion to use electric motors for the driving of auxiliaries, but recently it has been shown that, when a failure or interruption of supply has occurred, or where plant had to be started up suddenly, in case of a sudden demand, there was delay in getting the auxiliary plant started, owing to the means of driving it having also failed or being deficient. The supply of electrical energy to the motors driving the auxiliary plant was obtained from the main generators, either direct or from the main 'bus bars of the station. A stand by supply of energy may be obtained from a battery so long as the auxiliaries are small, but when we have to consider 50,000 kw. to 100,000 kw. generating stations, and the auxiliary plant amounts to between 5 and 7 per cent. of the whole steam capacity, it means from 2,500 kw. to 7,000 kw., and for this a battery stand-by is quite out of the question.

The importance of continuity of supply is next dealt with. In many power stations recently erected, the auxiliaries are direct-driven by independent steam turbines. This makes a very desirable combination, as the drive of the auxiliaries is self-contained in every respect, except as regards the supply of steam. On two 9,000 H.P. sets in the electricity works of the Glasgow Corporation, a small steam turbine of 200 H.P. drives the circulating, air and condenser pumps, together with a small force pump, all on one shaft, and a very reliable and simple combination of auxiliaries is thus provided. A drawback to the arrangement is that the most efficient speeds of these various pumps may not be the same. It is absolutely necessary for the efficient running of the works that all exhaust steam should be collected and used. In the new generating station to be erected at Dalmarnock, it has been decided to drive the auxiliary plant electrically. The source of supply will, however, be quite separate from the main 'bus bars, and will consist of turbo-alternators generating energy at 440 volts alternating current at 25 cycles per second. This decision has been arrived at for several reasons. The level of the Clyde, from which the condensing water is to be drawn, is 20 ft. below the condenser floor level. This means that the main circulating pumps will be in a pit, and an electric motor drive is the only one suitable. The air and circulating pumps will be driven by separate motors. The induced draught fans will be situated on the third floor of the boiler house, and if they were driven by steam, long stretches of steam and exhaust piping would be necessary.

The novel features in connection with the design of the Dalmarnock works, which are departures from standard practice, are as follows:—

The auxiliaries are all driven with three-phase alternating current motors, the energy for these motors being obtained, as already stated, from separate three-phase turbo-alternators, the exhaust of which will be used to heat up the condenser from the main turbines. This means that the condenser from the main turbine is to be used as the circulating water for the condensers of the auxiliary plant. The exhaust steam from the auxiliary turbines will raise the temperature of the condenser as circulating water from 80°F. to 140°F., after which it will be passed to the hot well, and later through an economiser. As the load on the auxiliary turbine, however, is likely to remain fairly constant, while the load, and therefore the condenser, from the main turbine will vary, the condenser of the auxiliary turbine will have a second set of tubes, through which river water can be circulated. The amount of river water will be automatically regulated by the amount of the condenser coming from the main turbine.

The other features of the new station will be the size of the boiler units, high superheat, an economiser for each boiler, large coal storage and, consequently, a very complete system of coal-handling plant.

I will now refer to the question of alternators and electrical pressure. Alternators are now artificially cooled by air, either forced through by means of an external motor and fan, or the rotor has fan blades mounted on it, the air being filtered by being passed through a cloth or water screen. The electrical pressure at which the energy is generated is coming to be regarded as a secondary question, and manufacturers are thus left free in the design of alternators to adopt one or two conductors per slot, as the energy has to be subsequently passed through a transformer, in order to raise it to its working pressure. The working pressure is a matter to be decided by the location and size of the generating station, and the location of the area to be supplied relative to the source of supply. Pressures of 3,000, 6,000 and 11,000 volts have been successfully used, but in a station having a capacity of 100,000 kw., pressures of 20,000 to 30,000 volts require to be adopted for the following, amongst other reasons. To distribute 100,000 kw. at 6,000 volts would necessitate the provision of at least 75 feeders or main cables. This in turn would mean a switchboard house out of all proportion to the size of the works. With 20,000 volts pressure 25 feeders would be ample for the distribution of the energy to the various centres. The energy generated at the pressure best suited to the size and design of the alternator is thereafter transformed either immediately after the generator or by means of a transformer on each feeder, to the transmission pressure. It has again to be transformed at the distributing centre. This may seem an unduly large number of transformations, but the total loss between the terminals of the main generator and the 'bus bars in the sub-station does not exceed 6 per cent. The loss that does take place as a result of these various transformations is more than counterbalanced by the enormous saving in copper, the reduction in the number of cables, and in the smaller buildings necessary to house the switchgear.

Taking the generating station as a whole, the power per square foot of land with buildings thereon has been increased six-fold. The Waterloo-street station had a little over 0·4 H.P. per square foot of

generating station area; Port Dundas and St. Andrew's Cross stations doubled this with 0·8 H.P. per square foot; and the new Dalmarmock works will have 2½ H.P. per square foot. This amounts to a considerable reduction in the cost of electricity, as it reduces expenditure on land and buildings relatively.

The sub-station containing transforming plant is the link between the generating station and the distributing system. If continuous current has to be supplied, the sub-station is an important item in the capital cost for land and buildings, and it has a considerable wage bill for attendance. I hope, however, that with the introduction of alternating-current distribution the cost of land and buildings for sub-stations will be materially lessened, and the wage bill for attendance will be almost eliminated. Experience has shown in Glasgow that the maximum capacity at which a sub-station can be economically operated is 6,000 kw. When the demand exceeds this amount it is cheaper to erect an additional sub-station mid-way between two sub-stations, rather than to run more mains from existing sub-stations.

Electrical practice 20 years ago is mentioned which leads to questions of economical distribution. To-day we find that the only economical method of distribution on a large scale is to generate three-phase alternating current, 25 or 50 periods per second, at pressures between 4,000 and 10,000 volts, to transmit this energy to sub-stations for transformation to low pressure alternating current, and thence to the public. If consumers will adopt alternating current and so get rid of the running machinery necessary for the conversion of alternating current to continuous current, as well as the wage bill for attendance, not only will the price of electrical energy be reduced, but the supply will be more reliable, and the duration of possible interruption will be shortened.

In America most of the hydro-electric schemes have their energy generated at 6,000 volts, and transformed up to 80,000, or even to 140,000 volts, for transmission by means of overhead wires, which can be easily kept some feet apart. To transmit these high pressures by means of underground cables is quite another problem. It is rather surprising that the Americans should have continued to adhere to 110 and 115 volts at consumers' terminals, instead of going to the higher pressures of 200 to 250 volts which we have adopted generally in this country. The amount of copper used in these American schemes on feeders, and in connection with switchboards, is colossal. One switchboard in Chicago has 72 sq. in. of copper on the 'bus bars, whereas the area of copper on the 'bus bars in our largest sub-station in Glasgow is 14 sq. in.

From the point of view of size of station there is no reason whatever why the whole of Scotland should not be supplied from two or, at the most, three central power stations. The present maximum demand on the 31 electricity supply concerns in Scotland is of the order of 120,000 kw.

If we divide Scotland into three areas, the lowlands south of the Tay will represent two areas, and the whole of the land north of the Tay will represent the third area. Taking Falkirk as the boundary between the two lowland areas, we find that the demand in the western area is 80,000 kw.; the demand in the eastern area is 25,000 kw.; and the demand in the third or northern area is 15,000 kw. Three moderate-sized stations would therefore meet the entire demand for Scotland, the major portion of the whole being from Glasgow and the West of Scotland.

In Chicago there was recently purchased 110 acres of land in the north-west of the city, and plans have been drawn up for the erection of two generating stations, with a probable third station on this site. Each of these stations will have a capacity of at least 250,000 kw. One of the stations has already been erected.

In a valuable report prepared by Mr. C. H. Merz, of Messrs. Merz & MacLellan, regarding electricity supply in London, a scheme is described of how to supply the whole of greater London from two generating stations, and this is not thought to be too large an area for two stations to undertake. The total maximum demand made in greater London (including the County of London and outer London) on electricity supply undertakings belonging to local authorities and companies, in 1912, only amounted to 196,000 kw. The total plant installed was 300,000 kw. The total units sold in greater London was 400,000,000, while the output of the Commonwealth Edison Co. in Chicago is nearly three times this, being 1,114,000,000 units.

The manufacture of cables, and improvements made, the rise in price of coal, and improvements in lamps are next mentioned. The fact that we are only able to obtain 15 per cent. of the heat value of the coal utilised, and in many stations half of this, is referred to, and it is hoped the maximum possible, viz., 19 per cent., may be reached.

In the original Paper the author gives an instance of the economies and advantages rendered possible to the public by a supply of electrical energy from large generating stations. An engineering works and a bakery may make a demand of 500 H.P., each to supply energy to drive their respective plants, but if these two concerns make their demand, the one during the day and the other during the night, the same 500 H.P. of plant in the generating station will supply both. The capital charges are, therefore, divided between them. That this does take place on a large scale is borne out by the fact that to-day there are 80,000 H.P. of motors connected to the Corporation mains, and the maximum load for power purposes is approximately 30,000 H.P.

It has been said that the greatest benefactor of mankind is he who can make two blades of grass grow where previously there has been only one. In the engineering world the best man is he who can make 1 H.P. of plant do the work which has hitherto required 2 H.P. And that is what is done in the large generating station. The generation and distribution of electrical energy on a large scale presents far-reaching possibilities. A large electricity supply undertaking can carry out comprehensive experiments and specialise in research work in a way that is prohibitive to the small isolated plant. Dr. Steinmetz, in America, speaking at an important electrical conference recently, said: "We are now recognising that we have reached a stage in industrial development wherein competition, instead of being the life of trade is its destruction"; and he argued in favour of a better organised combination and for mutual understanding amongst manufacturers. The tendency thus indicated is common to the whole of American industry, and it is bound to become increasingly evident in our own country. I think it is inevitable, and instead of trying to fight against it, the better policy would be to guide and control it to the best advantage. A large generating station is a concrete example of a centralised concern effecting economies which have a beneficent influence on every large industrial concern within the area of its operations. The saving in the consumption of fuel in a large electricity works, as compared with the consumption by a large number of small steam plants, is so enormous as to be a matter of national concern, faced as we are with the fact that our coal supply is limited. The total coal used by generating stations in Great Britain is approximately 5,000,000 tons per annum, and in Scotland alone 600,000 tons are used. By organised combination from 30 to 50 per cent. of this could be saved.

NOTES ON DESIGN OF ELECTROMAGNETIC MACHINES.

I. CONTINUOUS-CURRENT MACHINES.

BY STANLEY PARKER SMITH, D.Sc.

(*Continued from page* 430.)

Summary.—In the first part of the article the author deals with the principles underlying the design of continuous-current machines, and in the second part he applies these principles to the design of a 350 kw., 500-volt generator running at 200 revs. per min.

PART II.

Design of a Slow-speed Continuous-current Generator.

As an example of how a design can be carried out, let us take a slow-speed generator, suitable for direct driving from an internal-combustion engine, such as a Diesel motor. An example of this kind will present different alternatives for discussion.

Let us assume an output of 350 kw. at a constant terminal pressure of 500 volts and a speed of 200 revs. per min., with a temperature rise not exceeding 45°C. after working continuously on full load. The question of overload need not be considered for such a case, as the electric generator will be safe to do anything an internal-combustion engine can do with the same normal rating. The generator is to be shunt wound.

The full-load current is then

$$I=\frac{350\ .\ 1000}{500}=700 \text{ amperes.}$$

Method of Procedure.

There is no common method in use for designing machines. Designers usually follow the practice of the office in which they work, and though there is always more or less freedom in matters of detail, experience usually fixes the limits that can be worked to. Unless we are dealing with standard machines, *i.e.*, machines taken from a standard list, it is well to start from the output coefficient, which we can obtain from values of the magnetic and electric loading which experience has

shown to be admissible. After settling the main dimensions, we can proceed to design the armature winding, which is the most important part of a continuous-current machine.

Starting in this way, we shall assume for the *specific magnetic loading*, or the *mean flux-density* in the air-gap :

$$B_{mean}=\frac{\Phi}{YL}=6{,}000 \text{ lines per cm.}^2$$

where Φ=useful flux per pole,
Y=pole-pitch in cm.,
and L=length of core in cm.

For the *specific electric loading*, or the *ampere-conductors per cm. of the armature periphery*, we shall assume :

$$ac=\frac{ZI_a}{\pi D}=300,$$

where Z =total number of conductors in armature winding,
I_a=current per conductor or armature circuit,
$=I/2a$,
and D=diameter of armature in cm.

The *output coefficient* is then (eq. 16)

$$C=\pi^2 \,.\, B_{mean} \,.\, ac \,.\, 10^{-6}=9{\cdot}85\times6000\times300\times10^{-6}=17{\cdot}7.$$

From this we get the product D^2L straightaway (n=200/60) :

$$D^2L=\frac{P \,.\, 10^5}{C \,.\, n}=\frac{350 \,.\, 10^5}{17{\cdot}7\times3{\cdot}33}=590{\cdot}10^3.$$

To split up this product, we must again draw on experience. In large machines of this type it is found good practice to make the pole-shoes about square, *i.e.*, pole-arc=core-length. Denoting the polar arc by b in cm., we have then

$$L=b=aY=a\frac{\pi D}{2p}.$$

The ratio a=pole-arc/pole-pitch is made as high as possible to obtain as large a flux per pole as possible, but is limited by the need for securing a proper commutating zone, the space required by the interpoles and by leakage. It usually lies between 0·7 and 0·75.

Assuming $a=0{\cdot}73$, we then get :

$$D^2L=D^2a\frac{\pi D}{2p}=0{\cdot}73\pi\frac{D^3}{2p}=2{\cdot}3\frac{D^3}{2p}$$
$$=590{\cdot}10^3$$

whence $D^3=257{\cdot}10^3{\cdot}2p$.

This brings us to the question of the number of poles. In settling this we must make certain of a good armature winding. For a large machine like the one we are designing, to obtain good commutation conditions the armature winding should be quite symmetrical ; there should, if possible, be only one turn per coil or segment ; the current per circuit should lie between 150 and 250 amperes. To prevent risk of flashing over, the mean pressure between commutator segments should not exceed about 15 volts, corresponding with a maximum pressure of about $15/a=20$ volts. The pitch of the commutator segments should lie between 5 mm. and 10 mm. for mechanical reasons.

The *core-length* may lie between 30 cm. and 40 cm. in well-ventilating machines of this class which have to be built at a low cost.

A suitable *diameter of the commutator* is about 75 per cent. of the armature diameter, *i.e.*, $D_c=0{\cdot}75D$.

We now rough out 6, 8 and 10-pole alternatives with lap and wave windings.

$2p$ =	6	8	10	poles.
$D^3=257 \,.\, 10^3 \,.\, 2p$ =	1,542 . 10^3	2,056 . 10^3	2 570 . 10^3	
$D=\sqrt[3]{D^3}$ =	115	127	137	cm.
$L=590 \,.\, 10^3/D^2$ =	15	36·5	31·5	cm.
$\pi D \,.\, ac=\pi D \,.\, 300$ =	108,000	120,000	129,000	
$\pi D_c=0 \,.\, 75\pi D$ =	270	300	322	cm.

The 6-pole machine is seen to be unduly long, and, therefore, should be avoided if possible.

There are practically four windings we can try : (1) Lap winding with one turn per coil, (2) lap winding with two turns per coil, (3) two-circuit wave winding, and (4) four-circuit wave winding.

Proceeding on these lines, we have :—

First Trial.—Lap Winding, $a=p$, and One Turn per Coil.

$2p$=	6	8	10	poles.
$I_a=700/2p$	116·5	87·5	70	amperes.
$Z=\pi D.ac/I_a$=	925	1,372	1,840	conductors.
$C=Z/2$ =	462	686	920	com. bars.
$y_1=\pi D_c/C$ =	5·85	4·4	3·5	mm. bar pitch.
$V \,.\, 2p/C$ =	6·5	5·8	5·4	volts between bars.

None of these machines is really desirable ; the first would be too heavy, whilst in the other two the commutator bars are too many and too thin. Also the current per armature path is too small. All these machines would be expensive to construct.

Second Trial.—Lap Winding, $a=p$, and Two Turns per Coil.

Here the number of armature conductors and the current per conductor are the same as in the first trial, but the number of commutator segments is halved, whilst the pitch of the commutator segments and the mean pressure between segments are doubled.

$2p$ =	6	8	10	poles.
$C=Z/4$ =	231	343	460	com. bars.
$y_1=\pi D_c/C$ =	11·7	8·75	7·0	bar pitch.
$V \,.\, 2p/C$ =	13·0	11·7	10·8	volts.

We now obtain possible windings, and both the 8 and 10-pole alternatives come up for consideration. Owing to the unsuitableness of the two-circuit wave-winding, which we shall point out immediately, some makers would use this lap winding in preference to the equivalent four-circuit wave-winding. For our own part we should object on principle to such a winding, owing to the awkwardness of winding coils of two turns with strip copper and to the sensitiveness of the machine to sparking. Our main reason for rejecting the lap winding, however, is the superiority of a properly designed four-circuit wave winding with one turn per coil.

We now proceed to consider the alternatives with wave windings.

Third Trial.—Two-circuit Wave-winding, $a=1$, and One Turn per Coil.

$2p$ =	6	8	10	poles.
$I_a=700/2$ =	350	350	350	amperes.
$Z=\pi D.ac/I_a$=	308	342	368	conductors.
$C=Z/2$ =	154	171	184	com. bars.
$y_1=\pi D_c/C$ =	17·5	17·5	17·5	mm.
$V \,.\, 2p/C$ =	19·5	23·4	27·2	volts.

All these machines are seen to be quite out of the question, because of the excessive current per circuit and width of commutator segment, whilst the extremely high pressure between segments would make the machine very liable to flash over.

This brings us to the remaining alternative, namely, a wave winding with more than two circuits. The only case that calls for consideration is the four-circuit wave winding, *i.e.*, $a=2$, which gives a current of 175 amperes per circuit. Since a symmetrical winding can only be obtained when p/a is a whole number, the 6 and 10-pole alternatives are at once excluded. This leaves us with the 8-pole machine, which we now consider.

Fourth Trial.—Four-circuit Wave-winding, $a=2$, and One Turn per Coil.

$2p$ =	8	poles.
$I_a=700/4$ =	175	amperes.
$Z=120{,}000/175$ =	686	conductors
$C=Z/2$ =	343	com. bars.
$y_1=300/343$ =	8·75	mm.
$V \,.\, 2p/C$ =	11·7	volts.

This winding is exceedingly promising, and to our mind is much better than the other possible alternative—the lap winding with two turns per coil. It must be noted that the pitch of the commutator segments and the pressure between commutator segments is the same in the 8-pole machine with either winding.

With a mean pressure between segments of 11·7 volts, the maximum pressure, if there were no distortion, would be about $11{\cdot}7/0{\cdot}73=16$ volts, which is quite safe. The actual maximum

value can only be determined when the field-form on load is known.

We proceed now to examine if the other conditions of symmetry and the various manufacturing restrictions can be met by a four-circuit wave winding.

Main Dimensions.

We first round off the figures for the diameter and length obtained for the 8-pole machine in this preliminary investigation. Taking numbers suitable for standard dimensions, we make $D=130$ and $L=35$ cm. Then the output coefficient becomes

$$C=\frac{350\cdot10^5}{130^2\times35\times3\cdot33}=17\cdot8.$$

This agrees well with the figure obtained from the assumed values of B_{mean} and ac.

It is advisable to have ventilation ducts in a core of this kind. If we take 10 mm. ducts, one duct per 8 cm. to 10 cm. of core length is usually sufficient. In the present case we shall take 4-10 mm. ducts. With this low frequency there is no object in using plates thinner than 0·5 mm. The paper or other insulation, &c., between the plates increases the length of a core of 0·5 mm. plates by about 10 per cent., making the net iron length in the present case $L_i=0\cdot9\ (35-4)=28$ cm. Thus, for the leading dimensions we have

Number of poles	$2p=8$	
Armature diameter	$D=130$	cm.
Armature periphery	$\pi D=408$	,,
Pole-pitch	$Y=51$	,,
Total core length	$L=35$	,,
L—ducts	$=31$	,,
Net core length	$L_i=28$	,,
Pole-arc	$b=0\cdot73\ Y=37$	,,

These dimensions, of course, can only be fixed provisionally, because it is not possible to settle them finally until everything has been worked out. It is quite a common experience to find some difficulty in the field winding, or some detail in the efficiency upset the design when machines are worked out *ab initio*.

Armature Winding.

The first thing is to adjust the number of commutator segments to obtain a symmetrical closed winding. The closing rule for a wave-winding is :

$$\text{commutator pitch } y_c=(C\pm a)/p.$$

With $C=342$, $a=2$, and $p=4$, $y_c=\frac{342\pm2}{4}=86$ or 85.

When $y_c=86$, the H.C.F. of C and y_c is 2, so that there will be two independent windings; when $y_c=85$, the H.C.F. of C and y_c is 1, so that there is only one winding on the armature. We thus choose the latter value for the commutator pitch to get a single winding.

Applying, now, the rules of symmetry, the potential pitch,

$$y_p=\frac{C}{a}=\frac{342}{2}=171.$$

This is a whole number, so that this condition is satisfied.

Further, since $y_p=171=57\times3$, it is possible to get a three-phase pressure from the winding, which makes the generator suitable for use with a three-phase static balancer for a three-wire supply.

The remaining condition refers to the slots, and the number of these must now be settled. It is found that with about 1,000 amperes per slot a convenient size of slot is obtained. Following this empirical rule, we get $u=1{,}000/175=6$ conductors per slot. With $u=6$ and $Z=2C=684$ coil-sides, there will be $S=2C/u=684/6=114$ slots and no idle coils. Then $S/a=114/2=57$ is a whole number.

We thus see that with $C=342$, $S=114$, $p=4$, and $a=2$, C/a, S/a and p/a are all whole numbers, so that the winding is quite symmetrical.

Before definitely settling on 114 slots, we must see how the armature stampings are to be built up. With a diameter of 130 cm. it is cheaper to make the armature core out of segments, both on account of the price of wide sheets and the difficulty of using the centre and corner pieces, which are more than likely to become scrap. With 114 slots it is obvious that we can use six segments with 19 slots per segment. With two keyways per segment—that is, 12 keyways in all—the joints can be made to overlap in alternate layers. Thus, with $S=114$, we are able to build the armature without any difficulty.

We can now check the ampere-conductors per cm., namely,

$$ac=Z\ .\ Ia/\pi D=684.175/\pi130=294.$$

This agrees with what we assumed as permissible at the outset.

Flux.

Having fixed the number of armature conductors, $Z=684$, it is possible to find the useful flux per pole. We calculate this at no-load and at full-load.

At *no-load* the speed is somewhat higher than the normal speed. Allowing 3 per cent. for this, the speed at no-load is 206 revs. per min. Hence, for the normal pressure at no-load, the flux will be, with $n_o=206/60$ (*see* eq. 7) :

$$\Phi_o=\frac{a}{p}\frac{E}{Zn_o}\ .\ 10^8=\frac{2}{4}\frac{60}{684\times206}500\times10^8=10\cdot6\times10^6.$$

On *load* there is a drop of pressure in the armature, series and interpole windings and at the brushes. Assuming this to be 5 per cent. the flux on load must induce an E.M.F, so that with $n=200/60$:

$$E=525 \text{ volts},$$

$$\Phi=\frac{2}{4}\frac{60}{684\times200}525\times10^8=11\cdot5\times10^6.$$

(To be continued.)

TRAMWAYS AND LIGHT RAILWAYS ASSOCIATION.

The eighth annual congress of this Association was held at the Westminster Palace Hotel, London, on Friday last, the Chairman of the Council (the Hon. Arthur Stanley, M.P.) presiding.

The Chairman said the year's revenue from subscriptions was £775 (against £832 last year), the falling off being due to many members being away on active service, and the expenditure was £635 (against £822), the reduction being chiefly due to there being no expenditure on the congress or annual dinner in 1915, and to general strict economy. Adding £14 interest on bank deposit and War Loan and writing off £30 on subscription account, the excess of revenue over expenditure was £125.15s. 9d. and credit balance from previous year made the total to carry forward £430. He regretted the loss of Sir Charles Rivers-Wilson and Mr. Robert Hammond during the year. He sympathised with Mr. A. L. C. Fell, who had had a severe illness, and he hoped he would soon be amongst them again. New conditions and new legislation had affected the industry. Some undertakings had had from 40 to 60 per cent. of their staffs leave to join the Forces or some department connected with the war, but things had settled down now, and they knew where they were. Women conductors were now generally employed, with satisfactory results. They were also employed as drivers on some systems, but it did not seem at all likely that they would be generally used as drivers. Driving a tramcar was more difficult than driving a motor car. With regard to supply of materials, an arrangement had been arrived at with a committee of manufacturers for the delivery of steel tyres. The question of rails was more difficult, but was being dealt with by one of the Association's committees. They were disappointed in trying to get the Commission on Paper Manufacture to receive a deputation to urge that more than two-thirds of the usual supply should be allowed for tickets, but the difficulty was being met by reducing the size of tickets. With regard to the taxation of excess profits the Association decided to apply to the Board of Referees for the increase of the statutory percentage from 6 per cent. to 12 per cent., as they thought that a fair percentage for company undertakings having a limited tenure. The matter was under consideration. With regard to the Local Government (Emergency Provisions) Act, 1916, which prohibited new routes for motor omnibuses without the consent of the highway authority, there might be differences of opinion. They knew the old veto which had so long been a difficulty to the tramways, and they extended some sympathy to a kindred industry in regard to this new veto. If motor omnibuses were to be made to contribute towards maintenance of roads it would be fair to include heavy commercial vehicles, which caused greater damage. They, as an association, would prefer a general act applying to all users of the roads, and apportioning a fair proportion of the cost of maintenance to each section. The Tram-

ways and Light Railways Association, the Municipal Tramways Association, the two motor 'bus associations and the Association of Municipal Treasurers had been working together on the subject of income tax, and under the presidency of a member of the Council (Mr. R. J. Hawley) had submitted the results of their deliberations to the authorities at Somerset House. They hoped to obtain a standard assessment for motor 'buses as in the case of tramways. He congratulated their late vice-chairman, Mr. James Devonshire, on his appointment on the Board of Trade Committee on the Electrical Industry. He did not think they could have selected a better man. He proposed that Mr. Stephen Sellon be appointed to represent and give evidence on behalf of the tramway industry at the inquiry being held by the Electrical Committee.

He now moved that the report and accounts be approved.

Mr. HARRY ENGLAND seconded the motion, and it was carried unanimously.

Mr. A. H. Beatty, Mr. I. Bulfin, Mr. Vincent Edwards. Mr. A. W. A. Chivers, Mr. H. M. Sayers, and Mr. G. M. Harriss were elected, on the motion of the Chairman, seconded by Mr. A. V. Mason, to fill the vacancies on the Council caused by the retirement by rotation of Mr. S. E. Baker, Mr. John Cameron, Mr. J. W. Dugdale, Mr. Thos. B. Goodyer, Mr. C. Shirreff-Hilton and Mr. H. L. Williams.

The retiring hon. auditor (Mr. A. W. Chambers) having been re-elected, and Mr. Harry England having taken the chair, in the place of Mr. Stanley,

Mr. W. TUKE ROBSON (general manager of the Southampton Tramways) read the following Paper :—

TRAMWAY TRANSIT AND COMFORT.*

BY W. TUKE ROBSON.

Each undertaking is bravely engaged in fighting its own battles, and the publicity afforded by the generous assistance of the tramway press and the two tramway associations cannot be too highly praised.

Personally I feel that the opportunity to escape for even an hour from the vagaries of the women conductor, and the wiles of the war bonus, will be warmly welcomed by those of us who are visibly ageing through the strain and stress of war-time tramway administration.

The object of this Paper is to endeavour to point out that the passenger has not always been sufficiently considered in the prosperous times of the past. He has had a cheap ride, it is true, but not always a comfortable one.

The Track.—Just before the outbreak of war I rode down a steep hill on a certain tramway system in the upper saloon of a car. The speed was not particularly excessive, but the condition of the track, together with the condition of the car, turned that ride into a species of nightmare. We were hurled from side to side as the car rocked and bumped its way downwards, and by a merciful providence reached the bottom.

On reaching home I looked up the annual report of this undertaking, and found that the sum of roughly £20,000 had been allocated to the relief of rates out of the surplus profits in the last four years alone. A small proportion of this amount would have been much better spent in track renewals.

At present track renewals are difficult, if not impossible, but much can be done in the way of repairs of a permanent nature. It is surprising that so many systems have not done more to abolish hammered joints, considering the facilities which exist in the way of thermit and arc welding. There has been, I am afraid, a tendency to patch up, instead of getting rid of the trouble once and for all by effecting a lasting and permanent abolition.

Rail Cleaning.—The question of rail groove cleaning has never received the consideration which is due to this method of reducing noise, and one hopes that in the near future vacuum cleaning will bring about the desired result.

Trucks.—It is, however, in the direction of rolling stock that the hopes of a passenger desiring a more comfortable ride must principally be centred. We are mounting our cars on practically the same truck as we did 15 years ago, and, although we may add various devices in the hope of gaining flexibility and radial action, it must nevertheless be admitted that a really comfortable riding truck is not yet an accomplished fact.

Brakes.—One thing in particular always strikes one- that the principle of the hand-brake should show practically no improvement in all the years that have passed. To all intents and purposes it is the same brake as on the horse cars 20 years ago, and the unpleasant jarring action is only intensified by the greater speed and weight of the modern car, to say nothing of the extra elbow grease required by the operator. The various devices of inserted gearing have relieved this to a certain extent, but have not improved things from the point of view of those travelling in the car. An interesting experiment is being made at Huddersfield at the present time, in the nature of a brake drum keyed on an extended armature shaft in the same way as the pinion, with a Ferodo-lined band brake operated in the usual way by means of the brake spindle. The advantages of such a brake are obvious, and in actual practice it is proving a great success.

Seating.—The longitudinal seating of the usual British car, and the wearisome cry of " Move up, please," or " Sit closer together, please," makes one wonder why the use of cross-seats in the lower saloon has never become more common. The advantage of being able to tell at a glance if any seat is available is very obvious, and there is no sacrifice of capacity, as those who have had experience can testify. A 24-passenger cross-seat car holds 24, whereas on a longitudinal-seated car the best conductor often is unable to induce, say, 22 passengers to move up and make room for 24. There is infinitely more comfort in facing the direction in which the car is travelling and in being able to look out of the window without twisting one's neck into a species of spiral.

Seat Cushions.—Before leaving the question of seating, is it not time that the uncomfortably hard wood seat was superseded by something more comfortable to sit upon ? In the old days wool mats and rep cushions were used with insanitary success, but now there are natural glaze rattan spring seatings available.

Ventilation.—The best method I have yet found is to arrange the ventilator windows to open outwards on a quadrant, in the direction in which the car is travelling. A stop is provided with quadrant to prevent the entire closing of the frame, and a thumbscrew holds the ventilator open to the fullest extent in the summer time. In the old-fashioned car, which has no ventilator windows, a good plan is to insert wire gauze at the top of the door window. Experiments have been made with induced draught by means of a fan driven from the axle, and there would appear to be no reason why this method should not be adopted with success.

Exits.—The tendency of passengers to sit as near as possible to the rear end of the car in order to get out more easily is only natural, and it is quite evident that any arrangement whereby a passenger may alight from the near side of the front platform would both add to his comfort and also make the conductor's duties easier. There would appear to be difficulties in the way of ticket checking, and also by reason of the staircase at the front end, although this can be overcome by an adaptation of the reversed stairway on a slightly extended platform. It would be interesting to hear the experience of Newcastle and other places where experiments in this direction have been made.

Interior Finish.—A uniform finish in teak or oak is not nearly so attractive as a contrast afforded by, say, oak and mahogany, and although the heavy elaboration of carved mouldings has given place to simpler design, there are, nevertheless, still far too many sharp corners and ledges for the accumulation of dust. In the writer's opinion, the modern car should follow the example of the modern house, and have rounded corners without mouldings and dust-traps. Instead of mirrors, more or less mottled as years go by, the end panels might well serve as frames for attractive photographs.

Top Covers.—The value of top-covered cars, especially in wet weather, is, of course, appreciated to the fullest extent, but it is not so easy to understand why the top saloon is often so much more uncomfortable and unattractive than the lower one. They are in many cases merely a sort of box top, cramped and dirty looking, apparently designed with no desire to make them attractive or easy to clean. An interior finish of alternate light and dark matchboard with sashless lazy-tong windows and tip-up seats, allowing a clear floor for cleaning, with a row of ventilator windows to match those in the lower saloon, would give a wholesome attractive effect.

Odd Fittings.—It may appear a trivial matter to criticise the position of switches and waybill racks, but everyone must have seen the surprising effect when a conductor, fiddling about over someone's head, is caught unawares on a curve and launched broadside against an unoffending passenger. This would appear to indicate the desirability of fitting all switches, racks and articles of this description in the region of the platform.

Open-air Riding.—A year's experience of South country tramways makes one wonder if the British principle of a double-deck closed car has been too closely followed, at any rate in the south. The Continental open trailer and the convenience of being allowed to stand and smoke on a roomy platform certainly appeals to one as a passenger, and the extraordinary popularity of a car on the Blackpool toast-rack principle, adopted at Southampton, certainly leaves no room for doubt as to the preference of the travelling public. One of the most noticeable features of this car is that, except in very windy weather, there is no discomfort through draught, and, although the car was built as a pure experiment the idea certainly suggests itself that trailers on this principle would be a great asset to any system requiring additional cars for summer traffic.

Shelters.—It is hardly reasonable to expect intending passengers to stand and wait in wind and rain without feeling a natural annoy-

* Abstract of a Paper read before the Tramways and Light Railways Association at the Eighth Annual Congress.

ance, and there is no doubt that pavement verandahs are greatly appreciated.

Bill Sticking.—The practice of obscuring passengers' vision by sticking bills all over the windows has lately reached greater proportions than ever, and some of the large systems are the worst offenders in this respect. On some systems it is really difficult nowadays to see where you have got to, and the opportunity given to wags to scribble on the bills assists in the general untidiness of the car. Hanging cards are even worse, as they swing about and disarrange the hats of lady passengers.

Speed and Stops.—The writer once boarded a car passing through a town and was informed by the conductor that it was hardly worth while getting on, as the car was going to wait 10 minutes while he and his mate had their dinner. Such a proceeding being too much of a novelty to miss, I waited to see if such a thing could really be, and sure enough the car did wait 10 minutes, not at a terminus even, but at a passing place quite near the centre of the system.

Influence of Local Conditions.—It is somewhat deplorable, especially from a passenger's point of view, that on many systems some purely local obstruction should have been allowed to govern the design of the whole of the car service for future ages. Quite a number of tramway authorities have had to reduce head room to the smallest possible limit because of one wretched bridge or archway, with the result that the curses of the travelling public have fallen upon the cars themselves, instead of the real origin of the trouble. An expenditure at the beginning in reducing the road level or otherwise removing the obstacle in the way, would have been money well spent if it resulted in more roomy and comfortable rolling stock.

Parcels.—Large and awkwardly-shaped parcels are frequently a source of irritation to passengers, and the best way of dealing with this evil is to charge for parcels beyond a certain size and weight, and insist on them being placed on one or other of the platforms.

Meals on Cars.—When travelling on a certain northern system recently the edifying sight was witnessed of the conductor " wolfing " an 8 in. tea-cake in one hand, and alternately drinking from a huge jug held in the other. This was not even in an outlying district, but well within the mile radius from the centre of the town.

Fares.—The sale of books of tickets has recently met with so much success in certain towns that the subject ought not to be ignored in considering the point of view of the passenger.

Conclusion.—To dispose briefly of a number of minor details, one might mention that waste ticket boxes are greatly appreciated by those passengers who are inclined towards tidiness. A railway time-table at each end of the car is often very useful, and large illuminated route numbers are a great boon if the system is large enough to warrant them. Other matters, such as clocks in cars and cleanliness of person and uniform were dealt with by Mr. Mason last year, and it is to his excellent Paper that I am indebted for the idea which suggested itself (on being asked to contribute a Paper for this meeting) that the point of view of the passenger might reasonably be submitted this year instead of dealing with the aspect of tramway administration from within. Someone once said that tramway passengers were composed of all classes of humanity, mostly fools, but I venture to suggest that after nearly 20 years of electric traction, the travelling public are entitled to many things which on the average system they do not get, particularly in the nature of a more comfortable ride, less noise, easier exit, and less petty annoyance.

In conclusion, I would ask for mercy from certain undertakings whose failings are here disclosed (wild horses would not drag their identity from me), and as the object of a Paper should be to promote a live discussion, I trust that these somewhat disjointed views will afford an opportunity for both operating and commercial members to take part.

DISCUSSION.

Mr. A. V. Mason said his system (the South Metropolitan Electric Tramways) was using air brakes. Many motormen could not use a hand brake. With an air brake women could operate cars, but with hand brakes 20 years old they could not. He had experimented lately with ball bearings in trucks. They were rather expensive, but with an empty car they saved a great amount of current. When the cars were loaded the current consumption went up, as compared with the plain bearings. His experience with regard to trailers was exactly that of which Mr. Robson had spoken. When a man boarded a cross-seat car he stepped there. He agreed that pavement shelters were desirable, and he had been for years endeavouring to get his council to adopt them. In London they were not allowed to stick bills more than 6 in. down the windows, but they could put all they wanted there.

Mr. A. W. A. Chivers (British Electrical Federation) said the tramway passenger had had more done for him than he had paid for, and the average return on capital expenditure in many cases was extremely low. If he were studied to a much greater extent the return would be considerably less. He (Mr. Chivers) did not agree altogether with Mr. Robson with regard to trucks. He could name several instances where cars ran satisfactorily over sleeper construction. Many of the members when at Blackpool noticed what remarkably good riding there was on the Fleetwood line, where it was practically railway construction. He would like to have particulars of the hand brake that was being tried at Huddersfield. Some time ago he found by making tests that efficient braking on a tramcar was obtained with the ordinary drum kind of brake used on omnibuses. It was difficult to get the brake drum on the car axle, but it was possible, as it was being tried at Huddersfield now, to put the brake drum on the extended armature shaft. That idea was not carried into practice by his companies, because of the high armature shaft speed. There were many arguments in favour of longitudinal seats, especially to-day when cars were overcrowded. With longitudinal seating the collection of fares was facilitated and passengers on the outside of the cross-seats found it more difficult to signal to the conductor to stop. In manufacturing towns he thought seats without cushions were good enough.

Mr. Ernest Hatton (Newcastle-on-Tyne) said in his town they were using some front exit cars, and he thought ultimately all the cars would be adapted for front exit. They had the cross-seats on all their cars except about 20, but with the front exit the cross-seats were an obstruction, and they had to use longitudinal seating. The altered cars were very wide, and consequently there was a tremendous lot of room inside.

Mr. W. Vincent Edwards (Hastings) asked whether there was any difficulty with regard to Board of Trade Regulations if the front exit were used. His regulations stated that passengers must get out at the rear.

The Chairman said the Board of Trade had no objection, so long as the exit was on the near side.

Mr. C. W. Shepherd (Edinburgh) said comfort was the last thing that was thought of in the old tramways. The L.C.C. in adopting trailer cars were the only people who were trying to cater for the passengers. It was economical also, because there were often conductors available in excess of the number of drivers.

Mr. Fred. Bland (Messrs. Edgar Allen & Co., Ltd.) said he did not agree that track renewals were impossible. The Council of the Association had got over the difficulty of obtaining wheels and tyres and axles. Books of tickets were a nuisance. Tokens would be better.

Mr. E. H. Edwardes (Lancashire United Tramways) said the design of the tramway truck was very bad. Why should it still be made of solid steel instead of steel stampings or girder construction ? He tried some years ago to get steel stampings, but the makers would not make them unless he paid about £300 for dies. They said the tramway managers preferred solid steel frames. He had 40 or 50 trucks made abroad of steel stampings. They were in service 14 years and never gave trouble, but showed signs of cracking now top-deck covers were being put on the cars, due to the excessive weight. If these were strengthened they would be perfectly satisfactory. It would be a good thing if the Association appointed a committee of experts to design a truck made with stampings, and persuade a manufacturer to take it up. With regard to maintenance, they could not afford £17 and £18 a ton for rails. He had been quoted £56. 10s. a ton for steel centres for wheels.

Mr. Stephen Sellon said the small return on the capital, referred to by Mr. Chivers, was probably due to the capital expenditure being excessive. He thought there would be a large consensus of opinion that longitudinal seating was best for accommodation and for collection of fares.

Mr. L. E. Harvey (Ilford) said his experience of braced trucks was that they were a constant source of trouble, cracking in all parts. He was sorry most of his cars were equipped with them. He used tokens, of which 13 penny or 26 halfpenny were given for 1s. They answered very well.

Mr. J. W. Hame (York) said they had trailer cars in York to a limited extent, and they had been very satisfactory. The air brake might also be used more than it had been. What was the advantage of using a separate brake drum ? There must be an advantage in using the brake shoes on the wheels, which to some extent kept the wheels true. Every time a car moved with the wheels locked little flats were formed, which would develop, and the only way to grind them off was by putting them into a lathe. At York they diverted the line through specially constructed arches, so as to avoid reducing the height of the cars.

Mr. Benedict said if conductors could be taught to look out for passengers instead of gazing pensively into the cars it would be safer and more convenient. He suggested that tickets should be collected, and sent to the paper makers.

Major F. Coutts (Paisley) said books of tickets encouraged dishonesty. Conductors put in 1s., and took out 13 tickets, and then put in 13 tickets and took out 13d. The company with which he was connected tried to stop it. They issued them in lots of 30 and the purchaser had to give his name and address, but the conductors got their friends to buy them. Had any gentleman experience of cars without seats ?

Mr. Ernest Hatton said he had single deck cars built without seats to carry munition workers, but they could not set them entirely apart for that purpose. Longitudinal seats were put in, but enough room was left for 40 people to stand in two rows. When he was at Salford the Trafford Park Co. had very big cars without seats to carry people from the Westinghouse Works. The cars had turnstiles at each end.

A vote of thanks to Mr. Robson, on the motion of the Chairman, was then passed.

Mr. Robson, in reply to the discussion, said he agreed with Mr. Mason

that air brakes were specially suitable for women drivers, and he thought a brake much more easily acting could be made than those used at present. He thought the point Mr. Chivers rather missed was that tramways had to compete with 'buses which were being made very comfortable, and tramways must also be comfortable. With the air brake at Huddersfield one could brake the car with the finger and thumb. It was an ideal reduction gear. There was a proper brake material instead of metal, so that there was no skidding. Mr. Chivers thought that in manufacturing towns hard seats were good enough, but even in such towns the majority of the passengers were not working men. Railway cars in manufacturing and even coal districts were all fitted with rattan seats, which he thought were suitable for tramcars. He did not think sufficient ventilation could be obtained merely by building a car high. With reference to Mr. Shepherd's remarks, the manager's object was not to make passengrs comfortable, but to induce them to ride. He did not approve of eating and drinking on the cars, but if regular times for meals could not be arranged something in the nature of a "snack" might be allowed. He agreed with Mr. Edwardes that truck design was not satisfactory. Track renewals were not impossible if one had the rails, but if not, badly worn track could be improved as his had been by thermit welding of joints, taking the fishplates off and welding and grinding smooth.

Promptly at 4 o'clock, and according to programme, the members proceeded by motor 'buses supplied by the London General Omnibus Co. to the training school, which the latter has had in operation at Chelsea for some time past. The arrangements were made by Mr. H. E. Blain, who, as an old tramway man, renewed many past friendships.

On arrival at the training school the visitors were divided up into parties and taken through the premises. They were shown classes in operation for male and female conductors, chassis instruction, the clothing stores, and the large open yard in which the drivers are put through a variety of manœuvring tests.

The most interesting item of the programme was an exhibit of a series of films which the company has had prepared, showing how the 'buses should be operated, both by the drivers and the conductors, under actual traffic conditions. In each case the right and wrong way of going about the work was pictured, and most of the incidents typify the kind of thing that should and should not go on. The company has taken up the "safety-first" motto and has worked this so successfully that from their own records they can show a very large reduction in the accidents to the general public. The matter of lifeguards and the correct driving of 'buses has contributed largely to this desirable end. Mr. H. E. Blain, in a short speech after the visitors had been entertained to tea, explained how a policy of the company has been steadily worked out in this particular. During one year alone the number of accidents on the streets of London had been reduced by over 50 per cent., and the company took credit for a large proportion of this percentage as a result of their safety-first methods. The present side lifeguard, which, after a series of tests had been adopted by the police, was selected from no less than 123 specimens. Mr. Blain stated that the accident figure now stood at 2·15 accidents per 1,000 miles for the whole fleet of 'buses. The inspection of the schools lasted until nearly 7 o'clock, and there was then only just time for the members to adjourn for the annual dinner, which took place at the Trocadero the same evening.

The members' dinner at the Trocadero Restaurant closed the day's proceedings.

A MINISTRY OF SCIENCE.

SUGGESTIONS BY PROF. F. G. DONNAN, F.R.S.

I am strongly in favour of the idea of a separate department of State to be called the "Ministry of Science." The title is happily and correctly chosen, because any direct and immediate reference to trade and industry would bring the scheme into collision with the Board of Trade, and any reference to education would involve difficulty with the existing Board of Education. Let it be Science. I think that the functions of such a department might be outlined as follows:—

1. To establish national laboratories and "bureaus" for the purpose of undertaking extensive investigations concerning the advancement of scientific methods of control, standardisation and testing of materials, and concerning the application of scientific knowledge to every phase of national life, *e.g.*:—

(*a*) Manufactures.

(*b*) Agriculture, including forestry and breeding of plants and animals.

(*c*) Sanitation and national health, including the cure and prevention of disease.

(*d*) Mineral and other resources of the Empire, and their proper development and exploitation.

(*e*) The regulation and supply of pure water, milk, food, medicine, &c.

(*f*) The development of scientific methods and appliances for the naval and military services.

Here the question arises as to the relation of the new department to existing institutions, such as—

The National Physical Laboratory.

The National Health Insurance Commission and its Medical Research Committee.

The Imperial Institute.

The Board of Agriculture.

The Geological Survey.

The Government Laboratory (Strand).

The Government laboratories at Woolwich, &c.

2. To guide the domestic and foreign policy of the Cabinet by having ready at a moment's notice complete and detailed information concerning every question relating to Science, whether pure or applied, and by being in a position to know where and to whom to apply for special advice and information.

3. To foster, endow and promote the teaching and investigation of science at the "Hochschulen" of the country by giving much larger grants of money to the scientific laboratories for the purpose of:—

(*a*) More efficient teaching, by attracting better men and giving them more scope and better appliances.

(*b*) Research scholarships for students of proved merit and capacity.

(*c*) Increasing the speed and output of research by giving the laboratories special and generous endowments for the expenses of scientific investigations, and by altering our present cramped and obsolete "degree" system.

4. To promote and develop scientific manufacture and production by giving grants, bounties and other facilities towards the establishment of new, and the extension of existing, industries, and especially towards the cost of the investigation and research required for such purposes.

Perhaps this object might be achieved by the establishment of a great national bank, whose special concern would be the fostering of new and old industries based on scientific method and scientific research. Such a bank would act in conjunction with all the new associations formed or about to be formed, *e.g.*:—

(*a*) The Association of Manufacturers.

(*b*) The Association of Chemical Manufacturers, &c.

Thus we might gradually build up a complete, organised, controlled and guaranteed system, in which sound inventors and small and rising manufacturers would be helped, whilst there would be safeguards against fraudulent or semi-fraudulent misapplication of funds and against the stifling effect of monopolistic syndicates and rings.

5. To function as an intensely alert and active clearing house and *focussing centre* of the scientific life of the nation by continuously surveying, collecting, analysing and criticising the output of the nation in—

(*a*) Scientifically trained men.

(*b*) Scientific research.

(*c*) Scientific industrial activity and development.

(*d*) Skilled manual workers.

and by comparing the output with that of other nations. In this way to hold a watching brief in the interests of national welfare both in peace and in war, and by means of such a continuously active, wide, detailed and far-seeing survey to be in a position to so guide and direct the scientific forces of the nation and the Empire that the future is constantly prepared for.

6. To greatly increase the standard of scientific knowledge and method required of officers for the Navy, Army and Civil Services, and to enormously increase the facilities and opportunities at their disposal for such training.

7. To establish, endow and develop higher schools of commercial science, whether at the universities or elsewhere, so that we can raise up and train an alert host of men who are fit to compete with the alert and highly-trained commercial "clerks" of our enemies and Allies.

8. To establish, endow and develop *first class* trade schools for the training of skilled manual workers.

9. To establish, endow and develop schools for the scientific training of journalists so that there shall be produced men who are able to understand, follow and continuously present the results of scientific inquiry and scientific technical development to the readers of the *daily* press. In this way to gradually alter and modify public opinion, and to direct it towards ideals of national development and efficiency.

I have given you in the foregoing some of my ideas as to the more immediate scope and activities of a "Ministry of Science," but there is much more to be said. I have not entered into the thorny question of school education, as I do not think such a Ministry need concern itself *directly* with this subject. Indirectly, of course, it would be able to exert a *controlling* influence, or at all events a modifying one.

I recently took an active part in initiating an "Association of Chemical Manufacturers." During the six months' work involved in that I was amazed at the ignorance, pettiness and want of courage exhibited by many men.

It seems our fate in England to possess quite a large number of excellent and well-meaning persons who have not the faintest idea of the practical organisation of the modern world. The Germans know this, and they have often told me that they are amazed at the unpractical character of most of our schemes. They are not far wrong. We seem to be always blessing "practice" when it is theory that is wanted, and as often blessing "theory" when the real question is practice, and we dispute fiercely over the awful problem of *Theory* versus *Practice*, when the real solution involves no antithesis and no antagonism, but simply vastly more theory *and* vastly more practice.

THE TRAINING OF OUR CAPTAINS OF INDUSTRY.*

BY SIR ROBERT HADFIELD, F.R.S.

A good deal has been said, particularly in the last few months, with regard to the training of men on whom rest the responsibility to organise and direct the technical side in great industrial affairs. In my opinion neither the scientific man nor the practical man wholly fulfils the required conditions for the direction of great modern affairs. By the practical man I mean the man who has received a good secondary education, but not special scientific culture, and by the scientific man I mean the man who is completely instructed, but is a stranger to actual experience and practice.

It usually happens that the scientific man is as necessary as the practical man, but neither the one nor the other is a satisfactory organiser, because they do not unite in one head the combination of the two indispensable elements. It is therefore necessary to arrange our educational courses so as to combine the two; in other words, to find a third type of man in whom such knowledge will be united. The solution of the problem is not easy, but it is more than ever necessary that at the present time such a new type should be evolved and developed.

Until quite recently many mistakes were made, either because the scientific man had been installed in view of his special knowledge or, at the other end of the scale, the practical man was given the preference. In a general way neither of these types has been a success.

Industrial operations of every kind, and of an increasingly complex character, are developing every day, and they are also tending to be more and more technical. This is the normal consequence of the extremely rapid progress which every nation is making in the acquisition of knowledge which in itself is constantly becoming more varied, and yet more specialised.

It is most difficult to map out a programme of education which will combine both scientific and practical ideas, especially as the main functions of each of these are sufficiently defined and naturally fall into their respective spheres. The scientist has a satisfactory education in the Universities. The practical man is generally contented with an ordinary high school education, and sometimes, as is well known, he has not even had the benefit of this general education.

The scientist can certainly do excellent work in his laboratory, but generally speaking, he will only be able to render these services in this one capacity, because he has not had the opportunity to adjust his theoretical knowledge to industrial conditions. The practical man also in his vocation is able to do good work, but it is doubtful whether in these days he can ever furnish work of the highest order.

How, then, are we to obtain this important combination? How can we realise the combination of science and practice? The problem is admittedly most difficult, and the solution of it probably depends in a large measure on the individual character. By means of character and energy the scientist can acquire practical knowledge; that is, he can apply his scientific knowledge to practical questions. In the same way, the practical man can acquire scientific knowledge. Education will certainly help the formation of this mixed type, but it will not be created by education alone. It must be a result either of natural temperament, of faculties developed by force of character, or in certain cases through gifts transmitted by heredity.

Naturally the best path to follow is that of scientific education, but on condition that instruction furnished by practical observation is not neglected.

All things considered, the scientist will certainly be in a better position, but if he does not possess the necessary turn of mind and the natural qualities to which reference has been made, this education which should have given him a great advantage may cause his ruin. It may prevent him from attaining the height of success to which he might have reached by applying his knowledge to practical ends. He remains in the same sphere, and cannot emerge therefrom. Numerous are such cases, and numerous also the instances of non-success amongst men who are practical, in consequence of their lack of scientific knowledge.

Whilst much has already been done, there is much more to be accomplished in order to succeed in generating the evolution of the type of man required by modern conditions. Many facilities are offered to the practical man by the creation of the numerous and liberally endowed sources and seats of instruction which have been installed in all countries during the last 25 years. There has been the work of our Universities, also of the Departments of Applied Science attached to those Universities, of our schools and technical colleges, of our research laboratories, our societies and technical institutions, and finally our technical Press. All these are, in this order of ideas, of capital importance.

The combination of science and practice is of the greatest importance, but it is doubtful whether it can be obtained by education alone. In order to attain the highest degree of success a man requires something even more than education, that is, above all he must show personal application and intuition.

* Extract from an article in the "Iron and Coal Trades Review."

NEW BOOKS AND NEW EDITIONS.

[Copies of the new books mentioned below can be obtained *post free* from THE ELECTRICIAN Offices on payment of the prices indicated in parentheses. It is only necessary to specify the number when sending remittance.]

698. "Chemistry in the Service of Man." By A. Findlay. 6s. net (6s. 6d.)

699. "Synchronous Signalling in Navigation." By J. Joly, Sc.D., F.R.S. 3s. 6d. net (4s.)

700. "A Text-Book of Practical Hydraulics." By J. Park. 12s. 6d. net (13s. 3d.)

701. "Aeroplane Design: and a Simple Explanation on Inherent Stability." By F. S. Barnwell and W. H. Sayers. 2s. 6d. net (2s. 9d.)

702. "Discovery; or the Spirit and Service of Science." By R. A. Gregory. 5s. net (5s. 6d.)

703. "Large Electric Power Stations." By G. Klingenberg. 25s. net (26s.)

704. "Centrifugal Pumps and Suction Dredgers." By E. W. Sargeant. 10s. 6d. (11s. 3d.)

705. "Year Book of Wireless Telegraphy and Telephony, 1916." 3s. 6d. net (3s. 10d.)

706. "Mechanical Handling and Storing of Material." By G. F. Zimmer. 42s. (43s. 6d.)

707. "Elementary Applied Mechanics." By T. Alexander, C.E., and A. W. Thomson, D.Sc. 15s. net (16s.)

708. "Theoretical Elements of Electrical Engineering." By C. P. Steinmetz, A.M. Fourth edition. 12s. 6d. (13s. 3d.)

709. "Leçons sur le Fonctionnement des Groupes Electrogènes en Régime Troublé." By L. Barbillion. 7s. 10d. (8s. 9d.)

710. "Engineering as a Career." By P. & A. W. Marshall. 6d. net (8d.)

711. "The Principles of Automatic Telephony." (New Edition). By W. Atkins. 2s. 6d. net (2s. 8d.)

712. "The Development of Transportation in Modern England." By W. T. Jackman. 2 vols. 24s. net (25s.)

713. "A Combinatory Analysis." Vol. II. By P. A. Macmahon. 18s. net (19s.)

714. "Theory of Errors and Least Squares." By Le R. D. Weld. 5s. 6d. net (6s.)

715. "Electrical Engineering." By Berg & Upson. 17s. net (18s.)

716. "All the World's Air Craft." By F. T. Janes. 21s. net (22s.)

717. "Learning to Fly." By C. Grahame-White and H. Harper. 2s. 6d. (2s. 9d.)

718. "Industrial Gases." (Vol. VII. of Manuals of Chemical Technology). By G. Martin, E. A. Dancaster, J. M. Dickson, F. B. Gatehouse, E. Jobling and H. S. Redgrove. 7s. 6d. net (8s. 3d.)

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)

Phone: City **4698** & **4699.** *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed. Advertisement Rates, &c., forwarded on application.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d.; Canada and India, 2s.; Australasia and South Africa, 3s.; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Ready in a few days.* 15s. nett, post free 15s. 6d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRICITY IN HORTICULTURE. By Prof. S. Lemstrom. Illustrated. 3s. 6d. nett.

RADIO-ACTIVITY: AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M.A. Price 4s. nett.

MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by G. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.

ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.

A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Gelpel and H. M. Kilgour. Price 7s. 6d. nett.

THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol. I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.

THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.

ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.

THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. G. Bond, M.I.E.E. Price 2s. 6d. nett.

CARBON MAKING FOR ALL ELECTRICAL PURPOSES. By Francis Jehl Price 10s. 6d.

"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Down, Wh.Ex. & M.I.Mech.E. Price 2s. 6d. nett.

THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C.E., M.I.M.E., &c. Price 5s. nett.

INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 3d. nett.

INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.

ELECTRICITY METERS: THEIR CONSTRUCTION AND MANAGEMENT. By C. H W. Gerhardt. Profusely illustrated. Price 9s. nett. [Price 10s. 6d.

MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.

SIGNALLING ACROSS SPACE WITHOUT WIRES: THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.

BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By G. M. Baines. Price 7s. 6d. nett.

A RELIABLE WORK OF REFERENCE.

THE LOCALIZATION OF FAULTS IN ELECTRIC LIGHT AND POWER MAINS.
By F. C. RAPHAEL.

THIRD EDITION: *Now Ready.* Price **8s. 6d.** nett, post free **9s.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s.; post free, 2s. 4d.

A MINISTRY OF SCIENCE.

The suggestion has been made more than once that there should be a Ministry devoted exclusively to the claims of science, the view being that the Board of Trade and the Board of Education are insufficient for this purpose. The subject was raised in the "Daily Telegraph early this year by a writer signing himself "Efficiency," and the creation of such a Ministry was supported later in an article by Sir ROBERT HADFIELD, F.R.S. We think it will be generally admitted that the Board of Trade is entirely unsuitable for dealing with scientific matters, and has so far failed even to give satisfaction in that branch to which its activities are particularly devoted. On the other hand, it might be thought that the Board of Education would be capable of dealing with the scientific aspect of industrial matters, but judging by the past we must conclude that this Board is so far bound up with the dry bones of education that the soul thereof is forgotten. We must, therefore, turn to some other direction, and although we are by no means clear that a Ministry of Science would be the best solution, we think there is no question that the scientific needs of the country should be in the hands of some responsible body.

Assuming that such a body is desirable it is well to inquire what would be its functions. In this connection a statement by Prof. F. G. DONNAN, F.R.S., which we publish on another page, is of interest. The statement is so comprehensive that we do not propose to criticise the suggestions in detail. Generally speaking, the objects set forth refer to matters which are not already handled by other bodies, or would come within the ambit of existing bodies, except, perhaps, the suggestion that the Ministry should foster, endow and promote the teaching and investigation of science in what the Germans would call High Schools in this country; that is, in schools providing higher education of a university standard. It appears to us that the Board of Education should be able to deal with a matter of this kind.

Although the other objects outlined by Prof. DONNAN will, we think, meet with a good deal of approval, we would utter a word of warning. We must not make the mistake of thinking that the mere creation of a Ministry of Science, or any other body of this kind, will in itself produce a revolution in the industry of this country. If serious progress is to be made, the driving force must not be within the Ministry, but must come from without. For example, Prof. DONNAN suggests that the Ministry should promote scientific manufacture and production by giving grants towards the establishment of new, and the extension of existing, industries, and especially towards the cost of investigation and research required for the purpose. We agree that it is desirable to promote investigation by means of giving grants, but if these researches are to be of the greatest value, we must look to the manufacturers themselves to tell us what the researches should be. Unless manufacturers are prepared to come forward and take full advantage of the facilities provided, and to take some initiative in these matters, any such scheme will be comparatively barren in results.

Again, Prof. DONNAN suggests that the Ministry should continuously survey, collect, analyse and criticise the output of the nation in (*a*) scientifically trained men, (*b*) scientific research, and (*c*) scientific industrial activity and

development, and compare the output with that of other nations. It is certainly well for us to know where we are in regard to scientific output, more particularly compared with other nations, but it must be remembered that scientific life cannot be forced. It may be encouraged by making the conditions good under which it persists, but in the end we must depend upon the individual. It follows, therefore, that the important thing is to give the individual the proper opportunity to develop along the desired lines and the proper inducement as the result of development. Here we come to the question of the class of individual that is desirable.

Progress depends on Practice *and* Theory. As Prof. DONNAN says:—"'We seem to be always blessing 'practice' when it is 'theory' that is wanted, and as often blessing 'theory' when the real question is 'practice.'" There is no doubt that we require plenty of good theoretical men, men who can solve scientific problems having practical applications. On the other hand, it is essential to have practical men with a thorough grasp of the importance of theory. This is a matter of some difficulty, and was discussed recently by Sir ROBERT HADFIELD in an interesting article on the "Training of Our Captains of Industry." We suppose that most of our practical men in these days take a course at a technical college, where they obtain a general survey of the science underlying their particular industry. If their technical knowledge were maintained and expanded, all might be well, but we fear that in many cases this is allowed to take a very secondary position, until, finally, the practical side or commercial side is regarded as all important, and the scientific side is more or less forgotten. In many cases this frame of mind is probably encouraged by those who happen to be in authority. The ideal practical man is one who is able to judge at its true value the importance of investigation and new advances in various directions. For such a purpose technical knowledge is not necessarily very deep or specialised, but it should be broad. It seems to us that so long as the oldest practical or commercial men look upon the purely theoretical side as being comparatively unimportant, so long shall we fail to obtain the ideal practical younger men in the numbers required. It is partly a question of supply and demand, and must depend upon the attitude of the employer.

We have already remarked that we are somewhat doubtful as to the desirability of creating a Ministry of Science. What we fear is further bureaucratic developments which may be more harmful than useful, and the formation of a Ministry which, although a Ministry in name, may really be out of touch with the needs of the country. We are inclined to think that a more useful result might be obtained by the formation of a small Government department which would be in touch with an Advisory Committee of all the technical societies of the country. The Royal Society is already moving in this direction. These societies know, or ought to know, better than any other bodies what the needs of the country are in each individual industry, and such a committee ought to be capable of expressing views with authority. In this way use would be made of existing organisations, which might be expanded if necessary, instead of creating a large organisation which would very possibly only duplicate work that is already done. The chief advantage of creating a Ministry is that there would be a Minister whose voice would presumably be heard, but the selection of a suitable Minister for the purpose would not be an easy matter. It has been suggested that Sir J. J. THOMSON should be so appointed. We cannot help thinking, however, that to allow politics to interfere with the scientific work of a man like Sir J. J. THOMSON would not be in the best interests of the country, and would cause a serious loss to science. Moreover, we very much doubt if a pure scientist would agree to be mixed up in political matters. The first minister might be a success; the second might consider only the claims of his particular branch of science; and the third would probably be a mere politician having scarcely a nodding acquaintance with his subject. It seems to us that the whole position requires a good deal of careful discussion to avoid missing the goal after which we are striving.

REVIEWS.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

Wireless Telegraphy and Telephony: A Handbook of Formulæ, Data and Information. By W. H. ECCLES, D.Sc. (London: "The Electrician" Printing & Publishing Co., Ltd.) Pp. xx. +418. 12s. 6d.

The complementary title, "A Handbook of Formulæ, Data and Information," describes the aim and scope of this book. It is a volume of very moderate external dimensions, but containing a mass of well-ordered information. In comprehensiveness; in painstaking accuracy and careful phrasing; in internal consistency; in the absence at once of "padding" and of glossing over difficulties; in the direct, vigorous and scholarly style of every page, the book is a masterpiece, whose appearance would have been justified had there been works already available covering much the same ground.

The text begins with some 50 pages mainly occupied by tables of mathematical functions and physical constants. The information here is an undiluted statement of facts and of conventions as to units and symbols. There are some plainly set-out conversion tables, tables of logarithms and the like, tables of electric and other physical properties, tables of screw threads and wire gauges. Here, as throughout the book, thoughtful selection is in evidence; witness, for example, the inclusion of a table of "Standard Times" and "Great Circle Distances on the Globe."

Then comes an extraordinarily complete series of formulæ for capacity, inductance and high-frequency resistance, accompanied by many abacs of the type which consists of two scales side by side, like the Centigrade and Fahrenheit scales of a thermometer. For example, in a formula for the inductance of a square (side a) of round wire (radius r) comes a troublesome function of a/r. From the abac the value of the function can be read on one scale opposite the numerical value of a/r on the other. Never before, one feels, have so many inductance formulæ been collected together; and, indeed, their profuseness is rather overwhelming. Guidance as to when to use which of a series of formulæ for low, medium and high frequencies may be difficult to give, but is much to be desired. And there is a suspicion of mere collector's enthusiasm in the inclusion of a lengthy formula, followed by the remark that "this formula has recently been shown to be erroneous by S. Butterworth, who has given a better method" (not reproduced).

At page 80, with a section entitled "Electrical Oscillations," the quality of the text changes. Schedules of tables and formulæ give place to a more or less reasoned, if condensed, exposition of the principles and practices of wireless, and the work becomes more of a text-book. As the author states in the preface, "the intention has been, not only to set out a bare statement of observed and recorded facts in easily accessible form, but also to give brief accounts of the position of modern thought and speculation, and this without allowing the work to become an expository treatise."

Regarded as a condensed text-book of wireless, the outstanding characteristics of the book are its astonishing thoroughness and the inclusion of even very recent developments in an art which is advancing by leaps and bounds. And although in many cases the author has no doubt had to rely

chiefly on patent specifications, the descriptions and comments are always original and illuminating.

It is impossible to catalogue here the headings and subheadings of the book, but one or two illustrations of the thoroughness and modernness of the treatment may be given. A section of some 50 pages on the "Generation of High-frequency Oscillations" is divided into the following five main subheads: "Method 1. Charging or Discharging a Condenser," in which various ignition devices, and the recent important rapid-spark continuous-wave generator of Marconi, are described. "Method 2. By Aid of an Unstable Arc," with a concise "Rationale of Arc Methods." "Method 3. The High-frequency Alternator," mainly devoted to the Alexanderson and Goldschmidt machines. "Method 4. Frequency Changers," where the several methods depending on the magnetic-cycle properties of iron are conveniently collected. And finally "Miscellaneous Methods," including the less commonly known devices of Dubilier, Leslie Miller, E. and W. H. Wilson and the oscillating cathode-ray amplifier. In the next section, "Detection of High-frequency Oscillations," too, such recent introductions as Langmuir's cathode-ray tubes, and the reactive methods of using this class of amplifier are dealt with. At the same time that ancient adopted instrument of wireless, the telephone receiver, has a valuable page or two devoted to its theory. Telephone transformers might with advantage have received similar attention.

Near the end of the book is a description of special systems and stations. Much of this matter is necessarily touched upon at earlier stages, but adequate cross-references remove any objection to the divided treatment. The "Système à Onde Unique" of the S.F.R. is included here. The author appears tacitly to accept the claims as to the single wave, whereas we supposed they had been discredited, notably by Prof. Howe's criticisms published in this journal.

At the end of the book some 20 pages are devoted to Wireless Telephony. They include an interesting investigation of the most effective resistance of the microphone and the manner of coupling it to the antenna.

In a brief description of Squier's "wired wireless," as in the inventor's own Papers, it might perhaps be more clearly pointed out that the advantages of the system consist solely in its remarkable facilities for multiplex signalling, particularly telegraphy. As compared with ordinary wire telephony, in wired wireless the attenuation is enormous.

With most books it is easy to name subjects omitted which one feels ought to have been included. Not so here. Nevertheless, we think the book would be improved by some brief remarks on laboratory measurements. The reader, for instance, is nowhere told how the resistance of an antenna may be measured. And amongst the many inductance formulæ, one of the tables so useful in calculating inductances of much used single-layer solenoids and spirals would be very welcome.

The book is admirably printed and illustrated, and there seem remarkably few misprints. The index is complete, and there is a useful glossary of terms. There is, however, one serious deficiency. The references to original publications are insufficient to enable the reader to turn them up. Names are quoted, but in most instances nothing more. Perhaps in a future edition the complete references may be added. Possibly, too, some system of numbering in chapters or sections might be helpful.

The book meets a real want in an admirable manner. It will be a source of delight to many a wireless engineer.

L. B. Turner.

Experimental Physics: A Text Book of Mechanics, Heat, Sound and Light. By Harold A. Wilson, M.A., D.Sc., F.R.S. (Cambridge: University Press.) Cambridge Physical Series. Pp. viii. + 401. 10s. net

The plan of this book is to select the most important laws of physics, and deal with them rather more fully than usual, while omitting sundry facts and applications which appear to the author to be of secondary interest. Such a plan, in view of the great array of text-books already issued, offers little scope for originality. But the work gives a very pleasing impression of clearness and thoroughness. It is essentially a student's book, and should make a special appeal to those students who would rather learn from a book than from the words of a lecturer. A very commendable feature, not always sufficiently insisted upon in the orthodox Cambridge text-book, is Prof. Wilson's liberal supply of numerical data. In a science which is nearly all "measurement" this is of great importance. One may say, indeed, that a law of physics is useless until it has been put into figures; and to assign numbers to properties and their symbols is often a matter of considerable difficulty to the student, especially in dealing with electrical quantities. It was hardly avoidable that some chapters of this book should appear inadequate and, so to say, insufficiently balanced. Thus, we get a full disquisition on Lissajous' figures, but practically nothing about the vibration of rods. The correction of chromatic aberration is discussed in considerable detail, while "optical instruments" receive the shortest of shrifts. The last chapter, on the "energy of light," gives the energy curves of a black body without mentioning the simple and all important underlying laws of Stefan-Boltzmann and Wien. But such minor defects hardly detract from the undoubted solidity and excellence of this work, which is sure to be appreciated, as it deserves to be.

E. E. F.

ENGINEERING EDUCATION AND RESEARCH.*

Report of the Committee of the Council for Organising British Engineering Industry.

The present report indicates some of the changes which the Committee considers it most necessary to make in our present methods of educating engineers; it suggests legislative and administrative means of effecting some of these changes: and concludes by pointing out the need for greatly increasing the volume of research in connection with the British engineering industry.

Changes in the Education of Engineers.

A change in the attitude of engineering employers and of education authorities towards the whole problem of engineering education is needed before the changes recommended in this report can be brought about. Persons engaged in the engineering industry may be divided into two principal classes, manual workers and thinkers. How best to train the future workman and how best to train the future member of the highly-trained staff are each problems of the first importance. They are, however, two different problems. The comparative failure to solve either of them in the past has partly been due to the confusion of one with the other.

The Training of Workmen.

A system of education for workmen should not have in view merely the production of a man well skilled in a particular trade and acquainted with the materials and tools with which he deals. It should aim at making him a good citizen, satisfied with the honourable work upon which he is spending his life and sufficiently informed concerning economic and social problems to take an intelligent part in national affairs.

His first school will generally be a public elementary school. He should be transferred from the elementary school system at 12 years of age, and spend the next three years in a school of a different type. We should recommend for this purpose what is becoming known as a junior technical school.† In such a school it is usual to give one-third of the week to mathematics, drawing and elementary science; one-third to English, history, geography, and other general subjects; and the remaining third to practical work. The function of this practical work is not to make a more skilled operative, but rather to stimulate the boy's interest in his future occupation and so to form a nucleus for the whole wide interest which it is the object of the school to develop. Thus, the aim of the school is to prepare the boy for his whole life, social as well as vocational.

At the age of 15 he should enter works as an apprentice, but need not necessarily be indentured. His education ought not to be affected by the question whether he is indentured or not. Throughout the first years of his apprenticeship he should attend classes during part of his time—for, say, eight hours a week—and preferably during work-hours. Such attendance should, with certain exceptions, be made compulsory upon all employed persons who are under 18 years of age; and employers should be required to grant the necessary facilities. His part-time course may be described as a trade apprentice course, in order to distinguish it from other part-time courses.

Great stress should be laid upon the importance of close association between the trade apprentice course and the works. Firms employing

* Abstract.

† Junior technical schools are not trade schools; they do not attempt to teach a trade. Their object is rather to prepare a boy for apprenticeship.

a sufficient number of apprentices will be able to have their own classes, in which foremen and members of the staff will act as teachers. In this way an intimate contact between employer and workman will be established at the very beginning of the apprenticeship, and this will greatly improve their relations in after life.

The instruction given should be closely related to the apprentice's every-day work. It should include trade instruction such as can only be given by a workman who has had long experience at his trade. The apprentice should be taught the importance of economising in materials, effort and time ; in particular he should get some idea how the cost of manufacture is compounded of wages, material and overhead charges.

Where firms are not large enough to be able economically to provide for the education of a number of apprentices all at the same stage of training, arrangement should be made for these part-time courses to be conducted in some central building, in which suitable workshops, laboratories and class-rooms would be already available. Such an apprentices' school should, in our opinion, include as many as possible of the activities of a good boys' club ; it should, for example, have its own football and cricket teams, and, if managers could be found voluntarily to undertake the work, it should be open on several evenings in the week for recreative purposes. During the boys' passage through the trade apprentice course the teachers will be able to pick out particularly bright students. Scholarships should be granted to enable these to proceed to higher studies and then to enter a university course with a view to their taking rank among the highly-trained engineers.

A federation of manufacturing engineers already mentioned could do much to improve the training of workmen. Indeed it is difficult to see how some of the necessary improvements can be made except at the instance of such a federation.

The Highly-trained Staff.

The Association of Manufacturing Engineers, the need for whose influence upon the training of workmen is so marked, might do much to improve the education of the highly-trained staff. Its status should entitle it to nominate members of governing bodies of institutions, and especially of universities and technical colleges, in which future members of the highly-trained staff are educated.

Boys who are aiming at becoming engineers, managers or members of the commercial staff in engineering should for the most part continue to receive whole-time education until the age of 18. The best of them, and, as we think, the great majority, should remain at (higher) secondary schools until that age and then—perhaps after an interval in works—enter upon a university course. But even those who cannot secure such advantages would do well, wherever an efficient senior technical school exists, to leave their (lower) secondary school at 16 and to spend the last two years of their whole-time education in a senior technical school. The majority, however, should enter a university direct (or after a short interval in works) from a higher secondary school at about 18 years of age. During the last three years of their school education their curriculum should have a direct bearing upon the studies they intend to pursue in the university.

It is to be hoped that immediate steps will be taken to counteract the tendency in some modern secondary schools to dispense almost entirely with form masters. The influence of a good form master, especially in a day school and during the years when character is being most quickly formed, can hardly be over-estimated.

In order to secure an adequate supply of highly-trained engineers and to ensure that this supply shall include the more able, as well as the more wealthy, young men, the present provision of university entrance scholarships needs to be revised. In fact, the scholarships offered by local education authorities and other bodies should be increased in number and value until it is no longer possible for a boy to be prevented by financial reasons only from receiving a university training. The present provision of scholarships is very different. It is apparent that a boy's chance of winning a university scholarship depends upon the particular town in which he happens to live. That this state of affairs should continue is not in the interests of British engineering industry.

The object of lectures in our university courses should be more clearly defined. They should not take the place of text-books.

It has sometimes been asserted that university-trained men entering engineering works regard themselves as trained engineers, while as a matter of fact their training has not even gone far enough to make them profitable to their employers. It is, therefore, suggested that no more than the B.A. degree be conferred upon students at the close of their three years' university course in engineering. The specialised degrees, such as Bachelor of Technical Science or Bachelor of Engineering (which might also serve as professional qualifications), should be reserved for students who, after their university course, have completed at least two years of satisfactory practical training in their profession. The Master's degree should be awarded only on a thesis describing original research.

The apprenticeship spent in works, whether by trade apprentices fresh from school or by young college graduates, is not to be regarded as following upon the completion of their education but rather as continuing the education they have already received. During the period of post-graduate training in works, engineering students should attend courses of lectures delivered by leading engineers of their own or other firms, or should attend similar courses in some central college or university. These courses might well be directed to the designing, managing, or commercial sides of engineering work. The practical part of the post-graduate works training should aim at giving the student a wide knowledge of shop processes and methods. It is hardly to be expected that he should become a workman highly skilled in any particular process.

The question whether works training should precede, accompany, or follow a college course has been much discussed. General agreement has not yet been reached upon this matter. Something may be said for the view that the time spent in works between school and college is of great use in bringing the student into contact with things about which he will study at college, in broadening his outlook upon the world, and in subjecting him to works discipline. As, however, he has not yet learnt the principles involved in the machinery and processes displayed in the factory, he cannot hope to acquire knowledge at as great a rate as during the two years' apprenticeship following his college course. For this reason the time spent in works between school and college should not extend over too great a period, and this period should not reduce the essential training in works after the college course has been completed. The abler the student the less necessary in general is the short works course between school and college. Perhaps an ideal arrangement would be for a boy to win his university scholarship in December, leave school at Christmas, spend nine months in the works, and enter upon his college course in the following October. During each of the two long vacations in his three years' college course he might spend three months in works, thus completing some 15 months of works experience before taking his degree. There are objections to the introduction into England of what is known as the "Scotch sandwich system"—six months in college alternating with six months in works. A six months' break in college work is detrimental to academic training, and, moreover, any steps that would separate engineering students from other students in an English university are to be deprecated. The higher training given to engineers in England has a great advantage over the corresponding training given in Germany, in that the former (with one exception) is within the system of a university, while the latter (also with one exception) is quite outside it.

Research.

The university training of engineers should be conducted in the closest possible touch with engineering research which bears directly upon industrial needs. As the Royal Commission on University Education in London has said, "the personal influence of the man doing original work in his subjects inspirss belief in it, awakens enthusiasm and gains disciples." It is by associating students throughout their university careers with such men that their own latent originality is best developed.

While research is thus of great value because of its secondary effect upon the education of engineers, it may also have the most powerful direct influence upon the prosperity of British Engineering industry. The present provision for engineering and other industrial research in this country needs to be greatly extended.

At present much valuable research is carried out in the laboratories of universities and colleges. Full use is not, however, made of the facilities already offered. If, as may be hoped, the amount of research work undertaken increases rapidly in the near future, much of the new work should be done in the university and college laboratories. But much will also have to be done elsewhere ; for example, on the premises of individual firms or in a new central institution which several firms have combined to provide. Such a central institution will be equipped with machinery and plant on a scale beyond the reach of universities and colleges. To the cost of this equipment the Government might well be expected to contribute. The excellent results which have followed from the cross-fertilisation of the sciences suggest that similar advantages might be derived by the industries if the central institutions for different industries were situated near each other, or even housed in a single national establishment somewhere in the Midlands.

There are many major researches concerned with important problems which have been a long time before engineers, such as the more direct production of mechanical energy from the consumption of coal. There are also many researches which relate to heavy machinery and which can only be carried out at places where the machinery has been installed for commercial purposes.

The effect upon engineering research of the organisation of British manufacturing engineers should be not less marked and at least as beneficial as it will be upon the education of engineers. Such an organisation should include among its functions : (*a*) To undertake particular researches in co-operation with universities and colleges : (*b*) to advise members in regard to particular researches or tests which they may wish to undertake, or to have undertaken on their behalf, in the research or testing laboratories of some central university or college : (*c*) to develop co-operation between engineering firms on the one hand and universities and technical colleges on the other so as to establish such "schools of thought" as exist in the research departments of great Continental and American engineering firms, but cannot be fostered in the comparatively small establishments (and smaller research departments) of most British engineering concerns ; (*d*) to establish and conduct, with the co-operation of the Government, a central institution for research.

Summary of Recommendations.

This report recommends :—

1. The organisation of British engineering industry, by the federation of British manufacturing engineers, for purposes which include education and research.

2. The co-ordination of the existing means for educating engineers and, in particular, the provision of an adequate and more uniform system of scholarships.

3. That a large number of junior technical schools be established for the education between 12 and 15 of boys who intend to become apprenticed to engineering trades.

4. That all apprentices under 18 years of age be required to attend part-time classes for, say, eight hours a week during works hours : but

that this be subject to certain exceptions in the case of young people who continued in attendance at secondary or junior technical schools up to at least 15 years of age.

5. That the instruction given to trade apprentices in these part-time classes be reformed so as to relate it more closely to the apprentices' everyday work and so as to include what are known as citizenship subjects, for example, economic history; and that, where a sufficient number of apprentices is employed by the same firm such classes be conducted in that firm's own works and by the works staff.

6. That the specific education given to future members of the highly-trained staff be provided in a university or college of university rank for the majority who should be enabled to continue their studies up to 21 or 22 years of age; and in a senior technical school for the minority who may have to enter engineering works at 18.

7. That boys who are to study engineering in a university should carry their study of mathematics and physical science to a higher state before leaving school; and that, in general, the education of a boy a school, instead of being entrusted (as in some modern secondary schools) to six or seven specialist teachers whose business it is to advance his knowledge of a similar number of separate subjects to a uniform level of mediocrity, should be in the hands of a succession of form masters, who, knowing their boys well, may exercise a profound influence upon their characters and carry to a high level their studies in a more coherent curriculum.

8. That the conditions for admission to universities should be reconsidered and rendered more uniform as between different universities and less uniform as between different faculties and different honours schools in the same university; and that, in the interest of candidates of mature age and of other candidates approaching the university otherwise than through the normal avenue of the secondary school, university entrance tests should be distinguished from secondary school examinations.

9. The reform of university teaching in certain important respects, notably by a reduction in the number of lectures.

10. That the completion of a three years' university course in engineering should entitle students to no more than the B.A. degree: and that, until candidates have added works experience to academic training, they should not receive technical degrees (such as Bachelor of Engineering or Bachelor of Technical Science) which might then serve as professional qualifications.

11. That any time spent in works between school and college should not be unduly prolonged.

12. That university teachers be encouraged to undertake research on behalf of, and in co-operation with, manufacturing firms; and that additional Government grants be paid to universities and colleges with this end in view.

13. That, by the establishment of such an association of manufacturing engineers as we have advocated and by other means, the volume of research work carried out in connection with the British engineering industry be greatly increased; and that provision be made for this increase in the volume of research by fully utilising and extending the facilities already available in universities and colleges, as well as in the works of private firms, and also by establishing a central research laboratory for investigations that cannot be carried out elsewhere.

The report is signed by Messrs. A. P. Fleming, M.I.E.E., of the British Westinghouse Co.; J. C. Maxwell Garnett, M.A., Principal of the Manchester School of Technology; and Miles Walker, M.A., M.I.E.E., Professor of Electrical Engineering at the Manchester School of Technology.

ELECTRICITY REGULATIONS.

The following is Appendix I. of the "Memorandum by the Electrical Inspector of Factories (Mr. G. S. Ram) on the Electricity Regulations," second edition. This, it is stated, has been added to the Memorandum:—

NOTE ON LOW-PRESSURE AND MEDIUM-PRESSURE SWITCHBOARDS, WITH SPECIAL REFERENCE TO DISTRIBUTION BOARDS AND MOTOR STARTING PANELS.

It is sometimes overlooked that the term "switchboard" (*see* definition) includes all classes of switchboards, from large station switchboards down to distribution fuse boards for lighting circuits and motor starting panels. Mistakes, sometimes leading to serious accidents or involving somewhat extensive alterations, have been made by occupiers and others in not considering the conditions under which a switchboard is to be placed, particularly as to whether the conditions permit of the use of (*a*) an open-type switchboard—*i.e.*, one having the conductors exposed, or (*b*) one enclosed in a cabinet which has to be opened for use, thereby exposing the live metal; or whether one having all live metal permanently protected is necessary.

SWITCHBOARDS FOR USE ON SYSTEMS TO WHICH EXEMPTION 1 DOES NOT APPLY—*i.e.*, IN WHICH THE PRESSURE EXCEEDS 125 VOLTS ALTERNATING OR 250 VOLTS DIRECT.

Fuse holders which have to be handled whilst live, must be in all cases in accordance with the requirements of Regulations 3 (*c*) and 5 (third part). The construction should be such that, in putting the fuse holder in or out of the board (*a*) it is impossible for the hand inadvertently to touch any live part either of the fuse holder itself or of any adjacent live metal on the board—*e.g.*, the fixed contacts—and (*b*) the hand is screened from the flash should the fuse blow at the moment of being inserted.

All the regulations affecting switchboards are applicable. Thus, a switchboard, whether large or small, if it has bare conductors normally exposed so that they may be touched, must either be in an area set apart for the purpose and to which only authorized and competent persons may have access, or it must be suitably fenced or enclosed (Regulation 15).

The alternative method of enclosing the switchboard in a cabinet is very commonly adopted, but even so, the conditions must be carefully considered. Even if enclosed in a cabinet, the door of which has to be opened for use, thereby exposing bare conductors so that they may be touched, there must be a clear and unobstructed working platform 3 ft. wide (Regulation 17). Whether in a cabinet or not, it must be so placed that all apparatus which requires handling is within reach from the working platform (Regulation 16), and there must be an insulating stand (Regulation 23). Large switchboards are generally placed where all the above conditions can be complied with without difficulty. Smaller switchboards, such as distribution fuse boards or motor panels, cannot, however, always be placed so as to comply with these requirements. Thus, distribution boards may have to be placed out of reach from the floor, so that there is no working platform, or they may have to be placed over iron floor plates or damp ground where an insulating stand is impracticable, or they may be on a works where they may have to be used by persons devoid of any technical knowledge.

Where the requirements referred to cannot be complied with, or where for any reason it is not convenient to comply with them, other means of safety must be adopted. There is no difficulty in this. Thus, Regulations 15 and 17 apply only to switchboards having conductors exposed or arranged to be exposed when live so that they may be touched. All that is necessary to avoid having to comply with the requirements of these regulations is to provide a switchboard having no conductors exposed or arranged to be exposed when live so that they may be touched. Such complete protection is provided in the case of certain distribution fuse boards. In others the protection provided is not entirely complete, but is such that, under the terms of Exemption 3, it may be regarded as "adequate to prevent danger." Thus, all live parts are so protected that they cannot be *inadvertently* touched by a person handling the fuse holders, although it may be quite possible for him to touch them intentionally, as by putting a finger through an opening in the screen or guard provided for the entry of the contact of the fuse holder. As by the terms of the Exemption the responsibility for the adequacy of the protection provided rests with the occupier, he must take care in adopting such alternative means of safety that it is adequate. Switchboards constructed on such lines are now obtainable from a number of manufacturers, both for small distribution boards suitable for lighting circuits or larger ones for power circuits, but not all of those purporting to be in compliance with the requirements are adequately protected. Such construction may also effect compliance with Regulation 16 (last sentence) in regard to small distribution boards placed out of reach from the ground, provided that adequate means of access—*e.g.*, a step-ladder or ladder which can be securely placed, is available when required. For larger boards placed high up a platform is, however, generally necessary for safe access and working in any case.

Similar protection of all live parts within the cabinet may also be necessary in the case of metal cabinets even when placed within reach from an insulating floor of proper width. Thus, if the metal cabinet has a door hinged at the top, the operator has to hold the door open with one hand whilst handling the apparatus with the other and he is, therefore, in connection with earth, despite the insulating stand. With a side-hinged door which can be opened 180 deg. or thereabouts, there may be no need for this protection under these conditions although it is often desirable, or the cabinet may be made of hard wood or other suitable insulating material.

Distribution boards enclosed in cabinets, but not otherwise protected (*i.e.*, having live metal exposed when the door is open) are, therefore, permissible only if placed in accordance with the requirements of Regulations 16, 17 and 23; *i.e.*, they must be within reach of the ground or working platform, there must be a 3 ft. space in front and there must be an insulating stand. The cabinet should be preferably made of insulating material, but if of metal, the door must not be hinged at the top. For use under any other conditions there should be adequate protection of the live metal within the cabinet.

The question of accessibility of distribution boards, regarded merely from the point of view of convenience of operation, is often overlooked. It is not of great consequence in regard to boards containing fuses only and which require handling only occasionally, as when a fuse requires renewal or a circuit has to be made dead. If, however, they contain switches for controlling the branch circuits, it is obviously more convenient that they should be readily accessible. Whether containing switches or not, they should not be placed unnecessarily high up or otherwise inconveniently. To place them in positions involving danger to the attendant, as over running machinery, or close to shafting, as is sometimes done, is contrary to the requirements of Regulations 1 and 25.

Similarly, as regards convenience of operation, switches for controlling the branch circuits are better placed outside the cabinet, so that it is not necessary to open the door every time a switch has to be turned on or off. If, however, they are within the cabinet, convenience of operation is sometimes secured by the switch handles being extended through the base of the cabinet.

There are other types of completely protected switchgear, suitable for use under practically any conditions. Several firms make ironclad switchgear conveniently arranged, so that new panels can be added as

required. With such switchgear, the requirements as to the fuses (Regulations 5 and 3 (*c*)) must be properly arranged for, and no live metal must be exposed in the fuse chambers so that it may be touched inadvertently, when the fuse chamber is opened for renewal of a fuse. This may be arranged by the protection of all live metal within the fuse chamber and the use of properly protected switch-fuses ; or by the fuses and therefore all the conductors within the fuse chamber being on the dead side of the switch controlling the circuit, in which case safety is further ensured if the fuse chamber door is interlocked with the switch, so that it cannot be opened until the switch is " off " ; or by the use of properly constructed "fuse-switches " (p. 34). Where oil switches are used, there must be means of making the oil switch dead for examination or repairs (Regulation 7). In some, this is provided for by isolating switches, arranged to be operated from outside the casing, and in others by the oil switches being arranged on slides so that they can be withdrawn from contact with the 'bus bars.

Totally-enclosed ironclad switchgear for motor panels is now quite common. Here again attention should be paid particularly to the requirements as to renewal of the fuses (*see* also under Regulation 5).

SWITCHBOARDS FOR USE ON SYSTEMS TO WHICH EXEMPTION 1 APPLIES—*i.e.*, IN WHICH THE PRESSURE DOES NOT EXCEED 125 VOLTS ALTERNATING OR 250 VOLTS DIRECT.

A number of the Regulations do not apply in the case of such systems, and there is consequently greater freedom in the use of switchboards having conductors exposed or arranged to be exposed when live. Thus, Regulations 15, 16, 17 and 23 do not apply. At the same time there is no exemption from the requirements of Regulations 1, 5 and 14. Regulation 1 very definitely, although in general terms, requires that safety shall be provided for. Thus, switchboards having live metal exposed, although not required to be in an area set apart for the purpose, should obviously not be placed where persons are liable to run into them or touch live metal in passing or where engaged in their employment. There are no specified requirements as to working platforms and passageways. Nevertheless, these should be of reasonable width and where there would otherwise be danger of shock to earth, insulating flooring should be provided. Subject, however, to reasonable precautions being taken, open-type switchboards, motor starting panels, &c., are permitted without the full restrictions required in the case of those for higher pressures. The protection to be afforded will depend very much upon the particular circumstances of each case, and apart from the question of safety of employés, enclosed type switchgear may be necessary for the protection of the apparatus against damage. Enclosed type motor control panels are advisable in all cases where there is not plenty of space, and particularly where women are employed. Where machines driven by motors, have starting panels attached or otherwise so placed that the workers are liable to touch them when in contact with earth—*e.g.* laundry or printing machinery or machine tools—the switchgear should be of totally enclosed type.

Similarly, distribution fuse boards should in general be enclosed in cabinets. Regulation 5 must be complied with. Fuses must be of such a type or so enclosed as to prevent scattering and must be so constructed that they may be readily renewed without danger. They must be so constructed that the hand is shielded from the arc or hot metal should a fuse blow on being replaced on the board on a short circuit. Unless the distribution board is placed where the person renewing a fuse is insulated from earth, either as regards the floor or by reason of the fuses being in a metal cabinet with which he may be in contact, the fuse holders must also be so constructed that there is no risk of touching live metal when handling them. The 'bus bars and other live parts within the cabinet need not, however, be further protected. Similarly, if there are switches in the cabinet, so long as they have proper insulated handles no further enclosure of the parts is necessary. Again, distribution fuse boards need not be placed within reach of the ground if this is not convenient, but if they contain switches in addition it is much better that they should be placed within convenient reach. To place them in positions involving danger to the attendant, as over running machinery or close to the shafting, is contrary to the requirements of Regulation 1.

CORRESPONDENCE.

S. P. THOMPSON.

TO THE EDITORS OF THE ELECTRICIAN.

Dr. Russell's graceful tribute to the work of our revered and beloved friend incites me to write a few lines to suggest a suitable memorial, for, as Dr. Russell has implied, Thompson was certainly a professor who was in true sympathy with the engineer.

Shall we ever see again one of such varied and yet remarkable attainments amongst those associated with electrical science and engineering ? Unassuming and simple minded, like all really great men, he seemed quite unconscious of his vast talents.

Personally I shall never forget the infinite and laborious care with which, under considerable stress, he prepared the " Life " of Lord Kelvin. His taste and talent for investigating the actual facts connected with every important point was only equalled by the late Sir James Murray in the preparation of the greatest dictionary the world has ever seen.

A truly lovable character, with a kindliness of manner never to be forgotten, we can surely extend to Silvanus Thompson the bygone words of Huxley with reference to Lord Kelvin— " Gentler knight never broke a lance."

Yet I can but think some substantial memorial would be fitting, and it is for ventilating that view that I have ventured to trouble your columns, notwithstanding the stirring and busy times we are passing through.

Westminster, July 3. CHARLES BRIGHT.

PARLIAMENTARY INTELLIGENCE.

POST OFFICE SERVICES.

In the House of Commons on Monday the Post Office vote was taken, and on the vote to complete the sum of £26,537,145 to defray the salaries and expenses of the Post Office, including telegraphs and telephones, the Postmaster-General (Mr. J. A. PEASE) said it had been estimated that the extra charges imposed on letters and newspapers last autumn would produce £438,000, but the actual amount realised was £470,000. The extra penny placed on parcels had yielded £170,000, instead of £90,000. From the revenue point of view the surcharge of 3d. a telegram had also been justified, as it had produced £200,000 instead of the £107,000 anticipated. The increase of the cost of telephone calls to 3d. had not come to stay. It was estimated to yield £205,000 and had produced only £115,000. The total additional charges imposed last autumn were expected to yield £928,000, whereas they actually produced just over £1,000,000. The total Post Office revenue for 1915-16 was £33,650,000, an increase of £4,000,000 over the previous year, and £2,800,000 over the pre-war year. As the expenditure was £30,330,000, there was a profit balance of £3,300,000, against £3,380,000, and £6,650,000 in the year before the war. The expenditure due to the war was about £6,000,000. The economies effected in the home service of the Post Office during 1915-16 amounted to rather more than £1,000,000, but in the event of the war continuing during the whole of the current financial year the saving would go on at a much greater rate. Naturally some protest was to be expected against the decreased postal facilities and the increased charges, but he desired to express the gratitude of himself and his staff for the generous way in which the public had received the changes. Before the war Parliament sanctioned an expenditure of £1,000,000 on the construction of the Post Office tube for London. In October, 1914, when it was anticipated that it would be desirable to find occupation for labour thrown out of employment, a contract was entered into to construct the tunnel at a cost of £668,000. The Government had since considered whether they ought to suspend the work, but the materials had been to a large extent manufactured, binding agreements made, and postponement would have involved expenditure to prevent damage and construction at enhanced rates later. Owing to the demands on electrical plant it would, however, be impossible to complete the work in the immediate future. Economies had been effected in the building programme, the estimate this year being £111,535, compared with £225,000 last year. Only £1,000 was in respect of new work. The Regent's Park Parcel Post Office, for which £50,000 had been taken, had removed the congestion previously existing at Mount Pleasant, which prevented an efficient service either for the provinces or the army in the field. The sorting for the oversea forces was now concentrated in the new building at Regent's Park, and they had secured efficient deliveries not only to those in the field, but to the wounded in the hospitals and the prisoners in enemy countries. Our troops received weekly 7½ million letters and 700,000 parcels, weighing 1,500 tons, per week. From the field there was free postage, and the letters sent home amounted to five millions every week. There had been a steady development in the number of letters and parcels passing between the troops and those at home. Since the beginning of the war there had been sent to the men in khaki 6,500,000 books or magazines. The week before last there was sent to France 44,000, to the Navy 22,000, to prisoners and elsewhere 16,000. Out of a possible 90,000 of military age, 56,000 were now serving with the Colours, 7,700 had been medically rejected, and 21,700 attested under Lord Derby's scheme, the unattested being only 4,000. Of the 21,700 who attested, 6,000 belonged to the engineer signalling section, and were required in connection with the maintenance of telegraphs and telephones at home. There were about 9,000 who might be called up for service at any moment. Of the 4,000 unattested men, there were about 3,750 married, and they would come under the Military Service Act. Among those were a certain number of telegraphists, who were no longer required in the service. With regard to disabled soldiers, there had been no great demand to find positions for them in the Post Office employment ; but the department could find a large number of places for those who would probably receive pensions, and would be able to give increased help to them by providing work in the Post Office, such as on night telephones, cleaning of offices, lift work, and labour in the engineering and stores department. He wished to pay a tribute to the staff for the wonderful way in which those at home had shown their patriotism in endeavouring to meet the very difficult situation due to the great depletion of the staff ; 25,000 women had come forward to take

the places of those who had gone, and 22,000 men who were incapacitated from military service by age or defect of some kind had also come forward to fill vacancies. In connection with the Zeppelin raids, the work of the women who had come forward voluntarily to do duty at night deserved the highest praise. Hundreds offered to come forward, and when Zeppelin raids had been anticipated, and sometimes when they were going on, the women had come out of their homes, and even when bombs were dropping went to their posts in the various exchanges. In Dublin, during the rising, when bullets were flying and fires were raging, they stuck to their work, and it was by means of the telephonic exchanges that it was possible to obtain the military which suppressed the rising so rapidly.

In connection with the great storm of March last, 2,150 poles were broken, 6,150 uprooted and 33,300 blown over. The number of poles that had to be re-erected was 41,500, not including those on the railways. The copper wire broken into small fragments consisted of 17,000 miles in length, the whole of which had to be re-melted and re-manufactured, and weighed 1,500 tons. The storm was the worst this country had ever experienced, and he anticipated that the damage would not be made wholly good till about next Christmas. In the last few months something like 7,000 new telephones had been erected for the Army, and during the last year 1,500 new telephone connections and instruments had had to be erected for the Munitions Department. There had been a great tax upon the staff and upon the stock at the office. He believed there was a real advance to be made in connection with satisfactory telephonic communication by the very much increased development of automatic telephony. The only ground of complaint against automatic exchanges was that when telephone users made mistakes they had no operators whom they could abuse. A new telephone exchange was to be provided for Liverpool, and he hoped it would be erected before many months were over.

Referring to the contract with the Marconi Company, he said the House ought to realise what the position of the contract was which was sanctioned in August, 1913. There had been considerable delay between that date and the outbreak of the war in carrying out the contract owing to certain questions that arose. In the autumn of 1914 the company insisted that, in view of the delay, the terms of the contract should be considerably varied, and in consequence of the position on Dec. 30; as the result of a Cabinet decision, the Postmaster-General gave notice to the company to cancel the contract, the company, of course, in the event of that being agreed to, being reimbursed for out-of-pocket expenses. An immediate protest was made by the company against the repudiation of the contract. Immediately afterwards the Postmaster-General said that if the company were unwilling to acquiesce the Government were prepared to proceed on the original terms. The company declined to go on with the contract except on payment of compensation. Negotiations were reopened on June 15, and the company and the Admiralty arrived at a provisional agreement requiring the sanction of Parliament by a given date. In the autumn, however, the First Lord dropped the negotiations, because the Admiralty's needs did not justify proceeding with the contract. The result was that a petition of right was sent to the Home Office in December. When he took up the duties of Postmaster-General in January last and found that litigation threatening the Government, he consulted the Admiralty, the War Office, the Colonial Office and the India Office, and they came to the conclusion that four stations ought to be proceeded with. The Government had definitely offered the Marconi Company the following terms: That the 1913 contract should be varied, and that the erection of only four stations at the present time should be one of the variations; that compensation should be paid for the net loss, if any, which the company might prove that they had sustained owing to the delay of the work so far as that might have been caused by any act or omission of the Postmaster-General and owing to variations of the 1913 contract; that the compensation should be settled by an impartial body of arbitrators with judicial experience, or, failing agreement, by a court of law. In the event of those terms being accepted, they would be submitted to Parliament for ratification. As there seemed to be no prospect of agreement being arrived at with regard to the two points which he had mentioned, some kind of reference appeared to the Government to be the right course to adopt with a view to securing an amicable and satisfactory settlement. The Government were awaiting a reply to their offer.

After referring to the scheme of Government insurance against damage done by Zeppelins, war investments and thrift, &c., he concluded by stating that there had been, on the whole, vast improvement both in regard to the rapidity and accuracy of communication. Wireless telegraphy had made equal, if not greater, strides than other means of communication. That was not a time to dwell upon what they could do or could not do now; but we could take credit to themselves that so far as the progress of civilisation could be gauged by the rapidity and accuracy of communication, this country was not behind any other country in the world.

A discussion ensued, and Mr. PIKE PEASE, Assistant Postmaster-General, stated, in reply to question, that the number killed in action up to June 3 was 2,226. He could not definitely say whether the report of the Committee on high-speed telegraphy would be published, but the matter was under consideration. High-speed telegraphy was still in an experimental stage, and it was not proposed to spend more than £5,000 in ordering from America plant which could not be obtained in this country. The position was in no way prejudiced by that order. After the war the whole question would be reconsidered. The suggestion that a German was employed in the cable department was unfounded. No unnaturalised person was employed, and the department was confident of the loyalty of every one in its service. The question of the Marconi contract would come before the House in the ordinary way, and the House would have an opportunity of expressing its opinion should an agreement be arrived at. The department hoped to be able to extend the system of Post Office underground lines in Scotland.

The vote was agreed to.

SUMMER TIME ACT AND ELECTRICITY SUPPLY.

In the House of Commons on Monday Sir F. LOWE suggested legislation limiting the charges of electric lighting companies and local authorities in proportion to the saving of expenditure they were able to effect during the operation of the Summer Time Act.

In reply, Mr. HARCOURT said he was not prepared to introduce such legislation, as any reduction in the charges for electricity might encourage consumers to increase their consumption, and that would involve a corresponding increase in the use of coal by the supplying authorities. Further, the saving to the undertaking on the cost of the fuel economised was probably more than outweighed by the loss of revenue owing to the reduction in the amount of current supplied.

UNEMPLOYMENT INSURANCE.

The Government have introduced a Bill to extend the provisions of the National Insurance Act, 1911, relating to unemployment to all trades engaged in the making of munitions and in other forms of war work as a means of meeting the conditions resulting from the restoration of peace. It will come into operation on Sept. 4 next or later, if the Board of Trade consider a postponement necessary. The proposal is to bring under the provisions of Part II. of the National Insurance Act and the amending statutes, every workman who is engaged on, or in connection with, munitions work as defined by the Munitions of War Acts, except such classes of work as the Board of Trade may by order exclude, and every workman who is employed in the following trades: (1) The manufacture of ammunition, fireworks and explosives; (2) the manufacture of chemicals, including oils, lubricants, soap, candles, paints, colours and varnish; (3) the manufacture of metals and the manufacture or repair of metal goods; (4) the manufacture of rubber and goods made therefrom; (5) the manufacture of leather and leather goods; (6) the manufacture of bricks, cement and artificial stone, and 15 other artificial building materials; and (7) saw milling, including machine woodwork, and the manufacture of wooden cases.

The measure also applies the existing Acts to employers, while the Board of Trade will be given power under the new Bill to extend its provisions to any other trade or branch of a trade in which a substantial amount of munition or other war work is being carried on. So far as the measure imposes on employers and workmen a liability to pay contributions, it will cease to have effect at such date as the Board of Trade may by order determine, not being later than five years after the commencement of the Act, or three years after the termination of the present war, whichever of those dates may be the later, and so far as it confers on workmen a right to receive benefit in respect of such contributions, it will cease to have effect at the expiration of six months from the date so determined or at such later date as the Board may fix.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 SPECIFICATIONS.

8,227 HEYS (Newland Magneto, Ltd.) Magneto-electrical generating systems.
8,235 HEARTLEY. Electrical instruments of the moving-coil type.
8,512 MARK (Lamden, Friary & Clark.) Electrical heaters.
8,572 NEWLANT. Dynamo-electric machines.
8,739 WARREN & WARREN CLOCK CO. Electric apparatus for driving clocks.
8,929 BERRY. Electric heating and resistance devices.
8,927 MARCONI'S WIRELESS TELEGRAPH CO. & WRIGHT. Wireless telegraph receivers.
9,720 B.T.-H. CO. (G.E. Co.) Wireless signalling systems.
9,993 CROCKATT. Combined locking device and shade support for electric incandescent lamps. (30/12/15.)
10,709 STERLING TELEPHONE & ELECTRIC CO. & WARD-MILLER. Crystal detectors, particularly for wireless signalling.
12,617 B.T.-H. CO. (G.E. Co.) Method of marking glass.
16,671 JAMES. Electrodynamic brakes for use in connection with printing machines. (Addition to 596/15.)
16,692 SMITHSON & CALLENDER'S CABLE & CONSTRUCTION CO. Winding drums for electric mine cables and the like.
17,353 LOMAS. Repeater signalling apparatus for railways. (5/5/14.)
17,450 SIEMENS & HALSKE A.-G. Automatic selectors for telephone systems. (20/4/15. Addition to 23,336/13.)

1916 SPECIFICATIONS.

877 BOWMAN, W.F.J.H. Method of and means for transmitting signals to railway and like vehicles. (2/5/14. Divided application on 8,199/15.)

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	475	Peebles "C" Type Continuous-Current Dynamos and Motors. Illustrated	96
Imports and Exports of Electrical Manufactures	476		
Legal Intelligence	476		
Educational	478		
Business Notices	478	Traction Notes	480
Liquidations, Bankruptcies, &c.	478	Miscellaneous Notes	480
Electricity Supply	479	Tenders Invited	480
		Tenders Received & Accepted	481
The Round Table	91	Municipal Accounts	481
The Electrification of a Modern Flour Mill. Illustrated	92	Companies' Meetings and Reports	482
Belling Immersion Heaters. Illustrated	94	City Notes	484
		Electrical Companies' Share List	484

COMMERCIAL TOPICS.

Financial Support for Trade after the War. A committee has been appointed by the President of the Board of Trade to consider the best means of meeting the needs of British firms after the war as regards financial facilities for trade, particularly with reference to the financing of large overseas contracts and to prepare a detailed scheme for that purpose.

The committee will consist of: Lord Faringdon (chairman), Mr. B. P. Blackett, C.B., Sir W. H. Clark, K.C.S.I., C.M.G., Mr. F. Dudley Docker, C.B., Mr. Gaspard Farrer, Mr. W. H. N. Goschen, Right Hon. F. Huth Jackson, Mr. Walter Leaf, Hon. A. Mills, Mr. J. H. Simpson, and Mr. R. Vassar-Smith. Mr. Hartley Withers will act as secretary to the committee.

* * * *

Hydro-Electrics Within the Empire. In an article under the signature of "An Engineering Correspondent," "The Times" Engineering Supplement makes an appeal for the organisation of an industry of hydro-electric engineers. The arguments advanced are quite sound, and they represent a powerful case for the immediate foundation of a school of British hydro-electric engineering. This important section of electrical engineering has been allowed to drift into the hands of Continental and American firms because there is no great scope for hydro-electric development in these islands; the claims of the colonies and dependencies have been overlooked. Our contemporary urges that as the electrical industry is the chief benefactor by hydro-electric developments it should act as "foster parents" to educate young British engineers in these subjects. The contention that there is no market for such engineers is readily disposed of by a recital of the countries in which large quantities of natural power resources remain untapped. These are New Zealand, Burma, the Malay States, India, Egypt, Africa, Australia and Canada. In several of these countries the water-power resources have not yet been estimated; there would, therefore, be, within the Empire, enormous scope for development for many years to come. It is further suggested that British hydro-electric engineers will be welcome in Europe in the countries of our Allies, Russia, France, Spain and Italy. We hope that the commercial and industrial significance of Imperial hydro-electrics will be recognised and some efficient scheme put into practice for the training of the many men to whom this work would prove fascinating and of profit to the Empire and themselves. British engineers, belittled as they too often are, can do work equal to that of the Americans and the Swiss in this field of enterprise, and the Empire presents magnificent opportunities for the doing of it. As our contemporary puts it, "the allied trades should combine and co-operate as regards education, manufacture and finance."

* * * *

Coal and Coke Supplies. On June 27 His Majesty in Council amended the Defence of the Realm Regulations, 1914, by including after Regulation 2c the following:

"2D: It shall be lawful for the Admiralty, or Army Council or the Ministry of Munitions, or any person authorised by them to give directions as to priority in the execution of orders or contracts for the supply of coal or coke. . . . ." In Regulation 19, after the words "without the permission of the competent naval or military authority," there shall be inserted the words "or the Ministry of Munitions."

* * * *

Controlled Establishments. It is announced that the Minister of Munitions has made further orders under the Munitions of War Acts under which 339 additional establishments have been declared controlled establishments. The total number of controlled establishments is now 3,916.

* * * *

Sale of Shares in Enemy Companies. It was reported in the House of Commons on Monday that shares and debentures held by enemies in British companies of the nominal value of £1,300,000 had been vested by the Board of Trade in the Public Trustee for the purpose of sale. The sale of shares of the nominal value of £102,000 had been completed, and negotiations for the sale of the remainder were proceeding. Those shares had been sold by private treaty, and on the Stock Exchange in cases where there was a quotation. In several pending cases the shares were being put up for sale by public auction.

* * * *

Contrabrand of War. By a Royal Proclamation the following articles have been added to the list of those which during the continuance of the war will be treated as absolute contraband:—

Electric appliances adapted for use in war and their component parts; asphalt, bitumen, pitch and tar; sensitised photographic films, plates and paper; felspar, goldbeaters' skin, talc, bamboo.

* * * *

United States Trade with South America. Statistics of the foreign commerce of the United States for the year 1915 have been issued and show, as might have been expected, a considerable expansion in the export trade with the South American Republics.

The following figures for the years 1903 and 1913 illustrate the growth of British and American exports to certain countries of South and Central America:—

Exports of the United Kingdom.

Countries.	1903.	1913.	Increase.
Argentina	£8,602,189	£23,437,343	£14,835,154
Chile	3,332,131	6,369,322	3,037,191
Brazil	5,836,305	13,021,097	7,184,792
Peru	1,091,420	1,591,363	499,943
Mexico	1,998,516	2,498,199	499,683
Cuba	1,994,497	3,000,070	1,005,573

Exports of the United States.

Argentina	£2,854,355	£11,000,000	£8,145,645
Brazil	2,100,000	7,980,000	5,880,000
Chile	876,345	3,323,400	2,447,055
Peru	695,000	1,521,800	826,800
Mexico	8,700,000	9,610,000	910,000
Cuba	4,700,000	14,647,765	9,947,765

In the case of Cuba it must be borne in mind that since the American intervention a preferential tariff, ranging from 20 to 40 per cent., has been granted to American imports. It will be seen that the percentage increase of American exports is very much greater than in the case of the British. In view of the commercial importance of South America, and of the comparatively undeveloped state of many of the countries it would be well—nay, we think it highly desirable—for the Government to appoint special commercial or Trade Commissioners in all important commercial centres of Latin America. If we desire to extend our foreign trade, to secure new markets, or to maintain our position and prestige in the old markets, we must take a leaf out of our rivals' book. We must have organisation at home and abroad, and in regard to the latter we look to our Government to give more assistance than it has in the past.

* * * *

Capital and Labour After the War. Sir Hugh Bell delivered an interesting speech at the National Economy Exhibition on Tuesday. He said that the war had been expected to produce great distress among the labouring classes, but by reason of stimulating the textile and metal trades, and because of the great demand for men directly due to the war, it had added to the prosperity of the people of these islands.

Previously to the war a national income of about £2,400,000,000 had

been divided among the total population, but divided very unequally: and we had hoped that by taking part of what now went to the wealthy classes, and distributing it as increased wages, the position of the labouring classes could be improved. He thought that hope was doomed to disappointment. There was no possibility, ethically or economically, of increasing the return to labour by taking from interest paid on capital, or salaries paid to higher classes of workers. It could only be done by increasing production, and so increasing the total amount to be divided. The improvement in the position of labour had been accomplished by perpetually improving the appliances put into labour's hands. When he began to make pig iron the cost of labour at the furnace was about 6s. a ton. Before the war it had fallen to a little over 3s., yet every man was paid wages fully twice as much as at the earlier period. The problem was to get the workers to consent to continually improved machinery, despite the fact that it necessarily displaced labour when first introduced.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From June 25, 1916, *to* July 1, 1916.

IMPORTS.

GOOLE.—*Sweden:* Elec. machinery, 57 cases.

LIVERPOOL.—*Spain:* Elec. carbons, 18 cases. *France:* Elec carbons, 80 pkgs.

LONDON.—*U.S.A.:* Elec. lamps, £2,349; telephone material, £163; wire and cable, £439; unenumerated, £8,945 *Holland:* Elec. lamps, £5,421—735 pkgs.; wire and cable, £105; unenumerated, £2,138 *Japan:* Unenumerated, £290. *France:* Carbon candles, £522; elec. lamps, £1,414; unenumerated, £99—313 pkgs. *Switzerland:* Unenumerated, £1,955 *Canada:* Unenumerated, £495. *Spain:* Elec. machinery, £20. *Denmark:* Unenumerated, £230. *Italy:* Unenumerated, £13.

MANCHESTER.—*Sweden:* Elec. machinery, 7 cases.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Elec. machinery, £76; unenumerated, £519. *Melbourne:* Wire and cable, £56; unenumerated, £367. *Gisborne* Elec. machinery, £59. *Sydney:* Elec. machinery, £824; unenumerated, £361. *Wellington:* Elec. machinery, £75; elec. lamps, 11,850 no.; wire and cable, £202; telephone material, £382; unenumerated, £1,158. *Christchurch:* Unenumerated, £140. *Lyttelton:* Elec. machinery, £78; unenumerated, £59. *Dunedin:* Elec. machinery, £131; wire and cable, £33; unenumerated, £363. *Adelaide:* Unenumerated, £145. *Hobart:* Elec. machinery, £137; unenumerated, £105. *Brisbane:* Wire and cable, £138; unenumerated, £2,610. *Napier:* Elec. machinery, £14; unenumerated, £48.

AFRICA.—*Durban:* Elec. machinery, £763; wire and cable, £25; unenumerated, £150. *Cape Town:* Elec. machinery, £7; unenumerated £128. *Port Elizabeth:* Wire and cable, £29; unenumerated, £251. *East London:* Unenumerated, £513.

EGYPT.—*Port Sudan:* Elec. machinery, £47; telegraph material, £109.

ADEN.—Unenumerated, £10.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Wire and cable, £2,701; elec. machinery, £121; unenumerated, £1,214. *Penang:* Unenumerated, £112 *Singapore:* Elec. machinery, £282; unenumerated, £49. *Calcutta:* Unenumerated, £94. *Madras:* Unenumerated, £71. *Colombo:* Unenumerated, £166. *Saigon:* Elec. machinery, £301. *Port Swettenham:* Unenumerated, £193.

CHINA. *Shanghai:* Elec. machinery, £205; elec. glow lamps, £7,074 no.; unenumerated, £285. *Hong Kong:* Wire and cable, £200; unenumerated, £496. *Tientsin:* Elec. machinery, £140; Wire and cable, £14; unenumerated, £24

U.S.A. *New York:* Telegraph material, £92; unenumerated, £240.

SOUTH AND CENTRAL AMERICA. *Buenos Aires:* Wire and cable, £309; unenumerated £712. *Valparaiso:* Unenumerated, £144. *Tartar:* Elec. machinery, £25. *Lima:* Elec. machinery, £290; unenumerated, £162. *Arica:* Wire and cable, £213. *Talchuano:* Elec. lamps, 2,000 no.; unenumerated, £140. *Guayaquil:* Wire and cable, £403. *Tampico:* Elec. machinery, £21.

HOLLAND. *Amsterdam:* Wire and cable, £89; unenumerated, £160. *Rotterdam:* Elec. machinery, £76.

FRANCE. *Dieppe:* Unenumerated, £111.

CUBA Unenumerated, £260

SWEDEN. *Gothenburgh:* Elec. machinery, £31.

NORWAY. *Christiana:* Wire and cable, £250.

ITALY. *Genoa:* Elec. machinery, £482.

RUSSIA. *Petrograd* Elec. lamps, £2,882; elec. machinery, £23; unenumerated, £51.

JAPAN. *Yokohama:* Wire and cable £134; unenumerated, £146.

FOREIGN GOODS (duty paid and free).

Port Elizabeth: Unenumerated, £58. *Bombay:* Unenumerated £52. *Auckland:* Unenumerated, £63. *Canary Island:* Unenumerated, £63. *Genoa:* Unenumerated, £90. *Singapore:* Unenumerated, £20. *Wellington:* Elec. lamps, 3,400 no.; unenumerated, £659.

IN TRANSIT.

Shanghai: Elec. glow lamp, £1,414 *Adelaide:* Elec. lamps, £1,314. *Hong Kong:* Elec. lamps, £1,495. *Bombay:* Unenumerated £116.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

LEGAL INTELLIGENCE.

Monometer Manufacturing Co. v. Electric & Ordnance Accessories Co. (Ltd.)

Last week Mr. Muir Mackenzie, Official Referee, concluded the hearing of an action, part heard at Birmingham, in which the Monometer Mfg. Co. sought to recover from the Electric & Ordnance Accessories Co. (Ltd.) the cost of certain specially constructed and designed plant, consisting of furnaces for melting aluminium and other metals, &c.

Mr. Colam, K.C., appeared for plaintiffs and Mr. Hugo Young, K.C., for defendants.

By a contract made in January, 1915, between the parties, plaintiffs agreed to manufacture for defendants three furnaces for melting aluminium, each with a melting capacity of 1,000 lb., fitted with from eight to 10 burners each, and with the necessary parts for drawing off the metal into certain smaller furnaces, such parts to consist of a suitable base to bring the outlet pipe over the orifice of the smaller furaces, which had a melting capacity of 140 lb., so that the metal might be drawn direct from the larger furnace into the smaller. Plaintiffs agreed to supply these for £230 each, less 2½ per cent. discount, one furnace to be delivered at the works within four weeks from the date of the contract. Plaintiffs also agreed to supply 12 furnaces, to be used in conjunction with the three larger ones, each with a melting capacity of 140 lb., without parts for proving, but each to have three burners with a specially designed top. These were to be supplied for £52 each, and four of them were to be delivered within four weeks from the date of the contract. Next there were to be two other furnaces to be used in conjunction with the others with a capacity of 140 lb. each, to be fitted with pouring spouts and valves, for which the charge was to be £62 each. There were also three furnaces for melting aluminium swarf, each with a capacity of 600 lb., fitted with water-cooled chills for casting ingots of aluminium, which were to be supplied complete for £248 each. The burners were to consume only about 60 ft. of gas per burner per hour, and it was also agreed that all the furnaces should be bricked with special silica bricks, to cut down the consumption of gas per burner by about 40 per cent. and to reduce the consumption to a point lower than that of any other system of furnace heating. All the furnaces were to be fitted with special burners described as monometer low-pressure gas burners, monometer patented gas chamber and all the latest improvements.

Defendants said that the furnaces were not according to contract, and would not do the work for which they were required satisfactorily, and they counterclaimed for damages and for the return of money paid. They said that plaintiffs contracted that the furnaces should be reasonably fit for melting aluminium to be cast in chilled moulds for fuses, for producing a molten product of pure aluminium, absolutely free from particles of iron or other foreign matter, and free from porosity and other flaws and defects, and that the pots forming part of the plant should not produce scale, but should produce castings suitable for pressing and machining all over. Another condition was that the specified number of burners would produce such a temperature as would be required satisfactorily to melt aluminium for the production of castings. Defendants said those conditions were not complied with by the furnaces supplied; and they also stated that they required the furnaces and plant for melting aluminium for castings in chilled moulds for manufacturing fuses, for which manufacture they had prepared plans of a proposed new foundry in their factory, for an estimated output of between 50 and 60 tons of castings per week. Defendants further alleged that the delivery was not made to time, and that when delivered the furnaces did not work satisfactorily, and that they were not reasonably suitable for the work.

Plaintiffs' case was completed at the hearing at Birmingham, where the evidence of Prof. Arnold and other expert witnesses was taken in support of plaintiffs' contention that the furnaces were capable of carrying out the work for which they were intended.

Further evidence was called for the defence at the resumed hearing in London to prove that the specified number of burners did not produce such a temperature as was required sufficiently to melt the aluminium for the castings, and that the necessary degree of liquidity could not be produced with the consumption of gas indicated, and that, in fact, a much larger consumption of gas was used in attempting to obtain the liquidity.

Mr. Wilmott, defendants' works manager, was recalled and further cross-examined by Mr. Colam, when he said that the scum in the ladling pots was sometimes half an inch in thickness. The cold metal was put in at the top as the molten metal was drawn off at the bottom, and in that way the accumulation of scum might have been assisted. He had all through complained of the excessive oxidation. The monometer furnaces had been offered as being capable of minimising the oxidation, but practice had proved, in his opinion, that they did not. His view was that the principal cause of oxidation was the long time it took to melt the metal. The quicker the melting the less the oxidation. The average heating power was not sufficient, and consequently they could not get their output. When he complained plaintiffs expressed astonishment, and made certain alterations, but they did it on their own responsibility, and not in consequence of any request from him. In making the contract he wanted to get furnaces without compressed air or other forced draught, and plaintiffs represented that their furnaces did that.

In re-examination Witness said that to supply the shops he had to have a certain output from the foundry, and he wanted the quickest and best way of getting the metal down; but the plaintiffs' furnaces took a much longer time to get it down than had been represented, and that necessarily affected the output.

Mr. THOS. TURNER, professor of metallurgy at Birmingham University, gave evidence as to what was meant in the trade by the term "aluminium" and aluminium castings. The term to a chemist would mean pure metal, but in the trade it meant an aluminium alloy consisting of a percentage of zinc or copper. The melting of ordinary aluminium in an iron pot would have very little effect upon the pot, but in the case of an alloy of zinc the iron pot would be affected by the zinc, which would make a distinctly crystallised compound. The zinc would take up the iron, which was attacked very slowly after the melting point of the zinc was reached, and for practical purposes the iron pot ceased to be an iron pot. He attributed the accumulation of scum to reserve heat or to a longer time being taken in the melting. If the metal was a long time melting there would be oxidation. The scum on the top of the ladling pot would affect the molten metal underneath, because there would be a certain amount of oxidation distributed below any large amount of scum, and the effect would be that the castings would be less sound and harder to machine.

In cross-examination Witness said that if he ordered aluminium

articles he would expect to get an alloy, but if he ordered aluminium from a metal merchant he would expect to get aluminium of 99 per cent. pure. Sometimes a little magnesium was present in aluminium castings and sometimes he found a little iron. Pure aluminium would not attack the pots, but when there was a mixture of zinc with it the zinc would do so. Zinc always attacked iron, and would do so even though there was aluminium with it. It was a common thing to coat iron pots, but he objected to say what the coating was, as it was a secret process. It was a French secret, brought over by a Frenchman. It was in the form of a wash, and had to be renewed from time to time. It was largely composed of chalk or whiting, and was mixed with something which made it stick.

Other witnesses said that in consequence of the monometer plant failing to do its work properly there was delay in defendants' output, and they had to place some of their work in other hands. One witness said that up to the end of July the furnaces produced 1,200,000 castings, which represented about 20 tons a week, instead of 50 tons required. There was necessity for an even larger output than 50 tons required.

The Official Referee, after further evidence had been given for the defence, reserved judgment.

In giving judgment on Monday the Official Referee said that there were two questions for consideration. The first was what were plaintiff's obligations, and, secondly, did they fulfil them? Attracted by an advertisement, the plaintiffs said they could supply furnances in which the consumption of gas was less than that of any other furnace, and that they would melt aluminium without compressed air or other forced draught. Defendants approached plaintiffs, and as a result entered into a contract with them to supply certain furnaces with certain melting capacities, &c., and subsequently defendants required certain alterations, and made arrangements with plaintiffs. Defendants contended that it was part of the contractual obligations of the plaintiffs, first, that the furnaces should be capable of securing an output of from 50 to 60 tons a week, and, secondly, that the small furnaces would produce castings free from flaws and other defects, and that they should be fit for melting aluminium with copper. It was clear that notwithstanding the written contract, the additional obligations contended for could have been made binding upon plaintiffs by verbal understanding. Plaintiffs undoubtedly knew that the furnaces were required for turning out with rapidity castings for fuses, and that the metal to be used would contain a mixture of zinc, but he could not find that plaintiffs entered into any obligation with respect to the furnaces beyond those expressed in the contract, and the question was whether plaintiffs had made default in regard to those obligations. One cause of complaint was that the large furnaces did not provide sufficient output to feed the smaller furnaces, and that the iron pots were defective. As regards the large furnaces, the complaint was that the defendants did not get the quantity of molten metal required, but plaintiffs had not entered into any legal obligation that they should do so. The main cause of the trouble in the smaller furnaces was due to the mixture of other metals with the aluminium. Plaintiffs did not undertake that their iron pots would not be subject to damage by alloys being melted in them. He, therefore, found and decided against defendants on the main issue. Plaintiffs were not in default. Plaintiffs' claim included a large sum for extra work done, and defendants admitted that they ordered part of the work, claimed for. As regards nearly all of the items claimed for he decided in favour of defendants, who were not liable for additional work unless it had been ordered by them. The person who had contracted to have things done for a certain sum was entitled to resist all claims outside the contract. He decided that the extra items, which in the aggregate amounted to £648, should be struck out. There would be judgment for plaintiffs for £1,723. 10s. 3d. on the claim and the counterclaim would be dismissed. As to the costs, he ordered that the defendants should pay four-fifths of the taxed costs.

Daimler Co. v. Continental Tyre & Rubber Co.

On Friday last the House of Lords (Lords Halsbury, Mersey, Kinnear, Atkinson, Shaw of Dunfermline, Parker of Waddington, Sumner and Parmoor) delivered judgment in this appeal from a decision of the Court of Appeal. The question was whether respondent company, which was registered in England, but was composed (with one exception) entirely of German shareholders, had a right to maintain an action during the war to recover a trade debt due from appellants.

The Continental Co. sold in England motor-car tyres manufactured by a German company, who held the bulk of the shares in the English company. Of the four directors of the latter company, three were resident in Germany and the fourth left England immediately after the outbreak of the war. The only English shareholder was the secretary (Mr. Wolter), who was born in Germany, but became a naturalised British subject, and his interest in the company consisted of one £1 share.

Appellants applied for unconditional leave to defend the action on the grounds that (1) the company was in fact an alien company with whom it was illegal (apart from a licence from the Crown) to hold any commercial intercourse, which included payment of money for a trade debt; and (2) that the secretary had no power either to authorise the company's solicitors to issue the writ in the action or to give a receipt for the money when recovered. The Master gave leave to respondents to sign judgment, and his order was affirmed by Mr. Justice Scrutton in chambers, and afterwards by the Court of Appeal, Lord Justice Buckley (now Lord Wrenbury) dissenting. Their lordships heard the arguments on the appeal in February last, and judgment was reserved.

In delivering judgment, Lord HALSBURY said he was of opinion that the judgment should be reversed. The whole discussion was solved by a very simple proposition that by the law of England when the object to be attained was unlawful, the indirectness of the means by which it was to be attained would not get rid of the unlawfulness, and in that action the object of the means adopted was to enable thousands of pounds to be paid to the King's enemies. They were all Germans originally, though one afterwards became a naturalised Englishman. It seemed to his Lordship that the question became very plain when one applied the language of the law to the condition of things when war was declared. They could neither meet here, nor could they authorise any agent to meet on any company business. They could neither trade with the subjects of this country, nor could any British subject trade with them. The absence of the authority to issue the writ was only a part of the larger question. No one had authority to issue a writ on behalf of an alien enemy because he had no right himself to sue in the Courts of a King with whom his own Sovereign was at war. No person, or any body of persons, to whom attached the disability of suing in such circumstances could have authority. The Lord Chief Justice said that the company was a live thing. If it were, it would be capable of loyalty and disloyalty. But it was not; and the argument of its being incapable of being loyal or disloyal was founded on its not being "a live thing."

Lord ATKINSON, who delivered an exhaustive judgment, was of opinion that the appeal should be allowed, on the ground that the secretary had no authority to issue the writ and commence the action. On the main point he expressed no opinion, but he regretted that appellants were not permitted to defend, so that all the facts might have been elicited, and it could be determined whether respondent company resided and traded in Germany or not.

Lord SHAW of DUNFERMLINE agreed with the view of the Court of Appeal on the main point, but differed from them on the question of the secretary's authority.

Lord PARKER of WADDINGTON (in whose judgment Lord Mersey and Lord Kinnear concurred) stated that the judgment which he was about to read had been prepared with the assistance and collaboration of Lord Sumner, who authorised him to say that he agreed with it. When the action was instituted all the directors of plaintiff company were Germans resident in Germany. In other words, they were the King's enemies, and as such incapable of exercising any of the powers vested in them as directors of a company incorporated in the United Kingdom. They were incapable, therefore, of authorising the institution of that action. The contention that the secretary could authorise such institution was untenable. The resolution by which he was appointed secretary would confer on him such powers only as were incident to the performance of his secretarial duties. It was true that the directors might by a proper resolution in that behalf have conferred on him a power to authorise the institution of proceedings in the company's name, but they did not do so. It followed that the action was instituted without authority from the company, and in his opinion the Court (having notice of the fact) should have refused relief. It was true that a question whether plaintiff's solicitor had or had not been validly retained was in general brought before the Court by motion to which the solicitor was made a party. But when the Court in the course of an action became aware that plaintiff was incapable of giving any retainer at all it ought not to allow the action to proceed. It clearly would not do so in the case of an infant plaintiff, and he could see no difference in principle between the case of an infant and the case of a company which had no directors or other officers capable of giving instructions for the institution of legal proceedings. This was more especially so when, by reason of all the shareholders (with one exception) being the King's enemies, no agent or officer capable of giving such instructions could be validly appointed. It was suggested that the secretary, being the only shareholder who was not an enemy, could in some way or other call and hold a meeting of the company at which he might appoint himself to be a director or agent of the company with such powers as he might think fit. He had not attempted to do so, and after a careful examination of the articles he thought it reasonably clear that any such attempt would fail. Further, it was quite clear that the articles of association of the company did not contemplate or provide for the continuance of the company's trading without any directors at all, nor was a secretary of a company an official who *virtute officii* could manage all its affairs, with or without the help of servants, in the absence of a regular directorate. In those circumstances it was unnecessary to consider whether a company incorporated in the United Kingdom could under any and what circumstances be an enemy or assume an enemy character. The question had, however, been so elaborately argued that it would not be right to ignore it. He reviewed at some length the English and American authorities upon what constituted an enemy company, and then said the truth was that considerations which governed civil liability and rights of property in time of peace differed radically from those which governed enemy character in time of war. Joint stock enterprise and English legislation and decisions about it had developed mainly since this country was last engaged in a great European war, and had taken little (if any) account of warlike conditions. The ideal of joint stock enterprise, that with limited liability, the more unlimited the trading the better, was an ideal of profound peace. The rule against trading with the enemy was a belligerent's weapon of self-protection. He thought that it had to be applied to modern circumstances as they found them and not limited to the applications of long ago, with as little desire to cut it down on the one hand as to extend it on the other beyond what those circumstances required. Though it had been said by high authority to aim at curtailing the commercial resources of the enemy, it had, according to other and older authorities, the wider object of preventing unregulated intercourse with the enemy altogether. Through the Royal Licence, which validated such intercourse and such trade, they were brought under necessary control. Without such control they were forbidden. To his mind the rule would be deprived of its substantial justification and be reduced to a barren canon, if it were held, in circumstances

such as those, that it had no application by reason of the mere fact that the company was registered in London. Having regard to the foregoing considerations, he thought that the law on the subject might be summarised in the following propositions :—

1. A company incorporated in the United Kingdom is a legal entity, a creation of law with the status and capacity which the law confers. It is not a natural person with mind or conscience. "It can be neither loyal nor disloyal. It can be neither friend nor enemy."

2. Such a company can only act through agents properly authorised, and so long as it is carrying on business in this country through agents so authorised and residing in this or a friendly country it is *prima facie* to be regarded as a friend, and all his Majesty's lieges may deal with it as such.

3. Such a company may, however, assume an enemy character. This will be the case if its agents or the persons in *de facto* control of its affairs, whether authorised or not, are resident in an enemy country, or, wherever resident, are adhering to the enemy or taking instructions from or acting under the control of enemies. A person knowingly dealing with the company in such a case is trading with the enemy.

4. The character of individual shareholders cannot of itself affect the character of the company. The enemy character of individual shareholders and their conduct may, however, be very material on the question whether the company's agents, or the persons in *de facto* control of its affairs, are in fact adhering to, taking instructions from, or acting under the control of enemies. This materiality will vary with the number of shareholders who are enemies and the value of their holdings. The fact, if it be the fact, that after eliminating the enemy shareholders the number of shareholders remaining is insufficient for the purpose of holding meetings of the company or appointing directors or other officers, may well raise a presumption in that respect. For example, in the present case, even if the secretary had been fully authorised to manage the affairs of the company and to institute legal proceedings on its behalf, the fact that he held one share only out of 25,600 shares, and was the only shareholder who was not an enemy, might well throw on the company the onus of proving that he was not acting under the control of, taking his instructions from, or adhering to the King's enemies in such manner as to impose an enemy character on the company itself. It was an *a fortiori* case when the secretary was without authority and necessarily depended for the validity of all he did on the subsequent ratification of enemy shareholders. The circumstances of the present case were, therefore, such as required close investigation and precluded the propriety of giving leave to sign judgment under Order xiv.

5. In a similar way a company registered in the United Kingdom, but carrying on business in a neutral country through agents properly authorised and resident here or in the neutral country is *prima facie* to be regarded as a friend, but may, through its agents, or persons in *de facto* control of its affairs, assume an enemy character.

6. A company registered in the United Kingdom but carrying on business in an enemy country is to be regarded as an enemy.

The foregoing propositions were not only consistent with the authorities cited in argument, and in particular with *Janson v. Driefontein Consolidated Mines*, but they had, he thought, the advantage of affording convenient and intelligible guidance to the public on questions of trading with the enemy. It would be a misfortune if the law were such that during war every one proposing to deal with a British company had to examine the character of its shareholders and decide whether the number of the enemy shareholders coupled with the value of their holdings was such as to impose an enemy character on the company itself. It would be still more unfortunate if that question were a question for the jury in each particular case. No one could maintain that a company had assumed an enemy character merely because it had a few enemy shareholders. It might possibly be contended that it assumed an enemy character when its enemy shareholders amounted to, say, one-half or three-fifths or five-eighths of the whole, but how if the one-half, three-fifths or five-eighths held only one-sixth, one-fifth or one-quarter of the shares? The Legislature might, but no Court could, possibly lay down a hard-and-fast rule, and if no such rule were laid down how could any one proposing to deal with the company ascertain whether he was or was not proposing to deal with the enemy? It had been suggested in argument that acts otherwise lawful might be rendered unlawful by the fact that they might tend to the enrichment of the enemy when the war was over. He entirely dissented from that view. He saw no reason why a company should not trade merely because enemy shareholders might after the war become entitled to their proper share of the profits of such trading. It would be lamentable if the trade of this country were fettered, businesses shut down, or money allowed to remain idle in order to prevent any possible benefit accruing thereby to enemies after peace. The prohibition against doing anything for the benefit of an enemy contemplated his benefit during the war and not the possible advantage he might gain when peace came. The action was altogether irregular and should be struck out, all orders made therein being, of course, discharged. But there was no one before the House who could be made liable for costs or who could be ordered to replace in Court the moneys paid out to the secretary. There could, therefore, be no order as to costs.

Lord PARMOOR delivered a separate judgment, agreeing with the conclusions of Lord Shaw of Dunfermline.

Farnham Electric Lighting (Extension) Order, 1914.—The Board of Trade has extended for one year from July 31 the periods of two years and 18 months, respectively mentioned in sec. 21 of the schedule to the Electric Lighting Clauses Act, 1899, and incorporated in the above order.

EDUCATIONAL.

University of Liverpool.—In the Faculty of Engineering there are full courses in mechanical, civil and electrical engineering, naval architecture and marine engineering, mathematics, physics, chemistry, &c. Particulars of the entrance examination, prospectus of the Faculty, &c., may be obtained from Registrar, Mr. Edward Carey.

Manchester School of Technology.—The session 1916-17 will open on October 5th, and the matriculation and entrance examinations will be held in July and September. In the Faculty of Technology there are complete courses of instruction in mechanical, electrical and sanitary engineering, the chemical and textile industries, mining, architecture, &c. First-year courses will be specially adapted to the requirements of students who may wish to take commissions in H.M. Forces. Prospectuses (free) and particulars will be forwarded on application.

City and Guilds Technical College, Finsbury.—The training at this College is adapted to the needs of various students, including pupils above 15 from secondary schools, who desire a practical and scientific training bearing upon their future industry or profession, and young men who having previously served a pupilage or apprenticeship in works desire a more systematic training in engineering and applied chemistry. The College has well-equipped laboratories and workshops for practical work. The entrance examination will be held on Sept. 19. Further particulars, syllabuses of instruction, &c., may be obtained from the Registrar of the College, Leonard-street, Finsbury, London, E.C.

BUSINESS NOTICES.

The General Electric Co. (Ltd.), of London and Witton, Birmingham, &c., advise us that the address of their Cork branch (from whence all orders from the South of Ireland are attended to) has been altered to No. 76, Grand Parade.

Messrs. Waygood Otis (Ltd.), Falmouth-road, S.E., have made arrangements with the liquidator of the Easton Lift Co. (Ltd.) for the acquisition of the goodwill, patents, patterns, stock, spare parts and work in progress, and they will carry out all pending contracts, &c., of the Easton Co.

The business of publicity expert and advertising contractor carried on by Mr. A. J. Greenly will in future be carried on by Messrs. A. J. Greenly & Co. Additional offices at 37 and 38, Strand, W.C., have been taken for the increased staff.

It is announced that a qualified electrical engineer and a mechanical engineer are retained by the firm, who have recently secured the services of an advertising man well known in the electrical and motoring industry.

Messrs. J. H. Heathman & Co., of Parson's Green, Fulham, have opened extensive showrooms for their ladders, trestles, steps, trolleys, trucks and barrows, as well as portable telescopic scaffolds, at 35, Aldersgate-street, E.C., where their manufactures can be inspected in the City of London.

The partnership between Ethel Mary Downes and Fredk. W. Jackson (executors of Herbt. Laidlaw Jackson, deceased) and Percival Leonard Davies (surviving partner), electrical engineers, &c., 1 & 3, Stanley-street, Liverpool, and 78, King-street, Manchester, has been dissolved by the death of Herbt. L. Jackson. Debts by Mr. Davies, who continues as Downes & Davies.

Plant for Sale.—Messrs. Iliffe & Sons, Ltd., 19, Hertford-street, Coventry, advertise for sale a 400 amp. dynamo, switchboard, 40 h.p. d.c. motor, &c.

Water Power for Sale.—An advertiser has for disposal water power (up to 190,000 h.p.) in Western Norway.

Patent Development.—The proprietors of patents Nos. 15,951/1913 and 10,868/1914, for "Improvements in safety devices for electric conductors" and "Improvements in and relating to electrical condensers and a process of manufacture thereof," desire to enter into arrangements for exploiting same in this country. Particulars from Messrs. Haseltine, Lake & Co., Patent Agents, 28, Southampton-buildings, Chancery-lane, London, W.C.

LIQUIDATIONS, BANKRUPTCIES, &c.

A meeting of creditors of the Naylor Battery Co. (Ltd.) will be held on July 13 at the Blenheim Room, Hotel Cecil, London, W.C. Mr. H. Everett, 3/7, Southampton-street, Strand, London, W.C., has been appointed liquidator.

Meetings of the creditors and contributories of the Colston Electrical Works (Ltd.) were held at Bristol last week.

The Official Receiver said he had been appointed provisional liquidator and had collected book debts to the extent of £552, and there were two others which might come in at any moment, and would make up a total of about £850. There were practically no other assets. The

liabilities as regards creditors were £1,574, and assets £991. Bad debts, want of working capital, and losses through the failure of the Bristol International Exhibition were stated to be the chief causes of the company's insolvency.

Claims against the Omega Electric Lamp Co. (Ltd.) are to be sent by July 7 to the liquidator, Mr. R. T. Cuff, 8, Breams-buildings, Chancery-lane, London, W.C.

Claims against Russell E. Connold, late electrician of 6A, The Parade, Canterbury, are to be sent by July 18 to Mr. G. E. Corfield, 119, Finsbury-pavement, London, E.C., preparatory to the payment of a dividend.

ELECTRICITY SUPPLY.

EXTENSIONS.

Aylesbury.—An inquiry will be held on the 11th inst. into application for sanction to borrow money for extensions of the electric supply undertaking.

Fulham (London).—The Electricity Committee recommends an expenditure of £150 to extend mains to give a supply of energy to the Gallite rubber factory.

Luton.—The electrical engineer (Mr. W. H. Cooke) has reported on the need for additional plant to meet next winter's demand.

An increased demand of over 1,500 kw. is anticipated by that time, and Mr. Cooke finds it will be necessary to install two boilers of similar capacity to the last two installed, with stokers and an economiser, an additional feed pump with necessary steam, feed and blow-off piping, water-softening plant, and provision must be made for dealing with the ashes and clinkers from the boilers and soot from the flues and economiser. It has been extremely difficult to obtain reasonable quotations for the plant owing to the unsettled state of the market, but Mr. Cooke obtained tenders on which he estimated that an expenditure of £13,574 would be necessary. He had laid the matter before the Government department concerned, and it had authorised the boilers, economiser, &c., to be certified under class "A," which would give priority over all work in other classes.

The Electricity Committee has accepted the report, and immediate application is to be made to the L.G. Board for sanction to borrow the sum mentioned.

Salford.—The Finance Committee has agreed to the request of the Lighting Committee to be allowed to defray, out of moneys to be saved on other items included in the estimates, the estimated cost (£160) of the transfer of the electric lamps from the centre tramway standards proposed to be removed from the Crescent.

An agreement is to be entered into with Zama (Ltd.) for a supply of energy for five years, or such further period up to 10 years as the company occupy their premises.

The Electricity Committee has acceded to the application of the Peel Connor Telephone Co. for the supplies of energy to their premises in Upper Cleminson-street and Silk-street, to be treated as one supply under certain conditions.

Application is to be made to the L. G. Board for sanction to borrow (1) £2,279 to cover the cost of provision of additional plant and switchgear; and (2) £750 to cover capital expenditure prior to March 12, 1915.

Woolwich.—The charge for steam generated from refuse for electricity purposes for the year ended March 31 last has been fixed at £540.

The Electricity Committee has again discussed the subject of the supply of current for power. Having regard to the linking-up arrangements now completed with adjoining undertakers, and in order to meet further requirements, the Committee finds that it will be necessary to install an additional boiler at Globe-lane works. An agreement is, therefore, to be sealed with Babcock & Wilcox for the supply of the boiler, superheater and economiser for £5,890.

Mains are to be extended at a cost of £618 for the supply of current for lighting purposes to workers' hostels.

GENERAL.

Barnsley.—The charge for electrical energy for lighting has been increased by ½d. a unit, and for power by 10 per cent., as from the 1st. inst.

Bingley.—The Council have agreed to give a supply of electrical energy to the training college for a standing sum of £300 per annum, plus 2d. per unit, the arrangement to be for 10 years, and the unit rate to be dependent on the price of coal.

Darwen.—The Corporation have increased the charge for current supplied to the tramways from 1 5/16d. to 1½d. per unit.

Heston and Isleworth.—Owing to the Summer Time Act, the output in units for lighting has fallen by approximately 200 units per day on week-days and 100 units on Sundays.

It is calculated that during the 142 days during which the new arrangement will be in force the output for lighting will decrease by 26,000 units, representing a money value of from £400 to £450.

The Electricity Committee has discontinued the lighting of the public street lamps up to the end of September next, having regard to the fact that at present the lighting, upon which about £2,750 a year is spent, even under the restricted system, is of little practical value. The Committee has also decided to increase by 12½ per cent. all charges for current supplied for lighting, heating and power purposes.

Kingston-on-Thames.—Messrs. Banks, Warner & Co. are to be appointed at an inclusive fee of 50 guineas to act in an advisory capacity with the borough electrical engineer and the contractors in connection with the erection of the new crank shaft for one of the Diesel engines.

Gloucester.—The City Council has decided to increase the prices of electrical energy for lighting and power purposes by 20 per cent.

Hammersmith (London).—During the past month the Electricity Committee reports having granted 50 applications for the supply of current, equivalent to 8,388 30-watt lamps.

Leek.—It was reported to the Urban Council that Prof. Watkinson's report on the condition of the generating plant had been considered by the Lighting Committee, and it was decided that the gas engineer should be instructed to take control of the producer-gas plant at the electricity station. That had been done, and the electrical engineer (Mr. Bemrose) had tendered his resignation as from May 25, and it had been accepted.

The chairman of the Lighting Committee (Mr. Furmston) made a lengthy statement on the general position of affairs. He thought no one could read Prof. Watkinson's report without coming to the conclusion that it was unfortunate the late Electricity Committee had not had expert advice before the existing plant was installed some 10 years ago. Owing to the war and the great rise in the price of materials, as well as the improbability of the Council being able to obtain a loan at present, the committee were not in a position to carry out Prof. Watkinson's suggestions at once, but they wished to undertake such portion of them now as would not interfere with the completion of the scheme at a later period. He had asked the professor's opinion on the four following suggestions: (1) Was it advisable to scrap the whole of the present plant and replace it by a steam-driven one? (2) Was it desirable to scrap the gas-producer plant, and return to town gas? (3) Should a new and up-to-date producer plant be installed? (4) How could the present plant be most satisfactorily dealt with? Their plant could not be entirely remodelled now, owing to the difficulty of obtaining new capital. Further, their expert did not advise a steam plant for a station the size of Leek. The suggestion to return to the use of town gas was greatly favoured by the committee and offered decided attractions, but, as the Campbell engine was now a complete wreck, the committee could not at present afford to scrap the Mather & Platt engine, which could only be run by producer gas, so that it was necessary to continue the system at present. The increased cost of all machinery at present prevented them from installing a more modern type of producer plant, which they would very much like to do; hence, they had decided to take the course of putting the present Gas Engineer in charge of the gas-producing plant, and already he had been able to show very satisfactory results in decreased cost of working. It was confidently hoped that as time went on further improvement would be effected. The committee, however, intended to put down, as soon as ever they could obtain one, a new gas engine of the most modern type, and so constructed as to work on either producer or town gas with very simple alteration. That engine would replace the Campbell, which it was proposed to do away with at once. It would probably cost about £3,000. The Stockport engines had had to meet a heavy strain for the past six months, and it was proposed to overhaul them thoroughly. With these renovations carried out he thought the committee would be able to face the coming winter with far more security than they had enjoyed lately, and be able to give manufacturers all the current they required. As to the staff, the committee had decided that as they were retaining the system of a producer plant, it would be better to put the whole of the gas production under the care of the Gas Manager, who had a full knowledge of that system, as well as of gas engines. He also had a fair knowledge of electricity work. The combination of the two departments must lead to various economies, and would no doubt be beneficial all round. The following proposals were then formally adopted: "That the Campbell gas engine and dynamo be sold at once; that a new gas engine and dynamo of about 200 kw. capacity (to replace the Campbell engine) be purchased; that the Stockport engine be overhauled; that the necessary appliances suggested by Prof. Watkinson be purchased; that Mr. Ginman be appointed general manager of the electricity station; and that a chief assistant be appointed at a salary of £160 per annum."

London County Council.—On Tuesday sanction was given to Fulham Borough Council to borrow £2,500 for electricity purposes.

Yorkshire Linking-up Scheme.—A conference was held on Friday between representatives of Bradford City and Shipley Urban District Councils to consider the desirability of inter-connection between the electric supply undertakings of Bradford and Shipley.

A general discussion took place on the matter, but the conference found it impossible to decide on the information before them whether any

very considerable economies could be effected by the linking-up of the two systems. It was, therefore, decided that the two engineers should look into the matter and make reports to their committees, and that after these reports had been considered the representatives of the two authorities should again meet and discuss the question. The representatives of the two authorities recognised, however, that one advantage of linking-up the two systems was the utilisation of the spare plant of one undertaking by the other, a provision which might prove valuable in the case of a breakdown at one of the works.

TRACTION NOTES.

Darwen.—As new tram rails are so expensive the tramways manager (Mr. Hoskins) has made arrangements with Blackburn Council for the loan of special apparatus to cut away the bad portions of the lines and replace them with short lengths.

London County Council.—On Tuesday the chairman of the Highways Committee (Mr. Hume) stated that the question of providing seating accommodation on the Council's tramcars for women conductors would be considered by the committee.

Tramcar v. Motor Omnibus.—At the annual meeting of municipal and county engineers at Blackpool, on June 28, the new president, Mr. J. S. Brodie (Blackpool) said the controversy of the tramcar v. petrol motor 'bus was bound to come to the fore in the immediate future. The comparatively small first cost of establishing a fleet of motor omnibuses was likely to be counterbalanced by the greatly increased cost of petrol, and so the compromise known as the railless car, or the electrically-propelled motor omnibus, might come to have an extended trial, as, even at the present price of petrol, it had been found at Keighley that a loss of £1,100 a year from a petrol motor 'bus service had been converted into a profit of £1,000 a year by railless electric cars on exactly the same route. The motor omnibus would be further handicapped by the provisions of the Act providing for the control of omnibus routes by the highway authorities, and limiting the roads upon which motor 'buses could ply. It was also practically certain that the example of the Middlesex County Council, in regard to the New Western Road, where Parliament authorised a levy of ⅜d. per 'bus-mile, would be largely followed by road authorities in the future.

Woolwich.—The Borough Council has consented to the proposal of the L.C.C. to lay additional tram tracks in High-street, Plumstead.

MISCELLANEOUS NOTES.

Customs Decision.—According to a recent decision, flame arc lamp carbons, in chief value of lampblack or retort carbon, with or without a core impregnated with chemical salts, are subject to import duty of 40 cents per 100 ft., under para. 82 of the United States Tariff Act of 1913.

Enemy Firms Wound-up.—The Board of Trade have ordered the winding-up of 217 businesses controlled by alien enemies.

Included in the latest list is Kastner & Co. (Ltd.), 191, Regent-street, London, W., dealers in cabinet player pianos. (Controller: J. H. Stephens, 6, Clement's-lane, E.C.)

The Board has made an order prohibiting Turner & Burger, 149, Farringdon-road, London, E.C., electrical accessories merchants, from carrying on business after Sept. 29, 1916. (Controller: J. E. Percival, 6, Old Jewry, E.C.)

Claims against W. Mertens & Co. (Ltd.), Balfour House, 119-125, Finsbury-pavement, London, E.C., are to be sent by Aug. 10 to the controller, Mr. J. D. Pattullo, 65, London-wall, E.C.

Claims against the Wolf Safety Lamp Co., Star Works, Boston-street, and Arley-street, Sheffield, are to be sent by Aug. 7 to the Controller, T. G. Shuttleworth, Royal Insurance-buildings, Church-street, Sheffield.

Export to China and Siam.—The "London Gazette" of July 4 contains further lists of firms and persons in China and Siam to whom goods from the United Kingdom may be consigned. These include the Samsen Power Station (Bangkok) and Spicer Bros. (Bangkok).

Trading With the Enemy.—The "London Gazette" of June 30 contains further additions to the statutory list of persons or bodies of persons with whom trading by persons or bodies of persons in the United Kingdom is prohibited.

TENDERS INVITED.

Transformers.

MANCHESTER Electricity Committee require tenders by 10 a.m. July 10 for the supply and erection of Two 1,000 k.v.a. Static Transformers. Specifications, &c., from Mr. F. E. Hughes, Town Hall, Manchester.

Lift and Turntable, &c.

MANCHESTER Electricity Committee require tenders by noon July 11th for (*a*) Electric or Hydraulic Coal Wagon Lift and Turntable; and (*b*) Saddle Tank Steam Locomotive for their Stuart-street generating station. Specifications, &c., from the Secretary, Electricity Dept., Town Hall, Manchester.

Cables.

ROCHDALE Electricity Committee require tenders by noon July 12 for 12 months' supply of Paper-insulated Cables. Specification from Engineer and Manager, Dane-street, Rochdale.

MANCHESTER Guardians require tenders by July 12 for the Supply of Electric Cable for the Epileptic Colony, Langho, near Blackburn. Particulars from the Clerk to the Guardians.

ROCHDALE Electricity Committee require tenders by noon July 12 for 12 months' supply of Paper-insulated Cables. Specifications, &c., from the Engineer and Manager, Electricity Works, Rochdale.

Electric Screen-Cleaning Gear.

BARROWFORD Urban Council require tenders by July 8 for supply, erection, &c., of Automatic Control Electric Screen-cleaning Gear for sewage disposal works. Particulars from the Surveyor.

Telegraph and Telephone Material.

Tenders are invited up to Aug. 16 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are also invited up to July 19 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of Insulators (schedule 510). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. Aug. 8 for the supply and delivery in Melbourne, Sydney, Brisbane, Adelaide, Perth and Hobart of Standard Battery Material, including Pots, Porous Jars, Zinc, Carbon Rods, Chemicals, &c., for the AUSTRALIAN COMMONWEALTH, Postmaster-General's department. (Schedule 1,327.) Specifications, &c., from the Deputy Postmaster-General.

TENDERS RECEIVED AND ACCEPTED.

SALFORD.—The Tramways Committee of the Corporation has accepted the tender of Hadfields (Ltd.) for the supply of steel car wheel tyres and axles, at a schedule of prices amounting to £279. 4s.

The Electricity Committee has accepted the following tenders for work in connection with the installation of two water-tube boilers at Frederick-road station :—

J. Gerrard & Sons, foundations and structural work, £1,100 ; New Conveyor Co., coal conveyers, bunkers and chutes, £1,504 ; J. Russell & Son, mild steel piping, £210. 13s. 6d.

KINGSTON-ON-THAMES.—The Council has accepted the tender of the Craigpark Electric Cable Co. for the supply of 110 yds. of armoured cable at £14. 12s. An order has been placed with Belliss & Morcom for fitting the new crank shaft to the Diesel engine recently damaged at an estimated cost of £400.

NORTHAMPTON.—The Tramways Committee recommends the Corporation to accept the tender of G. W. Souster & Son, at £388. 15s., for the renewal of the wood work at the cooling tower.

BIRMINGHAM.—The Lighting Committee has accepted the tender of Herbert Morris (Ltd.) for the erection of an overhead electric runway, including a travelling electric pulley block and bogie trolley, for £421.

EXETER.—The Guardians have accepted the tender of Brooking & Co. for wiring one block at the Poor Law Institution, at £57. 4s. 6d.

WOOLWICH.—The Electricity Committee has entered into contracts with Siemens Dynamo Works (Ltd.) for the supply of switchgear and recording meters for £133 ; and with Babcock & Wilcox for an additional boiler, superheater and economiser, at £5,890.

HAMMERSMITH.—The Council is recommended to accept the offer of the Underfeed Stoker Co. to supply one class E underfeed stoker to a Stirling boiler for £446, plus cost of fixing and alteration of brickwork, estimated to cost not more than £200.

LUTON.—The Corporation are recommended to accept the following tenders :—

Clark, Chapman & Co., two boilers and stokers, £7,648 ; E. Green & Sons, economiser, £1,091 ; W. & T. Avery (Ltd.), coal weighing machines, £440 ; Harris-Anderson Patent Feed Water Filter Co., one water softener, £455 ; Hayward, Tyler & Co., one rotary feed pump, £258.

LONDON COUNTY COUNCIL.—The Asylums Committee have accepted the tender of Crysolco (Ltd.), at £92. for electric lamps.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Bury.—The accounts of the electricity department for the year ended March 31 show gross capital expenditure £203,356 (increase £7,587), of which £51,769 has been repaid, while the sinking fund available amounts to £13,643 and the reserve fund to £8,747.

Revenue was £41,508 (compared with £31,300 in previous year), generating costs were £25,455 (£16,912), interest required £5,989 (£5,052), and sinking fund £7,861 (£7,298) and net profit was £2,003 (£2,038), of which £1,000 (as in previous year) has been allocated to relief of rates and £1,003 (£1,038) to reserve. Generating costs were 0·45d. (0·38d.) and interest 0·10d. (0·11d.) and sinking fund 0·14d. (0·16d.) made the total costs 0·69d. (0·65d.). Units generated were 15,277,436 and sold 13,503,701 (10,694,744). Maximum load was 4,806 kw. (3,815 kw.) and load factor 32·1 (32) per cent.

The engineer and manager, Mr. S. J. Watson, says, in his report, there are 1,039 consumers connected with the equivalent of 287,779 8 c.p. lamps. Hired motors showed an increase of 29 H.P. and owned motors 501 H.P. The total number of motors connected is 1,009 (=8,513 H.P.). Average price of fuel was 15s. 9½d. (11s. 7½d.), and fuel used per unit sold was 3·06 lb. (2·99 lb.). Average price obtained was 0·734d. (0·702d.) per unit. The gross profit was £15,853 (£14,382) equal to 7·9 (7·6) per cent. on the average capital employed.

The capacity of the three-phase a.c. plant at the Chamber Hall power station is 7,200 kw. and the c.c plant at Rochdale-road 1,500 kw. Owing to the decision to defer the extensions originally contemplated at the Chamber Hall power station in deference to the wishes of the Local Government Board, the small and comparatively uneconomical plant at Rochdale-road had to be used during the year to a much larger extent than formerly, in order to meet the full requirements of consumers. Whereas the 1,040,917 units sold from Rochdale-road required a consumption of 2,564 tons of fuel at a cost of £1,972, the same output could have been dealt with at Chamber Hall by 1,300 tons of fuel at a cost of £1,040 had additional plant been available for the purpose. In view of the importance of conserving our national supplies of fuel at the present time it is unfortunate that the delay incurred in providing an extension of the modern plant should have led to the use of 1,264 tons more fuel than would otherwise have been necessary, and to an extra cost of £932.

Coventry.—At the recent meeting of the Council the accounts of the electric supply and tramways department were approved.

The chairman of the Electric Light Committee (Mr. Lee) said the gross profit of the department was £45,311, and the net profit £18,000. The committee recommended that £6,000 be paid over to the rates and £12,000 placed to reserve. He stated that practically 97 per cent. of the energy was used for power purposes, and only 3 per cent. for lighting shops and houses. They had been able to meet all the demands of new industries, and though times had been arduous they would be able to continue to meet the growing tax upon the resources of the department, and to supply all comers.

Mr. WALE, who presented the report of the Tramways Committee, said the balance was £5,001, of which the committee recommended £4,000 should be placed to reserve and £1,000 carried forward. Mr. Wale pointed out that if the male employés were depleted still further for the forces the committee would have to reduce the services on various sections.

The accounts of the electricity department for the year ended March 31 show gross capital expenditure £461,155 (increase £76,876), of which £17,063 has been repaid and £34,530 has been written off for obsolete and superseded plant.

Revenue was £108,543 (compared with £77,913 in previous year), and working and general expenses and special charges amounted to £63,232 (£33,142), the gross profit being £45,311 (£44,771), and after providing for capital charges, &c., the net profit was £18,058 (£23,148), of which £6,000 is being devoted to relief of rates and £12,009 to defraying capital expenditure for switchboards, re-instating of trenches and Nos. 7, 8, 9 and 10 cooling towers.

Ipswich.—The accounts of the electric supply department for the year ended March 31 show total capital expenditure £150,029 (increase £3,265), of which £69,619 is outstanding.

Revenue was £33,969 (compared with £27,886), working expenses were £23,030 (£17,285), interest required £4,837 (£4,272), and repayment of loan £6,787 (£5,786), the amount taken from the rates being £2,100. Units generated were 4,619,209 (3,541,525) and sold 3,734,158 (2,966,968). Maximum load was 1,475 kw. (1,400 kw. for lighting and power and 424 kw. (445 kw.) for traction. Total revenue per unit sold was 2·183d., working and general expenses were 1·480d., and capital charges, income tax and war service allowances amounted to 0·335d.

The engineer and manager, Mr. Frank Ayton, says in his report the increases in revenue were from lighting 10 per cent. and from power 54 per cent. During the year capital expenditure of £1,022 has had to be defrayed out of revenue, bringing the total deficit for the year to £2,086, against which the department has received from the rates £2,100 originally earmarked for the tramways. Public lighting units were reduced about 98 per cent., but units for all purposes increased 26 per cent. The cost of coal increased 87 per cent. (£4,421). Commencing with the September quarter, 10 per cent. was added to charges for current, except with regard to power supply agreements (in which there is a sliding scale), and, in consequence of coal and other costs exceeding the estimate, it has been found necessary to further increase the tariffs in the present year. In consequence of the L.G. Board's decision prohibiting the expenditure of further amounts on rental wiring the supply in the eastern district does not yet bring in an adequate return. The tender of Fraser & Chalmers for coal-handling plant was accepted in February, 1915. The L.G. Board, who declined to sanction the scheme then, was induced to sanction it in the autumn of 1915, but, owing to the difficulty of getting men and materials, the erection of the plant was only half way towards completion at March 31 last. The committee dealing with coal saving might be better employed in looking into the working of the collieries rather than in adjuring electric supply undertakings to reduce their consumption by methods which will not produce in practice the result aimed at. The charging of electric vehicles is a new source of revenue which has been tapped during the year. There are four such vehicles running in the town, of which one belongs to the electric supply department. It is expected that the number in use will considerably increase.

The capital expenditure on the tramways amounts to £115,675 (no increase), of which £92,803 is outstanding. Revenue was £28,286 (compared with £23,288 in previous year), and working expenses were £19,178 (£15,289), war allowances were £586 (£236), and repayment of loan required £2,274 (£2,206), the net result being a profit of £2,756 (compared with a loss of £2,104). Total revenue per car-mile was 10·94d. (8·705d.), and working expenses, including power, were 7·422d. (7·210d.). Passengers carried were 6,798,589 (5,610,332), car-miles run 620,115 (642,092), and units used 686,328 (670,809)=1·107 (1·045) per car-mile.

Manchester.—The tramway accounts for the year ended March 31 (which were approved by the Tramways Committee last week) show gross capital expenditure £2,231,547 (increase £15,539), of which £609,210 has been paid off or placed in sinking fund. Renewals and depreciation fund is £413,262.

Total revenue was £939,469 (compared with £901,875 in previous year), including motor 'buses £1,083 (£786) and parcels £3,405 (£3,639). Working expenses were £561,438 (£572,441), war service allowances £92,808 (£31,763) and gross profit, including bank interest, was £299,740 (£312,285). Interest on loans required £59,736, redemption £61,236, street improvements (interest and sinking fund) £6,128, rent, &c., of tramways £26,773, leaseholds (proportion of outlay) £684, and income tax £24,000; and of the balance, £121,181 (against £148,584), £21,181 (£48,584) has been placed to reserve, renewals and depreciation account and £100,000 (as in previous year) contributed in aid of rates. Total revenue per car-mile was 12·197d. (11·3d.), and working expenses, including power, were 7·289d. (7·172d.). Passengers carried were 209,877,667 (202,768,420), of whom 758,034 (1,186,569) were motor 'bus passengers, car-miles run were 18,486,440 (19,155,051), and units used 28,713,922 (29,922,197).

The general manager, Mr. J. M. McElroy, says in his report the aggregate length of single track open (including lines over which the Corporation exercises running powers) is 195 miles. In the early stages of the war the revenue was adversely affected, but during the year a remarkable recovery took place. Ordinary working expenses decreased, but the total expenses show an increase in consequence of the payment of war allowances, &c., £92,808. The number of cars in stock is 685. The construction of car bodies and covers is suspended owing to Treasury restrictions on capital expenditure. The parcels department carried 1,225,718 (1,236,500) parcels, and the total receipts were £14,185 (£13,571), and net receipts £3,405 (£3,639). Total track mileage, including lines over which the Corporation has running powers, is equal to 203 miles of single track. Traffic revenue on the motor 'buses was £4,080 (=11·84d. per car-mile, against 9·244d. in previous year), total working expenses were £2,470 (=7·17d., against 7·367d.), and, after providing £526 for depreciation, the balance was £1,083 (=3·143d., against 1·174d.).

COMPANIES' MEETINGS AND REPORTS.

Globe Telegraph & Trust Co. (Ltd.)

The forty-third ordinary general meeting was held on Tuesday, under the presidency of Sir JOHN WOLFE BARRY, K.C.B., the Chairman of the Company.

The SECRETARY (Mr. Sidney Collett) having read the notice convening the meeting and the minutes of the last meeting,

The CHAIRMAN said: Those of you who have looked into the report will have observed that certain changes have been made in some of the investments. All these changes, without exception, have resulted in benefit to the Company, and have tended to increase our income. In addition no less than four of the companies in which we are interested have increased their dividends during the year. In two of these we have our largest holdings—namely, the Eastern Telegraph Co. and the Eastern Extension Telegraph Co.—while the Western Telegraph Co. have also announced their intention of increasing their dividend when they make their final distribution in November next. So that altogether it is a great pleasure to be able to say to you that the report which we present to-day is the best which has ever been placed before the shareholders since the inception of the Company 43 years ago. Our total receipts for the 12 months ended May 31 last, after deducting the usual working expenses, amounted to £226,085, as against £209,161 in the preceding year, or an increase of £16,921, and makes with the balance carried forward from the preceding year a total of £253,740. We have already distributed to our preference shareholders the usual three quarterly interim dividends of 3s. per share, less income tax, and three quarterly interim dividends of 2s. per share, free of income tax, to our ordinary shareholders; these altogether have absorbed the sum of £122,932. Your Directors now recommend the payment of a final dividend of 3s. per share, less income tax, on the preference shares, making 6 per cent. for the year, and of 8s. per share, free of income tax, on the ordinary shares, making with previous distributions a total dividend for the year on those shares of 7 per cent., free of income tax. These final distributions will absorb a further sum of £93,959, and leave a balance of £36,848 to be carried forward to the next account. With regard to the changes in the investments I referred to a moment ago, you will see from paragraph 5 of the report that we have sold during the year stocks to the value of £3,700, and, in addition to this, a sum of £1,080 became available for investment by a drawing of nine certificates in the Submarine Cables' Trust belonging to this Company. We have invested the proceeds in shares of the Eastern Telegraph Co., the Telegraph Construction & Maintenance Co. and the Indo-European Telegraph Co.; and you will be interested to know that, while the dividends on the stocks sold were subject to tax, the dividends which we shall receive from those Companies in which the proceeds have been reinvested will come to us free of income tax. There is an increase of 1 per cent.—that is, from 7 per cent. to 8 per cent.—in the return on our holdings in the Eastern and the Eastern Extension Telegraph Companies; and an increase of 3 per cent.—that is, from 6 per cent. to 9 per cent.—on our receipts from the Central & South American Telegraph Co., and a further increase on the ordinary dividend in the Direct Spanish Telegraph Co. Last year they increased their dividend from 5 per cent. to 6 per cent., and now they have again increased it from 6 per cent. to 7 per cent. All these dividends, like those I have just referred to, come to us free of income tax, with the sole exception of that from the Central & South American Telegraph Co. There are also other changes which you will notice on comparing these figures with those of the preceding year, but these are entirely due to the incidence either of the British income tax or the rate of exchange with America, both of which have undergone great changes during the year, and affect especially those dividends which we receive on the American companies' shares. Then you will have also noticed from paragraph 6 of the report that, following the course adopted by the larger associated telegraph companies in this building, of which I may say the Directors of this Company are also directors, "The shareholders will be asked at this meeting to approve the payment of the Directors' remuneration free of income tax." I think I need not repeat here what I said at the meetings of the Eastern and the Eastern Extension Telegraph Companies on this subject, except, perhaps, to remind you that not only have the staff of this Company always received their salaries free of income tax, but our ordinary shareholders have likewise enjoyed the privilege of getting their dividends regularly free from any deduction of tax. The suggestion now laid before you is one which has already been authorised not only by the great telegraph companies in this building, but by many other leading companies in the City of London, the capital of which is to be reckoned by many millions. Your Directors feel sure that when I place the formal resolution before you, which I shall hope to do in a moment, it will receive the approval of the proprietors, who doubtless fully appreciate what has been done by their Directors. With regard to the auditing of the accounts, you will observe that on this occasion they are certified by one set of auditors alone—Messrs. Deloitte, Plender, Griffiths & Co. This is in accordance with the arrangement which was made at our meeting last year, when I mentioned to you with regret that Mr. Newton was no longer able to serve in that capacity. There is one other item which I generally mention at these meetings, and that is to inform you that the present market value of the securities we hold, taking the lowest market prices, shows a surplus over the original capital of £679,000. I now propose that the printed report and accounts be received and adopted, and that final dividends, as recommended, be declared.

Sir JAMES PENDER, Bart., seconded the resolution, which was carried unanimously.

The CHAIRMAN then moved that the Directors' remuneration be paid free of income tax, including the period covered by the accounts submitted to the meeting.

Sir JOHN DENISON-PENDER, K.C.M.G., seconded the motion, which was carried.

The retiring Director, Sir Albert J. Leppoc Cappel, K.C.I.E., was re-elected, and Messrs. Deloitte, Plender, Griffiths & Co., were re-appointed. A vote of thanks to the chairman, directors and staff concluded the proceedings.

BOMBAY ELECTRIC & SUPPLY TRAMWAYS CO. (LTD.)—The report for 1915 shows that the total revenue was £310,770, an increase of £8,200 over 1914; expenditure was £142,091, a decrease of £2,895; net profit aggregated £168,678, an increase of £11,095. After providing for interest on debentures, placing to sinking fund account £6,732, to depreciation fund account £28,000, providing for annual payments for redemption of second debentures of equivalent par value £8,000 and making a contribution to officers' and employés' provident fund of £2,507, there remains £87,670, to which is added the amount brought forward of £8,326. The directors recommend a dividend on the ordinary shares at rate of 7 per cent. per annum (tax free), leaving to be carried forward £9,602. The gross tramway receipts were £172,051, compared with £169,884; working expenses were £79,661, against £85,297. The balance of receipts over expenses is £92,386, compared with £84,587. The gross revenue from electric supply for the year (including amount represented by sale of current to tramways) aggregated £138,020, compared with £132,669. The working expenses were £58,132, against £55,734, and balance £79,888, compared with £76,935.

BRITISH THOMSON-HOUSTON CO. (LTD.)—The directors' report for the year 1915 states that the buildings and machinery of the company's works at Rugby, Coventry and Willesden have been maintained in first-class condition during the year. This year the company were able to take the usual inventory in their Rugby main factory, and the figures show a considerable increase over the book figures. The profits for the year (after deducting all expenses and charges other than interest on debentures and loans) are £262,361, 1s. 10d., and with amount brought forward (£13,797, 12s. 6d.) the total is £276,158, 14s. 4d. The amount paid for interest on debentures and loans during the year was £57,922 0s. 11d., leaving £218,236, 13s. 5d. The directors recommend the transfer for reserves and depreciation of £144,878, 1s. 2d., so as to strengthen still further the company's position, and to carry forward to new account £73,358, 12s. 3d. The amount carried forward includes a reserve to cover the sum payable to the Government for excess profits, which cannot be accurately determined at present. Under the terms of the trust deed securing the issue of the company's debentures, the company has this year to pay to the trustees the sum of £1,452, to be applied by them in redeeming debentures at 105 per cent. by drawings. Since the closing of the books debentures of the par value of £4,240 have been redeemed, making the total par value of debentures retired to date

£34,265, and leaving a net amount outstanding £177,735. During the year Mr. C. Burrell, who has been a director for 20 years, resigned from the board, which resignation was accepted with regret.

CONSOLIDATED ELECTRICAL CO. (LTD.)—Mr. H. Allen, who presided over the annual meeting last week, referred to the death of the secretary (Mr. T. Taunton), and said Mr. J. F. Clark had been appointed to the vacant position. Their total income from all sources for the year ended March 31, 1916, was in excess of the income for the previous year, but they were paying a slightly reduced dividend. They had made no attempt at a valuation of the investments, which figured in the balance-sheet at cost. The only two that gave cause for real anxiety were the shares and bonds of the Constantinople Telephone Co. The fate of the English proprietors of that undertaking must depend largely upon the fate of Turkey at the end of the war. Political influences apart, the Constantinople Telephone Co. was a most promising undertaking. Then what was regarded as almost their best investment—one made shortly before the war—had turned out to be the worst in the matter of depreciation, though it now showed some slight signs of recovery.

MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)—Mr. Godfrey C. Isaacs presided at the meeting on Friday last, and, after explaining the absence of Senator Marconi and giving an analysis of the accounts, he said that there was considerable work in certain parts of the world which they should have been doing, but which it had been impossible to do in consequence of the war. On the other hand, they had had some compensation by having many additional orders at home and from allied countries. In particular, they had done considerable business with the Admiralty, and nothing could have been more agreeable than the relations between the company and that department. Their associated companies had not been able in consequence of the war to make the progress which they otherwise would have done. That applied particularly to their Spanish and Argentine companies, to the Relay Automatic Telephone Co., and to a considerable degree also to the American company. The new direct trans-Atlantic service with New York, which was ready to open when war broke out, and to which they both had attached the very first importance, had continued in enforced idleness, the stations on this side having remained in the service of the Government. For that they hoped to receive due compensation. Their Belgian company had been unable again to make up any balance-sheet. Their programme in respect of the Canadian company had also been obliged to remain in abeyance. The French company had continued to do a satisfactory business, and had paid dividends equivalent to those of the preceding year. The Marconi International Marine Communication Co. had shown an increased profit, and was making excellent headway. Their Russian company had continued to be extremely busy, and had declared a dividend for the past year at the rate of 15 per cent. The Spanish & General Trust had suffered in consequence of the war. They had continued to do an important business with the Italian Government through their Italian agency under the energetic and able management of the Marquis Solari. They had had an excellent year, and, having £447,315. 0s. 7d. to credit of the profit and loss account, they were distributing only a small proportion of that amount, carrying forward £307,546. 4s. 7d. In harbouring their resources they were satisfied that they were acting in the best interests of the company. Had they known their position with regard to the several matters in respect of which they had to receive payments from the Government, they would have been able to be more generous in the distribution. There were four heads under which considerable sums were payable by the Government to the company. The first of those was the remuneration and compensation which is due to them from the Post Office, acting on behalf of itself and other Government departments, in respect of the use of the company's high-power stations since the beginning of the war, the staffing and management of those stations and other services in connection therewith. To the end of December, 1915, they had handled foreign messages in transmission, reception and delivery which represented in the aggregate a total of over 20,000,000 words. As regards compensation, they were aware that they had just completed the construction of their Carnarvon and Towyn stations, and also in America the American company had just erected its New Brunswick and Belmar stations, all of which represented a very considerable outlay, for the purpose of opening a direct telegraph service between Europe and America. Traffics during the period of the war had shown very considerable increase, and there was no doubt whatsoever that the business they should have done would have been on a very large scale indeed, and the profit since the outbreak of war would have, in their estimation, run well into five figures. They were of opinion that they should receive a substantial sum to compensate them for that loss. He had had the assurance of the Postmaster-General that those questions were receiving his earnest consideration, and every endeavour would be made to deal with them at once. In regard to their claim against the Admiralty in respect of the use of their patents since the expiration of the agreement on March 31, 1914, they had supplied the Admiralty with a very considerable number of installations since the outbreak of war under contract, and the royalty in each of those cases had been defined and paid, but there had been infinitely more installations which were already fitted, and others which had been constructed by the Admiralty themselves, in respect of each of which a substantial sum was payable to them. It was fair to assume that where they had not had the opportunity of making the manufacturing profit the royalty to which they should be entitled should not be less than in cases where it was accompanied by a manufacturing profit. They had a similar claim upon the War Office. They had never had any agreement with the War Office in respect of the use of the company's patents, and up to the time of the war there had been some use of their patents, but not on a large scale. An offer was made to the company in 1912 which was less per installation than what they had since been receiving from the Admiralty, and which they did not feel justified in accepting. Since then there had been an immense number of installations supplied to the War Office from outside sources, and a very large number also manufactured in the factories of the War Office, all of which came under their patents. The fourth item had reference to the claim on the Post Office for compensation in respect of its withdrawal from the contract for the Imperial chain of stations. It was by far the most important matter of all, and he had hoped that it would have been possible to have arrived at satisfactory terms which would have avoided the necessity of his saying more than a few words upon the subject. On Jan. 21, 1915, they were informed that the Postmaster-General was willing to proceed with the construction of all the six original stations. But he would remind them that they had been informed just before that the Government had decided not to proceed with the construction of the stations of the Imperial chain owing to the altered circumstances resulting from the war. They declined the Postmaster-General's offer to reinstate the contract, notwithstanding all the importance which they had always attached to it. In February, 1915, as Mr. Marconi told them last year, new negotiations were entered into with H.M. Government. On that occasion, however, those negotiations were not with the Post Office, but with the Admiralty, and in consequence of its being represented to them that four of the original stations were urgently needed, and although the conditions offered to them were (in his view) less favourable than those of the 1913 contract, the number of stations being reduced from six to four and the duration of the contract shortened, he felt himself constrained, in view of its national importance, to undertake to recommend his colleagues to accept the basis proposed for the new agreement. The draft agreement was to be submitted to them promptly, and the stations were to be proceeded with immediately. No draft agreement had ever been received. The company had never yet been officially informed why the draft had never been submitted to them. After several inquiries without result, and many more months of patient waiting, they realised that there was no alternative but to proceed with their claim for compensation. They were of opinion that they were entitled to a very large sum under each of those heads. There was but one other matter to which he wanted to make reference. They would remember that on April 3 last they were informed by circular that Mr. Marconi had been engaged in research work in Italy, where he had been able to carry out some important improvements and tests. The results obtained were far reaching and directly concerned the future practice of the entire science of wireless telegraphy and wireless telephony over both long and short distances, no matter whether conducted by means of ordinary sparks, quenched sparks or continuous waves, and that by that means results hitherto impossible would be obtained. Since then Mr. Marconi has been able to pay a visit to this country, and had described to him the nature of his new work. He announced at the meeting of the Marconi International Co. that in the very near future Mr. Marconi would introduce a new, independent and very simple installation, to be worked from the bridge of a ship, which would put an end to all danger of collision at sea in darkness or in fog. That represented but a part of Mr. Marconi's latest work. It was his belief that his new inventions would prove as epoch making in the progress of the art of wireless telegraphy as was in 1900 the now world-famous patent known as the four sevens.

TROWBRIDGE ELECTRIC SUPPLY CO. (LTD.)—The chairman (Mr. J. H. Blake) presided at the recent annual meeting, and stated that the profit for the year was only £348. 4s. 7½d., against £436 in 1915. The decrease was not because the company had had a reduction in sales, but because they were generous to consumers and did not increase the price as early as they ought to have done. They delayed putting the price up because they hoped the war would end and things become normal. The cost of the maintenance of the works had enormously increased, and in view of that he thought they could congratulate the managing director on keeping the expenses as low as he had, and that they were able to pay the same dividend as last year. Up to the present the directors had given their services free, but he hoped the time would come when they would be warranted in having some small acknowledgment for services rendered. They were still prohibited by the Council from erecting overhead wires in the Bradley-road district. It was quite impossible to give an underground supply, as the price was prohibitive.

J. G. WHITE & CO. (LTD.)—Mr. W. C. Burton, who presided at the meeting last week, said that the effect of the war had been largely to stop all business of the character which they were equipped to carry on—namely, engineering constructional works in all parts of the world. On the whole, a company in their position was fortunate in having been able to meet all its expenses and to show a net profit sufficient to cover 6 per cent. on its capital, with a comfortable margin, even though that figure was small compared with what the company had done in the past, and what it should do again under approximately similar conditions. The profit for the year to date amounted to £17,380, against £19,772 last year, a small and not serious reduction under the circumstances. With the amount brought forward there was £46,939 to be dealt with, out of which the directors were recommending a dividend of 6 per cent. upon both classes of shares. The future development of the business depended upon there being a supply of capital available for new constructional enterprises, and that could only be expected after the restoration of normal peace conditions. In the meantime they must husband their resources and keep together as far as possible the essential elements of their staff, and be in a position to take prompt advantage of the first opportunities. They were also endeavouring to develop new channels in which their experience could be utilised, more particularly by increasing and broadening the scope of their commission purchasing department, and,

in connection with J. G. White & Co., of New York, securing business with those American interests who were for the first time giving serious attention to foreign business in South America and elsewhere.

CITY NOTES.

MEMORANDA (July 5).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 61¼. Consols Pay Day, Aug. 2. Stocks and Shares Ticket Days, July 12 and 27. Pay Days, July 13 and 28. Price of silver, 30½d.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) The directors have declared an interim dividend for the quarter ended March 31 last of 3s. per share (tax free), payable on the 15th inst. The share register will be closed from July 7 to 14 inclusive.

HART ACCUMULATOR CO. (LTD.)—The net profit for 1915, including £11,394 brought forward, was £21,725. A dividend of 5 per cent. is proposed, carrying forward £16,948.

INDIA RUBBER, GUTTA PERCHA & TELEGRAPH WORKS CO. (LTD.)—The directors have declared an interim dividend of 5s. per share (tax free) on the ordinary shares.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—The directors have declared an interim dividend at rate of 7 per cent. per annum on the preference and 5 per cent. per annum on the ordinary shares for the half-year ended June 30, payable on Aug. 5 next.

TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)—The transfer books of this company are closed from the 3rd to the 13th inst., inclusive, preparatory to the payment of an interim dividend of 5 per cent. (12s. per share) to shareholders on the register on the 3rd inst.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date July 4, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	16d.
Solid Drawn Copper Tubes	13½d.
Brazed Copper Tubes	13½d.
Brazed Brass Tubes	18d.
Brass Wire	16½d.
Copper Wire	19d.
Rolled Brass	15½d.
Brass Sheets	16½d.

	per ton.
Copper Sheets	£152 0 0
Spelter	£51 0 0

	per ton.
English Lead	£20 10 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£95 0 0
Clean Brass Scrap	£61 0 0
Braziery Copper Scrap	£31 0 0
Old Lead	£23 10 0
Old Zinc	£31 0 0
Hollow Pewter	£120 0 0
Black Pewter	£30 0 0
Gun Metal	£63 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date July 4, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£95 0 0
Clean Mixed Brass	£57 0 0
Clean Copper	£83 0 0
Braziery Copper	£78 0 0
Gun Metal	£78 0 0

	per ton.
Old Lead	£25 0 0
Tea Lead	£23 0 0
Old Zinc	£35 0 0
Hollow Pewter	£120 0 0
Shaped Black Pewter	£30 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £85; Commercial Tinman's Solder, £112; Blowpipe Solder, £122.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, July 4. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., July 4.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	8⅞	5 11 8	Feb, Aug
10	6%	Do. 6% Cum 2nd Pref.	10⅞	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅞	7 12 5	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. C. Deb. St	80	5 0 0	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 8	Jan, July
5	2/3	Do. 4½% Pref.	3⅛	7 4 0	..
5	5%	Do. Ord.	3⅞	7 0 4	Aug, Feb
5	4½%	Do. City Pref.	2⅝†	7 18 3	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	2⅛	7 3 10	Mar, Sept
St.	4½%	Do. do. Deb.	87†	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12⅞	6 11 3	Feb, Aug
10	6/0	Do. 6% Pref.	10½	5 14 3	Mar, July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun, Dec
St.	4½%	Do. 4½% Debs.	91†	5 11 1	Jun, Dec
10	7%	County of London Ord.	10½	7 0 0	Mar, Sept
10	6%	Do. 6% Pref.	10⅜	5 15 8	Feb, Aug
St.	4½%	Do. 1st Deb.	87½†	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	83½	5 7 4	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	75½	5 18 10	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6%	London Elec. Supp. 6% Pref.	4½	6 13 4	..
St.	4%	Do. 4% Mort. Debs.	80½	4 19 9	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅜	6 6 4	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80†	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99†	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Debs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	2⅜	7 5 5	Mar, Sept
5	8%	St. James' & Pall Mall Ord.	5⅝	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅝	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	71½	6 5 10	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅜	6 14 9	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6⅞	5 15 6	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4½†	5 5 11	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	82	6 1 11	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	80	7 10 0	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	73	5 9 7	..
St.	4%	Do. do. Assented Def. Ord.	72	5 7 6	..
St.	4½%	Do. 4½% Pref.	82	5 9 9	Jan, July
St.	4%	Do 4% Deb. St.	76	5 5 3	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1895	70½	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅝	5 16 1	Jan, July
St.	4%	Do. 4% Pref.	68½	5 16 7	Mar, Sept.
St.	4%	Do. 4% Debs.	71	5 7 6	Jan, July
St	1%	Metropolitan Ry. Con. Ord.	27⅞	3 12 9	Feb, Aug
St.	3½%	Do. 3½% Pref.	65½	5 6 10	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	61⅞	5 13 4	Feb, Aug
St	3½%	Do. 3½% A Debs.	67½	5 4 7	Jan, July
St	3½%	Do. 3½% Debs.	70⅛	5 0 10	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19⅜	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	76½	5 4 7	May, Nov
St.	4½%	Do. 4½% First Pref.	74	6 1 7	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	110	5 9 1	Jan, July
St.	4%	Do. 4% Debs.	76	5 5 3	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	77½	5 3 3	Jan, July
St.	4%	Do. 4% Guar. Stock	70	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	3	5 0 0	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅝	5 6 8	Mar
10	5%	Do. Prior Lien Debs.	95½†	5 4 9	Jan, July
1	6%	Do. 6% Pref.	⅛	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	11⅝	7 14 8	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅞	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref	⅝	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	6 4 8	April
100	6%	Do. 6% Prior Lien Debs.	100½	5 19 5	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	66½†	6 0 9	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅝	8 5 10	Jan, July
5	5%	Do. 5% Pref.	4⅛†	6 1 3	Feb, Aug
St.	4½%	Do. 4½% Debs.	81†	5 7 2	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅛	7 7 8	Sept
5	..	Ellison & Swan U.Elec.Lt.A. £3 pl.	¼	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	⅜	10 0 0	May
1	7%	Do. 7% Cum. Pref.	⅝	7 4 6	Jan, July
St.	4%	Do. 4% Debs.	71¼	5 11 6	Jan, July
5	10%	General Electric Ord.	11⅛	8 11 1	July
10	6%	Do. 6% Pref.	9⅝	6 2 8	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15½	6 12 3	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4⅛	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	12⅜†	8 4 6	Feb, Aug
10	5%	Do. Pref.	8⅞†	6 1 8	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39½	6 2 4	Mar, July
100	4%	Do. 4% Debs.	95½†	4 6 0	Jan, July
1	7½%	Vickers Ord.	1⅛	4 1 4	May, Aug
1	6d.	Do. 5% Pref.	⅛	5 6 8	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 4	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 8	Jun, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40½	10 5 6	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	105	5 14 5	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23⅛	6 17 6	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	70†	5 14 3	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	7⅛	6 9 0	May, Nov
10	10%	Do. 10% Pref.	13½	7 7 10	..
5	5/0	Direct Spanish 10% Pref.	7⅛	6 13 4	..
10	4%	Direct United States	6⅝	7 15 10	Ja,Ap,Jly,O
St.	8%	Eastern Tel. Co. Ord.	149½	5 7 2	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	66⅛	5 4 10	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	77½	5 3 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78⅛	5 2 3	Feb, Aug
10	8%	Do. Ord.	15	5 6 8	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co. Ex. Coup. 10.	37⅛	5 16 9	Ja, My, Jly
25	13%	Indo-European	48½	6 14 0	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3⅛	3 1 6	April
1	7%	Do. 7% Pref.	2⅛	2 13 4	July
10	1%	West India & Panama Ord.	1⅛	9 10 11	May Nov
10	6%	Do. 1st Pref.	7⅛	7 17 5	May, Nov
10	8%	Western Telegh. Co.	141††	5 7 7	Mr,Jly,O,Dec
St.	4%	Do. 4% Deb. St.	78½†	5 1 11	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½	4 10 10	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅛	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	2	5 0 0	Apl, Oct
St.	4%	Do. Db. St.	79½†	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83†	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅜	6 0 9	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅛†	5 6 8	Jan, July
St.	4½%	Do. Deb. Stk.	85½†	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	13½	4 10 7	Sp,De,Mr,Jn
10	6%	Do. 6% Pf.	11⅜	5 8 2	Sp,De,Mr,Jn
100	5%	Mackay Companies' Common	83½	5 19 9	Ja,Apl,Jly,O
..	4%	Do. $100 Pref	67	5 19 5	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	5	6 0 0	Mar, Sept
St.	5%	Do. 5% Debs.	93½	5 6 11	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10⅞	5 16 4	..
St.	4½%	Do. 4½% Debs.	85½†	5 4 11	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6½	7 6 11	May, Nov
5	5%	Do. 5% Pref	4½	5 11 1	Mar, Sept

† Ex dividend or Interest.

† Ex dividend or Interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,991. [No. 15. Vol. LXXVII.] **FRIDAY, JULY 14, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 485
Arrangements for the Week .. 487
Graphic Determination of Hysteresis Loss. By A. Castex. Illustrated 488
High-Voltage D.C. Railway Practice. By C. Renshaw. 489
Power Requirements and Resources of New South Wales. By William Corin. Illus... 491
Notes on Design of Electromagnetic Machines. By Stanley Parker Smith, D.Sc.—*Continued* 493
The Place of Science in Education. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. 496
The Migration of the Ions. By S. W. J. Smith, M.A., D.Sc., F.R.S. Illustrated. 498
Instrument Transformers. By Chas. C. Garrard. Illus. .. 499
GRAPHICAL CHARTS 502
REVIEWS 503
The Mechanical Handling and Storing of Material [Zimmer]: Reviewed by H. H. Broughton.
REVIEWS—*Continued.*
Aeroplanes and Airships [Dommett].
The Design of the Audio-Frequency Circuit of Quenched Spark Transmitters. By Julius Weinberger. Illustrated 504
CORRESPONDENCE 505
Engineering Education and Research (A. G. Ellis).
S. P. Thompson (A. C. Eborall).
Electric Wiring Examinations (A. P. Lundberg & Sons).
"Parturiunt Montes Nascetur Ridiculus Mus."
The Measurement of Very High Insulation Resistances in Cables. By J. Fischer-Hinnen 506
PARLIAMENTARY INTELLIGENCE 507
Educational 507
The "Electrician" Commercial and Industrial Section .. 509-518

NOTES.

Uneconomical Plant *v.* Capital Expenditure.

WE recently referred to the state of affairs at Stoke-on-Trent, where some of the interconnected stations are using very old and uneconomical plant for the generation of electrical energy. Another case of the same kind is to be found at Bury, where there is a small station of 1,500 kw., and also a more modern station of 7,200 kw. Owing to the fact that the borrowing of capital has not been permissible, it has been found necessary to utilise the older plant to meet the demand, with the result that 2,564 tons of fuel have been used during the past year, whereas the same quantity of electrical energy could have been generated by more modern plant using only 1,300 tons of fuel. It is, of course, undesirable to permit the wholesale expenditure of capital in carrying out extensions of electricity works at the present time; but, nevertheless, it would be well for the Local Government Board to consider the other side of the question, and to determine whether in certain cases it would not be preferable to allow extensions with modern plant to be carried out, so as to conserve our national supplies of fuel as far as possible. Unfortunately, there are numbers of generating stations about the country using coal in most uneconomical fashion. This cannot very well be remedied except by a process of evolution, but there is no reason why a better state of affairs should not be obtained in those cases where extensions are necessary, and where the use of modern plant would result in material economy.

Obsolescence at Sheffield.

MR. S. E. FEDDEN has recently submitted a report to the Electricity Committee of Sheffield which deserves the serious attention of electricity supply engineers. There is often a tendency to assume that, so long as the capital charges are being met on a municipal undertaking according to the terms of the loan, all is well, and that the greater part of any surplus can be used for the relief of rates. This is a dangerous policy to follow. From the brief abstract which we give elsewhere it will be seen that, while the undertaking at Sheffield is complying with legal requirements as regards repayment of loans, Mr. FEDDEN feels that the reduction of capital indebtedness is not taking place fast enough to keep the undertaking in a financially sound position. In his opinion, the undertaking should be able to put away enough money to bring the reserve fund up to 10 per cent. of the indebtedness, and to build up a strong fund to deal with renewals and obsolescence. The question has been brought to the front, partly because it is felt that when trade conditions become normal once again the largest consumers will agitate for lower terms, and that if the department is not in a position to supply at the cheapest rates some of its consumers will be lost. But there are further very important facts. The plant at Sheaf-street station is entirely out of date, and yet, on the present method of repayment, it will take another 23 years to pay off the capital there involved; the plant is also out of date at Kelham Island, and yet contributions to the sinking fund must continue for another 14 years. Further, although Neepsend station was not opened until 1904, the first four turbines are also obsolete when compared with the efficiency of present-day plant.

IT is obvious from these statements that there is good ground for the view expressed by Mr. FEDDEN, and we do not suppose that this state of affairs is limited entirely to Sheffield. In fact, we believe that few electric supply undertakers have formed substantial reserve funds, as there is no statutory obligation upon them to do so, and in the past the practice of the Local Government Board in regard to loans has permitted local authorities to borrow for periods longer than the life of the plant, thus aggravating the situation. In our opinion, all electricity undertakings should have both a reserve fund for contingencies and a fund to provide for obsolescence. Considering the great advance that has been made in recent years in the efficiency of steam plant and in the reduction of capital cost per kilowatt, it is clear that every electricity undertaking should err on the side of providing for obsolescence rather than run on a basis which may in a few years turn out to be financially unsound. As the result of Mr. FEDDEN's report, the Electricity Committee recommends the City Council to increase all accounts for the supply of current by 10 per cent. where the price is more than 2d. per unit, and by 20 per cent. where the present price is 2d. per unit or less. We do not much like this precise method of dealing with a matter of this

kind, as it involves what mathematicians would call a discontinuity. Suppose, for example, that a consumer is obtaining his electrical energy at 2½d. per unit, then a 10 per cent. advance will bring his price to 2·337d.; on the other hand, if a consumer is obtaining his energy at 2d. per unit he will be subject to 20 per cent. advance, which will bring his price to 2·4d. In other words, the consumer who ought to be getting his electrical energy at the cheaper rate is charged at a higher rate than the consumer who is, presumably, less profitable.

Unco-ordinated Committees.

SINCE the outbreak of war committees innumerable have been appointed to investigate and report upon practically every sphere of human activity. During the last two years scarcely a week has passed that has not seen the formation of one or more committees having as their primary object the doing of something to help the country. The past week has seen the birth of several such committees. Were our faith less strong we should begin to think that our country must have been in an exceedingly bad way two years ago. The fact that for several years prior to the outbreak of war our industries enjoyed unparalleled prosperity may be taken as an indication that there is nothing fundamentally wrong with our methods. Beyond question, some of our institutions are archaic, but rather than do as the fool does, and pull down everything before we know for certain that we have something better to take their place, we would endeavour so to modify existing institutions as to bring them into line with twentieth century requirements. For this reason we are of the opinion that many of the new committees are a source of weakness rather than of strength. But the outstanding characteristic is that there is no proper co-ordination between one committee and another, and each is ploughing its lonely furrow alone. The inevitable result must be patchwork, and we have yet to learn that enterprise founded on such work is good either for the State or for the individual.

Science in Education.

PROF. J. A. FLEMING has contributed to the "Journal" of the Royal Society of Arts an interesting article, which we reproduce at some length on another page, the subject being "The Place of Science in Education." As is well known, Prof. FLEMING holds very decided views on the subject, and we make no apology for devoting space to the question, as it is only by dealing continually with a subject of this kind that a suitable impression can be made upon the public and upon those in authority. There are a few points in Prof. FLEMING's Paper to which we may call attention. One of these is the great use to which the cinematograph might be put as an instrument of education. Unfortunately, it is very rarely so used. It can, for example, be used to show a very slow phenomenon carried out quickly, or for showing how a very quick phenomenon is actually effected by running the film very slowly. As an example of the first we may take the growth of plants, and of the second the progress of explosive phenomena. We think it would be an excellent thing if the authorities would make it a stipulation that exhibitions of moving pictures should include certain educational subjects. They need not all be of the character to which we have referred, but might also very well deal with all kinds of industrial topics. By so doing some of the objectionable features of present-day picture palaces would be reduced. A great deal of Prof. FLEMING's Paper deals with the subject of instructing the very youthful mind. Education in the early stages is, no doubt, important, for the mind at that time is much more receptive than later on. We quite agree that boys should be allowed to perform experiments themselves, and not merely the teacher, science being thus treated on an experimental basis, and the purely lecturing part of the instruction being reduced to a minimum. By so doing, powers of observation are cultivated. With regard to the vexed question of science *v.* classics, the very practical suggestion has recently been put forward that science should be made a subject of capital importance in the Civil Service and Army entrance examinations, and a meeting was held, under the chairmanship of Lord RAYLEIGH, at which resolutions were passed urging this course. We hope that these resolutions will prove effective, for it is only by some such means that the idea of the supreme importance of classics as against science will be removed from the position which it at present holds.

Selective Telephones.—A Paper was read recently by Mr. G. Edmondson before the "Institution of Railway Signal Engineers" on "Faults on Telegraph and Telephone Circuits." The Midland Railway Co. prefers the ordinary telephone system, whereby any station can call up the train controller, or any other station. The "Engineer" points out that on the Taff Vale & Rhymney Railways, where the traffic is very dense, selective telephones are used with great success. The same is the case with both the Great Northern and Great Central Railways.

The Safety Lamp.—Profs. F. W. Hardwick, M.A., and L. T. O'Shea, M.Sc., read a Paper before the Institution of Mining Engineers on "The History of the Safety Lamp." During the period 1888-1913 the most striking feature was the large number of stations for testing lamps. Among the more important lamps of this period are the "Howat" lamp, the "Ashworth-Hepplewhite-Gray," the "Thornbury," the "Fumat," and the Hailwood "Combustion Tube" lamp. As the result of investigation there has been a tendency to restrict the use to "permitted" lamps.

Power Plant for Australian Dockyard.—It is announced that on the advice of the British Admiralty the Australian Naval Board has decided to install geared turbo-generator sets in the power station which will serve the needs of the dockyard at Cockatoo Island. Tenders had been originally invited for geared turbo-generator sets, reciprocating sets with exhaust turbines, reciprocating sets with exhaust geared turbo-generators and Diesel engine sets. Only one Australian tender was received. This was for a reciprocating engine installation, and the price quoted is said to have been 70 per cent. in excess of other tenders on the same lines.

Two-Speed Alternating Current Elevator Motor.—In the "Electric Journal" there is an article on the above by Mr. W. H. Paterson. The distinctive feature of the motor is the use of two windings on both the stator and rotor. These windings on a 60-cycle circuit give speeds of 250 and 840 revs. per min. respectively. On starting, the lower speed winding is connected to the circuit, and when the motor attains its maximum speed which corresponds to a car speed of 120 ft. per minute, the connections are automatically changed to the higher speed winding, with a resistance in the rotor circuit. Finally, this resistance is cut out, bringing the car to its maximum speed of 400 ft. per minute.

Electric Sub-Station Attendants.—A Committee of the Institution of Electrical Engineers, in co-operation with the Education Department of the London County Council, have arranged a four-weeks' course at the Northampton Polytechnic Institute, Clerkenwell, E.C., to enable disabled sailors and soldiers to qualify for training as sub-station attendants. A first batch of 14 men will complete their course about the third week in July, and successive batches will be available from time to time, if it is found that there is a demand for their services. Central station engineers having vacancies in their sub-stations which could be offered to these men are requested to communicate with Dr. R. M. Walmsley, Principal, Northampton Polytechnic Institute, St. John-street, Clerkenwell, London, E.C.

Women in Electric Supply Service.—The "Municipal Journal" states that the Electric Supply Committee of St. Marylebone Borough Council has engaged women to replace men who have joined the Forces wherever possible. A storewoman is now in charge of the generating station stores. With the exception of the chief technical clerk, all clerical work at the station is now done by girls. The committee is engaging girls for the switchboard galleries at the generating station and the sub-stations. A woman district representative has been engaged in the sales department, and the committee is making arrangements at Aybrook-street for the employment of women as lamplighters, meter readers, testers, and in any other capacity where they can replace men.

OBITUARY.

Sydney T. Dobson.—We regret to have to record the death of Mr. Sydney Thornton Dobson, chief engineer to the St. James' & Pall Mall Electric Light Co. (Ltd.), who was accidentally drowned in Poole Harbour on July 3. Mr. Dobson was born in London in 1866, and was educated at St. Paul's College, Stoney Stratford, and at King's College, London. He entered the service of Messrs. Edmunds & Goolden as an improver, and was engaged for some time on installation work, and in running the Hochhausen plant exhibited by that firm at the Health Exhibition. In September, 1884, he was apprenticed to Messrs. R. E. Crompton & Co., and during the latter portion of his time he carried out experimental work under Mr. James Swinburne. In March, 1887, he was sent by Messrs. Crompton to their installation at the Tilbury Docks as second engineer. In September, 1887, he left for Vienna to take up a position on the electrical staff of the Imperial Continental Gas Association, and as senior assistant had charge of the large central station employed in lighting the Court Theatres. At the time this station was the largest example of supply by means of low-pressure currents and storage batteries, the distribution being effected on a four-wire system. In September, 1889, Mr. Dobson returned to England to take up his appointment as chief engineer to the St. James' & Pall Mall Electric Light Co. (Ltd.), a position he occupied at the time of his death. He designed and carried out all the works and plant of the company; in 1900, when the St. James' & Pall Mall Electric Light Co. joined the Westminster Electric Supply Corpn. (Ltd.) in obtaining Parliamentary powers for the construction of large power works by the Central Electric Supply Co. for bulk supply to the two companies, he was associated with Sir Alexander Kennedy as joint engineer of the scheme. Mr. Dobson was a member of the Institutions of Civil, Mechanical and Electrical Engineers.

W. H. Ash.—We also regret to record the death, which took place on the 9th inst. at Wallington of Mr. William Henry Ash, late superintendent of the Eastern Telegraph Co. at Porthcurnow. Mr. Ash was born at Torquay, and began his telegraph career with the old Electric Co. there in 1861. After serving at Plymouth, Bristol and Haverfordwest, in 1869 he accepted an appointment in the Falmouth, Gibraltar & Malta Telegraph Co. (which, with other cable companies, was amalgamated into the Eastern Telegraph Co. in 1872). In June, 1870, Mr. Ash was appointed to open the London Cable Station at 74, Old Broad-street. At that time some 200 messages a day represented the traffic, while a total of 17,000 messages in 24 hours is now sometimes reached. It soon became necessary to remove the chief operating office to 11, Old Broad-street as the chief London station. In July, 1877, he was appointed Superintendent at Porthcurnow, where he remained for 36 years, and took his part in the growth of the great system of the Associated Companies, both in regard to the large increase in the number of cables, the increased speed of working and the training there of the large staff of operators, who, after passing through the London training school, go to Porthcurnow before being transferred to the companies' stations in Europe, Asia, Australasia and Africa. Hence the name of Mr. Ash is known as well in the furthermost corners of the earth as at home. He retired from active work in 1912. In this country and abroad his loss will be greatly regretted by a very wide circle of friends.

Capt. Rene Chasseriand.—We regret to learn of the death of Capt. René Chasseriand, chief editor of "La Lumière Electrique," who was recently killed by a shell at Verdun while in command of a field battery.

Killed in Action.—With regret we record the death of Captain J. S. Davidson (formerly of the 1st County Down Volunteers), only surviving son of Mr. C. S. Davidson, and a director of Davidson & Co. (Ltd.), of Sirocco Engineering Works, Belfast. He was 38 years of age, and at the time of his death was an Infantry Brigade Captain of the Ulster Division, and was in charge of a machine gun company.

We regret to announce that Capt. Alfred L. Wood, of the Lancashire Fusiliers, was killed in action on July 2. Capt. Wood, who was 30 years of age, was a B.Sc. of the Manchester University. He was associated in business with the Lancashire Dynamo & Motor Co., Trafford Park, and had acted as the company's representative in India. He joined the Fusiliers in October, 1914 and went to France in November last.

Capt. John Griffiths, B.Sc., of the R.I.R., has fallen in battle. He was science master of Larne Grammar School and Larne Technical School.

Second-Lieutenant Claude S. Coombs, of the Queen's Own Royal West Kent Regiment, has died in hospital from wounds received in action. He was educated at the City of London School and the City and Guilds Technical College, Finsbury, and was a student-member of the Institution of Electrical Engineers.

Lieut. James L. Gow, K.O.S.B., who has fallen in battle, was educated at the Heriot Watt College, Edinburgh. He was an engineer-draughtsman by profession.

PERSONAL.

The Right Hon. E. S. Montagu has been appointed Minister of Munitions in succession to the Right Hon. D. Lloyd George, who becomes Secretary of State for War.

Major W. A. Vignoles, borough electrical engineer of Grimsby, who has been on active service with the 10th Lincolns since the formation of the battalion, has been wounded. We are informed that he is now in hospital in London, and our readers will be glad to learn that he is making good progress and is able to get about a little. Major Vignoles had two or three fingers of the left hand badly smashed.

It is announced that Col. H. A. Johnson (a member of the firm of R. Johnson & Nephew), commanding a battalion of the Manchester Regiment, has been wounded.

Royal Engineers (T.F.)—The following appointments have been made:—

Tyne Electrical Engineers: Cadet D. S. Anderson (from Durham University O.T.C.), F. L. Adendorff and T. S. Rea to be second lieutenants (on probation). Lieut. (temp. Captain) C. M. Forster is seconded.

APPOINTMENTS VACANT AND FILLED.

A capable electrician is wanted, able to do repairs and familiar with upkeep and repairs of d.c. motors and generators. *See advertisement.*

An advertiser requires two expert male shorthand typists, used to electrical engineering terms.

Loughborough Electricity Committee invite applications for the post of engineer and manager of their undertaking. Salary £300 per annum. Applications to the Town Clerk by July 24.

Mr. R. C. Carter has been appointed mains assistant in the Rexhill electricity department.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Commanding Officer, Lt.-Col. C. B. Clay, V.D.

Orders for the Week.

Officer for the Week.—Platoon Commander J. R. G. Williamson.
Next for Duty.—Platoon Commander A. Gerard.

Saturday, July 15.—Parade 3 sharp, Golder's Green Station. Uniforms.
Monday, July 17.—Technical for Platoon No. 9, 46, Regency-street, S.W. Squad and Platoon Drill, Platoon No. 10. Signalling Class and Recruits.
Tuesday, July 18.—Officer's Instructional Class 6—7. Recruits 7—8. Lecture 7.15.
Wednesday, July 19.—Platoon Drill for No. 1 Platoon.
Thursday, July 20.—Platoon Drill, No. 5 Platoon. Recruits 5.45—7.45. Instructional Class 5.45.
Friday, July 21.—Technical for No. 10 Platoon, 46, Regency-street, S.W. Squad and Platoon Drill, No. 9 Platoon.
Saturday, July 22.—Instruction Parade, 2.30, Company Commander Fleming.
Sunday, July 23.—Entrenching at Otford. Parade Victoria (S.E. and C. Rly. Booking Office), 8.35 a.m. Uniform, Haversacks, Water bottles. Midday rations to be carried. Railway vouchers will be provided.
Otford Camp.—For the Standing Camp at Otford, *see* Monthly Orders.
Musketry.—For all Companies *see* Notice and Tables A and B at Headquarters.
Note.—Unless otherwise indicated, all Drill, &c., will take place at Chester House.

GRAPHIC DETERMINATION OF HYSTERESIS LOSS.

BY A. CASTEX.

Summary.—A description is given of an abac for rapidly estimating hysteresis losses.

The following is an abstract of a Paper entitled "Calcul des Pertes par Hysteresis au moyen d'un abaque à points alignés," which appeared recently in "L'Industrie Electrique."

It is pointed out that the ordinary Steinmetz formula for hysteresis loss when iron is subjected to cyclic magnetic changes, may be written :—

$$P=\eta f B_0^{1\cdot6}10^{-4},$$

where P represents the loss in watts per cubic centimetre, f the frequency in cycles per second, B_0 the maximum value of the induction in C.G.S. units, and η the Steinmetz coefficient. Owing to the fractional index it is necessary to use logarithms in calculating the loss, and this renders the calculation somewhat tedious.

A new application of nomographic methods of great generality has recently been given by Prof. M. d'Ocagne, of which there is no need to recall here the advantages, many of them being well known to engineers.

We may write the above equation in the form :—

$$\log f-\log P=1\cdot6B_0 10^{-4}-\log\eta,$$

which occurs in the category of equations represented by a nomogram of double alignment, and with parallel rectilineal scales.

One is aware that such a nomogram is composed of four scales, and a non-graduated axis, called line of pivots, or simply hinge, on which the offsets are made.

The moduli of the scales μ_1, μ_2, μ_3, μ_4 ought to be chosen in such a fashion as to satisfy the relation—

$$1/\mu_1+1/\mu_2=1/\mu_3+1/\mu_4$$

and their axes ought to be placed at distances δ_1, δ_2, δ_3, δ_4, from the hinge, so that—

$$\delta_1/\delta_2=-\mu_1/\mu_2,\ \delta_3/\delta_4=-\mu_3/\mu_4.$$

These three relations determine only imperfectly the eight quantities represented. Nevertheless, practically their choice is limited by the necessity of giving to the scales dimensions compatible with the size one gives the nomogram.

In order to obtain sufficient precision it is convenient to give the moduli suitable values for easy interpolation of all extended values of the graduations, and one ought to choose the distances between supports and hinge, so that the cutting of the scales are not made at too small angles, so as to render readings uncertain. The following method of construction assures a good practical arrangement of the abac :—

$\mu_1=25$ cm.	$\mu_3=12{\cdot}5$ cm.
$\mu_2=12{\cdot}5$ cm.	$\mu_4=25$ cm.
$\delta_1=-10$ cm.	$\delta_3=-5$ cm.
$\delta_2=5$ cm.	$\delta_4=10$ cm.

The logarithmic equation above is then represented by the four functions—

$$f_1=0{\cdot}250\log f,\qquad f_3=-0{\cdot}125\log\eta.$$
$$f_2=-0{\cdot}125\log P,\qquad f_4=-0{\cdot}400\log B_0 10^{-4},$$

which determine completely the nomographic abac.

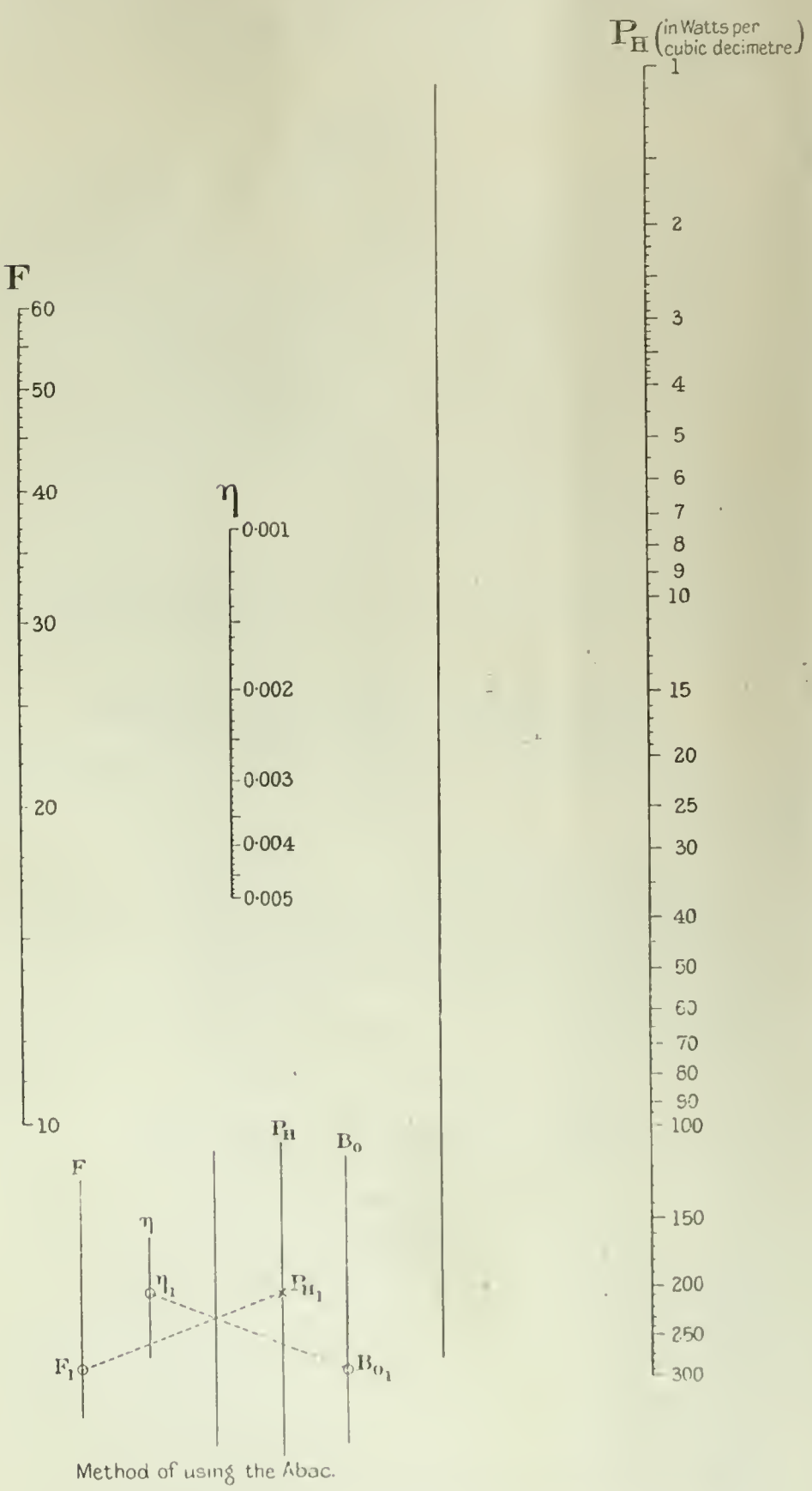
In order to construct the abac successive values of f, B_0, η and P are calculated, and marked on the lines. The first three start from the origin chosen arbitrarily, and the fourth is put in place by means of two alignments corresponding to the values given of f, B, η, for which one has previously calculated the value of P. In this way the scales shown in the figure have been obtained, the range of scales being such that they apply to practical cases occurring in manufacture.

We have already stated that in a nomographic representation with double lines, the points satisfying simultaneously the equation represented by the alignment on two upright lines, cut themselves on the hinged axis.

Suppose, for example, one wishes to find the loss corresponding to a given frequency and induction. On the abac is placed a piece of tracing paper or transparent sheet, on which has previously been drawn a line which passes through the points of the scales corresponding to η and B_0. The hinge is thus cut by the line at a certain point which serves as pivot, and one places the point of a pencil there; for a second alignment the position is determined by turning the line until it passes through the figure f of the frequency scale, the reading on P giving the value of the loss. These operations are indicated diagrammatically by the small figure in the bottom of the left-hand corner in the diagram.

It is evident that the abac is reversible, and permits the determination of any one of the quantities in the Steinmetz formula in terms of the other three. In particular, it has been used to find the maximum permissible magnetic induction for which a limit has been fixed by hysteresis loss. This determination can be made with great facility.

When the abac is used with a little care there is practically very little difference between the results obtained by it, and those obtained by calculation. This accuracy is uniform over the whole extent of the scale, and quite sufficient for practical requirements. Too great an accuracy need not be looked for, since the initial formula itself is only approximate.



ABAC FOR DETERMINING HYSTERESIS LOSSES.

HIGH-VOLTAGE D.C. RAILWAY PRACTICE.*

BY C. RENSHAW.

Summary.—The Paper deals first with the fundamental differences in apparatus for 1,200 or 1,500 volts as compared with the former 600-volt standards, and indicates the apparent tendency of general practice with regard to a number of alternative constructions which must usually be considered in each specific application of these systems. Referring, then, to the use of higher direct-current voltages which is just beginning, it points out the tendency to reach an ultimate maximum by employing a multiplicity of voltages differing but slightly from each other for successive installations. It recommends, in order to avoid the confusion which must surely result from this, that efforts be made to establish at once a single standard for high-voltage lines. The Paper shows that final standards in voltage are usually fixed by broad economic considerations rather than by physical limitations, and suggests that 5,000 volts direct current would offer a very satisfactory voltage for such a standard if commercial apparatus for this voltage were available. Finally, it touches briefly upon the operation of the experimental 5,000-volt line at Jackson, Michigan, which has been so successful as to give great hope that the system will be commercially developed.

Ten years ago the idea that approximately 600 volts was the maximum potential to be hoped for in the operation of direct-current railways was a firmly established belief. Then suddenly the plan was suggested of coupling the four 600-volt motors in pairs of two in series, instead of two in parallel, and of connecting the generators in the stations in a similar manner, so as to employ 1,200 instead of 600 volts. The plan was successful, and the use of voltages of 1,200 to 1,500 has become so common that we are able to discuss details of high-voltage direct-current equipment.

Motors.—The requirements for motors to operate two in series on high voltages differ from the designs for low-voltage service only in the fact that slipping of the wheels may interfere with the normal voltage distribution between them and concentrate a large part of the total voltage at the terminals of one machine. Experience, however, showed that special precautions were unnecessary. Insulation and creeping distances on motors must, of course, be made suitable for the full potential. The extra insulation required for 1,200-volt operation is now obtained by the use of better quality rather than greater quantity of material, and the extra distances by improved shaping and arrangement of parts. Generally speaking, therefore, motors for use in series on 1,200 or 1,500 volts have the same dimensions and weights as if made for use on only 600 or 750 volts.

There have been one or two instances where motors have been wound directly for the full line potential. Speaking generally, such motors are heavier and depart more radically from standard low-voltage designs than motors for operating two in series, and, moreover, they do not lend themselves as well to the operation of the cars partly on 600 and partly on 1,200 volts, as is so often required. In general they seem to offer no particular advantages, and are hence but little employed. High-voltage direct-current railway practice in the matter of motors may be said to consist in the use of two machines in series, these being identical in construction with standard motors for low-voltage service, except in the comparatively minor details of quality of insulation and length of creeping distances.

Control.—In control apparatus for high-voltage direct-current railway equipments the fundamental requirements are to provide sufficient circuit-opening capacity to overcome the greater tendency to hang which the high-voltage arcs possess, together with the necessary means to confine these arcs within proper bounds.

Our first 1,200 and 1,500-volt car equipments employed 13 pneumatically-operated switches, where, with the same current at 600 volts, eight would have been sufficient. Experience led to a reduction of these differences in the fundamental parts. Improvements in interlocking the work of opening the circuit at this time was transferred to another point, so that these extra switches could be omitted. Another switch had been employed, because it was feared that the high-voltage motors might require more careful handling, and hence more resistance notches than standard 600-volt motors. It was found later that such was not the case, and this switch also was omitted in later equipments. In these ways, in the types of equipment most generally employed, the additional switches necessary on account of the increased voltage have now been cut down to two for small equipments and three for large ones. In dimensions, also, it has been possible to work out designs for 1,200-volt switch groups with the same cross-sectional area and the same weight per switch as those for 600 volts.

Auxiliary Control Devices.—In the first equipments for use on 1,200 volts it was considered undesirable to employ this voltage for the auxiliary circuits, and so a dynamotor was included as a part of the equipment to provide a 600-volt supply. To reduce the size of the dynamotor the compressor motor was next wound for operating at full line potential, and later the two machines were combined in a dynamotor-compressor, the air compressor being connected to or disconnected from the dynamotor when required by a suitable clutch controlled by the pressure governor. In locomotives or other equipments where forced ventilation is required the blower fan is mounted on the shaft of the dynamotor.

On motor coaches of small or moderate size the above arrangement is handicapped in the matter of cost and simplicity as compared with 600-volt equipment, so the next step was to arrange the lighting and control circuits for operation directly from the line voltage. These two general arrangements constitute a dual standard, and one of the first decisions to be made in planning any given installation is between these two schemes.

Operation on Two Voltages.—The most prolific source of vexatious problems is the use of equipments, part of the time on low voltage and part of the time on high. As far as the main circuit apparatus is concerned, any high-voltage equipment will, of course, run on half voltage with a corresponding reduction in speed. In order that such operation may be satisfactory, however, special arrangements must be made to care for the auxiliary circuits.

Many high-speed interurban lines enter towns over the tracks of local 600-volt systems. High speed in the towns is not permissible, and so half normal speed on 600 volts is sufficient. Under such circumstances, it is common to provide for re-connecting the lighting and control circuits so that these will receive full voltage when the car is in the 600-volt section, but so that the main motors will remain permanently coupled in series. If a dynamotor compressor is employed, the same changes automatically connect it for full speed on both voltages. In cases where approximately half speed on low voltage is sufficient for the main motors the distances are usually short, and half speed of the air compressor also is sufficient. Where cars which operate in this way employ a high-voltage compressor instead of a dynamotor compressor no change is ordinarily necessary in its circuits for low-voltage operation.

Since the motors on high-voltage cars are in general wound for only 600 or 750 volts each, the car can, if desired, be arranged to operate at full speed on both high and low voltage. When the proper scheme of operation on the two voltages has been decided, the next point to determine is the manner in which the change-over should be effected. The simplest method is the use of a manually-operated switch on each car. It is sometimes desirable, however, to have the change-over switch located beneath the car and arranged for operation from the platform. In other cases it is desirable to have the switches arranged, not only for distant control in this way, but also for simultaneous operation throughout a train of cars.

Protective devices are sometimes desired to prevent or minimise trouble in case a motor coach is subjected to high voltage when its change-over switch is arranged in the low-voltage position. Such devices ordinarily consist of relays, which act quickly in case a voltage in excess of the normal is applied and cut off the circuits likely to be damaged.

While the choice between automatic and non-automatic acceleration is not influenced particularly by the use of high voltages, there is a tendency to adhere to non-automatic control for simplicity. The same applies with regard to field control.

Alternatives in Control Apparatus.—The most common questions are: (1) Should the voltage be 1,200 or 1,500? (2) Should the equipment be of the dynamotor compressor or of the non-dynamotor type? (3) Will it have to operate on high voltage only or on both high and low voltage? (4) If required to operate on low voltage as well as high, will half speed be sufficient on main and compressor motors or will full speed on both voltages be necessary? (5) Must the change-over switch be arranged for indirect control, or will manual operation be sufficient? (6) If indirect control is required, can it be confined to the individual cars, or will simultaneous operation throughout the train be required? (7) Is a protective device essential to guard against damage by the application of the wrong voltage, or will this not be required?

As far as the author can judge, current practice seems to be tending in the following directions: Where the high-voltage cars must run over existing 600-volt lines to any considerable extent, the exact ratio between 600 and 1,200 volts offers some advantages. Since high-voltage motors are made from existing standards also, there is a wider range of choice for 1,200-volt operation than there is for 1,500 volts, especially where small sizes of motors are required. So far, 1,500 volts has been used in sections where 600-volt lines have been established only to a limited extent—that is, in comparatively virgin territory—while 1,200 volts has been employed in sections where there has already been considerable 600-volt development. It seems probable that high-voltage practice will continue to follow these lines, except in the case of the electrification of branch lines on steam

* Abstract of a Paper read before the American Inst. Electrical Engineers.

railways or similar instances where connections with existing lines will have little bearing.

The general tendency is toward the use of the dynamotor compressor on large motor coaches, particularly where full speed is required on half voltage, since this arrangement lends itself readily to such operation. Dynamotor compressors, also, are particularly suitable for locomotives where forced ventilation is utilised. For smaller rolling stock, non-dynamotor outfits are generally employed. In the older sections of the country, where distances of four or five miles must sometimes be run on city tracks, and where through cars over 600-volt lines are likely to be employed, equipments are usually required to operate at full speed on half voltage. Where large cars are arranged for full speed on both voltages the tendency is toward the use of full speed for the air compressor. The general tendency is to employ the simple manually-operated type, except where cars are operated at close headway or are constantly used in trains. In most cases, also, devices to protect against the wrong voltage are not considered necessary.

Equipments With Drum Control.—In all of the above the author has had in mind equipments using indirect or multiple-unit types of control, and primarily with reference to those using electro-pneumatic control. While high-voltage equipments are occasionally used with drum-type controllers, especially double equipments with rheostatic control, where cars for city service are operated in small towns by interurban companies, the number of these is too small to warrant inclusion in any generalisation such as that with which we have been dealing.

Power Supply.—Direct-current power for high-voltage lines is generated in 1,200 or 1,500-volt machines, which usually employ a compensating winding as well as commutating poles. Twenty-five cycle synchronous converters producing 1,200 or 1,500 volts on one commutator are in successful use. With 60 cycles, the maximum voltage so far employed from a single machine is 750, so that two machines in series are still required for high-voltage lines. Common sub-station practice is to employ single converters where power at 25 cycles is available, and to use either motor-generator sets or two converters in series on 60 cycles. A particularly efficient sub-station arrangement on the latter basis is secured by installing three synchronous converters so arranged that any two of them may be connected in series.

Switching.—In the matter of switching, the principal changes which have been made in handling current at 1,200 or 1,500 volts have been for the purpose of ensuring safety. For this purpose switchboard panels have been made higher, and the circuit-breakers and knife switches are located so as to be out of direct reach. For opening and closing the breakers, long wooden rods leading to insulated handles on the lower part of the panel are provided. Barriers are placed between the circuit-breakers to prevent any tendency to flash across.

Line Construction.—Generally speaking, the most common practice is to employ catenary construction. Several interurban lines are using 1,200-volt third rail, but the voltage surges to which this may give rise, the difficulty of clearing a car in case of accident and the general safety hazard incident to the maintenance of a live conductor so close to the ground seem likely to limit the use of this form of construction. A growing practice is that of carrying the feeders for a considerable distance from the station before tapping into the trolley, so as to limit the possible current flow in case of trouble of any kind on the cars.

Economic Significance.—In studying the development of 1,200 and 1,500-volt practice, the fundamental point which appeals to the author is the ease, success and speed with which so radical a departure from previous practice has been carried out. In most developments of so far-reaching a nature many sources of difficulty are usually overlooked at first, and must be cared for in later apparatus at increased expense. Many of the possible difficulties seem to have been over estimated in importance, and much of the trouble anticipated has failed to appear. It has, therefore, been possible gradually to simplify and cheapen the various fundamental parts, instead of having to follow the opposite and more usual procedure. The general results of the high-voltage direct-current system have been to make possible the construction of inter-urban lines or the electrification of branch steam railway lines at considerably less expense for a given grade of construction than with 600 volts, or to render possible for a given expenditure the construction of lines capable of handling much heavier traffic.

Voltages of 2,400 and 3,000 Volts.—Inasmuch as the 1,200-volt systems have been brought about by the use of two 600-volt motors in series, and as a few motors wound directly for this voltage had been produced with no particular difficulty, the obvious procedure was to connect 1,200-volt motors and generators in series so as to operate at 2,400 volts. One line installed on this basis has had a remarkably successful record. From a general standpoint, however, while the results have been welcome as a contribution to the development of the art, suitable applications for this particular voltage are apparently somewhat lacking. For trolley roads of the usual interurban class it has the inherent disadvantage of requiring apparatus which departs too widely from the existing standards with which the operating forces have become familiar, as well as of not lending itself to interchangeable operation over 600-volt lines. For heavy traction, on the other hand, this voltage is much too low to solve the problem in a sufficiently comprehensive way to attract the investment of capital in electrification. Even 3,000 volts, while overcoming the latter disadvantage to some extent, does not do so completely. It is regrettable, also, that both 2,400 and 3,000 volts have been employed, and that in carrying on the upward progress in direct-current voltages 1,500-volt apparatus was not used at once for coupling in series without the intermediate step.

Ultimate Limits of Direct-current Voltage.—The general limits upon which standard practice ordinarily settles are usually fixed by broad economic considerations rather than by physical limitations. It is possible, for instance, to operate trains at maximum speeds of 90 miles per hour or more, yet the maximum ordinarily attained is from 60 to 80 miles per hour, and the general average on interurban lines is from 50 to 60 miles per hour. These values have been established by gradual increases from lower ones until, without any conscious effort, standardisation has been automatically secured.

In the voltages which may be employed with the direct-current railway system there is some tendency toward this same procedure. While in a way such a procedure would be the conservative and natural way for progress to come about in the use of higher direct-current voltages, its disadvantages are too obvious to require mention. The apparently more radical plan of trying to select in advance the voltage at which such increases would naturally stop and of going at once to this voltage would, hence, seem to be the more rational and really the more conservative as far as the general good of the industry is concerned. It has been with this idea in view that our efforts toward the use of direct current at 5,000 volts are being put forth. With practical apparatus for this voltage available, the problems of distributing and collecting the necessary power for the largest locomotives likely to be required can be readily solved, so that, although further increases might be possible, they should be entirely unnecessary.

Operation of 5,000-volt Equipment.—The general construction of the 5,000-volt experimental equipment on the Grass Lake line of the Michigan United Traction Co., and the results of its first few months' operation, have been so widely covered by the technical press that it is unnecessary to refer further to them, except to say that the equipment is still in operation on the same successful basis, and it has run a little over 30,000 miles. During the four months which are ordinarily considered the worst in the year the car ran 23,320 miles, or an average of 5,830 per month. Only two failures were in any way due to the use of 5,000 volts, and these consisted of grounds on the grid resistance, which took place through the water-soaked flameproof covering on certain of the leads where the cables had not been properly insulated and supported. Such troubles can be easily guarded against on new equipments.

Conclusion.—The pernicious flexibility of the 1,200 and 1,500-volt systems, and the innumerable alternatives which they present for application to any definite case in interurban work, seem to give timely warning of the great desirability of early standardisation in the matter of higher direct-current voltages. The comparative ease with which apparatus for these voltages has been developed gives a most encouraging feeling for further development along the same lines. The possibilities which a direct-current system at 5,000 volts would offer were the apparatus commercially available make this voltage seem a logical one, and the results obtained with the experimental equipment now in operation give great hope that this voltage may some day be established commercially as a standard of high-voltage direct-current railway practice.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Electrical Engineering: First Course." By J. E. Berg and W. L. Upson. (London: Hill Publishing Co.) Pp. xii. + 416. 17s. net.

"Discovery, or the Spirit and Service of Science." By R. A. Gregory. (London: Macmillan & Co.) Pp. viii. + 340. 5s. net.

"The Year Book of Wireless Telegraphy and Telephony, 1916." (London: The Wireless Press.) Pp. lxxx. + 876. 3s. 6d. net.

"The Railway Swindle." By Henry Murray. (London: Grant Richards, Ltd.) Pp. 160. 2s. 6d. net.

POWER REQUIREMENTS AND RESOURCES OF NEW SOUTH WALES.*

BY WILLIAM CORIN.

Summary.—This Paper is divided into three parts. In Part I. an inquiry is made as to the present total power in use in the State, and an attempt is made to forecast the extent to which power may reasonably be anticipated to be required in the immediate future. Part II. is a discussion of the resources available for meeting the anticipated demand; and in Part III. the author has attempted to indicate in what manner these resources should be developed in order best to provide for the requirements so as to supply power at the lowest rates, and in such a manner as to invite the establishment of new industries in New South Wales.

I.—Power Requirements of N.S.W.

It will be convenient to discuss this subject under four headings, subjecting each in turn to such analysis as will show the probable growth within a period, which the author, for the purpose of discussion, has set at 15 years—*i.e.*, until 1930. These headings are as follows: (*a*) Manufacturing industries; (*b*) Towns supply; (*c*) Rural supply; (*d*) Locomotion.

As regards the first two headings, in attempting to forecast the future requirements, there has been considerable progress up to the present date, of which a careful scrutiny enables valuable deductions to be drawn as regards the future. As to the second heading—*i.e.*, towns supply—the development in New South Wales has been insignificant compared with what has been done in other parts of the world, and with what might have been expected in this State; whilst rural supply is in a still more backward position.

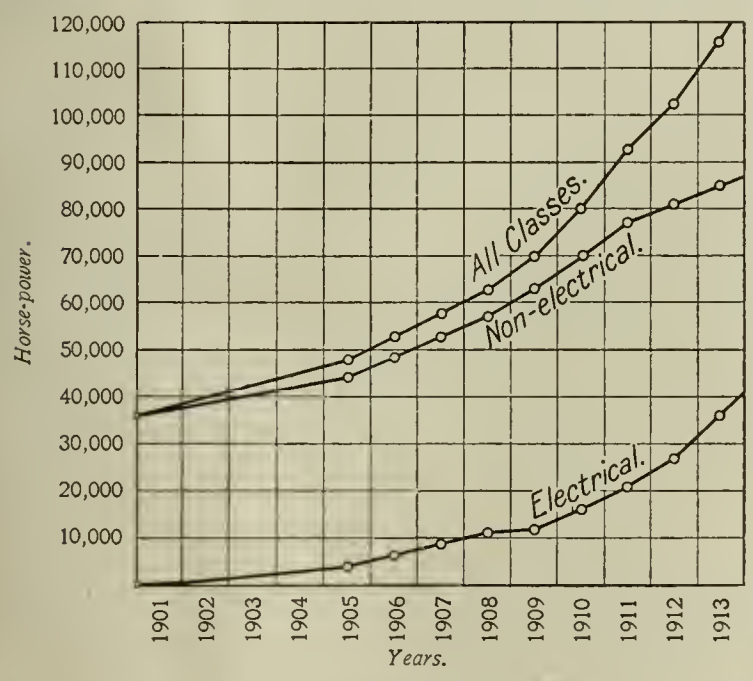


Fig. 1.—Stationary Industrial Prime Movers. Increase of Horse-power from 1901 to 1913.

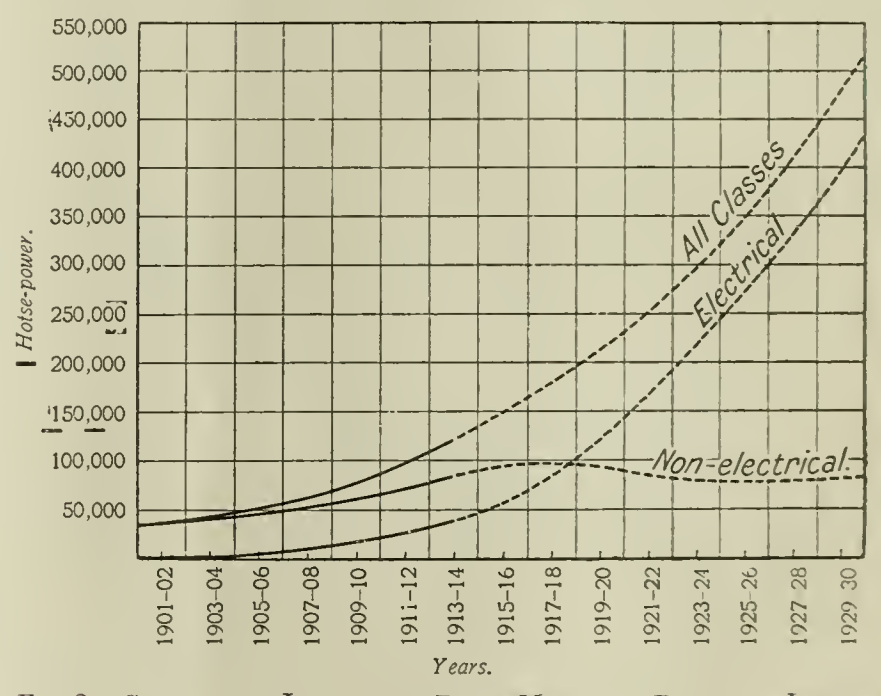


Fig. 2.—Stationary Industrial Prime Movers. Probable Increase of Horse-power from 1913 to 1930.

Manufacturing Industries.—As above hinted, New South Wales has been notoriously backward in connection with electrical applications, but the State Statistical Register shows that since the beginning of the present century a notable advance has been made, and electricity now bids fair to take its proper place in manufacturing in New South Wales, just as it has so established itself in other parts of the world.

The curves in Fig. 1, deduced from the State Statistical Register, show the average horse-power in the State in use for industrial manufactures of all classes, excepting, of course, electrical power stations, from the beginning of this century. These curves show, *inter alia*—

That, as might be expected from the considerations set forth above, the curve of total power has a decided upward tendency. Dividing the period from 1901 to 1913 into three intervals of four years each, the increases for the successive intervals are: 10,648, 22,511 and 45,954 H.P. respectively.

That whereas at the beginning of the century the horse-power supplied from other forms of prime mover was 112 times that supplied by electric motors, at the close of 1913 this ratio had been reduced from 112 to $2\frac{1}{4}$.

That whilst the total horse-power (average used) had increased 3·12 times during this period, that supplied by electric motors had increased 108·7 times, as against only 2·2 times for other forms of prime mover.

That whereas the electric motor curve shows an accelerating upward tendency, the non-electric curve reached a point of inflection in 1911, since when the rate of increase shows retardation to have commenced, and the curve may be expected to fall after a few years to a point where it will probably remain fairly steady for some time, representing the power taken by those industries for which direct application of steam engines has been proved to form at least one satisfactory solution of the driving problems involved, after which it is possible that it may slowly rise again.

In Fig. 2 the same results are plotted to a flatter scale, and the curves are continued in an upward direction until 1930. Two methods suggested themselves for continuing these curves; one the strictly synthetic method of attempting to evaluate the respective influences of increase of mechanical application, initiation of new industries, rise of wages and growth of population—a difficult though interesting task, and, though considered, not adopted by the author. The other, to find the equation to a curve approximating to that plotted and then simply to continue it.

The net result is that for the next 15 years the increased power demand for stationary industrial uses may be anticipated to amount for the whole of the State to a total of 479,500 H.P.—*i.e.*, 381,000 H.P. in addition to that in use in 1913. Of this total, 416,000 H.P. may be anticipated to be supplied electrically, and the balance, 81,500 H.P., may be regarded as non-electric. Allowing for diversity factor and losses, the 416,000 H.P. will require 300,000 kw., and will use, with a load-factor of 23 per cent., 600-million units per annum.

Various industries, including calcium carbide, alkalies, copper, iron, steel and aluminium, are then dealt with, and the author then discusses the question of towns supply, rural and suburban tramways, and eventually arrives at the following estimate as to the probable requirements for 1930:—

	Kw.	Millions of units.
Manufacturing industries requiring—		
(i.) Mechanical power	300,000	600
(ii.) Power for electrochemical and electrothermic processes, say	100,000	700
Towns supply, exclusive of manufacturing	15,000	15
Rural supply	100,000	100
(i.) Tramways	35,000	145
(ii.) Urban and suburban railways	150,000	300
(iii.) Main line railways	Not included	
Total for 1930	700,000	1,860

Mr. H. R. Forbes Mackay, general manager of the City Council's electric light department, Mr. J. E. Donoghue, general manager and chief engineer of the Electric Lighting & Power Supply Corpn., Mr. Guy Allbut, city electrical engineer of Newcastle, and a number of the town clerks and managers connected with the various electric supply stations throughout the State, have favoured the author with data dealing with the growth of their respective undertakings, which show the very rapid rise in the demand since the commencement of the century.

Figures are plotted in Fig. 3, the intervening years between 1913 and 1930 being filled in by a dotted line, showing approximately in what way, from year to year, the curves may be expected to rise, though it is to be noted that the irregularities which may be expected from three to five years hence from the sudden increases, owing to the electrification of the city and suburban railways, are smoothed out.

The forecast for the five years from 1915 to 1920 thus shows a probable increase of 106,000 kw., with an output of 312 million units. Preparation for this increase needs to be taken in hand immediately.

* Abstract of a Paper read before the Electrical Association of Australia.

If all the units under the curve from 1916-30 inclusive were provided by the most efficient steam plant obtainable (allowing the extreme figure of 1,000 units per ton of coal), no less a quantity than 14·3 millions of tons would be used for this purpose. Adding the 21·8-million tons for main line passenger and goods locomotives, it is seen that the total coal that may be expected to be used for power purposes, if all the power is so derived for the years 1916 to 1930, is 36·1 millions of tons.

II.—Power Resources of New South Wales.

There are supplies of wood in some parts of the country which can be either burnt in boilers or carbonised, and the charcoal used for suction gas engines. The author considers that small suction gas plants could not compete successfully with a comprehensive supply system.

Of natural gas, in the Pittsburg sense of the term, there is none. Kerosene shale of very high quality exists, and if the Federal Customs tariff were so proportioned as to allow of the successful commercial development of this mineral, and if railway freights for the resulting fuel were reduced, it is possible that a fair quantity of comparatively cheap crude oil would be marketed at a price low enough to allow for power from engines of the Diesel type to compete with steam. But the known deposits of kerosene shale are extremely limited when compared with the vastness of the coal fields of the State, and at present the industry is practically at a standstill. Crude petroleum, as a native product, is unknown in this State, and, omitting consideration of those natural resources which are common to most parts of the globe, and the proposed use of sewer gas, as to which the author has no reliable data, there remain but the two chief sources of power mentioned to consider

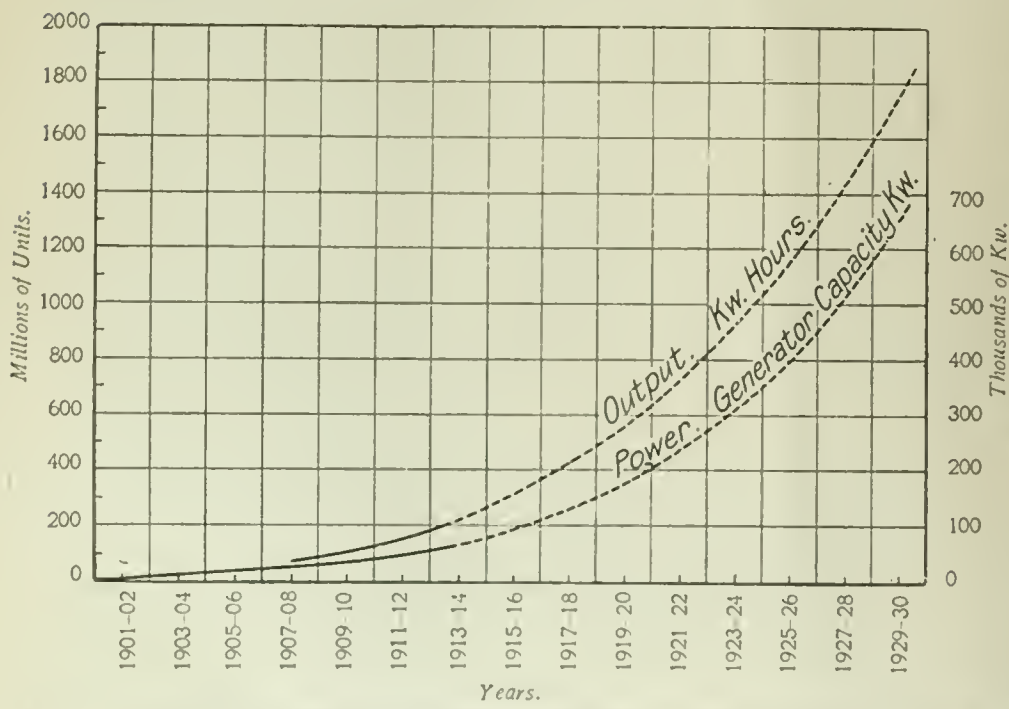


Fig. 3.—Electrical Supply Stations of N.S.W. Power and Output from 1901 to 1913 and Anticipated Requirements to 1930.

A.—Coal

Mr. E. F. Pittman, in his "Coal Resources of N.S.W.," gives estimates showing the total coal in the State, within a depth of 4,000 ft., to be probably in excess of 117,000-million tons. The annual coal production of the State was 10½ million tons in 1913. If the production of the State were increased 100 times, so as to equal the world's production, 1,250 million tons, there would be still about 100 years' supply within 4,000 ft. of the surface.

It must be recognised that at present the mining companies are of necessity utilising the best and most easily won of this store. Competition demands that the best coal available be offered at the lowest price. There are many difficulties involved in the use of inferior qualities, and indeed in the mining of some of the better classes, where Nature has been so prodigal of her resources as to provide a 30 ft. seam. The majority of the problems presented will probably be left for posterity to solve. With increasing wages and increasing distance from the surface, the cost of winning will surely rise; but at the same time we may look forward to more economical methods of use, so that a corresponding rise in the price of power does not necessarily follow.

The locality of coal measures is then dealt with and the various coal are stated to have calorific values between 10,000 and 13,000.

The poorer classes of coal referred to will assume greater importance as the price of the better class, for the reasons referred to above, increases.

B.—Water Power

It need scarcely be pointed out that there are few water-power developments in which the cost of the hydraulic work is not so heavy that it becomes a question whether the interest on capital cost will not more than counterbalance the advantages of machinery needing less attendance and upkeep generally, and requiring no fuel. The question as to whether water-power is worth developing is almost entirely a financial matter, the considerations governing the decision being the relative cost of power derived from water and from any other competing source at the point where used. If in any locality the price as above determined were so nearly balanced that a slight preponderance one way or the other in the calculated cost is within the limit of probable error of the calculation, the decision should be in favour of water power. For the choice lies between, on the one hand, making use of kinetic energy, derived from water raised by the sun and drawn down by gravitation, which would otherwise be absolutely wasted in heat, noise and rock erosion, and on the other, of using up part of the national store of bottled energy in the form of coal, which once used can never be replaced.

Cotter River.—A concrete example, now outside the limits of the State, will serve as an illustration. One of the most favourable schemes examined by the author since his connection with the Public Works Department was that first suggested, he believes, by Mr. E. M. de Burgh (now chief engineer for water supply and sewerage in the Public Works Department), of a combined water supply and hydro-electric power scheme from the Cotter River for the Federal capital.

One of the proposals previously reported on in connection with the water supply involved a high-level dam from the Cotter River, with a pipe-line delivering water by gravitation to the capital, and a suggestion had been made that this pipe-line might be broken at two or three intervals where power stations would be situated. At this stage, as the result of Mr. de Burgh's recommendation, the author was instructed to examine and report on the possibilities, and after a careful investigation, he advocated a dam somewhat higher up the Cotter River than the one previously proposed for the gravitation scheme, a race or fluming thence with inverted syphon over an intervening gap for a distance of 20 miles to the summit of Mount Macdonald, whence a fall of 880 ft. is available to the Murrumbidgee River. The author's proposals consist of a 150 ft. dam on the Cotter River, with a draw-off, whence a race and pipe-line with a total fall of 65 ft., 20 miles long, terminating at a balance reservoir on the summit of Mount Macdonald with top water level 2,390, whence a pipe-line in duplicate would lead down the hillside to the Murrumbidgee, the reduced level of which, at this point, is 1,504 ft., giving a total working head, after allowing for pipe friction and keeping the station well above flood level, of 830 ft.

A preliminary report embodying these proposals was communicated to the Federal authorities, but it received criticism at the hands of one of their technical advisers, who, in spite of some pains taken to explain the point, did not appear to understand the function of the balance reservoir, and seemed to think that it was essential to a hydro-electric scheme for the maximum demand to be maintained continuously.

If the initial expense be an objection to the hydro-electric scheme it may be urged in reply that the work can be carried out in three divisions as the population increases. By suitably damming two small feeders from the Brindabella Mountain, some 7½ miles from Mount Macdonald, that end of the race could be first constructed, and the water and electric supply would be sufficient for an initial population of from 10,000 to 15,000. As the population grew, the race would be extended back to a small dam above the main dam site. It is pointed out that 20 years' working of the complete steam scheme for 50,000 people would result in the waste of 310,000 tons of coal, with the doubtful benefit of a smaller capital expenditure.

By the direction of the Hon. Arthur Griffith, then Minister for Public Works, examination was made by the author of the Tumbarumba, Buddong and Gilmore Creeks, and of the Shoalhaven River, the investigation being more complete in this instance. The author has been entrusted with an investigation into the total water-power of this State, and is carrying it out on the following lines: Regarding 250 miles as the present commercial limit of power transmission, the preliminary examination will be principally with map and aneroid. In respect of each of the favourable positions indicated, the catchment areas above such positions and probable run-off, the estimated flow and the available power, will be catalogued, and suitable sites having been determined, gauging stations will, where possible, be established, and arrangements made for the regular reading of the gauge boards.

Two classes of water-power have generally to be examined, viz., those where there is a small volume of water with a large fall, and

those where the fall is small and the volume large. A list of the chief rivers to be examined is given in the Paper.

Since instructions were received a commencement has been made, and an interim report on the Tumut River has been presented, and reports on other rivers are in course of preparation; progress, however, being necessarily slow because of the fewness of officers on account of the war.

The following figures have been taken from reports which have been furnished in the past for the water continuously available, the working head, and the consequent available continuous power and total energy per annum respectively:—

Name of River.	Flow. Sec. ft.	Head. Ft.	Power. Kw.	Energy. Millions of units.
Tumberumba Creek and Tributaries	30	1,600	3,000	23
Snowy River	300	1,200	22,500	172
Shoalhaven River	123	1,010	7,500	57
		Totals ...	33,000	252

With a 30 per cent. load-factor, 100,000 kw. is seen to be available from these few streams.

The possibility of shortage of water during drought years is one objection often raised against water-power schemes. This objection disappears if the hydro-electric stations are tied in with a general power scheme, including coal stations. If the power of the few streams mentioned above were developed and tied in with a general power scheme for the State, the 33,000 kw. available continuously would, making full allowance for losses, provide 252,000,000 units each year, thus saving the coal resources to the extent of about 250,000 tons per annum. The figures for the Snowy River are to be taken as tentative only, the present investigation not being completed.

Again, if the Shoalhaven River alone were developed and connected with the Sydney tramways and municipal supply systems, being worked continuously so as to utilise all the available water in normal seasons, the investigation already carried out shows that it would be possible for the two systems to be supplied with power for considerably less than ¼d. a unit, and for all three power stations, Ultimo, White Bay and Pyrmont, to be closed down during the night shift, so that only morning and afternoon shifts would have to be worked.

(To be concluded.)

NOTES ON DESIGN OF ELECTROMAGNETIC MACHINES.

I. CONTINUOUS-CURRENT MACHINES.

BY STANLEY PARKER SMITH, D.Sc.

(Continued from page 463.)

Summary.—In the first part of the article the author deals with the principles underlying the design of continuous-current machines, and in the second part he applies these principles to the design of a 350 kw., 500-volt generator running at 200 revs. per min.

We now come to the armature slot, on the design of which depends the flux-density in the teeth, and the copper and iron losses in the armature that are permissible.

Armature Slots.

Each conductor carries a current of $I/2a=700/4=175$ amperes. In a large, well-ventilated machine we ought to be able to work the copper at a density of about 4 amperes per mm², which gives a cross-section $A=175/4=44$ mm². For this cross-section a copper strip is doubtless best. The dimensions of the strip depend on the width and depth of the slot. Practically all continuous-current machines have open slots with parallel sides, in large types the conductors being held in the slots by means of wood wedges about 3 mm. to 5 mm. in thickness. There is some difference of opinion as to the best relation between the slot-depth and slot-width, owing to the varying practice of using few slots with several conductors per slot or many slots with few conductors per slot. Generally speaking, the former is cheaper whilst the latter is better for commutation. The ratio of slot-depth to slot-width usually lies between 2 and 4. With the experience on which we are basing our design a ratio of about 3 will be found satisfactory.

A bare copper strip, 3×15 mm. with rounded edges, has approximately a section of 44 mm². To insulate, the conductors can be taped half-lap and dipped in varnish, making the overall dimensions 3·7×15·7 mm. The width and depth of slot needed are then as follows:—

Slot-width:

Conductors	3×3·7	= 11·1 mm.
Slot insulation	2×1	= 2·0 ,,
Slack		= 0·9 ,,
Total		= 14·0 ,,

Slot-depth:

Conductors	2×15·7	= 31·4 ,,
Slot insulation	3×1	= 3·0 ,,
Insulation between layers		= 1·0 ,,
Insulation at bottom of slot		= 1·0 ,,
Slack		= 1·6 ,,
Wedge		= 4·0 ,,
Total		= 42·0 ,,

The slot insulation can be presspahn, leatheroid, or other suitable substance. Some firms use mica paper, but this is scarcely necessary at this pressure.

Thus we find a slot 14×42 mm. is needed, and this agrees well with the remarks made concerning the ratio of slot-depth to slot-width. A section through the slots is shown in the drawing of the machine.

Check on Flux-density in Teeth.—We must now check whether the density of the flux in the teeth with these slot dimensions is permissible. The maximum density occurs at the root of the teeth, where the area of the magnetic path is least.

In salient-pole machines practically the whole of the flux goes through the teeth directly under the pole-shoe. The number of teeth under a shoe is equal to $\frac{\text{pole-arc}}{\text{slot-pitch}}=\frac{b}{y_s}$.

The slot-pitch $y_s=\pi D/S=408/114=3{\cdot}58$ cm.

Teeth per pole $=b/y_s=37{\cdot}0/3{\cdot}58=10{\cdot}3$.

There are different ways of taking fringing into account, but it is sufficient as a rule to estimate this from experience. We shall round off the teeth per pole=11, to allow for fringing.

At root of teeth, the slot-pitch $=\pi(130-8{\cdot}4)/114=3{\cdot}34$ cm. Then maximum width of tooth (top) $=3{\cdot}58-1{\cdot}4=2{\cdot}18$ cm. and minimum width of tooth (bottom) $=3{\cdot}34-1{\cdot}4=1{\cdot}94$ cm.

The iron-length of the core $L_i=28$ cm., hence we have maximum area of teeth $=A_{t_{max.}}=11\times28\times2{\cdot}18=670$ cm.²

minimum area of teeth $=A'_{min.}=11\times28\times1{\cdot}94=600$ cm.².

Taking the full-load flux, minimum flux-density in the teeth

$$B_{t_{min.}}=\frac{\Phi}{A_{t_{max.}}}=\frac{11{\cdot}5\times10^6}{670}=17{,}200;$$

maximum flux-density in the teeth,

$$B_{t_{max.}}=\frac{\Phi}{A_{t_{min.}}}=\frac{11{\cdot}5\times10^6}{600}=19{,}200.$$

This is not too high with respect to the requisite ampere-turns. On the other hand, in an interpole machine, there is no object in expending too many ampere-turns in the teeth in order to increase the ratio of field to armature ampere-turns.

With respect to the loss in the teeth, there will be nothing to fear in this slow-speed machine where the frequency is only $f_r=pn=4\times200/60=13{\cdot}3$ cycles; for with a frequency of 50 cycles the teeth can be worked at a density of 17,000-18,000. We now proceed to calculate the iron loss in the teeth and core.

Iron Loss.

It is not easy to estimate the iron loss in a machine correctly for many reasons. If a formula were used containing the constants for the loss due to hysteresis and eddy currents as derived from laboratory tests taken on prepared samples, it would be found to give losses far below those measured when the machine is built. It is hard to enumerate all the reasons for this great discrepancy, but many of them

are quite obvious. Thus the actual flux-densities are probably different from the mean densities for which the losses are calculated. Also the grade of iron, punching the plates, filing the slots, imperfect insulation between plates, all have their effects on the iron loss. Then there are additional losses due to flux pulsations, thick end plates, through bolts, &c., which, on test, are measured with the iron loss proper.

It is not at all infrequent to find the measured loss double the loss calculated from practical formulæ (such as that given below), though these formulæ give values well in excess of laboratory tests. At the same time, it is often found that by dismantling the core and grinding off all burrs and then insulating and annealing the plates before assembling will halve the measured loss. The following formula gives results which may be expected when every care is taken to reduce avoidable losses to a minimum.

Iron loss $=2{\cdot}5fB^{1{\cdot}6}10^{-8}+0{\cdot}01B^2t^2f^2 10^{-8}$ watts per kg.; where f denotes the frequency and t the thickness of the plates in millimetres.

If this formula is used for ordinary worked plates, where no precautions are taken to reduce the avoidable losses, the measured loss may be double the calculated proper iron loss.

Iron Loss in the Teeth.—The volume of the teeth can be found at once. Thus :—

$$\text{Volume of teeth}=114\times28\times4{\cdot}2\frac{2{\cdot}18+1{\cdot}94}{2}=27{,}600 \text{ cm.}^3.$$

Weight of teeth = volume of teeth × density,

$$=27{,}600\frac{7{\cdot}8}{1{,}000}=216 \text{ kg.}$$

Applying the above formula, we estimate that in the teeth the iron loss per kilogramme = 4·0 watts, making a total iron loss in the teeth $=4{\cdot}0\times216=864$ watts.

Iron Loss in the Core.—We must first settle the core depth h. The core segments are built up on a cast-iron spider, the diameter of which depends on the permissible flux density in the core. At the low frequency of 13·3 cycles, we can safely allow a density in the core of $B_a=15{,}000$ on full-load. Denoting the iron area of the core by $a_a=h\,.\,l_i$, we have for a flux of 11·5 megalines :—

$$a_a=11{\cdot}5\times10^6/15{,}000\times2=385 \text{ cm.}^2.$$

(We divide by 2 because half the flux goes to the right and half to the left.)

Hence, core-depth $h=a_a/L_i=385/28=13{\cdot}8$ cm.

The inside diameter of the core (or the diameter of the spider) is then $D_i=130-2\times4{\cdot}2-2\times13{\cdot}8=91$ cm.

The volume of iron in the core is then

$$\pi h(D_i+h)L_i=\pi13{\cdot}8(91+13{\cdot}8)28=131{,}000 \text{ cm.}^3,$$

hence the weight of iron in the core $=131{,}000\frac{7{\cdot}8}{1{,}000}=1{,}020$ kg.

At a density of 15,000, the loss per kilogramme from the above formula = 2·7 watts, making a total iron loss in the core $=1{,}020\times2{\cdot}7=2{,}754$ watts.

Total Iron Loss.—Iron loss in core + teeth = 2,754 + 864 = 3,618 watts.

The Winding Pitches.

To obtain the weight of copper on the armature and the copper loss, we must first settle the winding pitches in order to find the length of a conductor.

We chose the commutator pitch $y_c=85$ segments in order to obtain a single winding. In a wave winding, the resultant winding pitch $y_r=2y_c$ coil-sides is equal to the sum of the back-winding pitch (or coil-span) y_b and the front-winding pitch y_f. Hence, $y_r=2y_c=y_b+y_f=170$ coil-sides. This must now be split up into y_b and y_f. Since y_r is even, y_b and y_f must be both odd, in order to include all the coil-sides when connecting up the winding.

In order to obtain straight-line commutation with the minimum width of interpole, the coil-span is made as nearly equal to a pole-pitch as possible. With the total number of coil-sides = 684, the number of coil-sides in a pole-pitch = 684/8 = 85·5. The nearest odd numbers to this are 85 and 87. If we choose $y_b=85$, the three top coil-sides of slot 1 belong to the three bottom coil-sides of slot 15, so that all coils have a constant span of 14 slot-pitches. Arranged in this way, the three coils can be taped together and, in winding, inserted in the slots as one coil—a great convenience from a mechanical standpoint and cheap to wind. On the other hand, if we choose $y_b=87$, two of the top coil-sides of slot 1 belong to bottom coil-sides in slot 15, while the third top coil-side in slot 1 belongs to a bottom coil-side in slot 16. The mean span of the coils in this case is $14\frac{1}{3}$ slot-pitches, and the three coils must be wound separately. Since there are $114/8=14\frac{1}{4}$ slot-pitches per pole-pitch, the mean coil-span with $y_b=87$ is more nearly equal to a pole-pitch than with $y_b=85$, consequently a narrower commutating zone is obtained by having "split" coils; but the difference is so small ($14\frac{1}{4}-14\frac{1}{3}$, instead of $14\frac{1}{4}-14$ slot-pitches), that it is not worth the extra expense of splitting the coils. Many designers make a practice of never splitting the coils at all, but the author's experience has taught him that making the coil-span as nearly equal to a pole-pitch as possible and designing the interpole to give straight-line commutation is very sound practice, and fully justifies splitting the coils where necessary. Also with a large number of coil-sides per slot, splitting the coils often prevents blackening of certain bars.

Making $y_b=85$, then, in the present case, the front pitch $y_f=y_r-y_b=170-85=85$.

Resistance of Armature Winding.

To find the length of a conductor, the coil is laid out as shown in the drawing. This diagram is also needed for obtaining particulars for the winding former. In this way we measure the length of a conductor to be 100 cm., so that the total length of copper in the armature winding is

$$L=684\,.\,100\,.\,10^{-2}=684 \text{ metres.}$$

The section of the armature conductor $A=44$ mm.^{2}.

Now, the total length L is divided into $2a$ parts, which are joined in parallel to make $2a$ circuits, hence we have :—

Length of an armature circuit $=L/2a$ metres.

Total area of $2a$ circuits in parallel $=2a\,.\,A$ mm.^{2}.

The resistance of the whole armature winding is then :—

$$R_a=\varepsilon\frac{\frac{L}{2a}}{2a\,.\,A}=\varepsilon\frac{L}{(2a)^2A}=\frac{684\times0{\cdot}02}{16\times44}=0{\cdot}0195 \text{ ohm,}$$

where $\varepsilon=0{\cdot}02$ for copper at 55°C.

Pressure Drop and Copper Loss in Armature Winding.

At full-load the pressure drop in the winding is :—

$$V_a=I\,.\,R_a=700\times0{\cdot}0195=13{\cdot}7 \text{ volts :}$$

and the copper loss :—

$$P_a=I^2R_a=700^2\times0{\cdot}0195=9{,}550 \text{ watts.}$$

Check on Armature Heating.—Having calculated the copper and iron losses in the armature, we must now see whether the temperature rise falls within the guaranteed figure. There are different ways of estimating the temperature rise, nearly all of which are based on empirical formulæ. Such rules are only reliable when the mode of construction is known and a fairly wide acquaintanceship with the cooling properties of the type of machine in question is available. In calculating the cooling surface, some designers take into account as far as possible all surfaces from which heat is carried away, apportioning to each part the cooling value they consider appropriate. Others prefer to dispense with all such refinements in connection with any given class of machine, and merely work with a comparative figure, based on the cylindrical surface of the armature.

In the present design we shall adopt the latter method, though when sufficient test data is available it is doubtless advisable to go into the matter more closely to ensure a reliable commercial design.

From the drawing, the overall length of the armature is 68 cm., so that with a periphery of 408 cm. the cylindrical surface of the armature $=40{\cdot}8\times6{\cdot}8=280$ dm.^{2}.

The total armature loss = 3,618 + 9,550 = 13,168 watts.

The specific loss is then $\xi=13{,}168/280=47$ watts/dm.^{2}. This is quite a common value for machines of this class.

To estimate the temperature rise we can use a formula similar in form to that given by Kapp—namely,

$$t^\circ = k\frac{\xi}{1+0{\cdot}1v}\,^\circ\text{C}.$$

where v=peripheral speed in metres per second, and k is a constant varying from 1·5 to 2 for large open machines.

The peripheral speed $v=\pi D.n10^{-2}=408.200/6{,}000=13{\cdot}6$ metres per second. Taking $k=1{\cdot}8$, we get for the temperature rise

$$t^\circ = 1{\cdot}8\frac{47}{1+0{\cdot}1\times 13{\cdot}6}=36^\circ\text{C}.$$

We are, therefore, well within the permitted limit.

Weight of Armature Copper.—The weight of copper on the armature is

$W=8{\cdot}9V$ gm., where V=volume of copper in cm.^{3}.
$=8{\cdot}9\times 68{,}400\times 0{\cdot}44\times 10^{-3}$ kg.
=268 kg.=590 lb. (nett).

Equalising Rings.

In the prelude to the design it was pointed out that the consensus of opinion is in favour of using equalising rings in all lap or wave windings with more than two circuits.

Equipotential coils in a symmetrical winding are a potential pitch apart. Thus, $y_p=C/a=342/2=171$; so that any two bars 171 bars apart can be joined together. In the present case, where there is only one turn per coil, the equalisers can be connected to the back of the winding—an arrangement which is often more convenient for the shops.

Regarding the number of equalising rings to be used, since $y_p=171=9\times 19$, we could have nine rings 19 bars apart, or 19 rings nine bars apart.

The latter number of rings is rather large, though the former number errs on the other side. Since, however, it is somewhat inconvenient to accommodate so large a number of rings as 19, we shall only use nine, three of which can be used for three-phase tappings if needed. The nine equalising rings must be connected to the following bars or joints :—

Equalising ring:	1	2	3	4	5	6	7	8	9
Join bar to bar	1 to 172	20 to 191	39 to 210	58 to 229	77 to 248	96 to 267	115 to 286	134 to 305	153 to 324
Phase:		I.			II.			III.	

There is no need to choose a number of rings equidistant from one another, but it is usual to do so where practicable.

Regarding the section of the equalising rings different opinions prevail. To completely neutralise all inequalities and dissymmetry, they should be of ample section ; but if it is merely desired to provide an alternative path for the equalising currents, and so relieve the commutator brushes, no such expenditure of copper is needful. The author has obtained quite satisfactory results with equalising rings of half the section of the armature conductors. In the present instance we shall make the equalisers of copper strip of 20 mm.^{2} cross-section.

Three-phase Tappings.

To get a symmetrical N-phase pressure from a winding, the potential pitch y_p must be exactly divisible by N, so that successive phases are $1/N$th of a cycle or $2\pi/N$ radians apart.

With $N=3$, $y_p/N=C/aN=171/3=57$, so that successive phases are 57 bars apart. Thus, we can use equalising rings 1, 4 and 7 (as marked above) for this purpose.

It is, further, interesting to note that the number of slots $S/a=114/2=57$ between two equipotential points is exactly divisible by 3, so that successive phases are exactly 19 slot-pitches, or 120 elec. deg. apart. Hence the three-phase pressure obtained in this way is quite symmetrical.

The section of these three rings must be designed in accordance with the load to be taken off the three-phase slip-rings.

It is seen that it is not possible to obtain a symmetrical four- or six-phase pressure from this winding.

Commutator and Brushgear.

The diameter of the commutator can be made about 70 to 75 per cent. of the armature diameter, or $D_c=0{\cdot}73D=95$ cm.

The commutator periphery is then $\pi D_c=298$ cm.

The pitch of the commutator segments $y_1=\dfrac{\pi D_c}{C}=8{\cdot}7$ mm.

This is a very convenient width for the segments; we shall make the segments 8 mm. and the mica 0·7 mm.

The peripheral speed of the commutator $v_c=\pi D_c n10^{-2}=10$ metres per second, which is quite moderate and calls for no special construction.

Brushes.

For the brush gear we shall use as many spindles as there are poles. This is now standard practice on all large machines, and, indeed, on most continuous-current machines, except where special conditions prevail, as in traction motors. The chief advantage in using as many brush spindles as there are poles with a wave winding is the shortening of the commutator which is thereby effected.

With four like spindles, the current per spindle=700/4 =175 amperes. Using a medium hard carbon brush, which we can work at about 5–8 amperes per cm.^{2}, we shall need a brush surface of, say, 175/7=25 cm.^{2}. Settling the dimensions of the carbons is largely a matter of taste. Taking substantial holders of the box type, and three boxes per spindle, each carbon must have a surface of 25/3=8·3 cm.^{2}. With a brush width $b_1=20$ mm., the carbon will cover 20/8·7=2·3 segments, which is quite suitable. Taking the axial length of the carbon =40 mm., the brush surface per spindle will be $3(40\times 20)$ =24 cm.^{2}, thus giving a density under the brushes of 175/24 =7·3 amperes per cm.^{2}.

Allowing 1 cm. for each box with slack, the active length of the commutator will be 3(4+1)=15 cm. It is true that by using a wider brush it is often possible to shorten the commutator, but usually at the expense of the commutation, because of the increased circulating currents due to the higher difference of potential between the brush tips. It is not at all uncommon to find wide brushes used to decrease the current-density under the brush when this is specified very low and it is desired to use a standard commutator—a very undersirable practice.

Check on Commutator Heating.—In machines running at ordinary speeds with carbon brushes, the contact resistance loss forms a useful and simple check on the commutator heating, without troubling about the effect of the brush friction loss. Considering only the contact resistance loss, the commutator can dissipate about 40 watts per dm.^{2} without exceeding a temperature rise of 40°C. Taking 1 volt drop per brush—a good average value—the contact resistance loss=700.2=1,400 watts. The active surface of the commutator=29·8×1·5 =45 dm.^{2}, whence the specific loss=1,400/45=31 watts per dm.^{2}, which is quite satisfactory.

Commutating Poles.

It is desirable to have interpoles on machines of this class, for not only do these raise the sparking limit to the heating limit, but also enable the designer practically to disregard commutation in settling the main points of the design, and thereby to utilise his material much better.

Density of Commutating Flux.—To save copper and improve ventilation, it is usual to make the axial length of the interpole shorter than the core length, and to make the interpole narrower than the shoe when circumstances make this advisable. The decrease in length is really limited by the saturation at the top of the pole, because it is needful to have the magnetisation curve of the interpole circuit a straight line to make the commutating flux directly proportional to the load. Measurements show that the leakage of commutating poles is very high, and it is not uncommon to find a leakage coefficient of 300 per cent. This is due to the fact that the uesful interpole flux is very small, whilst the ampere-turns on the interpoles are very high. It is, therefore, not desirable to have the density in the pole behind the shoe, or in the gap when no shoe is used, much greater than 5,000.

Taking the length of the commutating poles $L_c=20$ cm., and $\lambda=6$ for a brush covering about $2\frac{1}{2}$ segments, we get the density of the commutating flux from equation (21) as follows :

$$B_c=\frac{L}{L_c}ac\lambda=\frac{35}{20}294{\cdot}6=3{,}100.$$

Width of Commutating Poles.—We shall design the shoes to be wide enough to keep the coil in the commutating field so long as the reversal of the current is taking place, in accordance with equation (23) :—

$$b_c=\frac{D}{D_c}\left\{b_1+y_1\left(1-\frac{a}{p}\right)\right\}+y_s,$$

$$=\frac{130}{95}\left\{2\cdot0+0\cdot87\left(1-\frac{2}{4}\right)\right\}+3\cdot6=7\cdot0 \text{ cm.}$$

This is a fairly wide shoe, and it is advisable to use a narrower pole. If we make the interpole 4 cm. wide, the density in the pole behind the shoe will be $3,100\times7/4=5,400$. If the leakage coefficient were 3, the density in the pole near the yoke would be about 16,000, which is permissible. The pole-shoe will also serve as a support for the coil.

Ampere-turns on the Commutating Poles.—From equation (22) the ampere-turns per pole-pair on the interpoles are :—

$$AT_{cp}=Yac+AT_c,$$

where $Yac=51\cdot294=15,000$=armature ampere-turns per pole-pair.

The chief item in the ampere-turns AT_c needed to drive the commutating flux through the magnetic circuit is the gap. It is well to have a fairly long gap for the interpole both to stiffen the commutating field and to make it less susceptible to pulsations arising from the teeth. Taking a gap of $g_{cp}=1$ cm., the ampere-turns required for two gaps$=2\times0\cdot8\times g_{cp}B_c=1\cdot6\times1\cdot0\times3,100=5,000$. Adding 1,000 ampere-turns for the iron part of the circuit, we get $AT_c=5,000+1,000=6,000$. Hence,

$$AT_{cp}=15,000+6,000=21,000.$$

With a full-load current of 700 amperes, the series winding on a pair of interpoles will need $21,000/700=30$ turns, so that each pole must have a coil of 15 turns to carry a current of 700 amperes.

(To be concluded.)

THE PLACE OF SCIENCE IN EDUCATION.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

On all sides we see evidence of a widespread feeling that we shall not be able to secure our national position after the sacrifices of the war unless attention is at once given to the more systematic development and application of scientific knowledge and a radical improvement effected in its position in our educational schemes.

This opinion is showing itself in the establishment of numerous committees, boards and conferences of various kinds. These discussions may be necessary to clear the ground and awaken interest, but they will be futile if they have no other result than mere assertions of national inefficiency or neglect.

The need of the moment is a careful and searching analysis of the causes of this failure to cultivate sufficiently scientific knowledge, and of the small popular appreciation of it, and we shall then perhaps be able to agree on the practicable remedies. Above all, we must estimate and define its proper place and function in popular education, so that we may not err in undervaluing or in overstating its importance.

The author refers to the enormous progress during the last half century. We are compelled to pursue knowledge not only for its intrinsic advantages, but in order to combat its misapplications. A too exclusive study of the subject has its special dangers and disadvantages.

Important questions arise as to the place and character of scientific instruction in primary and secondary education; methods for stimulating public opinion, and steps to encourage and assist scientific investigation.

As regards elementary education, our first duty to the child is to teach him or her something of the laws and phenomena of the physical universe into which it has been born, something concerning its own bodily structure and powers, so that it may learn to live well and in right relations to its fellows, and also to other forms of life around it.

The author refers to the education of the child, and is of the opinion that the majority of children are educated into stupidity by the greater stupidity of the adults around them. Reading and learning strings of words by heart are strongly condemned, and the danger done by picture palaces to town-bred children is mentioned.

Consider for one moment the great service the "moving picture" could render to education. It can, in the first place, represent to the eye moving animal life, the habits of animals and their ways of life. By taking photographs of growing plants at intervals of a few hours and then uniting them sequently on the film it can represent the growth and development of a chestnut blossom or a blade of wheat in a few seconds, which in Nature takes days or months. It can thus bring to the eye the facts of botany and the perpetually repeated miracle of the spring or summer, and this appeal to the eye can be interspersed with short instructional remarks or explanations. It can give ocular demonstrations of facts in physics, mechanics or astronomy which no stationary pictures can do. The progress of a solar eclipse, with all its impressive phenomena, can be shown to a class, and the action of a steam-hammer or petrol engine explained in detail by motion pictures, which are under complete control. Instead of this we allow the whole of this invaluable means of scientific education to be enlisted in the service of frivolity and the demoralisation of children by cheap exhibitions, which more than one police-court magistrate has described as an unmitigated evil.

Then as regards school instruction in scientific knowledge, this should begin with elementary facts of astronomy and natural phenomena, such as the properties of air, water and common substances, the effects of heat and cold, the simplest facts, light and sound, and the growth and structure of familiar plants and trees. All this should be taught by appeal to the eye and by motion pictures or models, the principal aim being to train the child's powers of observation, description and logical inference.

It will require a greater national expenditure than at present, but the nation has to learn the truth that there is no economy so false as economy in national primary education.

Coincidently with this Nature study, the child should be taught reading, writing, elementary arithmetic, and drawing; but beyond this the training of eye and hand, the practical arts of life, co-operative action in drill and dancing with the aid of music should take precedence of books and words.

The main thing is that the child shall be taught to *do* things, or effect practical achievements, and not simply to store memory with words or the analysis of them. The right use of language and its employment to describe experience, should be conveyed by example and imitation from the living teacher and not the dead book.

Turning, then, to a more advanced stage of education, we find at present a strong consensus of opinion that radical changes are necessary in the curricula of public schools. The large amount of time spent at present over the grammar and literature of Latin and Greek brings no return at all proportional to the effort and expense spent over it. The mental discipline can be obtained more usefully in other ways.

There are four great groups of educational subjects which should be put on an exactly equal footing, and claim each a quarter of the whole working time of the schoolboy. These are: (1) Language and literature, considered chiefly as a means of expressing thought and experience; (2) science, or a knowledge of the facts and laws of the physical universe; (3) mathematics and graphics, or the study of number and form, including arithmetic, geometry and algebra, and drawing in various forms, geometrical and freehand; (4) civics, or the preparation for citizenship, which includes history, both of the world and of the native country, elementary political economy, religious or ethical instruction, elocution and military drill or exercises.

Assuming a total of working hours of about 40 per week, this would give 10 hours a week, or, say, 360 a year, for the study of scientific subjects. In the next place we have to consider what these subjects should be. When science-teaching was first introduced into schools, chemistry seems generally to have been selected, and under its schoolboy designation of "stinks" has been the principal subject always taught. Chemistry, however, is not regarded by the author as the most suitable for initial instruction. Mechanics is much better as a starting point.

It is a great mistake to lecture too much to boys as if they were adults. This type of oral teaching is easy to give, but most ineffective in results. The students should perform the experiments and not the teacher, and the work should consist in making careful observations or measurements, which are then as carefully described by the boy in his own language in writing. The proper description of experiments or observations in good, simple, lucid English should be strongly insisted upon, and marks given for this as well as for accuracy in results.

It is advisable to postpone the study of chemistry until after the elementary physics and mechanics, and until a little training in experimental work has been acquired. In some schools a great show is made with carpenters' or engineering workshops. This impresses parents and attracts boys with a mechanical turn of mind; but

* Abstract of a Paper in the "Journal" of the Royal Society of Arts.

there is little or no real scientific training in it. The making of a model steam engine is an amusement for leisure hours or wet half-holidays, but is perfectly useless as a means of scientific education for boys.

Here as elsewhere the man counts for more than the machine or apparatus. Nevertheless, the good teacher is wasted unless he has the necessary appliances. For this reason every public school should be adequately provided with museums containing geological, mineralogical, botanical and zoological specimens, and these should be continually increased and well arranged. The physical and chemical laboratory accommodation should be ample and well equipped. Every school should also have a small astronomical observatory with an equatorial telescope, clock and transit instrument, and an outfit of surveying instruments, such as a theodolite, chain, level, and surveying staffs. Trigonometry as a mathematical subject should be taught in a practical manner by the aid of these last-named appliances, and not merely made to consist in the memorising of formulæ.

Instruction in elementary astronomy, comprising a practical knowledge of the constellations and movements of the sun and moon, should form part of all school education. It is lamentable to notice how few adults even in the educated classes have the smallest knowledge of these things, or the faintest conception of the reasons for the tidal movements of the sea, the changes in the seasonal appearances of the starry heavens, the phases of the moon, or the phenomena of eclipses.

A classical scholar, on being told that on a certain night an eclipse of the moon would be visible, observed to the writer of this article that it was " fortunate " that the moon would be full on that night, as the eclipse would be better seen. It is a most elementary fact of astronomy that it cannot occur at any other time except at full moon.

One of the essential things is to give proper dignity and importance to scientific knowledge and teaching. It has been far too long considered as the Cinderella of school subjects.

An influential meeting was, however, held lately, under the chairmanship of Lord Rayleigh, at which important resolutions were passed, urging (1) that the study of Nature sciences should form an integral part of the educational course at all the great schools of the country and of the entrance examinations of the universities, old and new; (2) that the Government should encourage this study by assigning capital importance to scientific knowledge in the competitive examinations for the home and Indian Civil Service, and for admission to Sandhurst. If these resolutions are acted upon by the authorities, pressure would at once be put upon the public schools to reform and augment their scientific teaching. We should not then in the future run the risk of our legislators in Parliament exhibiting, as they have done recently, the most astonishing ignorance of simple facts of chemistry.

The revision of the relative value of the scholarships in classics and science is urged. What is required is, not merely to produce scientific specialists, but even more to create appreciation of, and sympathy with, scientific work and aims in the mind of the general public.

Assuming, however, that a reform in the public school methods will lay the foundations for this increased sympathy, it is then essential that scientific men should continually endeavour to place the results and methods of their work in such form as to encourage and justify public interest. The chief method by which this can be done is by public lecturing and also by written communications to the public press, chiefly the great daily newspapers and the more widely circulated general magazines. The public lecturing is by far the most important, because this can be illustrated by actual experiments, diagrams, lantern slides, projections or specimens.

Faraday, Tyndall and Huxley were past masters in it. It demands not only trained elocution, but the power of marshalling ideas and uttering them in apt and forceful phrases with attention to time limits and public capacity to assimilate new ideas. Lecture experiments and demonstration need also special abilities and ingenuity.

The Friday evening discourses at the Royal Institution, or the afternoon lectures in the same place, may be taken to represent generally the highest achievements in this form of public teaching, as also do the similar lectures at the Royal Society of Arts. Most large cities have institutions at which similar public scientific discourses are given at frequent intervals. The Gilchrist Educational Trust has also done a great and useful work in the last 30 years in enabling large popular audiences all over the country to receive such instruction in scientific matters from the most eminent exponents and lecturers. The discussions and popular lectures at the British Association meetings are also of service in the same sense.

Of late years the ancient as well as the modern universities have added greatly to their equipment in laboratories and museums, with all the appliances of scientific study. Nevertheless, too much of it has been devoted to the purpose of making graduates rather than investigators.

The chief function of a university is to increase our knowledge, and not merely to put the hall-mark of a degree on young men who have acquired a certain store of learning concerning the achievements of others. The obsession of the written examination paper and degree still holds us in its grip. Whilst it is essential to insist on a certain breadth of acquaintance with known things to prevent the creation of narrow specialists, the university does not accomplish its final purpose if it fails to animate its students with an intense zeal and some ability to push forward the confines of knowledge. Hence the main duty of a university is research. The duty of advancing pure scientific research is the particular responsibility of the science teachers and advanced students and graduates in it. No one is fit to fill the post of a university teacher who is not actively engaged in research in his own special department of knowledge. His success ought largely to be gauged by the degree to which he gathers round him students who can take part in and assist in new investigations.

The value of this work has to be measured by its quality as well as its quantity. There is at the present time an enormous output of published researches, but a great deal of this is work which is concerned with minor questions, quantitative measurements, and with the gleaning of corners of the scientific field. The really great investigations are those which open for the first time some novel and rich mine of scientific truth. Such, for instance, were the epoch-making investigations of Sir J. J. Thomson on masses smaller than atoms; those of Hertz on the creation of electromagnetic waves; of M. and Mme. Curie and Sir E. Rutherford on radioactivity; of Sir William Huggins on stellar spectroscopy; and of Röntgen on the X-rays.

A most important matter is the consideration of the conditions under which this stimulative originality can be fostered and increased. One thing is certain, that too much devotion to the study of what others have done is apt to diminish original powers. The great inventors and discoverers instinctively turn to new fields of research. When a man has this notable originative power, everything should be done to facilitate his possession of every material means necessary. It is the most wanton waste of rare gifts if an experimental genius is allowed to spend much of his life in a heart-breaking struggle to acquire merely the implements of research. The British nation has yet to learn the immense resources which in Germany, and also in the United States, are being put at the disposal of those who have proved powers of scientific investigation.

The Kaiser Wilhelm Institute is referred to, which is devoted to the highest class of research work.

It is not a day too soon, therefore, that the Government has created a Committee of the Privy Council to deal with scientific and industrial research, and an Organising Council to direct the disposal of the funds which will be administered.

There are indications that this will be done by grants to learned scientific societies for special researches, by grants to universities and colleges, and to individuals and committees for definite research work. By the assistance of research scholarships and fellowships it will be possible to give the necessary financial assistance to trained men who have exhibited the necessary qualities of mind. We have to search diligently for this capacity and cultivate it, not simply to wait for it to turn up, and we may then hope to increase greatly the systematic pursuit of advances in scientific knowledge.

One great difficulty which presents itself is the small faith which so many British manufacturers have at present in the utility of scientific research. This shows itself in the unwillingness to make the necessary investment of money in it.

The technical problems are often insoluble unless very considerable expenditure is made on the preliminary research. To make a large effective improvement in a dynamo, an optical glass or a dye, an expenditure of anything from £20,000 to £100,000 may be necessary. It is, therefore, necessary to have a strong confidence in the ability of research to justify the expenditure.

Again, if our educational methods are directed sufficiently to the production of men who can do new things, and not merely know about old ones, we shall provide the manufacturer with the men who can give him the efficient assistance. We have, therefore, to make science an integral part of our national education. We have to create conviction in the public mind that only in this manner can we forge the weapon which shall give us the ability to retain our place as a world power. We have,therefore,to reconstruct the basis on which our educational systems rest and make a study of the laws, phenomena and processes of Nature of primary importance to them.

It has to be clearly realised that, great as are the victories of science in the past, there are revolutionising discoveries and inventions yet to be made which will affect human life in every way. We cannot afford to be and remain content to have no part in them, but they will only come as the reward for strenuous labour on our part. We may not be able to effect all the reforms in education which are an essential precursor, but we can do something, and we can do it at once

THE MIGRATION OF THE IONS.*

BY S. W. J. SMITH, M.A., D.SC., F.R.S.

Summary.—The difficulties inherent in the usual explanatory diagram are first dealt with, and a better explanation is given. Some illustrative experiments are referred to, and a new diagram of ionic migration is proposed.

The object of this note is to attempt to remove an imperfection from a much-used graphical "explanation" of the phenomenon known as the migration of the ions.

The explanation in question proceeds briefly as follows: It is supposed that a solution of a salt, MX, is being electrolysed, that M is depositing upon the cathode C, while X is similarly escaping from solution at the anode A, and it is desired to show that the rate of impoverishment of the solution round C is to that round A in the ratio $v : u$ of the ionic velocities of X and M. For this purpose a diagram of the following kind is drawn to represent (i.) the initial state of the electrolyte and (ii.) its state after a time, t.

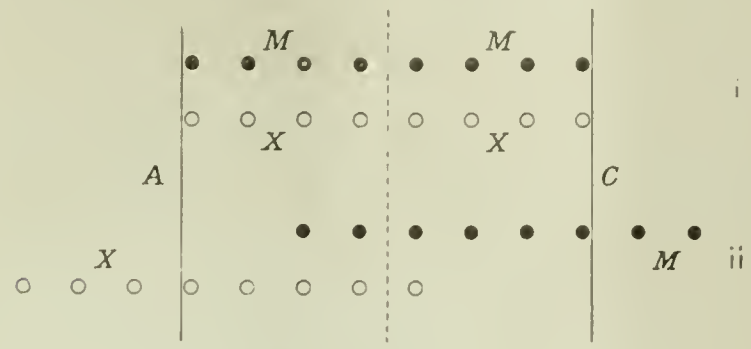


Fig. 1.

For purposes of illustration a simple ratio of u to v is chosen—*e.g.*, 2 : 3, as in the figure. It is pointed out that the number of molecules to the left of the median line is fewer by two than the initial number, while the number to the right is fewer by three. Then it is said that it is seen in this way that three molecules are lost at the cathode, while two molecules are lost at the anode, and that, therefore, the cathode loss is to the anode loss as 3 : 2.

It is pointed out that the same diagram can be illustrated as any thick and thin lines to represent the movements of ions. The truth of the matter is that no explanation of the relation between the electrode losses can be satisfactory if it does not emphasise the difference between the way in which the current is conveyed from one layer of the liquid to the next, and that in which it is conveyed from the liquid to either electrode.

In the liquid the transference is partly by positive ions travelling in one direction, and partly by negative ions travelling in the opposite. At the electrodes the transference is by ions of one kind only—by positive ions at the cathode and (in the simple case supposed) by negative ions at the anode.

In consequence of this, more cations are deposited at the cathode, and more anions at the anode, than those for which the ionic streams, due to the applied potential gradient, are responsible.

What happens may be represented symbolically in the following way:—

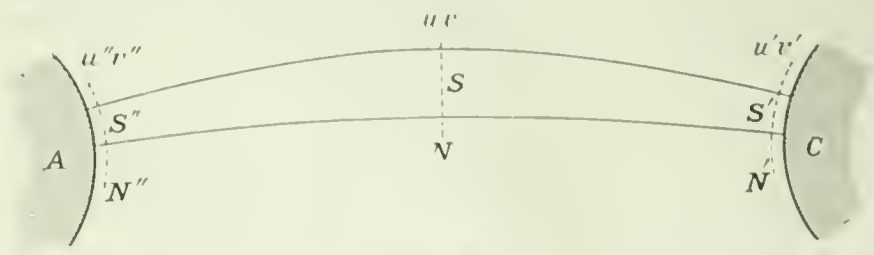


Fig. 2.

In the figure let A and C represent sections of the electrodes, and let the curves extending between them represent the section of a tube bounded by current stream lines at any time, t. Suppose, for simplicity, that the ions M and X are of equal valency, and carry respectively the charges $\pm\epsilon$. Let the potential gradient at any cross-section of the tube, of area S, be such that the ionic velocities are u and v respectively, and let N be the number of ions of each kind per unit volume near S. Let S', u', v', N' and S'', u'', v'', N'' be corresponding quantities for the sections S' and S'' in the immediate neighbourhoods of the electrodes.

Then the condition that there should be no accumulation of free electricity in any element of volume of the tube while the current flows gives

$$N(u+v)=N'(u'+v')=N''(u''+v''). \quad . \quad . \quad . \quad . \quad (1)$$

The ratio of the ionic velocities is constant, since these vary in the same way with the potential gradient.*

Hence, $$u/v=u'/v'=u''/v'',$$

and, therefore, from (1)

$$Nu=N'u'=N''u'',$$

and $$Nv=N'v'=N''v''.$$

The current across any section of the tube at the time considered is $N(u+v)\epsilon$, and the quantity of electricity conveyed through the solution in the time dt is $N(u+v)\epsilon dt$. During this time the number of cations deposited upon the cathode is, by Faraday's law, $N(u+v)dt = N'(u'+v')dt$. Similarly, the number of anions deposited upon the anode is $N(u+v)dt=N''(u''+v'')dt$. The number of cations brought by the current to the cathode in the same time is $N'u'dt$, and of anions to the anode $N''v''dt$.

Thus we see that the number of cations deposited upon the cathode exceeds the number brought up by the current by $N'(u'+v')dt - N'u'dt = Nvdt$, and the number of anions deposited upon the aonde exceeds the number brought up by the current by $N''(u''-v'')dt - N''v''dt = Nudt$.

In seeking for the source of supply of these excess cations and anions deposited upon the electrodes, we notice that, in order to satisfy the equation (1), $N'v'dt=Nvdt$ anions must pass outwards through S' and that $N''u''dt=Nudt$ cations must pass outwards through S''.

Therefore, equation (1) will be satisfied if the following processes occur:—

During the deposition of $N'(u'+v')dt$ cations upon the cathode, $N'v'dt$ molecules dissociate (ionise) in the immediate neighbourhood of this electrode. The $N'v'dt$ cations of these molecules are deposited along with the $N'u'dt$ cations carried in by the cationic stream, while their $N'v'dt$ anions pass away from the electrode to maintain the anionic stream.

During the deposition, contemporaneous with that above, of $N''(u''+v'')dt$ anions upon the anode, $N''u''dt$ molecules dissociate in the solution in contact with this electrode and deposit their $N''u''dt$ anions along with the $N''v''dt$ anions carried to the anode in the anionic stream, while their $N''u''dt$ cations pass away from the electrode to maintain the cationic stream.

In this way during the passage of $N(u+v)\epsilon dt$ units of electricity through the solution, $N(u+v)dt$ cations are deposited upon the cathode, and $N(u+v)dt$ anions are deposited at the anode. The cathode space loses $Nvdt$ molecules, and the anode space loses $Nudt$.

Hence, we see at once that the ratio of the cathode loss to the anode loss, in any given element of time, is $v : u$, and we see also at once where the "lost" molecules have gone.

A glass tube of any convenient length and diameter is taken, together with two corks, through which pieces of stout copper wire are inserted centrally to act as electrodes. The tube is fixed in a vertical position with one of the corks fitted tightly into its lower end. The tube is nearly filled with a concentrated solution of copper sulphate: it adds to the instructiveness of the experiment if a saturated solution is used. The other cork, which is fitted rather loosely, is then inserted into the upper end, so that a centimetre or two of the wire which passes through it is immersed in the solution. A current from a 2-volt accumulator is then passed through the solution for some hours, the lower wire being the anode and the upper the cathode. The colour of the solution round the cathode gradually disappears. The manner of its disappearance is insignificant.

It is easily seen that the loss of colour is not confined to the immediate neighbourhood of the wire, but extends over the whole of the liquid above a horizontal plane lying near the lower end of the wire. The inferences from this are that convection currents are circulating continuously in the upper part of the tube, that one part after another of the liquid contained in this space comes into the region where the main portion of the current is flowing, and that this liquid gets continuously poorer in copper sulphate, because each part loses a fraction of its salt content as it moves over the electrode. There is, therefore, no difficulty in this case in seeing where the bulk of the additional molecules are obtained. It may be interesting to add that, when saturated solutions are used, crystals of copper sulphate can be observed round the anode at the conclusion of the experiment. These represent the "anode gain," just as the destruction of colour in the upper part of the tube represents the (equal) "cathode" loss.

This experimental illustration can be made additionally instructive, from the point of view of this note, if a second tube of identical construction is arranged in series with the first. The two tubes are placed side by side, and the upper electrode is the cathode in each. The solution in the second tube, besides being saturated with copper sulphate, contains (for example) an equivalent amount of zinc

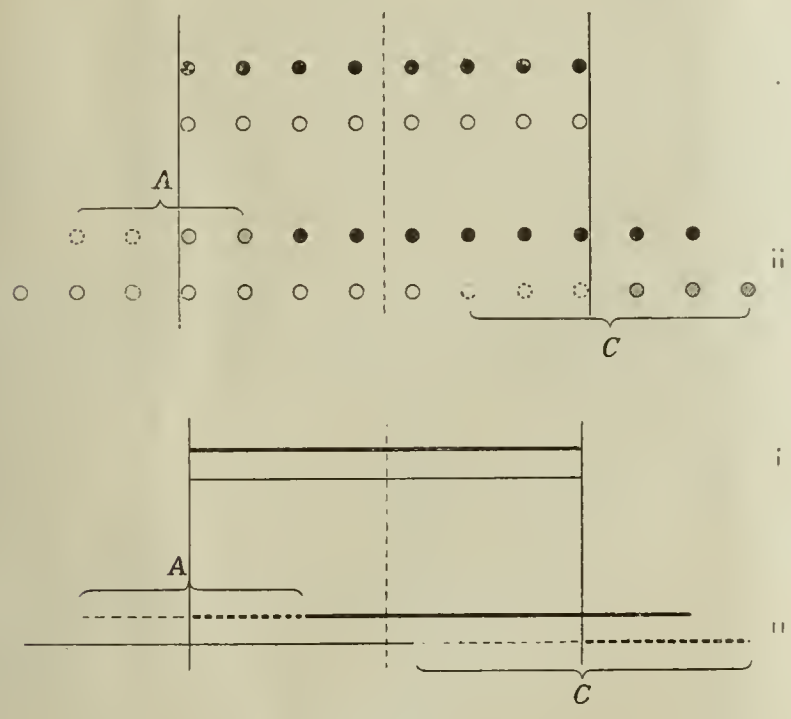
---

* Abstract of Paper read before the Physical Society.

* For the present purpose the fact that u, v may vary with N can be ignored.

sulphate. By comparing the colours of the two cathode spaces from time to time after the current has begun it appears that the solution round the cathode in the second tube loses copper at the greater rate. In this tube the cationic stream consists partly of zinc ions, and the amount of copper carried to the cathode per second by the current is, therefore, less than in the first tube. Hence, since the rate of deposition of copper on the two cathodes is the same, the solution round the cathode in the second tube has the greater demand made upon its supply of copper. The rates of loss will be, approximately, in the ratio $(v+\frac{1}{2}u) : v$, if we suppose the zinc and copper ions to be equally concentrated in the second tube, and to have approximately the same velocity.

The following diagram makes the action more intelligible.



FIGS. 3 AND 4.

The molecules contained within the bracket near C in each figure are those which actually disappear from the cathode space, while those contained within the bracket near A are those lost by the anode liquid. The ions to the right of C and to the left of A are those removed from the solution at the same time.

These diagrams show explicity that ionised molecules of salt have to be fed into the current stream at the electrodes in order to keep it going, and it is just this essential feature of the phenomenon that the usual diagram omits.

INSTRUMENT TRANSFORMERS.*

BY CHAS. C. GARRARD.

Current Transformers.—Current transformers are at the present time indispensable to the best practice of electrical engineering. Some years ago it was usual to connect measuring instruments directly in high-tension circuits. This often led to trouble for several reasons. One difficulty, of which the effects were much more apparent than the cause, was electrostatic attraction between the moving parts of soft iron ammeters and the fixed parts of the instrument. This led to "sticking" and inaccurate readings. A method of obviating this and which was used in Ferranti "box type" ammeters is illustrated in Fig. 1. As there are still numbers of these instruments in use this description may be of general interest. It will be seen that the plunger hole is lined with tin foil. taking care not to form an entirely closed circuit, and this is metallically connected to the soft-iron plunger. The side of the plunger hole and the plunger are thus at equal potentials and electrostatic attraction between the two cannot occur.

The advantages that the use of current transformers entails can be summarised as follows :—

1. Instruments are safe to handle and can be situated at considerable distances from the high-tension circuits. For remote control, therefore, series transformers must be used.

2. With large low-tension currents owing to the non-necessity of taking current through the instrument, a great saving in cost is attained.

3. A considerable number of instruments can be fed by one transformer.

4. Electrostatic and similar troubles are obviated.

There can be no doubt that series transformers have received inadequate attention from manufacturers. This is evidenced by the extreme variety of designs which are on the market, the difference in cost of such transformers put forward by different makers for similar purposes being sometimes in the ratio of 5 to 1. These transformers are labelled as 10 watt, 50 watt, &c., in a very haphazard manner, and it would appear very desirable to lay down some standard method of rating of current transformers.

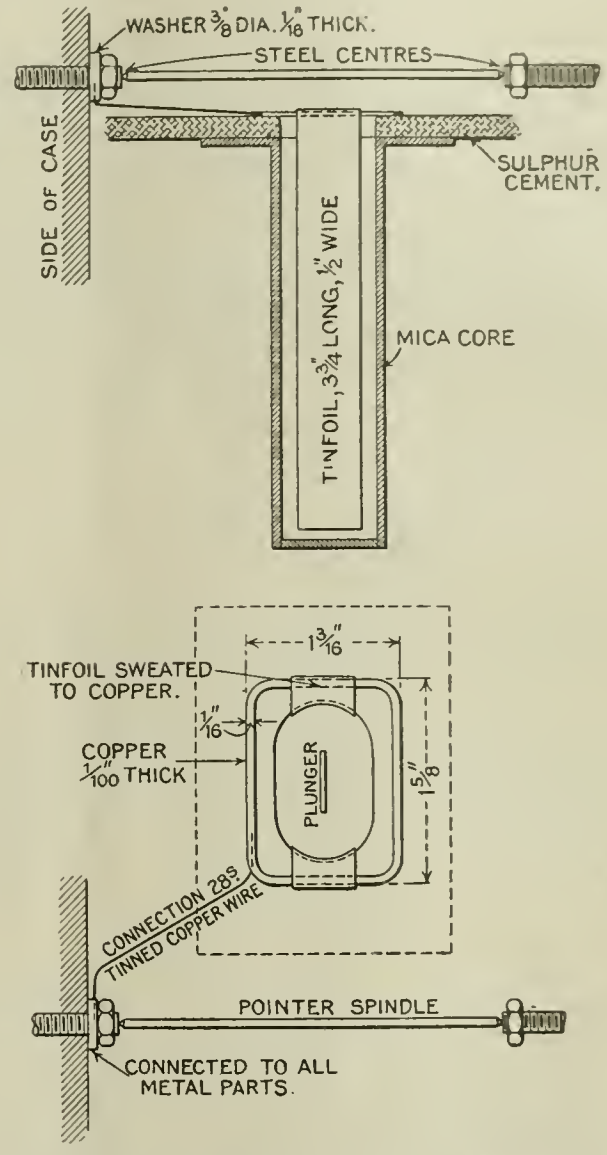


FIG. 1.—PLUNGER AND CORE OF BOX TYPE AMMETER. METHOD OF OBVIATING ELECTROSTATIC ATTRACTION IN HIGH-TENSION AMMETERS.

Vector Diagram of Current Transformer.—The vector diagram of the series transformer is similar to the ordinary transformer diagram in general character. The interpretation of the various vectors, however, requires some care. For ease of consideration we will assume a nominal ratio of 1/1. Let OE_s (Fig. 2) be the voltage induced in the secondary; therefore OE_p will be the applied voltage necessary to overcome the back E.M.F. in the primary and $OE_s=OE_p$. Let the secondary current which is driven through the secondary circuit by OE_s be OI_s lagging by the angle θ behind the driving voltage. If the current transformer were a perfect one the primary current would be exactly equal and opposite in phase to OI_s. As the transformer is, necessarily, not perfect, we will represent the primary current by OI_p. Now the primary current does three things : (*a*) it produces the secondary current OI_s. (*b*) it provides a magnetising current to produce the magnetism which produces the voltage OE_s, (*c*) it provides a watt current to make up the losses entailed in producing the said magnetism. The components under (*b*) and (*c*) refer only to those magnetic lines which actually embrace the secondary winding and produce the voltage OE_s. Thus ohmic loss in the primary does not affect the watt component in the diagram ; in fact, the efficiency, or goodness, of a current transformer is independent

* From a forthcoming book on "Electric Switch and Controlling Gear." Copyright. All rights reserved.

of the resistance of the primary. Losses due to magnetisation other than that magnetisation which produces OE_s are also without effect. Thus the transformer may have an iron case in which there is considerable loss. If this loss be only due to leakage *from the primary* it is without effect on the current transformer. If, however, it be due to leakage from the secondary, it is a different matter, as will be explained later.

The magnetising component (b) must evidently be at right angles to OE_p and 90 deg. behind it in phase. The watt component must be in phase with OE_p. The magnetising and loss currents are, therefore, represented by the vectors OI_M and OI_H. The primary current is, therefore, the vectorial sum of OI_M, OI_H, and OI_s reversed. This is shown in Fig. 2. It will be seen that OI_p differs both in length and phase from OI_s, and we have

$$\frac{I_p}{I_s}=1+N,$$

where N is always a positive quantity. The primary current lags by the angle α on the secondary current. It is the object of the design of the current transformer to keep N and α as small as possible. It is evident from the diagram that α depends on θ.

In order to compare the transformer angles of two current transformers it is necessary to specify the angle of lag of the secondary current at which the measurement is made. The standard condition should be with the secondary current in phase with the secondary terminal voltage; this does not

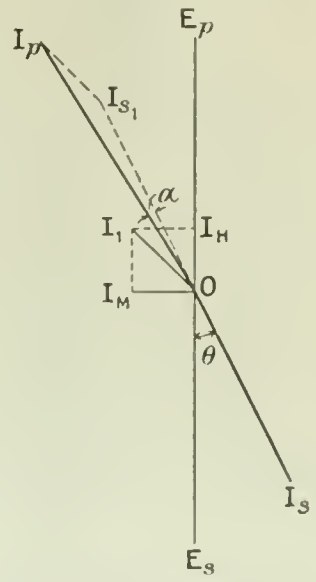


Fig. 2.—Vector Diagram of Current Transformer.

necessarily mean that $\theta=0$. With this proviso the values of N (or rather the variation of N with load) and α for a current transformer afford a criterion enabling one to judge of the quality of the transformer. The three terms to be stated are the value of α at full load (*i.e.*, with full load current and full load rated volt-ampere output), the value of N at full load (as above) and the value of N at 1/10 rated full current, but with the transformer secondary closed through the same resistance which gives full load volt-amperes at full load current. It is necessary to give the value of N at two points as it is the variation of N which matters. All figures apply to a non-inductive load. The Author would suggest that it is upon these lines that standardisation of current transformers should proceed.

Influence of N and α on Instrument Readings.—*Ammeters, Maximum Current Relays and other Current Devices.*—On these only the variation of N is of effect. If the instruments are calibrated together with the transformers, of course the variation from nominal ratio does not matter. It is now usual, however, to specify that current transformers should be interchangeable one with another. This is, of course, regarded from the practical standpoint, a highly desirable thing, and for commercial accuracy does not present any great difficulty. If the transformers which are to be interchangeable are all equally loaded, then even a large variation of N is of no great importance provided the N of each transformer is the same and the variation of N with current is similar in each transformer. These latter two conditions are easily obtainable by regularity in the construction of the transformers. The modus operandi is then simply to adjust the ratios, by manipulating the primary and secondary turns, so that they are all equal and each equal to the nominal at the full load. The scales of the instruments can then be marked off when fed by one of the transformers.

When the transformers are used for feeding relays the variation of N with large overloads is of paramount importance. In most cases, however, the loads to be borne by the various current transformers are not equal. It is at the present time considered the best practice to have a single transformer per panel and let that feed all the instruments on that panel. But the number of instruments per panel varies considerably. To get interchangeability under these circumstances is naturally more difficult and can be done only by using a transformer with small variations of N, say, 1 per cent. The error, therefore, caused by interchanging the instruments and transformers would not exceed 1 per cent., which for "current" instruments should not be considered too great.

Wattmeters, &c.—With this type of instrument not only is the "N" of the transformer of importance, but also the angle "α." The "N" effect can be allowed for as described above.

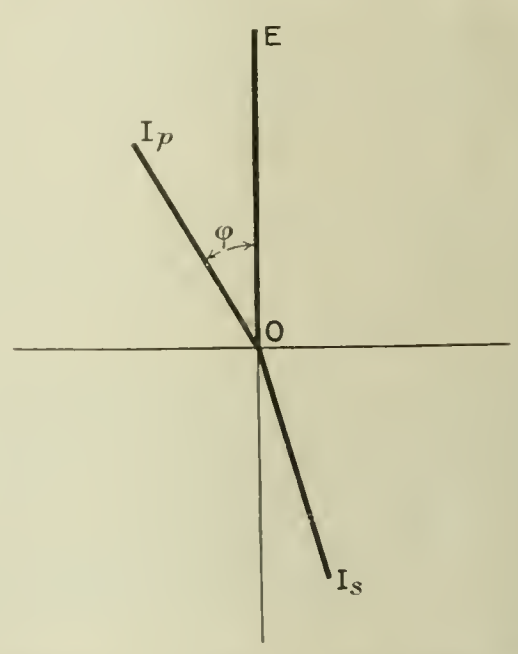


Fig. 3.—Diagram illustrating Current in Wattmeter fed by Current Transformer.

The error caused by the angle "α" however, cannot be obviated by this method but has to be corrected for within the wattmeter itself. We will, therefore, consider the effect of "α" alone, neglecting "N" on wattmeter accuracies in general. We shall then have to distinguish between the two different types of wattmeters, viz., (a) dynamometer type wattmeters and (b) induction type wattmeters.

Calculation of the Effect of the Transformer Angle α on the Accuracy of a Perfect Wattmeter.—We will consider a single-phase circuit. In the diagram, Fig. 3, let OE equal the voltage of the circuit in which the wattmeter is connected, and OI_p the main (primary) current lagging behind the main volts by the angle φ. Then the true watts $=IE\cos\varphi$. Owing to the interposition of the current transformer instead of the current OI_p flowing through the meter, we have the current OI_s flowing through, which is equal in magnitude to OI_p (neglecting "N" and assuming 1/1 ratio), but is inclined to it at the angle $180+\alpha$. The instrument therefore indicates $EI_s\cos(180+\alpha-\varphi)=-EI_p\cos(\varphi-\alpha)$. As $\varphi-\alpha$ is a smaller angle than φ it means that the wattmeter will indicate higher than the true watts. The minus sign in the equation simply means that the wattmeter reading is reversed, which is got over by suitably crossing either the current or volt leads. The percentage error introduced by

$$\alpha=\left(\frac{\varphi\cos(\varphi-\alpha)-\cos}{\cos\varphi}\right)100 \text{ per cent.}$$
$$=(\cos\alpha+\tan\varphi\sin\alpha-1)\ 100 \text{ per cent.}$$

Now α is a small angle generally of the order of one or two degress or less, therefore, cos α=1 (approximately).

Therefore, percentage error =sin α tan φ 100 per cent.

If α be 1 deg. we get from the above the following table :—

Power factor of main circuit. Cos ϕ.	Tan ϕ	Percentage error in wattmeter reading due to α=1°.
1	0	0
0·75	0·887	1·55
0·5	1·73	3·02
0·25	3·92	6·85
0	∞	∞

Correction of Wattmeter for Transformer Angle.—As stated above, the transformer angle can only be corrected for within the wattmeter itself. The principle of the correction is to make the wattmeter itself slightly wrong (*i.e.*, low, on inductive load), with the error in the opposite direction to that caused by α. The transformer angle causes the combination of meter and current transformer to read high on inductive load if not corrected for. We have to distinguish, however, between the two different types of wattmeters, the induction and the dynamometer type. Considering the latter first :—

Dynamometer Type Wattmeter.—Probably the majority of wattmeters work on this principle—viz., the electro-dynamic action of one current-carrying coil upon another. The criterion of accuracy of a dynamometer wattmeter on inductive load is that the shunt coil should have negligible self-induction. Should, however, the shunt coil current lag by the angle β behind the impressed volts, then the wattmeter only indicates true watts when the power factor of the main circuit is cosine β. In all dynamometer wattmeters made by reputable makers β is extremely small, and very much smaller than the angle α, which will be introduced by even a good current transformer.



Fig. 4.
Series and Shunt Fluxes in Dynamometer Wattmeter when fed by Current Transformer.

Considering the diagram in Fig. 4, let OB represent the shunt flux in the wattmeter and let OA represent the series flux when the meter without current transformer is on non-inductive load. Under these conditions the meter will, *ceteris paribus*, read correctly on inductive load. The current transformer, however, displaces the series flux to the position OC, where the angle COB is equal to α. In order to render the combination accurate on inductive loads it is necessary now to shift the phase of OB by the angle α forward ; that is to say, on non-inductive load, with the meter alone the shunt flux should lead on the series flux by the angle α. With dynamometer wattmeters this is a very difficult thing to arrange. It could only be done by inserting a condenser in the shunt circuit, which would be awkward and costly. It is for this reason that dynamometer wattmeters are not so suitable for use with current transformers as are induction-type meters. Most manufacturers of dynamometer wattmeters specify that when used with current transformers the power factor of the main circuit should not fall below 0·6. As dynamometer wattmeters are often put forward in conjunction with very poor (magnetically leaky) current transformers as "standard" instruments, it is necessary to remember that it is quite impossible for such combinations to indicate correctly on inductive loads.

Induction Type Wattmeters.—In this type of instrument we have two magnetic fluxes reacting together on a metal rotor, causing the same to rotate by virtue of the eddy currents induced in it. The chief condition for accuracy is that on non-inductive loads the shunt flux must lag exactly 90 deg. behind the series flux. In Fig. 5 let OF_M be the series flux and OF_s be the shunt flux ; on non-inductive load the angle between these two vectors must be 90 deg. If, now, the main current lags, then OF_m approaches OF_s, until at zero power factor they both lie in the same straight line, and there is not any torque exerted on the meter rotor. If, now, a current transformer be interposed the current vector is caused to advance α to the position OF'_M. In order to render the combination accurate on inductive load it is still necessary that the main flux and shunt flux should be in quadrature on non-inductive load, which result can be obtained by shifting OF_s to the position OF'_s—*i.e.*, advancing it by the angle α. This can be attained at once by simply altering the time constant of the shunt coil of the meter ; that is to say, simply increasing its ohmic resistance or decreasing its inductance in the right proportion. Thus, the combination of induction wattmeter and current transformer can be rendered perfectly accurate, even down to the lowest power factors. It is for this reason that the induction type wattmeter is the better instrument to use on all commercial installations where the meters have to be used in conjunction with current transformers. For all commercial tests of alternator efficiencies, &c., a good type of induction watthour meter and current transformer is to be preferred to any other system of measurement. For accurate standardising work, if possible, current transformers should not be used, but dynamometer wattmeters arranged to carry large currents without the interposition of transformers. As such work can nearly always be done with low-tension current, this procedure presents no difficulty ; for high-tension measurements, however, current transformers are generally indispensable.

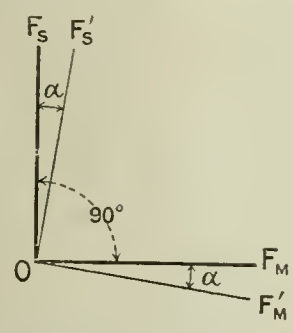


Fig. 5.—Diagram illustrating Correction of Induction Type Wattmeter for Transformer Angle.

(*To be concluded.*)

Coating Metals with Zinc.—According to the "Iron Trade Review," an interesting instance of adopting a process to changed conditions is found in a new apparatus for coating metals with zinc film. The Metals Coating Co. of America has developed the Schoop metal spraying process in which zinc wire or other metal wire is melted in a gas flame and projected under pressure on the surface to be coated. Under present conditions in the metal market this wire has become exceedingly expensive. To fill the need for a less costly process, the apparatus has been modified to permit the employment of zinc in the less costly form of dust. It consists of a conical receptacle which has another similarly-shaped receptacle inside, with a small space between. Zinc dust is placed in the inner cone and compressed air is admitted through a hose at the top of the space between the two cones. A valve at the bottom of the inner compartment allows the zinc dust to be caught up by the air current and carried through a discharge tube to a spraying device. The zinc dust is there blown from an inner nozzle through an acetylene gas flame, the heat of which is sufficient to melt the zinc. In the melted condition the particles of zinc are projected at high velocity upon the surface to be coated by the action of the blast. Adjustable valves regulate the quantity of zinc dust allowed to pass into the air current and also the quantity of gas used to melt the metal. The apparatus is said to weigh about 20 lb. and uses air at a pressure of about 5 lb. per square inch. Acetylene gas, the heating agent, is easily available, and has been found to give good results with zinc dust. The present cost of zinc wire is about 5s. per pound, while zinc dust, which is a by-product of the zinc smelter, may be obtained at about 1s. 3d. per pound.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE

Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.
WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.
THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.
THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.
THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. 2s. 6d nett, post free 2s. 9d.
THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone. 9s. nett, post free 9s. 4d.
STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett
ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S. Heather, M.I.E.E. 9s. nett.
AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.
THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.
WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.
ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.
LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.
ELECTRIC BLASTING APPARATUS AND EXPLOSIVES : With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.
THE SHOT-FIRER'S GUIDE : A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.
THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.
THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*
LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.
ELEMENTARY THEORY OF ALTERNATE-CURRENT WORKING. By Capt C. L. Hall. R.E. 3s. 6d. nett.
COMMON BATTERY TELEPHONY SIMPLIFIED. By W. Atkins. *Third issue* 3s. nett, postage 3d.

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM): A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d each, post free. Hanging Cards : 1/- each post free. Pocket Books, complete in envelope, 2s. 6d., post free

ENTIRELY NEW BOOK.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s.** nett. post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

GRAPHICAL CHARTS.

Many theoretical investigations lose much of their practical importance because the results are not presented in a form such as the busy engineer can apply at once to the work on which he happens to be engaged. The fault, if it be a fault, is more that of the investigator than of the practitioner, as it is only in exceptional cases that the latter can find the time either for extended study or for making complex calculations. This is a matter that is sometimes overlooked by the investigator.

From the point of view of the pure mathematician it is folly to plot curves and to have recourse to graphical constructions, seeing that in the one case the equation itself gives all the information required, and in the other that the answer is only approximate. We know of wranglers who are so completely the slaves of their subject as to find the use of squared paper methods abhorrent to them. The work of the technologist, and more particularly of the engineer, consists of approximations, and the rigid accuracy demanded by the mathematician does not enter into any of the problems which have to be solved. An engineer uses mathematics in much the same way as the limit-system is used in the workshop, and the artisan of experience knows when to use a two-foot rule and when to use a micrometer for measuring a length.

It is more than a coincidence that graphical methods of solving problems and of recording facts are largely used in those countries in which one finds science the handmaiden of practice. Of the graphical methods of presenting facts some form of chart is probably the most convenient, since such charts are found to save a good deal of time in the works, in the drawing office or in the engineer's office. Foremost amongst graphical charts is that which is plotted to rectangular co-ordinates. So common is the use of squared paper to-day that it is difficult to realise such paper costing 8d. per sheet 40 years ago when Prof. PERRY and the late Prof. AYRTON began to use it extensively in Japan in teaching mathematics and mechanical and electrical engineering and laboratory work.

The use of logarithmic divided paper is to be recommended for the study and determination of some law of the relation between certain numbers, or during an experiment. Many of the diagrams employed in technical investigations are more easily plotted out on logarithmic paper than on ordinary squared paper, because the more commonly occurring curves are readily obtained as regular lines on logarithmic divided paper. Prior to the outbreak of war such paper came from Germany, and sheets 12 in. by 8 in. of good quality, accurately ruled, cost about 8s. per 100. Polar co-ordinate paper of excellent quality came from the same firm and cost 6s. per 50-sheet pad. For both papers there is likely to be a big demand in the future, and there is no reason why they should not be ruled in this country.

Although diagrams plotted to rectangular co-ordinates are most widely used, for some purposes, and particularly when there are many variables, the system is less convenient than the alignment chart or abac, as it is called. Other useful methods are the hexagonal index chart, the proportional chart, the stereographic chart and solid model. An excellent example of the latter is the tri-axial model which makes

it possible to take into account four variables, three of which add up to 100 per cent. As an illustration of the utility of this model may be mentioned the recording of one of the physical properties of an alloy composed of three metals. Engineers will call to mind the extensive use made of solid models by Herr LASCHE in his important research on high-speed bearings.

In recent years the alignment chart, which is said to be of French origin, has been successfully applied to the solution of engineering problems, thanks largely to the efforts of Prof. J. B. PEDDLE, whose little book can be recommended to those in search of information on the subject. An interesting application of the alignment chart to a familiar problem in electrical engineering is given elsewhere, and although it would be idle to pretend that the determination of hysteresis loss by means of the well-known Steinmetz formula is of much practical importance, it will be understood that any formula of the same kind lends itself admirably to solution by graphical methods. The convenience of being able to obtain commercially accurate solutions to complicated expressions containing many variables by drawing two or three straight lines on a chart will be appreciated by the busy man, and we venture to think that the subject is one to which many of our readers can profitably give attention.

Not only is the alignment chart applicable to the solution of given equations, but, as Prof. PEDDLE has shown, it may be used for the derivation of equations to fit a given set of empirical data. Up to the present, with relatively few exceptions, such charts have been most used in mechanical engineering, but there is no reason why they should not be equally useful in other branches of engineering.

REVIEWS.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

The Mechanical Handling and Storing of Material. By G. F. ZIMMER. (London: Crosby Lockwood & Son.) Pp. xiv.+752. 42s. net.

It is fortunate for us that authors are to be found who write books without hope or thought of monetary reward, and that there are still some publishers who are prepared to handle such books, notwithstanding the fact that it would, on the face of it, be more profitable for them to invest their money either in cinema palaces or in pier companies.

An inspection of the book under review leads us to the conclusion that Mr. G. F. Zimmer is entitled to be regarded as a man who writes without hope of monetary reward. A conservative estimate of the time expended and of the probable return will quickly reveal the truth of this, for he is unlikely to secure even the remuneration that an engineering apprentice can command. Nor are the publishers likely to secure a return commensurate with the outlay. But, as we have said, it is fortunate for us that some men find work itself a sufficient reward, and that publishers still live who do things for the "credit of the house." Were it otherwise, in all probability this two-guinea book would never have been written.

In excusing himself for venturing again before the technical world, the author points out that the importance of the mechanical handling and storing of material increases daily, as technical progress is, and has been, increasing by leaps and bounds in the last decade. "There is no factory now," continues Mr. Zimmer, "that can afford to do without machinery for handling and storing its raw materials and finished products if it is to be a commercial success. The national economy of the civilised world cannot do without the mechanical handling and storing of material, and . . . the toll claimed from the ranks of labour by the European War and the consequent shortage of hands will force even those who are slowest to adopt modern means to replace the man by the machine wherever possible." To this we would add that the labour troubles, which assuredly lie before us, imperatively demand the storage and rapid handling of huge amounts of coal by railway companies, gas works and power stations.

The sub-title, "Being a Treatise on the Handling and Storing of Material such as Grain, Coal, Ore, Timber, &c., by Automatic or Semi-Automatic Machinery, together with the Various Accessories used in the Manipulation of such Plant," gives a clear idea of the scope of the work which, we should imagine, is intended more for the user than for the designer, although the latter will find plenty to interest him on the particular branch of the subject in which he has specialised. The book is divided into six parts, namely, Continuous Handling of Material, Continuous Handling of Material by Pneumatic and Hydraulic Means, Intermittent Handling of Material, Unloading and Loading Appliances, Miscellaneous Installations and Automatic Weighting of Material.

Elevators and conveyors are dealt with in the first part, which consists of 18 chapters. Somewhat fuller treatment of the chapter devoted to elevators seems to be called for in order to obtain a better balance. The chapters on conveyors give probably the most complete account in the language of this important class of machinery, and the many types are described at considerable length. In the second part, in addition to chapters on handling by pneumatic means and conveying material by hydraulic means, there is a useful chapter on disposal of ashes from steamers, in which the author traces the development of ash ejection, and describes the ash hoist, hydro-ejectors and ejector pipes, besides giving an account of the latest developments.

To the intermittent handling of material eight chapters are given, and in addition to haulage systems, ropeways and cableways, the author describes the coaling of vessels at sea, monorails and telphers, and deals with the handling of raw material in connection with blast-furnaces, and with the mechanical handling of coke from coke ovens. The chapter on the handling of raw material at blast-furnaces is insufficiently complete to make a strong appeal to ironmasters, and particulars of a number of modern equipments would be welcomed by many.

Chapters XXX. to XXXVIII. are devoted to the description of unloading and loading appliances, and the matter in this section of the book is well found. An opportunity was missed in not emphasising the advantages of the electric drive, in so far as hydraulic machinery is still used, and, in our opinion, improperly used to a considerable extent for the driving of loading appliances. It would have been well to describe some of the notable coal and ore dumpers of American manufacture which hold the record for quick loading: the more so since many engineers in this country incline to the view that for this purpose the hydraulic machine is unrivalled. It is now generally admitted that the rapid technical progress in the mechanical handling of material, to which the author refers in the Preface, is due in large measure to the introduction of electrical energy as a motive power. Some idea of the ground covered in this important section will be gathered from the following: After describing the various kinds of skips and grabs in use, a chapter is given on transporters, bridge or cantilever cranes. This is followed by chapters on barge or ship elevators and marine legs; on floating loading devices, including self-emptying barges; on self-emptying hopper wagons; on tips or hoists and on colliery tips or tipplers. To loading coal into ships otherwise than by tips, and to miscellaneous loading and unloading devices separate chapters are given, and these bring the section to a close. An account of the very extensive coal-handling appliances installed at Cristobal and Balboa on the Panama Canal ought surely to have been included. Although descriptions were published but a short time ago, it is probable that the makers would have supplied the author with full particulars beforehand.

In the section on miscellaneous installations there is compressed into 50 pages a large amount of material, divided into four chapters, on the coaling of railway engines; coal, coke and

ash handling plants for boiler houses and gasworks; the storing of coal and other minerals in stock heaps and silos, and the warehousing of grain. To the descriptions of the many granaries one would like to see added an account of the recently constructed granary at Glasgow, which is probably one of the most up-to-date granaries in existence.

Chapter XLIII. on automatic weighing is a useful one, containing as it does descriptions of the principal weighing appliances and machines. This is followed by a very full table giving the weights of various materials. After the Index, which is well arranged and very complete, is given a Trade Directory of firms of repute who are makers of the different machines for the mechanical handling and storing of material. We like this feature least of all, for, if incomplete (and the list here given is incomplete) an injustice is done to those firms of repute whose names do not appear in the list.

The suggestions made above refer more to matters of detail than to arrangement or faulty treatment. Practically the only criticism we have to offer is that the author has not laid due stress on the importance of adopting the electric drive for most of the appliances he so ably describes. This is fundamental, and it is a vital matter for the user to know that it is only by adopting the electric drive that full advantage can be derived from the use of these labour-saving devices.

In criticising the conclusions arrived at by Messrs. Baxter and Dixon as the result of their experience with the electrically-operated coal hoists at Glasgow, the author states: "With regard to cost . . . . , this was based on the cost of 9d. per 1,000 gallons of pressure water. This estimate is considered excessive by hydraulic experts, and it is asserted that hydraulic power can be produced at from 2d. to 3d. per 1,000 gallons."

The reviewer asks: "By whom is it asserted that pressure water can be produced at 2d. per 1,000 gallons?" This figure corresponds to a total works-cost for electrical energy of 0·3d. per B.O.T. unit. Electrical engineers know that it is in only the largest generating stations working at very high load-factors that such low works-costs can be obtained.

From carefully-kept records it appears that the absolute cost of water, at 750 lb. per square inch, varies from 1·49d. to 20d. per 1,000 gallons. The former figure, which is taken from Mr. Macaulay's contribution to the discussion on Messrs. Baxter and Dixon's Paper on "Electrical Dock Equipment," is for a modern installation (at Newport) pumping about 170 million gallons per annum. At Swansea the average quantity of water pumped during the three years 1906-8 was 211 million gallons per annum, and the average cost, including working costs, capital charges and administration allowance was 8·22d. per 1,000 gallons at a pressure of 750 lb. per square inch. Notwithstanding the adverse conditions under which the Glasgow hoists were working (an average load of 7·9 tons on a 32-ton hoist) at the time Messrs. Baxter and Dixon's Paper was read, it is doubtful whether a lower energy cost per ton has ever been recorded by a fully-loaded and modern hydraulic tip. If lower costs have been obtained they have not been published so far as the reviewer is aware.

The exclusion of the many special types of crane used in the heavy industries is clearly intentional on the part of the author. They are nevertheless at least as important and numerous as the many systems described, but to have included them would have doubled the size of the book. As it is, there are over 750 pages and more than 1,000 illustrations.

To those who wish to be conversant with the part played by the machine in the handling and storing of material, and to those who, having to handle either large or small quantities of material, are faced at the present time, or will be faced in the future, with shortage of so-called inexpensive labour, Mr. Zimmer's great book is unreservedly recommended. Moreover, designers and manufacturers will turn to its pages time after time for inspiration.

Having given due credit to the author, it only remains for us to add a word of praise to the publisher, the printer and the draughtsman. Both of the get-up of the book and of the illustrations it may be said that they are worthy of the text. From an inspection of many of the illustrations it is evident that both the author and his publishers know the value of a good drawing, and only those who have made or have paid for the making of such drawings can form an accurate idea of the amount of labour involved in their production, and it is for this reason we believe the author finds his reward in the knowledge that the job has been well done. In an age when, probably more than at any other period in our history, men work principally or solely for money it is refreshing to come across a man who attaches greater importance to performance than to profit.

H. H. Broughton.

Aeroplanes and Airships. By W. E. Dommett. (London: Whittaker & Co.) Pp. 106. 1s. net.

This little book contains nine chapters, dealing with early investigations, general principles, descriptions of machines, propelling plant, steering and manœuvring, offensive and defensive duties, bombs and automatic rifles, searchlights and the various forms of dirigibles. In addition, there are 12 plates, some of them being from photographs taken on the spot. The book contains a considerable amount of information, both as regards the machines and apparatus described, and their use in actual warfare.

THE DESIGN OF THE AUDIO-FREQUENCY CIRCUIT OF QUENCHED SPARK TRANSMITTERS.*

BY JULIUS WEINBERGER.

Summary.—The Paper discusses the theory of the power circuit transformer and alternator circuit of generated spark transmitters.

In actual practice, such as in the operation of quenched gap sets, the requirement of a clear note involves the discharge of the secondary condenser at the peak of the wave each half cycle. It would seem, therefore, that the *transient* phenomena in the circuit would be the determining factors of voltage and current, rather than those of the steady state of affairs.

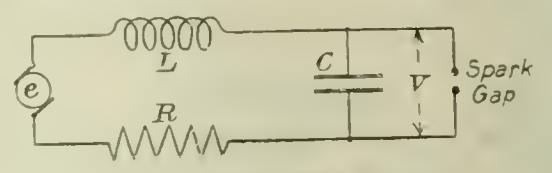


Fig. 1.—Resonance Circuit.

We can reduce the whole resonance transformer circuit to that of a simple inductance, capacity and resistance in series (Fig. 1), as has been shown by Mr. Hallborg. The inductance L includes all the inductances in the circuit generator inductance, transformer leakage inductance, inductance of any series choke coils, and so on. The condenser C is the secondary condenser reduced to the primary circuit by multiplication by the square of the ratio of transformer voltages. The resistance R includes resistances in the primary circuit and resistances in the secondary circuit reduced to the primary by division by the square of the ratio of transformer voltages.

The differential equation for such a circuit is

$$e = E\cos(\theta - \theta_0) = Ri + x\frac{di}{d\theta} + x_c\int i\,d\theta,$$

where E = maximum generated† voltage, x_c = condenser reactance, x = inductive reactance, $\theta = \omega t$, θ_0 = an angle to be subtracted from θ if e is not zero for $t = 0$. The P.D. across the condenser terminals can be found from

$$V = x\int i\,d\theta$$

when equation (1) has been solved for i.

Since we are mainly concerned with this V, we will omit writing the solution for i, but give that for V immediately:

$$V = \frac{Ex_c}{Z}\sin(\theta - \theta_0 - \gamma) - \frac{Ex_c}{Z}\epsilon^{-R\theta/2x}\left\{\sin(\theta_0 + \gamma)\cos\frac{q}{2x}\theta + \left[\frac{R}{q}\sin(\theta_0 + \gamma) - \frac{2x}{q}\cos(\theta_0 - \gamma)\right]\sin\frac{q}{2x}\theta\right\}$$
$$= \epsilon^{-R\theta/2x}\left\{e_0\cos\frac{q}{2x}\theta + \frac{2Re_0 + 4\pi x_c i_0}{2q}\sin\frac{q}{2x}\theta\right\}$$

* Abbreviated from the "Proceedings" of the Institute of Radio Engineers.

† This is not the voltage across the generator terminals. If the generator armature has appreciable inductance the generated volts will exceed the terminal volts.

where Z=impedance, γ=phase difference between generated E.M.F. and i, $q=\sqrt{4xx_c-R^2}$, e_0=value of P.D. across condenser terminals at the time $t=0$, i_0=value of current through the circuit at the time $t=0$.

Immediately the condenser has discharged then $t=0$. The important thing to be determined is, What will be the voltage across the condenser for $\theta=\pi$ (that is, at the next peak of the cycle)? Will it rise so a sufficient value to cause another discharge? Or, rather, will it rise to a value equal to that, at least, at which the previous discharge took place?

Taking the equation given for V, we can introduce the following simplifications: (1) Since we will consider the circuit as being resonant, we have $x_c=x$, and shall substitute x for x_c accordingly throughout. (2) Since the circuit is resonant, the current and generated voltage are in phase, hence $\gamma=0$. (3) When the condenser discharges, the P.D. between its plates is reduced to zero. Hence,

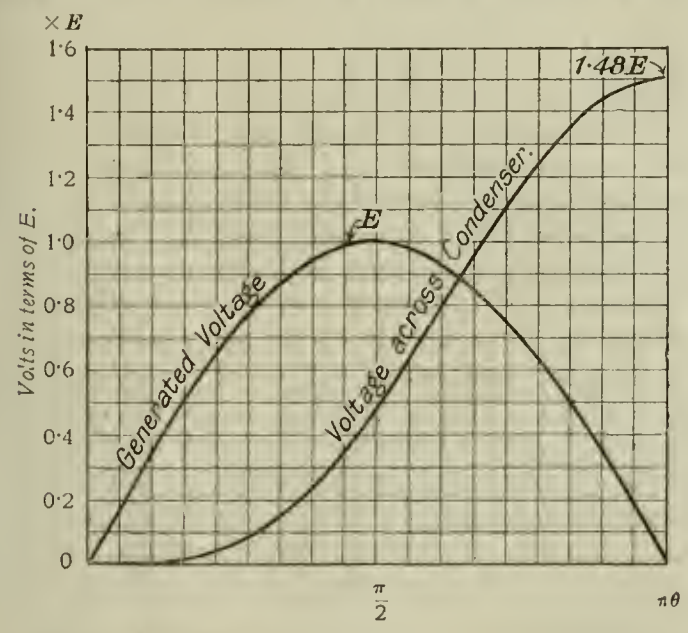


FIG. 2.—VOLTAGE ACROSS CONDENSER AFTER TIME. $t=0$.

at the moment we are considering, $e_0=0$. (4) The spark occurs when the generated voltage is zero. Since i_0 is in phase with e_0, $i_0=0$. (5) Since the circuit is resonant, $Z=R$. (6) R^2 can usually be neglected as compared with $4xx$.

Hence $q=2\sqrt{xx_c}$. Or, since $x=x_c$, $q=2x$; (7) in our case, $\theta_0=\frac{1}{2}\pi$. Substituting these conditions, we obtain

$$V=\frac{Ex}{R}(-\cos\theta)+\frac{Ex}{R}\epsilon^{-R\theta/2x}\left\{\cos\theta+\frac{R}{2x}\sin\theta\right\}.$$

To show the general shape of this curve, which gives the voltage across the condenser at any moment after the time $t=0$, it has been calculated for a specific case ($C=20$ microfarads and $R=1$ ohms), and is shown in Fig. 2, and the curve of generated voltage (a sine wave) is given for comparison.

This condenser voltage V will reach its maximum for $\theta=\pi$. It will then be

$$V_{max.}=\frac{Ex}{R}\left(1-\epsilon^{-\pi R/2x}\right).$$

This, then, is the potential at which our "reduced" condenser will discharge. The actual condenser across the transformer secondary will, of course, discharge at a voltage which is simply this $V_{max.}$ multiplied by the transformer ratio. In Fig. 3 curves are given for $V_{max.}$ in terms of E (the maximum generated voltage). It will be seen that for ordinary conditions of resistance (that is, R between zero and 1 ohm) $V=1{\cdot}5E$ is a good average value.

To find the R.M.S. or effective value of V is desirable, since this is the voltage that a voltmeter placed across the transformer primary will read, and this is also the voltage for which the transformer primary must be designed when the equation

$$V_{eff.}=4{\cdot}44ABnf\times10^{-8}$$

is used, where $V_{eff.}$=R.M.S. volts across transformer primary, A=cross-sectional area of core in square centimetres, B=flux density in lines per square centimetre, N=number of turns of primary winding, f=supply frequency. This effective value of V is given in the Paper, and it is found* that $V_{eff.}=0{\cdot}504\,V_{max.}$

The design of a quenched gap set to operate under resonance conditions becomes a relatively simple matter. Let us take a numerical example for a 500-cycle 1 kw. set, operating with a 110-volt generator (154 volts maximum).

We shall first find the equivalent primary condenser (*i.e.*, the secondary condenser reduced to the primary circuit) required to absorb 1,000 watts from $W=nCV^2$. Since

$$V=1{\cdot}5E=(1{\cdot}5)(110)\sqrt{2}=233\text{ volts.}$$

Hence $C=37$ microfarads. To tune to 500 cycles with this capacity an inductance of 2·5 millihenrys is required.

The value of the equivalent primary condenser (or rather the "reduced" secondary condenser, as I have called it) being now fixed, the actual secondary condenser is determined by deciding on a suitable transformer ratio. The value of this secondary condenser is usually limited by conditions of wave length and also by the discharge current which the quenched gap in use will stand. A large condenser means heavy currents and considerable heating in the gap, while a high discharge voltage and a small condenser would require many gap sections and cause insulation difficulties.

Having thus determined the ratio of primary to secondary capacities, the transformer ratio is of course fixed; and it is only necessary to design a transformer of the ratio desired—a simple matter with a closed core transformer of negligible leakage. Note should be

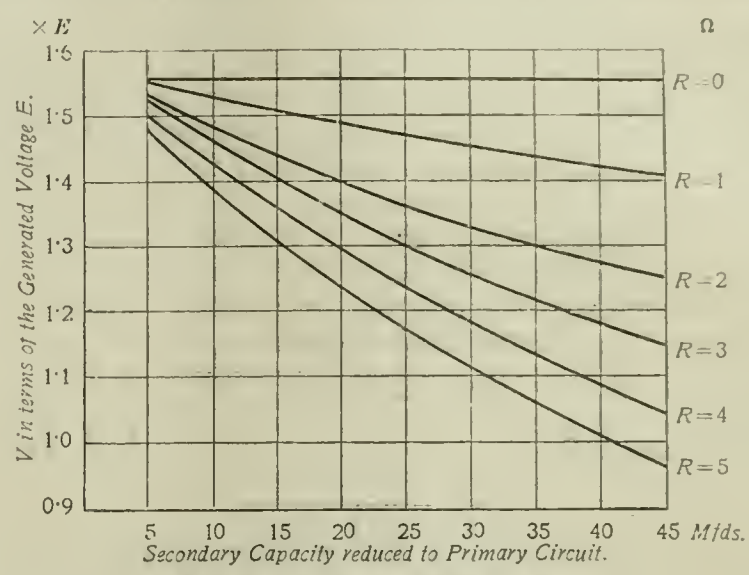


FIG. 3.—V_{max} IN TERMS OF E.

taken of the fact previously mentioned that when the usual transformer formulæ are used the effective value of V (that is 0·504 $V_{max.}$) should be used as the voltage across the primary.

Practically, the operation of quenched gap sets is at a point slightly "off" resonance. However, it is hardly necessary to operate with a condenser as much as 20 per cent. larger than the resonance capacity. The foregoing results can be applied as very good approximations to actual practice.

The author states that, since the above was written, he is aware that an article appeared in THE ELECTRICIAN, Vol. LXIX., 1912, p. 694, by L. B. Turner, on the same subject. Turner, however, neglects R and obtains $V=\frac{1}{2}\pi E$. This, the author states, would lead to errors for large values of R.

* This value was determined graphically, the integration being done by measuring the area of the squared curve with a planimeter.

CORRESPONDENCE.

ENGINEERING EDUCATION AND RESEARCH.

TO THE EDITORS OF THE ELECTRICIAN.

Everyone who has the future welfare of the engineering industry at heart should welcome the timely appearance of the report of the Committee of the Council for Organising British Engineering Industry, of which you publish a comprehensive abstract in your current issue.

The report should be given the widest publicity, as it contains a number of concise practical suggestions for preparing the industry for the commercial war which is expected to follow the present war.

The signatories to the report are to be complimented on their practical propositions, out of the rut of tradition which trammels the educational system in this country, and on their effort to break down the walls of the water-tight compartments in which the various stages of English education are at present housed.

The keynote of the whole matter is "co-ordination" and "continuity." One of the most important points in the report is the proposition for bridging the gap between the secondary schools and the universities, the need for which any of us who have been taken straight from the one to the other will appreciate, and which has been solved in general on the Continent.

While there is little in the report to which exception can be taken, it appears to me that there is one class of technical man who is not directly catered for. While the mechanic and the highly-trained engineer have full consideration, there is a large body consisting chiefly of draughtsmen, test assistants, &c., for whom no specific course is suggested. I have recently returned from several years spent on the Continent, where such positions are filled by men designated as "Techniker." These men are usually drawn from the more intelligent artisans and trade apprentices, who then spend two complete years at a technical school, the "Technikum." This school is not of university rank, and men who have taken its courses do not rank as engineers, though a certain number attain to positions usually filled by university trained men.

So far as I have seen, the average level of capability and intelligence of draughtsmen and the like is thereby greatly enhanced, and something on these lines might well be incorporated in the proposals made by the reporters.

I understand from Mr. Fleming that this class would be recruited largely from the brighter trade apprentices by a process of weeding out in the works trade school; but although this is on the right lines, it would hardly suffice in the course of time to supply the whole demand.

Still any progress on the right lines is to be welcomed, and it is to be hoped that the efforts of the Council for Organising British Engineering Industry will be strongly backed by the engineering press and the Institutions, as the future, not only of engineering industry but, to a large extent, of England is involved.

Manchester, July 8. A. G. Ellis.

S. P. THOMPSON.

TO THE EDITORS OF THE ELECTRICIAN.

The admirable suggestion made by Mr. Charles Bright in your last issue in respect to the creation of a substantial memorial to the late Dr. Thompson will certainly meet with the approval of all who were privileged to work under or with one of the most able and far-seeing men of our time. Moreover, the electrical industry as a whole will, without doubt, desire to mark its great appreciation of one who took a great, although unobtrusive, part in its development.

In the creation of research or other scholarships we have a ready means of giving effect to the suggestion in a form in keeping with the views so often expressed by Dr. Thompson, and with the spirit of the times. I sincerely trust that Mr. Bright will see his way to carry the matter further, and that he will give us all the privilege of supporting him in his efforts.

Westminster, July 10. A. C. Eborall.

[We are in full sympathy with Mr. Bright's suggestion.—Eds. *E.*]

ELECTRIC WIRING EXAMINATIONS.

TO THE EDITORS OF THE ELECTRICIAN.

We notice that at the annual general meeting of the Electrical Contractors' Association Mr. W. R. Rawlings referred to his appointment as examiner in Electric Wiremen's Work for the City and Guilds of London Institute, and to the fact that at present no more than 25 per cent. of the enrolled students attend the examinations.

We do not think this is so much the fault of the examinations as of lack of proper tuition and of facilities for the same. There is proof of this in the fact that—compared with the electrical engineering subjects—a mere handful of people take up electric wiring. The reverse ought, of course, to be the case.

Whatever views one may have on the scope of past examination papers, it must not be forgotten that the inclusion of the subject, Electric Wiremen's Work in the C.G. syllabus was largely due to the efforts of the resigning examiner, Mr. Frank Broadbent: and the profession and trade are heavily indebted to him for that, and for his subsequent work.

We gather from the report of the meeting that Mr. Rawlings is going to give us something fresh in the way of examination questions, and that the latter will tend more to the practical than to the theoretical side of the subject.

While that is good news, we should like to point out that, unless the methods of tuition are radically overhauled beforehand, there will not be any more grist for the mill than there has been hitherto.

As the Electrical Contractors' Association is so closely concerned with the matter, they should certainly make themselves and their wants known to those in charge at our Technical Institutes all over the country, some of whom hardly recognise the existence of the subject of Electric Wiremen's work.

London, July 7. A. P. Lundberg & Sons.

"PARTURIUNT MONTES NASCETUR RIDICULUS MUS."

TO THE EDITORS OF THE ELECTRICIAN.

This morning I received a card from the Institution of Electrical Engineers asking me to answer a number of impertinent questions. I have already torn up the card and thrown it into the waste-paper basket, and now I am wondering what action the Council will take against me when it discovers that I have dared to refuse to make "the return" for which it asks. Will it resolve itself into a court of summary jurisdiction (as the lawyers say), or arrogate to itself the powers of the Star Chamber, and endeavour to extort the information by administering some modern form of "thumbscrew," such as the application of electric shocks with high-tension current?

Is this ridiculous card the outcome of the great meetings and fiery speeches? If so, could anything more absurd be imagined than that the Institution will be cleansed of German spies by the futile method of sending out these cards? It would be interesting to know how much of the Institution money has been spent on this puerile campaign.

Will not several leading lights of the profession form a new society, which some of us who are very dissatisfied with the I.E.E. could join, and elect a council that at any rate would have a sense of humour?

London, July 6. "Civis Romanus Sum."

THE MEASUREMENT OF VERY HIGH INSULATION RESISTANCES IN CABLES.*

BY J. FISCHER-HINNEN.

These lines are intended to explain a very simple method of measuring the insulation resistances of cables, especially in cases where the galvanometer is not sufficiently sensitive. The idea is derived from Siemens' well-known method. Let us suppose an electrometer to be connected to the coatings of a cable of capacity C—that is, charged to a voltage E_0; the charge then falls away according to the law

$$Q = Q_0 e^{-\frac{t}{rC}} \quad \ldots\ldots\ldots\ldots \quad (1)$$

where Q_0 is the original charge; $e = 2{\cdot}718$, the logarithmic base; t is the time in seconds from the stopping of the charge; r = the insulation resistance.

But $$Q_0 = E_0 \cdot C.$$

Therefore $$E = E_0 \cdot e^{-\frac{t}{rC}} \quad \ldots\ldots\ldots\ldots \quad (2)$$

At the time t_1 the voltage is given by the equation

$$E_1 = E_0 \cdot e^{-\frac{t_1}{rC}} \quad \ldots\ldots\ldots\ldots \quad (3)$$

Therefore $$r = \frac{t_1}{C \cdot \log (E_0 / E_1)} \quad \ldots\ldots\ldots\ldots \quad (4)$$

The objection to this procedure is that a preliminary test is necessary to determine the capacity C, which at the moment is unknown. In order to meet this point one can proceed as follows: Let the above experiment be repeated with the addition of a shunt of known resistance (r_n) to the electrometer. Then the voltage will naturally fall off more quickly at a rate corresponding to the increased conductivity. Let us suppose the voltage after an interval (t_2) to be E_2 volts. Let us denote the initial voltage by E_0' and the combined resistance by r'. Then we have the following equations connecting these quantities:

$$1/r' = 1/r + 1/r_n,$$

$$r' = \frac{1}{1/r + 1/r_n} = \frac{r \cdot r_n}{r_n + r}; \quad \ldots\ldots\ldots\ldots \quad (5)$$

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 8, 1916.

and from equation (4) we can deduce the following equation—viz.,

$$r' = \frac{r \cdot r_n}{r_n + r} = \frac{t_2}{C \cdot \log(E_0'/E_2)} \quad \ldots \quad (6)$$

Generally speaking, E_2' will be equal to E'. These voltages can, however, differ if the charging takes place with alternate current, and not with direct current, seeing that in this case the precise instant of interruption determines the matter. From equations (4) and (6) we get

$$\frac{r_n + r}{r_n} = \frac{t_1}{t_2} \cdot \frac{\log(E_0'/E_2)}{\log(E_0/E_1)},$$

or

$$r = r_n \left[\frac{t_1}{t_2} \cdot \frac{\log(E_0'/E_2)}{\log(E_0/E_1)} - 1 \right] \quad \ldots \quad (7)$$

If possible, it is well to choose the voltages so that

$$\frac{E_0'}{E_2} = \frac{E_0}{E_1},$$

or

$$E_2 = E_1 \cdot \frac{E_0'}{E_0} \quad \ldots \quad (8)$$

Then it is only necessary to measure the time t_2 till the voltage has fallen by the requisite amount, and the insulation resistance is then given by the equation

$$r = r_n \left(\frac{t_1}{t_2} - 1 \right) \quad \ldots \quad (9)$$

As for r_n, its order of magnitude can be determined somewhat as follows: Let us suppose we require to determine the insulation resistance of a cable 5 km. long, having a nominal insulation resistance of 30 megohms and a capacity of 1 microfarad. We determine the time which is necessary for the voltage to fall to one quarter of its original value. Then from equation (4) we have

$$t_1 = r \cdot C \times 2{\cdot}3 \times \log\left(\frac{E_0}{E_1}\right) = 30 \times 10^6 \times \frac{1}{10^6} \times 2{\cdot}3 \cdot \log 4,$$

and this works out to about 42 seconds. If we suppose, for example, that $t_2 = 14$ seconds, then we obtain from equation (9)

$$r_n = \frac{r}{t_1/t_2 - 1} = 15 \text{ megohms.}$$

Silit is probably the best material to use for the resistance, because these resistances take up little space, and also because their values are fairly constant when such extraordinarily small currents are allowed to pass.

PARLIAMENTARY INTELLIGENCE.

DEFENCE OF THE REALM (ACQUISITION OF LAND) BILL.

This bill was read a second time in the House of Commons last week.

In explaining the measure, Dr. ADDISON said that large sums had been spent by Government departments in building huts, sheds, factories and storehouses on land for purposes connected with the war. The work had to be proceeded with rapidly under emergency conditions, and there was no time to investigate and settle questions of title or questions of purchase price. These things had to be left to be dealt with afterwards. The general object of the bill was to place the State, as far as possible in a secure position in respect of the expenditure which it had incurred in that work, and to safeguard it against unreasonable and avoidable loss. Millions of money had been spent upon land which had been taken under the Defence of the Realm Act or the Royal prerogative, and it was obviously in the national interest that there should be power to acquire that land. Oddly enough, in many cases the price of the land bore a very small relation to the total expenditure incurred in the erection of factories and buildings upon it. As much as £2,000,000 had been expended in buildings upon a relatively small piece of ground, and it was right to guard against the emergency which might arise at the end of the war, when the Defence of the Realm Act lapsed, that these buildings and plant, which had been provided at so great a cost, should become forfeited to the owners of the sites. The first clause enabled the Crown to continue for a limited time after the war in possession of land occupied during the war for purposes of the defence of the realm. Under the clause the occupation might be extended to four years with the consent of the Tribunal to be set up under the bill. A number of public buildings had been taken, and everyone would wish that they should revert to their proper use with as little delay as possible. Whilst land had been occupied during the war, compensation had been granted ex gratia, but if the occupation was continued after the war, a right to compensation was conferred under the bill. The basis of compensation was to be the direct loss suffered by the claimant by reason of the exercise by the Crown of its powers. The second clause dealt with the power to remove buildings, machinery and plant which had been erected. The Government would either restore the land to its original condition or pay compensation for disturbance. The third clause was perhaps the most necessary one. It dealt with the class of cases in which it might be necessary to acquire land permanently because of the great expense that had been incurred in erecting factories on it—factories which it would be a great waste of money to pull to pieces. That power would also relate to cases where the Government had borne the cost of extending other people's buildings. Sometimes they had had to do very drastic things in connection with railways, and clause 6 provided for the continuance of the use of certain light railways and sidings subject to appropriate orders by the Board of Trade. They also had to deal with cases where they had arranged for the supply of light and power outside the area of existing supply authorities. It had been decided that the Railway and Canal Commission was the most suitable body for dealing with the questions arising under the bill. They would have the assistance of assessors and would be authorised to make local inquiries. That would simplify procedure and limit expense.

GAS (STANDARD OF CALORIFIC POWER) BILL.

This bill was read a second time in the House of Commons last week.

Mr. PRETYMAN explained that the main object of the bill was to encourage gas companies to increase supplies of benzol and toluol. It was quite out-of-date to insist upon the quality of gas being gauged by the illuminant power, and many gas undertakings had already obtained from Parliament power to change the standard to one of calorific power. It was not intended to make the change of general application during the war, except upon condition that the gas companies should erect plant for the manufacture of toluol and benzol. The question whether they should require gas companies to reduce the price of gas to consumers would be considered in connection with the issue of orders under the bill.

EDUCATIONAL.

Manchester School of Technology.—In the Faculty of Technology there are complete courses of instruction in mechanical, electrical and sanitary engineering, the chemical and textile industries, mining, architecture, &c. First-year courses will be specially adapted to the requirements of students who may wish to take commissions in H.M. Forces. Prospectuses (free) and particulars will be forwarded on application.

Sheffield University.—It is proposed to adopt new ordinances relating to the granting of a diploma in glass technology.

The first examination for the diploma will be in chemistry, glass technology, physics and mathematics, and the subjects for the second will be glass manufacture and practical glass technology; refractory materials, fuels and pyrometry; geology and mineralogy of glass-making materials; physical chemistry of glass; engineering principles, including applied mechanics, heat engines and electrotechnology; mechanical drawing.

City and Guilds Technical College, Finsbury.—The training at this College is adapted to the needs of various students, including pupils above 15 from secondary schools, who desire a practical and scientific training bearing upon their future industry or profession, and young men who having previously served a pupilage or apprenticeship in works desire a more systematic training in engineering and applied chemistry. The College has well-equipped laboratories and workshops for practical work. The entrance examination will be held on Sept. 19. The programme of the College has just been issued, and gives full particulars of the courses of instruction, fees, time-tables, &c. Further particulars, syllabuses of instruction, &c., may be obtained from the Registrar of the College, Leonard-street, Finsbury, London, E.C.

City and Guilds of London Institute.—The thirty-sixth annual report of the Council (for the year 1915) has been issued.

The report states that the gradual elimination of the older students continued to the end of the session. The absence of many members of the staff threw considerable extra work upon those left behind and upon heads of departments. The staff, and to some extent the senior students, have undertaken much new and original work in the design and manufacture of munitions of war of various kind, and in the investigation of constructional problems, especially those connected with aeronautical and submarine services. The Institute's laboratories and workshops are being utilised to their full extent in these directions. The report refers to the delay in completing the Goldsmiths' Company's Extension of the City and Guilds (Engineering College), to the death of Prof. Meldola and to the changes in the staff, &c.

The Delegacy of the City and Guilds (Engineering) College reports that during the session 1914-15, 382 students were in attendance, exclusive of 131 students who were on the register of the College as due to return, but had joined the Forces. During the session, 102 students went on active service, making a total of 233 on military service, exclusive of past students. Thirty more had entered munition work outside the College, and 31 members of the staff had joined the Forces. The Roll of Honour totalled 811 names (to Nov. 10, 1915), 514 being commissioned officers and 297 N.C.O.'s and privates. Very important work was being done by Profs. Dalby and Mather in connection with war problems. Of a total of 382 students (compared with 532 in 1913-14, and 570 in 1911-12), 202 were engaged in Civil and Mechanical Engineering, 71 in Electrical

Engineering, and 56 in special courses, while 44 students of the Royal College of Science were attending the College for Applied Electricity. The Siemens Memorial Medal and premium for the student of greatest merit in electrical engineering were awarded to B. Hague. Last year 13 students of the College obtained the degree of B.Sc. (engineering) in the University of London.

Out of 59 second and third year students attending the City and Guilds Technical College, Finsbury, 40 joined the Forces. Important work in connection with the war had been carried on at the College. The number of day students attending the College in the winter of 1915 was 121, of whom 48 were in electrical engineering. The evening classes were suspended.

In the Department of Technology the number of candidates for examination fell from 23,119 to 15,623 for the United Kingdom. The total number examined was 18,327.

King's College, University of London.—In presenting a report on the past year's work on Commemoration Day last week, the Principal (Dr. R. M. Burrows) said the regular men students of English birth had fallen from over 800 in the year previous to the war to a little over 100.

The college had contributed 512 officers to the Army and Navy, eight of whom had won the Military Cross, and one the V.C. Fifty-seven students had lost their lives. Twenty-one members of the staff were on war or military service, three of whom held the rank of lieutenant-colonel. On the science side every laboratory in the college was being worked in the service of the Government. Prof. Jackson, in the medical department, had solved the formulæ for making the delicate kinds of glass, including miners' safety lamps, which had hitherto been made in Germany and Austria. The department of engineering had in the absence of its regular students devoted itself to training unskilled labour for munition factories. It has turned out over 300 skilled artisans and over 100 inspectors of aeroplanes.

Teaching of Science.—At a meeting of the Governing Body of the Imperial College of Science and Technology, last week, the Marquess of Crewe announced that the Government had decided to appoint a special Committee to inquire into the question of scientific teaching.

His lordship mentioned that memorials had been received from professors of the College on the subject of the teaching of science in our national system of education, and also a protest against our past neglect of such teaching. It was the intention of the Government to appoint a special Committee to inquire into the question of scientific teaching, and there might be other Committees. That particular Committee would act in close concert with the President of the Department of Education. It would not be a departmental Committee, but would be composed of scientific men in whom the country could have confidence. The Committee would have a close connection with the Government, brought about to some extent by the fact that the Government had chosen him (Lord Crewe) to preside over it. The general objects of the Committee would be, broadly speaking—

To inquire into the position of national science in our educational system, especially in universities and secondary schools. Its duty will be to advise the authorities how to promote the advancement of pure science, and also the interest of trades, industries, and professions dependent on the application of science, bearing in mind, of course, the whole time the needs of what is described as a liberal education.

The investigation would be made as wide as possible, having regard to the urgent need of some action as early as possible. He thought the world of science would agree that the step taken by the Government was as reasonable a method of procedure as could be devised.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 SPECIFICATIONS.

4,080 JUST. Refractory materials applicable also as electric resistances. (23/3/14.)
8,651 MOORE & BERRY. Railway signalling systems.
8,718 B.T.-H. Co. & MARTIN. Electrical motor-control systems.
Consists in arrangements for operating induction motors, so that two or more of these motors may be run at exactly the same speed or the same proportional speed without being mechanically coupled together, said arrangements consist in connecting corresponding slip-rings in parallel to the starting and controlling resistance through reactances in series. In the case of two motors, corresponding slip-rings are connected together through reactance coils and the regulating resistance is tapped from the middle of the reactances.
8,850 ZENAKY & GILMAN. Electric meter.
9,012 ELECTRICAL POWER STORAGE Co. (in liquidation) & SCHOFIELD. Secondary battery plates.
9,113 INTERNATIONAL ELECTRIC Co. & LE NOIR. Telephone transmitters.
9,960 B.T.-H. Co. (G. E. Co.) Vapour electric devices.
The insulating material arranged between the vaporisable cathode and the main metallic wall of the device is provided with ridges extending transversely to the vapour blast so that in the recesses separating the ridges conducting material will not be deposited, thus insuring clean bands or zones on the surface of the insulation.
10,837 DOWNES. Flexible electric conductors.
13,441 CUTHBERT. Clamping devices for electrically conducting wires.

1916 SPECIFICATIONS.

198 BRITISH WESTINGHOUSE ELECTRIC & MFG. Co. Starting mechanism for automobiles. (5/1/15. 100,006.)
1,707 KIELL, I., & STOW, A. A. Electric heat-regulating switch. (4/2/16. 100,060.)

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

May 31, 1916.

7,689 PEDLER. Electrical switchgear for operation of reverse current relays, &c.
7,694 COX & THORNE. Electric switches.
7,708 CROMPTON & Co. & PENSABENE. Dynamo-electric machines.
7,730 DAVEY. Electrical signalling systems.

June 1, 1916.

7,750 INRIG & INRIG. Electric fuses.
7,796 CABOT. Electric conversion.

June 2, 1916.

7,844 QUAIN. Metallic filament lamps.
7,848 WOOD. Devices for stripping insulated wire. (22/6/15, U.S.)
7,859 O'GORMAN & WHIDDINGTON. Transformer condenser combinations.
7,856 ANDREWS. Electric light switches.

June 3, 1916.

7,882 HAMILTON. Four-line field telephone exchange.

June 5, 1916.

7,934 GJEST & MERRIMAN. Electric transmission and control of motion.
7,936 SANDRINI. Portable electric battery. (5/6/15, Italy.)
7,942 B.T.-H. Co. (G.E. Co., U.S.) Systems of ship propulsion.
7,963 DECKER. Electric switches.

June 6, 1916.

7,995 HEURTLEY. Telegraphy.
8,008 KNIGHT & MYERS. Alarm apparatus, &c.
8,011 B.T.-H. Co. (G.E. Co., U.S.) Wireless signalling systems.
8,021 SHARMAN. Synchronizing unconnected periodic actions.

June 7, 1916.

8,042 TRIM. Ear-protector for telephone and wireless telegraphy head receivers.
8,055 BARR. Electrical water-heaters.

June 8, 1916.

8,091 KLUIJTMANS. Combined electric iron and heating apparatus.
8,103 THOMPSON. Field telephones.
8,111 SIEMENS & HALSKE AKT.-GES. Electrolytic apparatus. (24/6/15, Germany.)
8,112 & 8,127 JONES. Fire alarms.
8,128 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems.
8,150 KESSELRING. Continuous-current dynamos.

June 9, 1916.

8,178 HERINK & RELAY AUTOMATIC TELEPHONE Co. Telephony.
8,179 HERINK & RELAY AUTOMATIC TELEPHONE Co. Telephone systems.
8,166 SOC. ANON. DITE ATELIERS DE CONSTRUCTIONS ELECTRIQUES DU NORD ET DE L'EST. Electric traction systems. (2/12/15, France.)
8,191 CUTLER-HAMMER MFG., Co. & IGRANIC ELECTRIC Co. Electromagnetic switches or contact makers.
8,199 DECKER. Electric trucks. (9/6/15, U.S.)
8,211 CHADWELL. Printing telegraph systems.

June 10, 1916.

8,216 JOHNSON. Sparking plugs for internal-combustion engines.
8,232 EVANS. Electric generators for road vehicles.
8,238 & 8,239 LINZELL. Manufacture of galvanic batteries.
8,240 GREVILLE. Device for passing through the human body currents derived from ordinary town main electrical supply.
8,245 IRELAND & SIEMENS BROS. & Co. Electric ignition or sparking arrangements.

June 12, 1916.

8,274 ROELS. Variable-ratio power-transmission systems.
8,278 BEYNON. Electric incandescent lamps.
8,285 SANDERS. Portable electric lighters for gas.
8,291 B.T.-H. Co. (G. E. Co., U.S.) Recording and reproducing audible and visual indications.
8,303 DIXON. Transforming motion into electrical waves and impulses. (19/7/15, U.S.)
8,305 PORTER. Telephone transmitter. (12/6/15, U.S.)
8,310 BRITISH WESTINGHOUSE ELECTRIC & MFG., Co. (Westinghouse Electric & Mfg. Co.) Electric meters or relays.

June 13, 1916.

8,320 RADWAY & SWITCHGEAR & COWANS. Electrical regulators or rheostats.
8,321 TRENTHAM. Holders for electric lamps.
8,334 DENNISON. Electric detonators or fuses.
8,339 BENJAMIN. Lamp sockets. (8/7/15, U.S.)
8,359 BRITISH WESTINGHOUSE ELECTRIC & MFG., Co. (Westinghouse Electric & Mfg. Co.) Arc lamps.
8,360 BRITISH WESTINGHOUSE ELECTRIC & MFG., Co. (Westinghouse Electric & Mfg. Co.) Control systems for electric motors.

June 14, 1916.

8,393 JENKINS, PATTINSON & WELLESLEY. Electrolytic cells.
8,394 HARRIS. Electric keyboard transmitting apparatus.
8,416 SNOWDON. Electric resistances.

June 15, 1916.

8,430 STOCKS. Field-magnets for magnetos, &c.
8,433 CABLE ACCESSORIES Co. & REEVES. Electric heaters.
8,436 DELEBECQUE & WALSALL ELECTRICAL Co. Ammeters and voltmeters.
8,457 BENNETT. Magneto-electric machines.
8,458 BENNETT. Electrical make-and-break devices.
8,467 BARR. Attachment for electric torches.
8,470 LAMKIN. Device for attachment to sparking plugs of petrol, &c., engines for automatically cleaning and cooling sparking points of such plugs.
8,473 PULLINGER & WESTERN ELECTRIC Co. Machine switching telephone exchange systems.
8,474 & 8,476 RATHS. Electric and steam power generating systems. (14/6/15, Germany.)

June 16, 1916.

8,488 LIVINGSTONE. Eye-protector.
8,499 ROLLS-ROYCE & ROYCE. Electrical turning gear for starting internal combustion engine.
8,509 CHLORIDE ELECTRICAL STORAGE Co. & DEAN. Secondary batteries or accumulators.
8,521 HARRINGTON. Fittings for preventing theft of electric incandescent lamps.
8,533 BALMFORTH & Co. & KITCHEN. Electric furnaces, &c.

June 17, 1916.

8,536 CAMPEN. Electric bell actuated by sound waves.
8,550 CARR. Field telephone equipment.
8,551 CLARK & COOK. Electric lamps, &c.
8,558 LAUFER & GYR SOC. ANON. Variable rate electricity meters with two counters. (22/6/15, Switzerland.)
8,567 HEYER, HEYER & HEYER. Signalling apparatus.
8,574 B.T.-H. Co. (G.E. Co., U.S.) Electrical motors.
8,577 KNOX & O'DONNELL. Railway signalling apparatus.
8,581 HALTON. Rotary motors actuated by alternating fluid currents.
8,583 MASON. Ignition dynamos. (19/6/15, U.S.)

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

COMMERCIAL TOPICS	509	Autosynchronous Motors. Ill.	101
Imports and Exports of Electrical Manufactures	510	"Modern Electrical Plant." Illustrated	102
LEGAL INTELLIGENCE	510	British Replacement Batteries for American Cars. Illus.	104
Liquidations, Bankruptcies, &c.	511	Ironclad Distribution Fuse Board. Illustrated	104
Electricity Supply	511	The Refectory, Golders Green	106
Traction Notes	512	Tenders Invited	514
Empire Notes	512	Tenders Received & Accepted	514
Foreign Notes	513	Municipal Accounts	515
Miscellaneous Notes	513	Companies' Meetings and Reports	516
The Round Table	99	New Companies, &c.	517
Garage Lighting with Osram "Atmos" Lamps. Illus.	100	City Notes	518
Tumbler-Switch Controls for Small Continuous-Current Motors. Illustrated	100	Electrical Companies' Share List	518

COMMERCIAL TOPICS.

Engineering Trades After the War. The Board of Trade announce that, in view of the wide range of the industries included within the scope of the Committee appointed to deal with the position of the iron, steel and engineering trades after the war, and in order to expedite the inquiry, the President has decided to subdivide the work of the Committee between two committees, dealing with the engineering trades and the iron and steel trades respectively. He has accordingly appointed the two following Committees:

For the *Engineering Trades:* Sir Clarendon Hyde (Chairman), Mr. Arthur Balfour (Sheffield), Mr. A. J. Hobson, Mr. W. B. Lang, Sir Hallewell Rogers, Mr. H. B. Rowell and Mr. Douglas Vickers. Mr. A. F. Ilsley will act as secretary to the Committee.

For the *Iron and Steel Trades:* Mr. G. Seoby Smith (Chairman), Sir Hugh Bell, Bt., Mr. Archibald Colville, Mr. James Cox, Mr. James Gavin, Mr. George Mure Ritchie, Mr. Henry Summers and Mr. Benjamin Talbot. Mr. C. R. Woods, of the Board of Trade, will act as secretary to the Committee.

* * * *

After-war Problems. The Press Bureau has made an announcement, in which it is pointed out that in March last the Prime Minister appointed a Committee of the Cabinet, of which he is chairman, to consider and advise upon the problems that will arise on the conclusion of peace, and to co-ordinate the work which has already been done by the departments in this direction.

Any suggestions or other communications from individuals or organisations bearing upon these questions should be addressed to Mr. Vaughan Nash, C.V.O., C.B., Secretary of the Reconstruction Committee, 6A, Dean's-yard, Westminster, S.W. They will be considered and referred in suitable cases to the department concerned, or to one of the sub-committees to which particular subjects or groups of subjects have been referred by the Reconstruction Committee. It is not expedient in the public interest to specify the nature of many of the inquiries which are being undertaken, and no announcement will be made concerning them; but it is hoped that the entire range of subjects which will call for immediate treatment at the close of the war may be covered.

* * * *

Trading With Firms in Neutral Countries. Doubts arise from time to time with regard to the position of British exporters and firms who have trade relations with persons in neutral countries.

An interesting article on this subject was recently contributed to the "Sheffield Daily Telegraph" by Mr. P. A. Reuss, who asked the Controller of the Foreign Trade Department for a ruling on the matter. He put the case before the Controller, pointing out that on the one hand it was the patriotic duty of firms or individuals to facilitate the ingress of moneys owing to anyone in this country, yet, on the other hand, by so doing firms or individuals might render themselves liable to severe penalties in simply asking for the payment of moneys lawfully due from neutral countries for debts contracted prior to the war. On May 13 Mr. Reuss received a reply as follows: "I am directed by Secretary Sir E. Grey to inform you that there is nothing in the Trading with the Enemy Acts or Proclamations to prevent your receiving money from firms in neutral countries not on the statutory list issued in accordance with the Trading with the Enemy (Extension of Powers) Act, 1915, and the Proclamations thereunder or treated as enemies under the previous Trading with the Enemy Proclamations or Acts; but licences, for which applications should be made to this Department, are necessary with regard to any persons or firms whose names appear on the statutory list." On June 10, in a further communication, received in reply to further letters addressed to the Controller on the point of making application to enemy debtors in neutral countries, it was stated that so far as the Department was concerned, there was no objection to making application to any debtors established in neutral countries for payment by them of sums of money owing, provided that the names of such debtors do not appear on the statutory list of firms with whom trading is prohibited.

* * * *

General Electric Co.'s Report. Notwithstanding the industrial difficulties, the General Electric Co. appears to have had a very successful year. The total net profit for the year ended March 31 was £196,275, which creates a record. With £56,701 brought forward, and after deducting debenture and depreciation amounting to £27,259, the available balance is £205,716. The dividend, however, remains at 10 per cent.; the bulk of the extra profit being placed to reserve, which is increased by £40,000, compared with an appropriation of £20,000 last year, while the balance carried forward is increased from £36,701 to £48,053. Employés' bonuses absorb £12,701, and allowances to dependents of men in the Forces £12,962. Attention is drawn to the steady increase in the trade investments (valued in the balance-sheet at £357,835). These investments comprise five manufacturing companies, seven trading companies in the Argentine, South Africa, Belgium, France, China, Australia and India, and seven electricity supply companies operating at home and abroad. The position of the company is undoubtedly a strong one, goodwill and patents being valued at £1.

* * * *

The B.T.-H. Report. The British Thomson-Houston Co., whose report appeared in our last issue, also appear to have had a very successful year. The total profit was £262,361, after deducting all expenses and charges other than interest on debentures and loans, or a sum somewhat more than double the profit of the previous year. Very substantial sums have been written off for depreciation of the assets, including £30,718 off goodwill, patents and licences, and £60,000 off plant account, and £11,290 off shares and debentures. A sum of £25,000 has been reserved in respect of raw materials, and in the balance-sheet has been written off the book-value of that asset. A balance of £73,358 is carried forward, this sum including a reserve for the amount payable to the Government in respect of excess profits.

* * * *

The June Exports. The figures of the imports and exports for June indicate that, notwithstanding the labour and freight difficulties, British trade and commerce are maintaining their position very well. The value of the total exports for June was £56,147,267, against £42,583,907 in June, 1915, and £48,626,410 in 1914. In comparing the figures for the month of June in each of the past three years account must be taken of the higher value of goods now compared with the pre-war period, but even so the record for the past month is quite good.

The value of the electrical goods and apparatus (other than machinery and uninsulated wire) was £476,954, against £293,806 and £271,280 in June, 1915 and 1914 respectively; machinery represented £1,771,881, against £1,856,202 and £3,098,382; cutlery, hardware, implements (except machine tools) and instruments, £518,150, against £436,652 and £645,984; iron and steel and manufactures thereof £5,277,910, against £3,427,487 and £3,743,429; and other metals and manufacture thereof, £1,210,211, against £899,877 and £958,888 respectively.

* * * *

Metal for Munitions. The Minister of Munitions has issued an order under Regulation 30 (A) of the Defence of the Realm (Consolidation) Regulations, 1914, that the war material to which the Regulation applies shall include:—

Metallurgical coke and pig iron of certain descriptions, bar iron, steel of certain classes and descriptions, joists, ship and boiler plates, railway

rails, sheet and tin plate bars, blooms and billets, &c., and high-speed tool steel.

Notice is also given that persons are permitted to buy, sell or deal in the war material referred to on certain conditions. Maximum prices of materials are also set out in the order. Communications should be addressed to the Minister of Munitions, Armament-buildings, Whitehall-place, S.W.

* * * *

Alien Enemy Firms.

It is announced that the Advisory Committee appointed under the Trading With the Enemy (Amendment) Act, 1916, have investigated the businesses of 415 companies and firms, and it is anticipated that there may be over 200 additional cases for their consideration. Most of the important cases have already been considered by the Committee, and in view of the progress which has been made and the desirability of uniformity of treatment, it is not considered necessary to appoint any further committees.

* * * *

Japan's Trade with China and the East.

An authority in the Japanese Department of Agriculture and Commerce is credited with an announcement that Japan's electrical industry has recently undergone a marked development.

Efforts are being made to further national interests by promoting the export of the various products of the industry. The Government is, therefore, considering means to encourage the export of electrical machinery and apparatus to China, India and other accessible places. A new item of expenditure is to be provided in the next Budget for subsidising this export. It is reported that this scheme has not, however, been considered by the Cabinet in detail. Owing to the war, European competition has ceased, and the present time is looked upon as presenting the best opportunity for consolidating the foundation of Japan's business and industrial potentialities abroad.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From July 3, 1916, *to* July 7, 1916.

IMPORTS.

GOOLE.—*Sweden:* Elec. machinery, 92 pkgs.
SOUTHAMPTON.—*France:* Elec. cable, cases, £66.
LIVERPOOL.—*U.S.A.:* Electrodes, 71 pkgs.; unenumerated, 42 pkgs.
LONDON.—*U.S.A.:* Carbon electrodes, £42; carbon candles, £464; wire and cable £50; telephone material, £57; unenumerated, 4,247—212 pkgs. *Holland:* Elec. lamps, £2,860—57 pkgs.; wire and cable, £965; unenumerated, £270. *Japan:* Elec. lamps, £1,067; unenumerated, £1,092—17 pkgs. *France:* Elec. cable, 9 pkgs.; carbon candles, £638; Elec. lamps, £150; unenumerated, 42 pkgs. *Canada:* Unenumerated, £184, *Norway:* Unenumerated, £679.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Unenumerated, £226. *Melbourne:* Wire and cable, £550; unenumerated, £130. *Sydney:* Unenumerated, £47. *Wellington:* Elec. machinery, £130; unenumerated, £188. *Christchurch:* Elec. machinery, £160; unenumerated, £407. *Lyttelton:* Elec. machinery, £61; unenumerated, £28. *Dunedin:* Elec. machinery, £22; wire and cable, £44; unenumerated, £100. *Brisbane:* Elec. machinery, £70; unenumerated, £59. *Rockhampton:* Elec machinery, £80.
AFRICA. *Cape Town:* Unenumerated, £80. *Port Elizabeth:* Unenumerated, £1,137. *Beira:* Telegraph material, £144. *Zanzibar:* Wire and cable, £27.
EGYPT. *Alexandria:* Telegraph material, £10; unenumerated, £20.
ST. HELENA. Telegraph material, £25.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Unenumerated, £791. *Singapore:* Unenumerated, £15. *Calcutta:* Wire and cable, £27; telegraph material, £12; unenumerated, £774. *Madras:* Elec. machinery, £654. *Karachi:* Unenumerated, £678. *Colombo:* Wire and cable, £167; unenumerated, £223. *Bankok:* Elec. lamps, 1,500 no.; unenumerated, £41.
CHINA.—*Shanghai:* Unenumerated, £344. *Hong Kong:* Elec. machinery, £140; unenumerated, £112. *Hankow:* Unenumerated, £151. *Tientsin:* Unenumerated, £22. *Foochow:* Elec. machinery, £244. *Saigon:* Elec. lamps, 1,000 no.
SOUTH AND CENTRAL AMERICA.—*Buenos Aires:* Wire and cable, £348; unenumerated, £920.
HOLLAND. *Amsterdam:* Unenumerated, £146. *Rotterdam:* Unenumerated, £488.
FRANCE.—*Dieppe:* Elec. machinery, £220; unenumerated, £71. *Bordeaux:* Wire and cable, £162; unenumerated, £170. *Marseilles:* Elec. machinery, £60.
EAST INDIES.—*Sumatra:* Unenumerated, £28.
NORWAY.—*Christiana:* Unenumerated, £59.
MALTA. Telegraph material, £106.
DENMARK. *Copenhagen:* Unenumerated, £100.
SPAIN. *Malaga:* Wire and cable, £17. *Cadiz:* Unenumerated, £120.
PORTUGAL.—*Lisbon:* Telegraph material, £226; wire and cable, £1,183; unenumerated £112.
ITALY.—*Genoa:* Unenumerated, £385.

FOREIGN GOODS (duty paid and free).

Calcutta: Unenumerated, £17. *Cape Town:* Unenumerated, £82. *Lisbon:* Unenumerated, £115. *Amsterdam:* Unenumerated, £210. *Brisbane:* Unenumerated, £18. *Copenhagen:* Unenumerated, £22. *Wellington:* Unenumerated, £63. *Singapore:* Unenumerated, £96.

IN TRANSIT.

Hong Kong: Elec. lamps, £365. *Wellington:* Elec. lamps, £744. *Melbourne:* Elec. lamps, £1,608. *Sydney:* Elec. lamps, £1,392.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

LEGAL INTELLIGENCE.

Pritchett & Gold and Electrical Power Storage Co. v. Currie and The Hamble River Luke Co. (Ltd.)

This case came before the Court of Appeal (the Master of the Rolls and Lords Justices Pickford and Warrington) on Friday upon the appeal of the liquidator of defendant company from a judgment of Mr. Justice Sargant.

Mr. MARK ROMER, K.C., in support of the appeal, said his clients (the Hamble River Luke Co.) were in voluntary liquidation, and the question raised by the case was whether the property in an electrical storage battery which had been ordered by defendant company before their liquidation from plaintiffs passed to defendant company before the liquidation. If it did then plaintiffs had to prove in the liquidation with the other creditors for the price of the battery, and if the property did not pass then in the events which had happened plaintiffs were entitled to be paid in full for what they had supplied. Mr. Justice Sargant held that the property in the battery had not passed and ordered the sum of £255, which had been paid into Court by Mrs. Currie, who had interpleaded, to be paid out to plaintiff company. Defendant company were a firm of contractors, and they entered into a contract for the supply of an electric installation at a house belonging to Mrs. Currie. That electrical installation involved the supply of a storage battery, and that they ordered themselves from plaintiffs as sub-contractors, and the battery was delivered by plaintiffs to defendants. It was said that the price which defendants agreed to pay plaintiffs for the battery included the erection of the battery at Mrs. Currie's house. Having been delivered to defendants the defendants called upon plaintiffs to proceed with the erection of the battery at Upham House. Plaintiffs, however, refused to proceed with the erection except upon the terms that they were guaranteed the price under the contract. Thereupon defendants erected the battery at Mrs. Currie's house themselves, and completed the contract with Mrs. Currie. Then plaintiffs alleged that the property in the battery had never passed from themselves, and they ultimately sued the lady, not for the return of the battery, but for a declaration that the property in the battery was still in themselves, and that they were entitled to a lien for the value of the battery upon the contract price paid by the lady to defendants under the contract between them. Mrs. Currie then issued an interpleader summons, and the Master ordered the appellants to be added as defendants, and ordered Mrs. Currie to pay into Court the £255, which was due from her to the defendant company, and that being done the proceedings against Mrs. Currie were stayed, and the action went on as between plaintiffs and defendant company. The result of Mr. Justice Sargant's decision was that plaintiffs had been paid in full for the battery, and did not have to prove in the liquidation of defendant company in competition with the other creditors, which he (counsel) contended was their only right. He then dealt at length with the evidence given in the Court below.

At the conclusion of the argument of counsel, their Lordships held that the property in question did pass to appellants, and that plaintiffs, as the sub-contractors, were not entitled to a lien for things which only formed part of a head contract.

The appeal was accordingly allowed.

Publication of Military Information.

At the North London Sessions on Friday last Mr. Clarence Edgar Allen, editor of "Machinery," appealed against a sentence of three months imprisonment in the second division for publishing information calculated to be useful to the enemy, in an article entitled "The Manufacture of Trench Howitzer Shells."

A number of witnesses were called, and the assistant Judge (Mr. Lawrie) said that it seemed to him that it would be impossible to contest the contention that the information might be calculated to be of assistance to the enemy, but if Counsel for the appellant thought that more evidence would have a reasonable chance of success on those lines, he was prepared to listen to it. On the other hand, said the Judge, having clearly taken the view that appellant's motives were in all probability patriotic and obviously not unpatriotic, he should certainly think that the justice of the case would be met by withdrawing the term of imprisonment and substituting a fine.

Mr. BODKIN (for the prosecution) said he certainly should not say that that was the worst case of its kind, but the regulation was so utterly essential to the country that it should receive implicit obedience. He hoped that the risk appellant had run would show editors that they must err on the side of caution.

Mr. LAWRIE said the real purpose of the prosecution had been obtained. As appellant's intention was to assist the country and not the reverse, he felt justified in taking a lenient view. The appeal would be dismissed, with costs, but the sentence would be reduced to a fine of £100.

Comins v. Weld-Blundell.

Last week Mr. Justice Darling and a special jury heard an action in which Mr. Charles Comins, C.A., was awarded £500 damages against Mr. C. J. Weld-Blundell, director of the Float Electric Co. (Ltd.), who did not appear and was not represented.

Mr. LEWIS THOMAS (for plaintiff) said the action was brought in respect of a letter Mr. Weld-Blundell wrote to another accountant, Mr. J. H. Stephens. Mr. Weld-Blundell had considerable means, but he put his money into companies somewhat recklessly, and, when the money was lost, he turned round and said things about people. The Float Co. was

incorporated in 1910 for developing an electric lamp. Mr. Blundell was chairman of the company; he held all the shares except seven, and all the debentures except one. On May 3, 1911, Mr. Low was appointed manager, and continued in that position until he resigned in October, 1912. He was succeeded by a Mr. Hurst, who had been his assistant manager. In 1915 apparently Mr. Hurst required further capital, and he wrote to defendant about guaranteeing an overdraft at the bank. Instead of replying merely assenting or refusing, Mr. Blundell, who had invested £13,000 or £14,000 in the company, wrote a letter of the most intemperate description to Mr. Stephens. In the letter he said: "But my experience with workmen is that they all follow exactly the tricks and rogueries of their predecessors, and his predecessor, with the help of the rest of the gang —— and Comins managed, by just the same manœuvre and pretext, to get £2,000 or £3,000, and Comins sheltered him completely and pretended that the money had been fairly used in trade transactions." Counsel added that Mr. Comins did not know of the letter at the time, and a few weeks afterwards was reappointed auditor of the Float Co.

After plaintiff had given evidence judgment was entered for plaintiff with costs.

L. H. Cumberland v. Newport Corporation.

This action, which was brought by a former engineer-in-charge of the Newport (Mon.) electricity department against the Corporation for an alleged breach of agreement in regard to terms of service, was down for hearing at the Bristol Assizes on Monday. As plaintiff did not appear, the jury returned a verdict for defendants, for whom judgment was entered, with costs.

Munitions Tribunal Case.

Last week a parcel messenger of the Manchester tramways department asked the Local Munitions Tribunal for a leaving certificate, which he alleged the department had unreasonably refused or neglected to issue to him. He wished to take advantage of an opportunity he had of becoming a fitter's apprentice in a munitions works. He would be 16 years in December, and after that age it would be too late to get an apprenticeship.

The General Manager of the tramways (Mr. J. M. McElroy) said that was a test case, and should complainant succeed many other boys would leave the service. The Manchester tramways department was certified as being a munition works, and the parcel department was an important branch of the concern largely used for the transport of small parts of munitions. At present it would be a very serious matter to be deprived of the services of those boys. The parcel department had to be run almost entirely by boys, as practically the whole of the adult male staff had joined the Colours.

The Chairman (Mr. P. W. Atkin) asked Mr. McElroy if he would undertake to release the complainant in November. The war would not go on for ever, and it might be the department would not need him as much in November as now.

Mr. McElroy agreed to the course suggested and the complainant withdrew his claim.

LIQUIDATIONS, BANKRUPTCIES, &c.

Claims against Wm. D. Birkett, factor of electrical goods, Arnside, Windsor-avenue, Whitley Bay, Northumberland, are to be sent to Mr. C. Woollett, 30, Mosley-street, Newcastle-on-Tyne, by July 27, preparatory to the payment of a dividend.

Fredk. Wm. and Chas. Wm. Owens, electric lighting engineers, &c., Pontardawe, Glam., have dissolved partnership. Debts by Mr. C. W. Owens, who continues the business as W. T. Owens & Sons.

ELECTRICITY SUPPLY.

EXTENSIONS.

Bristol.—The Electricity Committee reports that they have reluctantly adopted the suggestion of the L.G. Board, that, in view of the desirability of spending as little money as possible during the present crisis, a 3,000 kw. turbo-alternator should be put down for present use, instead of a 6,000 kw. machine suggested by the committee, and agreed to by the Council in April, 1915.

Haslingden.—Hitherto Haslingden has been supplied with electrical energy exclusively by Accrington, but the increased demand in both towns has made it difficult for Accrington to keep pace with customers' requirements. Under the circumstances, Accrington has concurred in Haslingden entering into an arrangement to obtain a supplementary supply from Rawtenstall, and the L.G. Board have sanctioned an expenditure by Haslingden of nearly £2,000 for cables and switchgear, the charges for which will, however, be largely borne by Rawtenstall.

Kirkcaldy.—At the meeting of the Council on Monday the Tramways and Electric Lighting Committee recommended that expert advice be got on a report by the borough electrical engineer and tramways manager (Mr. O. F. Francis) that it was advisable to build new electricity works immediately, as the present works were quite unable to cope with the demand.

As it was considered inadvisable to go in for new undertakings at present, the report was referred back.

Sheffield.—Mains extensions estimated to cost £299 have been authorised.

The formal sanctions of the L.G. Board have been received to the borrowing of £42,926 for turbo-alternator and switchgear; £37,201 for boilers and foundations; £324 for coal shoots (total £80,451, being part of £137,104 applied for); £51,000 for four boilers and accessories at Neepsend and £10,000 for buildings in connection with above.

The Electricity Committee has resolved that the expenditure on mains extensions during last year and the present year, other than mains for special power purposes, should be defrayed out of the renewals and special expenditure fund.

Walsall.—D.c. mains are to be extended from Charlotte street to the works of Messrs. Satchwell & Gittings.

The existing e.h.t. feeders to Sandwell-street sub-station via Darwall-street are overloaded, and, as a temporary measure of relief, cable for connecting up Wolverhampton-street generating and sub-stations has been ordered.

Wigan.—The Corporation have applied to the L.G. Board for sanction to borrow £535 for a centrifugal pump, valves, &c., £325 for cable to give a supply of electricity to the works of Messrs. Gallagher Bros., and £1,163 for pipe work, foundations, &c.

Worcester.—The Council have entered into an agreement with the King's Norton Metal Co. to supply electrical energy for power and lighting at their factory at Blackpole, and application has been made to the L.G. Board for sanction to borrow £14,000 for extensions of mains and plant.

GENERAL.

Battersea (London).—The Electricity Committee recommends the Council to re-open negotiations for linking-up the electricity undertaking with those of Fulham and Hammersmith, in accordance with the Board of Trade's letter.

Bray.—The Council have decided to procure and fix tar oil apparatus to the Diesel engine at a cost of £128. 10s.

Derby.—The Corporation have agreed to give a supply of electrical energy to new works in the Osmaston Park-road.

Edinburgh.—There is a deficiency of £8,075 on the past year's working of the electric supply department.

Increase of Charges for Electrical Energy.—During the week many additional electric supply companies and local authorities have increased their charges for the supply of electrical energy.

At Dalkeith the Electric Supply Corporation proposes to charge 5¾d. per unit for all lighting and 2d. per unit for domestic heating and power, and for industrial power supply will be charged according to the aggregate B.H.P. of motors supplied through each meter and the number of units used per quarter.

Rathmines Urban Council have increased the charges for private lighting from 4½d. to 5d. per unit; for places of worship, public and charitable institutions, shops and places of amusement, from 4d. to 4½d. per unit, and for power and heating from 1½d. to 1¾d. per unit.

St. Helens Corporation have increased their charges for electrical energy for lighting and power by 10 per cent.

Salford.—71 of the employés of the electricity department have joined the Colours, and of these five have been killed and four discharged owing to wounds or ill-health, the remainder being on active service.

The clerical branch supplied 13, the stores three, the power station 29 and the mains and motor branches 26. Two members of the staff, Mr. T. E. Dransfield, first assistant mains engineer, and Mr. F. Birch, superintendent of the motor department, have recently been granted commissions as temporary lieutenants in the Royal Navy, and are now on active service with the Fleet in the North Sea. The five men who have lost their lives are E. A. Greenhalgh, draughtsman, who served as a sapper in the Royal Engineers and was killed in action in Gallipoli on Aug. 7, 1915; H. F. Andrews, switchboard attendant, Sergeant in Lancashire Fusiliers, was killed in action in Gallipoli on June 6, 1915; C. Cooper, fireman, went to Gallipoli with the Naval Brigade where he was severely wounded and he died in Netley Hospital on Sept. 5, 1915; H. Foulkes, labourer, an acting petty officer on H.M.S. "Cressy," and lost his life when that boat was lost on Sept. 2, 1914; N. Higgins, labourer, a private in the King's Royal Rifles, was killed in action in France on Dec. 8, 1915.

Three of the men: E. Oddie, boiler cleaner in power station; A.

Quinney, testing assistant ; and C. Gray, labourer in mains department, have been severely wounded. E. Oddie, whose right leg has been amputated, is now back in the department as a motor lorry driver.

The 62 men now serving are represented in the Service as follows : Royal Navy, two ; mine sweeping, one ; infantry, 38 ; Royal Engineers, six ; Army Service Corps, four ; Royal Field Artillery, three ; Royal Horse Artillery, two ; Royal Garrison Artillery, two ; Royal Army Medical Corps, two ; Army Ordnance Corps, one ; Royal Flying Corps, one ; total, 62. Several men have also been released from the department for munition work. Female labour is now largely employed for clerical work, also for meter reading and as switchboard attendants. Mr. J. A. Robertson, borough electrical engineer, shows great interest in the men who have joined the Colours.

Sheffield.—The general manager of the electricity undertaking (Mr. S. E. Fedden) has reported upon the advisability of revising the existing charges for the supply of electric current.

In the report Mr. Fedden states that he feels grave anxiety both as regards the financial stability of the department and for its ability to supply cheap units in the future if the charges generally are so fixed as to yield a very small available surplus. Whilst the undertaking was complying with legal requirements as regards repayment of loans in the shape of sinking fund, they were not reducing capital indebtedness fast enough to keep the undertaking financially sound. The undertaking ought to be able to put by enough money to bring the reserve fund up to 10 per cent. of the capital indebtedness, and to build up a strong renewals and special expenditure fund to deal with obsolescence ; this sum should not fall below £60,000, and should preferably amount to £100 000 on the present size of the undertaking. Mr. Fedden is of opinion that on the return to normal trade conditions many of the largest consumers would be agitating for lower terms, and if the department was not in a position to supply at the cheapest possible rates, it would undoubtedly lose some of those consumers either to an outside undertaking or by the firms putting down their own plant. The following facts are cited in explanation of his views : The large amount of capital represented by Sheaf-street station plant, which is entirely out of date, and on which the capital repayment has still another 23 years to run ; the same remarks apply to the plant at Kelham Island, in this case sinking fund repayment has to continue for a further 14 years. The Neepsend station was not opened till 1904, yet the first four turbines are obsolete when compared with the efficiency of present day plant, but the sinking fund payments on these plants will not be extinguished till 1927. In conclusion, the report stated that the present power tariff was framed many years ago, and had enabled the department to build up a huge power load. It was based on the price of coal being purchased at 2½ times less than the existing price, but notwithstanding the gradual increase in the cost of fuel that has taken place in recent years, there was still a sufficient margin between the cost and sale price of the unit to produce a small surplus owing to the reduced cost of production in other directions. Now, however, owing to the abnormal conditions prevailing on account of the war and the general increase in the price of all materials and labour, the charges for current should be revised to enable the undertaking to attain the above-mentioned objects.

The Electricity Committee recommends the City Council to increase all accounts for the supply of current by 10 per cent. where the present price is more than 2d. per unit, and by 20 per cent. where the present price is 2d. per unit or less.

Wimbledon.—The L.C.C. Board has sanctioned the borrowing of £5,020, being expenditure in excess of loans already sanctioned and the estimated expenditure of the electricity department to March 31, 1916, in respect of mains, house services, &c.

As regards the remainder of the application, however, the Board saw no reason why sanction should be given, having regard to the need for economy in the capital expenditure of local authorities. The committee recommends that the price of current to ordinary lighting consumers be increased to a sum not exceeding 6d. per unit, and for power or heating to a sum not exceeding 2d. per unit.

Wolverhampton.—The Electricity Committee has approved the agreement with the Midland Electric Corpn. for Power Distribution for the supply of current in bulk by the company for consumers of the Corporation in the Bushbury area.

Yeovil Electric Lighting Order, 1914.—The Board of Trade have extended for one year from July 8 the periods of two years and 18 months, respectively, mentioned in sec. 21 of the schedule to the Electric Lighting Clauses Act, 1899, and incorporated in this order.

TRACTION NOTES.

Blackburn.—The Tramways Committee is paying allowances of £1. 00 a year to men who have joined the Colours. Other expenditure has also increased, but the receipts have declined, and the question of increasing fares is under consideration.

Electric Vehicles for Municipal Purposes. The Borough Engineer of the Southwark (London) Borough Council has reported upon the use of electric vehicles for traction purposes.

The report states that electricity had appealed to him as likely to be the most useful for municipal purposes, but upon investigation the time had always appeared to be unripe for its adoption, although there was no doubt that eventually the difficulties standing in the way would be overcome. At present most of the electrical vehicles are of American design ; electric power is more in general use there than in any other country, and even there the question is very much debated and trials are being made to get over some of the difficulties by the combination of petrol and electricity. No doubt electricity will become adaptable for our general use probably in some five or ten years, but the charges of one or two vehicles would be of no assistance to the Council's electricity works, and working them would be more expensive than petrol plant. At the beginning of this year municipalities had in use 1,539 motor vehicles, of which 85 were electric. Out of the former number, tramways having electric generating plant had in use 228 (those having electricity as motive power numbering 32) and electricity departments had 83 (22 electric). Some of these electric vehicles had been adopted with the object of advertising the station and trying to advance the design of electric vehicles. One of the difficulties in connection with vehicles for municipal purposes is that manufacturers do not realise the great difference between municipal and commercial purposes, which may be put as follows : A commercial vehicle is generally loaded at one place from a platform, and may be unloaded at several places, the level of the vehicle being at a suitable height, whereas a municipal vehicle is loaded at many places, and not from a platform, and is unloaded almost always at the same place. Another question to which the report draws attention is the difficulty of getting advice from outside authorities on electricity who are not fully acquainted with the details of the work to be carried out, which cannot in any way be considered parallel with ordinary traction purposes.

The Works Committee approved the report of the engineer.

Glasgow. Last week the Finance Sub-committee of the Tramways Committee considered the application by tramcar drivers and conductors (both sexes) for a war bonus of 6s. per week to date from March 1, and the application of the truckmen and controller men for a similar war bonus of 6s. per week.

The general manager (Mr. J. Dalrymple) stated that there were 3,067 drivers and conductors, and to grant each of those a bonus of 6s. would represent an additional annual expenditure of £47,845. The net balance of revenue over expenditure at the close of the last financial year was £43,548. After considerable discussion, it was decided by the casting vote of the convener (Deputy River Bailie Macnaughton) not to grant a bonus to the drivers, conductors, truckmen or controller men.

Halifax. The Corporation are to make another attempt to come to terms with Hebden Bridge Council on the tramway question.

The Tramways Committee have, therefore, appointed a sub-committee to consider the whole matter with full power to obtain expert advice. Over three years ago when the Corporation first sought to extend their leases to run trams in districts outside the borough, Hebden Bridge was the only local authority which declined to accept any arrangement, as the Corporation refused to extend the tramways from the present terminus at Hebden Bridge to Whiteley Arches.

Kirkcaldy.—It is proposed to abolish half-penny fares, except on workmen's cars.

Manchester. The new double tramway line in Cross-street, between King-street and Albert-square, was opened for traffic on the 6th inst.

Rotherham.—The Corporation has been recommended to lay a double line of rails in a portion of Westgate.

EMPIRE NOTES.

Australasia.—It is stated that the construction of the first two sections of the underground tunnels of the Sydney city railway system, the Wynyard square and the Quay, will shortly be commenced by Messrs. Norton, Griffiths & Co.

A recent report on the city railway scheme shows that the total cost will be about £20,000,000. The inner zone railways to Parramatta, Hornsby, Sutherland and Bankstown and the outer zone railways to Penrith, Campbelltown, Waterfall, the Hawkesbury river, and various branches in the suburban area are to be electrified, and new lines to the eastern, western and northern suburbs are to be constructed.

The Snowy River (N.S.W.) hydro-electric scheme is estimated to cost £5,000,000, and it is calculated that electric power will be supplied in Sydney from the Snowy River at 2d. per unit.

Proposals for the installation of an electricity supply system for the Birkenhead and Northcote districts (suburbs of Auckland) are being discussed by the respective Councils. A report has been prepared showing that the expenditure would be £10,000.

Statistics show that the decrease in the Victorian railway receipts due to the opening of the Kilmore road and Maribyrnong River (Essendon) tramway was £10,290 during last year, and the decrease in the railway receipts during the same period in consequence of the opening of the Prahran-Malvern tramway was £39,774.

In order to guard against shortage of male telegraph operators through enlistment, the New Zealand Government is commencing in Wellington classes in telegraphy for girls, with the intention of extending the scheme to other centres later.

Geelong (Victoria) City Council is considering a proposal to municipalise the local electric lighting and tramway undertakings, both of which undertakings are owned and operated by the Melbourne Electric Supply Co. The tramways are equivalent to 5·67 miles single track, the suburbs served being East, West and South Geelong and Newtown.

Owing to the shortage of coal from the Victorian State colliery at Wonthaggi, Melbourne City Council's contract for supplies for the electricity department (hitherto 40,000 tons) has had to be cut down to 14,500 tons.

The "Chamber of Commerce Journal" says the Australian Minister of Customs has been asked to move in the matter of the duty on electrical goods, which, it is alleged, penalise the British manufacturers and grants a preference to the foreigner.

British goods are sold in England for export at a lower price than for home consumption, and do not carry the royalty which is or was paid to the German patentees. The Customs Department levies the duty on the market price in the port of shipment for home consumption. Where extra discounts are given for large quantities for export it is stated that the price for home use is almost twice the export price. Thus the preferential duty of 20 per cent. on the home consumption price is equal to 40 per cent. on the export price. The foreign article pays only 25 per cent., so that it has an advantage of 15 per cent.

India.—"Indian Engineering" says the Mysore Government is to be allowed to complete the great reservoir which will retain for electric purposes a great deal of the water which would otherwise have flowed down the Cauvery.

When the Mysore project was started the matter was referred to an arbitration board, and the board judged in favour of Mysore being allowed to carry out its project. An appeal was made to the Government of India, who confirmed the board's decision. It remains to be shown that there will really be any deficiency of water for agricultural purposes.

The Government of Madras are examining the financial aspects of the Siruvani hydro-electric scheme, in the Coimbatore district, from which it is proposed to supply power to work railway workshops to be established by the South Indian Railway at Podanur, and also about 3,000 H.P. for Coimbatore mills, in addition to providing an adequate water supply for Coimbatore and Podanur.

Newfoundland.—An Act to incorporate the Union Electric Light & Power Co. has been passed.

The capital of the company will be £20,550, and the company is authorised to generate and supply electricity for motive power and heating, and to install an electric lighting system and operate electric tramways in the towns of Trinity, Catalina, Bonavista, &c., and to use the waters of certain lakes and streams. All plant, machinery and materials required by the company for construction work will be admitted into Newfoundland duty free.

FOREIGN NOTES.

Brazil.—Mr. Bremner, British Vice-Consul at Pará, has compiled the following information as to German methods of business in his district :—

The prices of goods were the prices at the factory in Germany, with packing, carriage, insurance, &c., added, and a commission of 2½ (or 5) per cent. was charged on the total value of the invoice. Interest was charged on the whole amount, generally 1 per cent. above current banking discount rate for the number of months of credit given plus two months, which extra two months' interest was charged for the time occupied in transporting the goods to Brazil and the time required for the remittance to reach Europe. The average credit given by German exporters was 90 days. Collection was made by draft drawn by the exporter on the customer. The bill of lading and consular invoice were sent direct to the customer, but the draft was generally sent to a local banking firm, which obtained the acceptance and made the collection when due, the customary charge of the banks for this service being from ¼ to ½ per cent. In the case of firms of first-class credit, German exporters introduced the custom of sending the draft direct with the documents, with a letter instructing the customer to whom payment should be made when due. This system was flattering to the customer and was doubtless influential in diverting trade to Germany. In the case of non-trading buyers with special orders, such as machinery, launches, &c., c.i.f. quotations were generally made. If desired the local agent converted the quotation into Brazilian currency, and by adding the calculated costs of duties and other expenses at the Brazilian end the contract would be closed in Brazilian currency for the goods landed and duty paid. Mr. Bremner advises that no contract should be undertaken by British merchants or exporters in which payment is to be made in Brazilian currency or promissory notes.

Colombia.—Carmen Municipal Council (Department of Antioquia) and Anori Municipality, both in the Department of Antioquia, have been empowered to borrow up to 5,000 pesos gold (£1,000) and 8,000 pesos (£1,600), respectively, for establishing electric power plants.

Manizales Municipal Council (Department of Caldas) has been authorised to borrow 30,000 pesos gold (£6,000) for an electrical plant and the repair of an aqueduct. For similar purposes the Municipality of Filadelfia, in the same department, is permitted to borrow 15,000 pesos gold (£3,000).

Finland.—A report from Mr. Kestell-Cornish (British Consul at Helsingfors) says Germany, Sweden and Switzerland have hitherto held the market there in electrical machinery, and in this line there should be an opening for British enterprise.

In the case of large orders for machinery, the usual German terms are one-third of the price with order, one-third upon delivery and one-third after three months. The British terms are usually cash against documents. The German manufacturers allow drafts at three and six months' acceptance as payment, and they will always turn out fresh types of machine when required. The machines imported include electrical machines, steam engines and turbines, boilers, lathes, planing, shaping and all kinds of machinery for workshops. Most of the turbines have hitherto come from Germany and Switzerland, principally the former ; steam engines from the United Kingdom, Germany, Sweden and Denmark ; boilers from Germany ; lathes, planing, &c., machinery equally from the United Kingdom, the United States, Germany and Sweden. The American machines are usually cheap, though not so solid as those of the United Kingdom or Germany. The United States manufacturers, like those of the United Kingdom, do not readily adapt themselves to local requirements.

MISCELLANEOUS NOTES.

Controlled Establishments.—At a recent meeting of representatives of Government-controlled iron and steel and allied establishments in Scotland it was agreed to form the "Controlled Establishments Association," for dealing with certain questions which had arisen since Government control began, and for protecting the interests of the firms concerned.

Enemy Firms Wound Up.—The Board of Trade has ordered the winding up of 228 firms controlled by alien enemies.

The latest lists include : Hermann Rudolph, 9, Wood-street square, London, E.C., manufacturers' agent and importer (Controller : H. E. Sier, 99, Cheapside, E.C.); E. Merck, 66, Crutched Friars, London, E.C., chemical manufacturer (Controller : B. D. Holroyd, 6, Great Winchester-street, E.C.); Austrian Daimler Motor Co., 112, Great Portland-street, London, W., agents for the sale of motor cars (Controller : R. E. Smith, 53, New Broad-street, E.C.); A. Hurst & Co., 28, Gamage-buildings, 118, Holborn, London, E.C., glassware merchants (Controller : J. H. Stephens, 6, Clement's-lane, E.C., to whom claims by Aug. 8.); A.E.G. Electric Co. (Ltd.), Caxton House, Westminster, S.W., manufacturers of electric equipments (Controller : M. Jenks, 6, Old Jewry, E.C.); A.E.G. Electrical Co. of South Africa (Ltd.), Caxton House, Westminster, S.W. (Controller : M. Jenks, 6, Old Jewry, E.C.).

Claims against the London Electron Works Co. (Ltd.) are to be sent by Aug. 15 to the controller, Arthur Taylor, Thames House, Queen Street-place, London, E.C.

Claims against the Berndorff Metal Works, 231, Regent-street, London, W., are to be sent to the controller, Wm. Strachan, 50, Gresham-street, E.C., by July 22.

Claims against Griesheim Elektron (Ltd.) are to be sent by Aug. 19 to Wm. Eaves, 15, Fountain-street, Manchester.

Claims against Th. Goldschmidt (Ltd.) are to be sent to Arthur Taylor, Thames House, Queen-street-place, E.C., by Aug. 15.

Exports to Siam.—The "London Gazette" of July 11 contains a further list of persons and firms in Siam to whom goods may be consigned from the United Kingdom.

Memorandum on the Electricity Regulations.—Members of the BEAMA have been notified that the new issue (second edition) of this Memorandum, just published, contains certain additions to and alterations of the text agreed between the Association and Mr. Scott Ram, H.M. Electrical Inspector of Factories.

Military Tribunal Case.—At Newcastle-on-Tyne last week application was made for exemption of three employees of the A.E.G. Electric Co.

The general manager stated that an official of the Board of Trade controlled the company. The business, which had its headquarters in London, was carried on solely in the national interest. The company was composed of British directors, and they had an entirely British staff. The only thing that might be against them was that the capital was provided by Germans a good many years ago. A considerable number of the employees had joined other firms, and over 50 had gone into the Army. Some had gone back to Germany, but not since the war broke out. Badges had been applied for, but were refused as the firm was not doing Government work. It was working for Government contractors, however, many of whom depended on the A.E.G. plant.

The superintendent engineer was given conditional exemption, one was given two months, and the other was ordered to join up.

Plant for Sale.—Messrs. Iliffe & Sons, Ltd., 19, Hertford-street, Coventry, advertise for sale a 400 amp. dynamo, switchboard, 40 h.p. d.c. motor, &c.

Telegrams by Telephone.—The Post Office has drawn the attention of its telephone subscribers to the facilities offered for the delivery of telegrams by telephone.

There is a difficulty in obtaining boys for messenger duties, and the

employment of girls is not always practicable, especially after dark, in rural districts. Moreover, the telegraph service has to deal with a large number of telegrams of urgent Government business, and the prompt delivery of telegrams is made difficult. Proposals are under consideration for the suspension of telegrams except urgent ones after dark in outlying districts, and there is an advantage to subscribers in being able to obtain telegrams by telephone in such circumstances.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during June, 1916, and (*b*) the aggregate figures from Jan. 1 to June 30, with increase or decrease compared with corresponding periods of 1915:—

Electrical machinery, (*a*) £157,680 (increase £17,212), (*b*) £650,096 (decrease £200,556); including generators and motors other than for aeroplanes, motor cars and cycles, (*a*) £24,821 (increase £9,502), (*b*) £102,349 (decrease £39,298); and electrical machinery unenumerated, (*a*) £132,859 (increase £7,310), (*b*) £548,257 (decrease £221,258); telegraph and telephone cables other than submarine, (*a*) £8,525 (increase £6,112), (*b*) £52,186 (increase £37,248); telegraph and telephone apparatus, (*a*) £41,012 (increase £37,323), (*b*) £194,719 (increase £159,544); other electrical wires and cables, rubber insulated, (*a*) £15,162 (increase £13,642), (*b*) £64,850 (increase £22,614); with other insulations, (*a*) £497 (decrease £4,729), (*b*) £3,711 (decrease £12,829); carbons, (*a*) £5,399 (decrease £10,026), (*b*) £48,433 (decrease £10,058); glow lamps, (*a*) £22,781 (increase £8,085), (*b*) £134,076 (increase £65,924); arc lamps and electric searchlights, (*c*) nil (decrease £133), (*b*) nil (decrease £1,586); parts of arc lamps and searchlights (other than carbons), (*a*) £16,244 (increase £9,549), (*b*) £48,166 (increase £6,294); primary and secondary batteries, (*a*) £14,933 (increase £8,075), (*b*) £100,908 (increase £39,779); meters and measuring instruments, (*a*) £2,618 (decrease £740), (*b*) £18,012 (increase £3,662); switchboards, (*a*) nil (decrease £310), (*b*) £257 (decrease £3,199); electrical goods and apparatus unenumerated, (*a*) £26,741 (increase £4,456), (*b*) £154,463 (increase £57,170). Total of electrical goods and apparatus other than machinery and uninsulated wire, (*a*) £153,912 (increase £70,004), (*b*) £819,781 (increase £364,573).

Exports.—The exports of electrical machinery, material, &c., (*a*) during June, 1916, and (*b*) from Jan. 1 to June 30, with increase or decrease compared with corresponding periods of 1915, were as follows:—

Electrical machinery, (*a*) £137,707 (increase £13,849), (*b*) £648,227 (decrease £68,639); including railway and tramway motors, (*a*) £1,725 (decrease £9,769), (*b*) £17,027 (decrease £64,974); other generators and motors except for aeroplanes, motor cars and cycles, (*a*) £81,295 (increase £24,465), (*b*) £343,924 (increase £26,299); and electrical machinery unenumerated, (*a*) £54,687 (decrease £847), (*b*) £287,276 (decrease £29,955), telegraph and telephone cables, submarine, (*a*) £121,700 (increase £85,975), (*b*) £222,477 (increase £37,098); other than submarine, (*a*) £21,487 (decrease £21,802), (*b*) £282,688 (increase £55,434); telegraph and telephone apparatus, (*a*) £24,746 (increase £12,480), (*b*) £132,221 (increase £32,814); other electrical wires and cables, rubber insulated, (*a*) £68,121 (increase £44,095, (*b*) £253,793 (increase £112,684); with other insulation, (*a*) £93,912 (increase £46,300), (*b*) £428,312 (increase £222,670); carbons, (*a*) £596 (decrease £234), (*b*) £4,739 (increase £1,369); glow lamps, (*a*) £18,102 (increase £4,095), (*b*) £87,980 (increase £19,565); arc lamps and searchlights, (*a*) £361 (increase £16), (*b*) £5,659 (increase £3,618); parts of arc lamps and searchlights (other than carbons), (*a*) £5,193 (increase £4,538), (*b*) £10,181 (increase £2,009); primary and secondary batteries, (*a*) £20,842 (increase £354), (*b*) £129,642 (increase £26,711); meters and measuring implements, (*a*) £21,693 (increase £9,021), (*b*) £96,673 (increase £19,616); transformers, (*a*) £17,470 (increase £428), (*b*) £47,713 (increase £8,425); switchboards, (*a*) £1,690 (decrease £6,542), (*b*) £31,377 (increase £615); electrical goods and apparatus unenumerated, (*a*) £61,011 (increase £3,965), (*b*) £204,668 (increase £8,497). Total of electrical goods and apparatus, other than machinery and uninsulated wire, (*a*) £476,954 (increase £183,148), (*b*) £2,038,123 (increase £551,125).

TENDERS INVITED.

Telegraph and Telephone Material.

Tenders are invited up to Aug. 16 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. Aug. 8 for the supply and delivery in Melbourne, Sydney, Brisbane, Adelaide, Perth and Hobart of Standard Battery Material, including Pots, Porous Jars, Zinc, Carbon Rods, Chemicals, &c., for the AUSTRALIAN COMMONWEALTH, Postmaster-General's department. (Schedule 1,327.) Specifications, &c., from the Deputy Postmaster-General.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

Rotary or Motor Converter and Switchgear.

WALTHAMSTOW Urban Council require tenders by noon July 26 for supply and erection of 500 kw. Rotary or Motor Converter, e.h.t. l.t. Switchgear. Specifications from Mr. G. R. Spurr, Electricity Dept., Priory-avenue, Walthamstow.

Signal Lighting Transformers.

The VICTORIAN RAILWAY COMMISSIONERS want tenders by 11 a.m. July 26 for 400 Signal Lighting Transformers (contract No. 29,997). Specifications from the Commissioners' Offices, Spencer-street, Melbourne, Victoria.

Motors, Starters, &c.

The VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

Meters.

DUBLIN Electricity Supply Committee require tenders by noon July 20 for the supply of a.c. Slot Meters. Specifications, &c., from the City Electrical Engineer.

Steam Turbo-Alternator, Condenser, &c.

The Town Clerk, INVERCARGILL (N.Z.) will receive tenders until 4 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 40). Specification, &c., from the Town Clerk.

TENDERS RECEIVED AND ACCEPTED.

WOLVERHAMPTON.—Messrs. Willans & Robinson have received an order from the Corporation for a 5,000 kw. Zoelly type of turbine, running at 3,000 revs. per min., with Siemens' generator, also for a surface condensing plant of their own manufacture with Rees Roturbo pumps for use in conjunction with the turbine.

ABERDARE.—The Urban Council have accepted the tender of J. A. Bosher for the supply and laying of cables.

ROTHERHAM.—The Council have arranged for the purchase from Steel, Peech & Tozer of 40 tons of rails, at £16. 10s. per ton.

BRISTOL.—The tender of Fraser & Chalmers has been accepted for a 3,000 kw. turbine, coupled to a Vickers alternator (with condensing plant by the British Westinghouse Co.), for £11,608.

BATTERSEA (LONDON).—The Borough Council have ordered a 350 kw. rotary converter from Bruce, Peebles & Co., at £1,330, and motor converter switchgear from the British Thomson-Houston Co., at £328. 14s.

SCHOOL LIGHTING.—The London Education Committee has received five tenders for wiring the County Secondary School, Forest Hill, and the lowest, that of Alex. Hawkins & Sons, has been accepted, at £372. 5s.

SHEFFIELD.—The Electricity Committee has accepted the following tenders:—

Steel Barrel Co., petrol storage installation, £195; Willans & Robinson, replacing spare turbine blading material, £283.

The Council is recommended to accept Messrs. Hadfields' offer to renew the Fitzalan square tramway junction.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Bolton.—On the tramways department at March 31 the total capital expenditure was £570,554, of which £324,994 is outstanding.

Year's revenue was £142,090 (compared with £141,409 in 1914-15), working expenses were £73,589 (against £76,130), interest and income tax required £13,518 (£12,237), sinking fund £17,671 (£17,519) and parliamentary charges, &c., £2,332 (£981), and of the remainder £18,544 (£18,339) has been set aside for renewals, £17,000 (as in previous year) voted to relief of rates, and £397 (£58) carried forward. Average total revenue per car-mile was 13·097d., and working expenses (including power) were 6·783d. Average fare charged per mile was 0·633d. Passengers carried were 31,839,150 (31,370,166), car-miles run 2,603,764 (2,886,180), units used 4,247,198 (4,514,010)=1·63 (1·56) per car-mile.

The Tramways Committee say in their report that there were 25 female conductors acting at March 31. Certain track reconstruction work will be carried out in the current year, as the tracks are in a very bad condition, although the cost will exceed considerably the amount provided in the depreciation fund, owing to increased cost of labour and materials. Rails which could be bought early last year at £6. 5s. to £6. 10s. per ton now cost £13 to £14. 10s. The Committee have decided to place a contract with the Woods-Gilbert Rail-Planer Co. (Ltd.) for re-grooving various sections of rails, taking out corrugation, &c., at an estimated cost of £5,797.

Bradford.—At the meeting of the Electricity Committee on Friday the balance-sheet of the department for the year ended March was presented.

The profit for the year was £15,989, compared with £18,955 in 1914-15. With the exception of the item for fuel all the works costs were lower, notwithstanding the increased output of five million units. The cost of coal increased by £12,055, but a substantial proportion of this was met by the arrangement of a percentage addition to the charges for bulk supply of power according to the increases from time to time in the price of fuel. The rates increased by £2,040, but other charges of management showed a decrease. The income from the sale of electricity was £156,806 (increase of £18,000), and total income was £167,022. After payment of all working expenses the gross profit was £79,958 (increase of £3,961). Allowances to dependents of men who joined the Forces were £1,610, compared with £593. Interest and sinking fund charges were £63,969 (increase £6,928), leaving a net profit of nearly £16,000. On capital account there was spent during the year £56,580, making a total to date of £990,865, against which there had been provided by means of sinking fund £469,606, leaving a net capital outstanding of £521,259.

Burnley.—The accounts of the tramways department for the year ended March 31 show capital expenditure £232,996 (increase £416). The total amount placed to sinking fund is £81,161, the reserve fund invested amounts to £20,756, and suspense accounts to £12,850.

Revenue was £83,238 (compared with £78,467 in previous year), and working expenses were £53,572 (£55,835), interest required £6,552 (£6,797), and sinking fund £8,497 (£8,284). After paying rent of tramways owned by outside authorities, £1,752 (against £1,899), and income tax, £2,542, the balance was £6,010, which is to be devoted to relief of rates. Average revenue per car-mile was 12·92d. (11·45d.) and expenditure was 8·31d. (8·15d.). Passengers carried were 16,946,677 (15,867,699), car-miles run 1,546,389 (1,644,712), and units used 3,367,869 (3,621,567)=2·16 (2·19) per car-mile.

Glasgow.—The accounts of the tramways department for the year ended May 31 show gross capital expenditure £3,835,156 (increase £83,448), of which £1,391,889 has been repaid. Reserve funds amount to £31,106 and depreciation, &c., fund, to £2,447,945.

Revenue was £1,157,336 (against £1,076,877 in previous year), and working expenses were £693,004 (£684,170), or £773,442 (£735,987), including European War expenses (allowances to dependants, &c.) Interest required £90,473 (£78,797) and sinking fund £109,614 (£105,491), leaving net profit £43,548 (£12,951), which has been handed over to the common good. Average total revenue per car-mile was 11·127d. (10·674d.) and working expenses, including cost of power and permanent way renewals, were 8·304d. (8·478d.). Average fare charged per mile was 0·44d. Passengers carried were 362,371,464 (336,260,758), car-miles run 24,963,309 (24,214,460), and units used for traction and car lighting 36,611,255 (33,848,947). Average length of (equivalent) single track in use was 196¼ miles, in addition to 14½ in Paisley, over which the Corporation have running powers. Average number of cars in use 651 (628).

The Committee's report states that claims and expenses paid for third-party risks amounted to £31,715. The department has carried its own third-party risks since June, 1914. The department has also undertaken its own employer's liability and workmen's compensation risk since May, 1915. Claims and expenses for the year were £798.

Launceston (Tasmania).—The accounts of the electricity department for the year ended June 30, 1915, show total capital expenditure £165,281, in addition to £30,976 taken from reserve. Sinking funds amount to £33,819, and reserve fund to £7,940.

Revenue was £22,867, and working and general expenses were £9 212 (=0·771d. per unit sold), leaving gross profit £13,654. Interest required £6,024, and sinking fund £1,560, the surplus being £6,070 (compared with £5,368 in previous year). £1,800 (£2,500) has been transferred to the city funds in aid of rates, and £4,270 (£2,868) to reserve. Mr. R. J. Strike (city electrical engineer) says in his report units generated were 3,307,450 (increase 76,772) and sold 2,866,543. Steam was used to reinforce the hydraulic works on 95 days. Heating devices =777 kw. are connected.

The capital expenditure on the tramways to June, 1915, was £86,214 (increase £10,875). Contributions to sinking fund amount to £2,818, and reserve fund is £4,590. Revenue was £19,316 (13·042d. per car-mile), and working expenses, including power, were £11,599 (=7·831d.), gross profit being £7,717 (=5·211d.). Interest required £3,190, and sinking fund £801, surplus being £453 (£1,777), of which £337 (£1,556) has been transferred to reserve. Mr. Strike reports that 2,385,860 passengers were carried (increase 35,049), car-miles run were 355,421 (increase 15,793).

Loughborough.—The electricity department's accounts for the year ended March 31 show total capital expenditure £47,929 (increase £2,651), of which £3,250 has been repaid, while investment on account of sinking fund amounts to £10,541.

Revenue was £8,291 (compared with £6,503 in previous year), and working expenses and special charges amounted to £4,496 (£3,511), leaving gross profit £3,794 (£2,992), to which is added balance from previous year, £104. After meeting capital charges and writing £59 off free wiring account and £1. 13s. 5d. for bad debts, the balance was £201. Coal cost 0·276d. (0·237d.) per unit sold, and total working costs were 0·774d. (0·836d.). Units generated were 1,667,400 (1,194,310) and sold 1,303,341 (929,051). Maximum load on feeders was 772 kw. (559 kw.). Total connections are equal to 1,694 kw. (1,505 kw.). Motors connected are 186(171)=1,100 H.P. 940 H.P.

Luton.—The electric lighting department's accounts for the year ended March 31 show total capital expenditure £154,650 (increase £2,497), of which £124,414 was borrowed and £100,993 is outstanding.

Revenue was £44,366 (compared with £32,822 in previous year), and working expenses were £27,639 (£19,048), leaving gross profit £16,727 (£13,773). Interest required £3,850 (£3,613), instalments of principal and sinking fund £5,872 (£5,630), and other charges £777 (£100), leaving net profit £6,228 (£4,430). Units generated were 14,146,120 (9,399,750), and sold 12,254,529 (8,380,731). Motors connected are equal to 6,632 H.P. (5,996 H.P.) and heating devices equal to 1,576 kw. (1,465 kw.). Total maximum supply demanded was 4,208 kw. (3,189 kw.).

The borough electrical engineer (Mr. W. H. Cooke) informs us that the works cost per unit remains at 0·54d., in spite of the price of coal having advanced 40 per cent., the output having increased by nearly four million units. Average price received per unit dropped to 0·86d. (against 0·91d.), but the net profit rose to £6,227, after reserving £700 for excess profits duty. The Council has decided to charge against these profits various items of capital expenditure such as house services and meters, railway wagons, &c., amounting to £2,155, and to allocate the remainder to working balance.

Stockton-on-Tees.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £64,719 (increase £1,405), of which £62,617 was borrowed and £30,601 has been repaid.

Revenue was £9,651, and working expenses and special charges amounted to £6,320, leaving gross profit £3,331. Interest and redemption required £3,828, and income tax £212, the net deficit, charged on district rate fund, being £814. Units generated and purchased were 1,840,150, and sold 1,668,773.

Sunderland.—For the year ended March 31 last the revenue of the Corporation tramways was £79,389.

Working expenses were £44,455, interest required £6,277 and repayment of capital £10,708, leaving net balance £17,949. Average total revenue per car-mile was 13·1d. (compared with 12·2d.), and working expenses, including power, were 7·3d. (compared with 6·7d.). Average fare charged per mile was 0·68d. Passengers carried were 19,908,911 (compared with 18,619,364), car-miles run 1,447,177 (1,486,201), and units used 1,839,671. The outstanding capital expenditure is £164,120.

Mr. A. R. Dayson (general manager and engineer) says in his report the work of repairing the track has been severely handicapped by shortage of labour. The electric welding plant has been of great value, and has more than justified its purchase. There are 65 female conductors.

Walsall.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £208,948 (increase £40,886), of which £176,779 was borrowed, and the sinking funds amount to £54,073, less amounts paid off (£23,871).

Revenue was £29,573 (compared with £25,879 in previous year), and working expenditure and special charges amounted to £18,789 (£14,293), leaving gross profit £10,784 (£11,586), the net deficit for the year, after meeting capital charges, &c., being £899 (compared with £1,385 net profit for previous year). Total costs, exclusive of capital charges, were 1·17d. per unit sold, and interest and sinking fund charges were 0·73d. Units generated were 5,348,621 and sold 3,862,200. Total maximum demand was 1,786 kw.

The tramway accounts show gross capital expenditure £189,814. The total amount of the sinking fund is £38,013 and of the reserve fund £36,138. Revenue was £40,291, working expenses were £22,955, interest required £4,826, and sinking fund £4,088, the net balance being £2,372, of which £2,000 has been devoted to relief of rates. Total revenue per car-mile was 13·217d. (against 11·353d. in previous year), and working expenses, including power, were 7·53d. (7·267d.). Average fare charged per mile was 0·79d. Passengers carried were 7,886,190, car-miles run 731,640 and units used 882,078.

The income of the motor services from May 23 to Dec. 31, 1915, was £4,099 (13·837d. per 'bus-mile), and the working expenses were £2,239 (7·558d.), leaving £1,860 to carry to net revenue account.

West Hartlepool.—The total capital expenditure of the tramways undertaking at March 31 was £83,762 (increase £2,031), of which £5,599 has been redeemed.

Year's revenue was £19,482 (against £19,505 in 1914-15) and working expenses (including power) were £13,126 (£11,574), leaving gross profit £6,355 (£7,931). Interest on loans was £2,364 (£2,569) net, and £500 (as in previous year) was paid as rent for section of line in Hartlepool. Sinking fund required £1,186 (£1,059), repayment of loans £816 (£787), and the surplus for the year (placed to reserve or renewal fund) was £1,278 (£3,018). Revenue was equal to 9·97d. (9·77d.) per car-mile and working expenses were 6·72d. (5·80d.).

The electricity department accounts show gross capital expenditure £145,423 (increase £2,290). £44,251 of debt has been extinguished, and the sinking fund amounts to £9,621. Revenue was £18,939 (against £17,552 in previous year) and working expenses were £8,747 (£7,851), leaving gross profit £10,192 (£9,701), and the surplus, after providing for interest, income tax and redemption, was £316 (£44).

York.—The accounts of the electricity department for the year ended March 31 show gross capital expenditure £210,888 (increase £4,786), of which £76,918 has been repaid.

Revenue was £37,860 (compared with £29,343 in previous year), and working expenses and special charges (including £1,275 for allowances to men on military service) amounted to £21,360 (£18,702), leaving gross profit £16,559 (£15,096). Interest and sinking fund required £14,685 (£12,549), and tax on profits £418 (£281), and the surplus £1,456 (£2,265) has been transferred to reserve and renewals fund. Units generated were 11,044,629 (8,651,478), and sold 9,364,009 (7,417,089). Total maximum supply demanded was 3,487 (3,316) kw.

The capital expenditure on the tramways and motor omnibuses is £194,892 (increase £31,008), of which £8,770 has been repaid, and £3,356 is in sinking fund. To this expenditure there has to be added £26,151 for purchase of land and property and street works, the annual charge for which is £1,393. Revenue was £35,735 (against £30,126), including motor 'buses £2,009, and working expenses were £24,532 (£21,651), including 'buses £1,361, and allowances to men on military service £1,674 (£910), the gross profit being £11,202 (£8,471). Interest required £6,138 (£5,176), and sinking fund £3,272 (£2,084), the balance, carried to reserve and renewals account, being £1,792 (£1,211). Tramcar miles were 763,027 (764,540), and 'bus miles 61,490. The 'buses commenced running on Feb. 15, 1915.

COMPANIES' MEETINGS AND REPORTS.

CHILI TELEPHONE CO. (LTD.)—The report of the directors for the year ended March 31 states that the aggregate number of subscribers at all centres at the end of the year was 13,307, compared with 13,095 at the beginning, an increase of 212 for the year. The gross revenue from all sources was £121,972, against £112,361 in 1914-15, an increase of £9,612. The total expenditure was £72,388, against £64,396, an increase of £7,992. The net revenue from all sources was £49,585, against £47,965, an increase of £1,620. The balance to credit of revenue account (including £1,339 brought forward) is £53,924, of which £2,644 has been expended on replacements, &c., of plant. An interim dividend of 3s. per share, tax free, was paid in January last, and after carrying £18,577 to general reserve and adding £2,000 to reserve against loss on investments the directors now recommend a final dividend of 5s. per share, tax free, leaving £4,302 to be carried forward.

CUBAN TELEPHONE CO.—The gross increase in rentals and service during 1915 was $154,203, and was handled with an increase in operating expenses of only $4,013, the net gain being $150,190. This gain was partially offset by heavier expenditures for interest, and the net surplus shows an increase of $105,426, compared with 1914. Nearly $450,000 of the accumulated net cash surplus has been used for carrying on the construction work required to be done under its concession and to provide for the constantly increasing additions to both the local and long-distance systems.

EDMUNDSONS' ELECTRICITY CORPORATION (LTD.)—The net profit for the year ended March 31, after providing for mortgage and debenture stock, interest and redemption, amounts to £13,259, 10s. 3d. After adding £3,365, 12s. 3d. brought forward and deducting the interim half-yearly dividend paid in January last on the cumulative preference shares, there remains £10,625, 2s. 6d., which the directors are applying in paying the final half-yearly dividend for the year ended March 31 last on the cumulative preference shares (£6,000), leaving to be carried forward £4,625, 2s. 6d. The 20 subsidiary and other companies in which the company is interested had the equivalent of 2,145,220 33-watt lamps connected at March 31, 1915, against 1,994,936 33-watt lamps in 1914.

GENERAL ELECTRIC CO. (LTD.)—The net profits for the year ending March 31 amount to £196,274, 13s. 2d., to which has to be added £36,701, 9s. 6d. brought forward, making a total sum of £232,976, 2s. 8d. After deducting debenture interest and depreciation amounting to £27,259, 15s. 7d., the available balance is £205,716, 7s. 1d., which the directors recommend should be appropriated as follows: Dividend at rate of 6 per cent. per annum on preference share capital for year (£42,000), managing directors' and employés' bonus (£12,701, 9s. 9d.), dividend at rate of 10 per cent. per annum on ordinary share capital for the year (£50,000), reserve account £40,000, grants to dependants of men on active service £12,961, 13s. 2d., balance to be carried forward £48,053, 4s. 2d. The result of the past year has been generally satisfactory. All the company's works have been fully occupied throughout the year, and have been mainly employed in the production of material essential for purposes of war. Although the demands on the company were mostly confined to the electrical field, many requisitions were made for appliances of entirely new types and patterns, and great difficulties had to be overcome. Some 1,500 experienced members of the staff and workpeople now serving at the front had to be replaced by untrained substitutes. New workshops had to be erected for special work. The scarcity of labour, the difficulty in obtaining new machinery or of adapting existing plant to the production of new articles and the occasional dearth of raw material caused temporary delay and disorganisation. If the present results are satisfactory, they are entirely due to the unselfish devotion, initiative and unremitting energy of the staff and workpeople. The capital expenditure on new works at Witton during the past year amounted to approximately £70,000. The extensions planned and referred to in previous reports have been suspended until the advent of a more favourable moment for carrying out such constructional work. For the same reasons, no further progress has been made with the Kingsway building. The various selling branches of the company have all done well. In spite of the reduced output of the works available for private and ordinary industrial purposes, the company's large reserve stocks have been helpful in the past to make good the deficiency. The export business of the company records very large inquiries, but, owing to well-known causes common to all exporters in this country at the present moment, only a small proportion of the demand could be filled. The directors draw attention to the increasing investment account. Particulars of the company's investments are given, and these are subdivided into—

(a) *Manufacturing Companies*, for which the company is the distributing agency for nearly the whole of the output of their works, and has the control both as to financial interest and management. The Pirelli-General Cable Works (Ltd.) is also a manufacturing company, in which the General Electric Co. holds at present half the capital, the other half being held by Messrs. Pirelli & Co., of Milan. No profit has as yet been made, nor was it anticipated, as the works have only been running for a part of the year. The works both in construction and equipment are most complete and up to date, and the directors are well satisfied with the progress made under prevailing conditions. (b) *Trading Companies*, whose object is to sell in their respective territories the products of the British works. (c) *Electricity Supply Companies* and (d) *Sundry Investments*. Mr. Montagu F. Armstrong, Mr. George H. Ide and Mr. Maurice Solomon have joined the board, and their appointment will be submitted to the shareholders for confirmation.

MONTREAL LIGHT, HEAT & POWER CO. (LTD.)—The gross revenue for year ended April 30 was $6,877,167, of which expenses of operation and maintenance absorbed $2,856,798, and $675,000 was placed to depreciation and renewal reserve, leaving $3,345,369. Deducting fixed charges ($487,181) and dividends paid and payable ($1,870,940), the surplus earnings were $987,248, and after making provision for certain payments the balance ($772,518) has been carried forward. It is stated that in the city there are at present upwards of 8,000 vacant houses and stores due to the war and recruiting among householders. The increased earnings were in large measure due to electrical energy and gas sales for power purposes.

SOUTHERN BRAZIL ELECTRIC CO. (LTD.)—The report for the half year to Dec. 31 states that the operations of the various undertakings in which the company is interested have shown satisfactory progress. The net revenue of the Campinas shows an improvement over that of the previous year, due to increasing demands for electric light and power. The tramway receipts were affected by temporary causes in the early months of the year, but have now recovered the loss then suffered, and show a steady improvement. The net revenue from the steam railway shows an improvement, but the full benefit of the service will not be felt until the

electrification of the line is complete. Owing to the very high price of coal, the results from the gasworks continue unsatisfactory, and arrangements are being made to introduce electric cooking stoves in place of the existing gas stoves, as practically all the output is utilised for cooking purposes only. The returns for the six months from Piracicaba show a slight improvement. The revenue from the tram service is very satisfactory, and will continue to improve as more mileage is put into operation. The new 665 h.p. turbine has been put to work with satisfactory results, and the old turbine and generator have been thoroughly overhauled. Work is in progress on the distribution network of cables in the city, separating the public from the private lighting, which will tend to greater efficiency. Contracts for the supply of power to several large industrial concerns have been made. Under the terms of the concession granted in September last permission was given to supply current to several outlying towns and villages, one of which (Rio das Pedras) is now connected, thus permitting of the costly steam installation in that town being shut down. The revenue from electric power at Amparo remained normal, but recently requests for supply have been received from several plantations in the district, and transmission lines are being erected, some of which will be in operation this year. The balance to the credit of profit and loss account, after deduction of all charges in Brazil and London and of interest on debentures to Jan. 1, 1916, is £945, to which has to be added the amount remaining to credit of this account (£2,127), making a total of £3,072, which the directors propose to carry forward.

VENTURE TRUST (LTD.)—The report for the year ended June 30 states that the trust has formed the British Electrolytic Zinc Co. (Isherwood Process), Ltd., with a share capital of £62,500 and a debenture issue of £25,000. The electrolytic treatment of zinc ores has for some time past occupied the attention of the producers of spelter, and it is claimed that the Isherwood process, which the new company has agreed to acquire, presents a means of treating complex zinc lead ore far superior to the smelting methods now in general use. At the Raritan works (New Jersey) of the Amalgamated Copper Co., of New York, a single-unit plant was kept in continuous operation for nine months, with the result that their experts reported that the process did what was claimed for it, and produced electrolytic zinc of high purity at a cost that compared favourably with fire smelting. Premises and plant, which were secured at Widnes, should in a few weeks be producing electrolytic zinc.

WELSBACH LIGHT CO. (LTD.)—For the year ended March 31 the net profit was £18,949, and with the balance carried forward the total is £24,658. The directors recommend a dividend of 2½ per cent. per annum on the share capital (less tax), carrying forward £18,033, subject to any liability for excess profits duty. No dividend has been received in respect of the company's shareholding in the Austrian company since the year ended March 31, 1913. It is proposed to alter the articles of association so as to provide (inter alia) that no one but a British subject shall be qualified to act as a director of the company.

WESTERN CANADA POWER CO. (LTD.)—The gross earnings for 1915 were $316,554 and expenses $89,626, leaving $226,927, which was insufficient to meet interest on the first mortgage bonds, while interest on the refunding mortgage bonds and interest payable on current account were not earned. Apart from loans of nearly $550,000, the company will require $100,000 to install the third generating unit. They failed to get permission to make a public issue of securities in London, but a compromise with the Committee representing the holders of the first mortgage bonds has been effected, whereby it is proposed (among other things) to provide sufficient funds for the installation of a third generating unit in the power house at Stave Falls. To carry out the terms of the compromise and to avoid the sale of the properties in foreclosure proceedings, it is necessary that the holders of the $2,495,000 par value of the shares should subscribe for a sufficient number of the proposed new issue of preferred shares to realise $374,240 in cash. The Noteholders' Protective Committee have procured the formation in New York of a syndicate which will underwrite an issue of at least $850,000 of preferred shares. The company, which now has $9 000,000 of mortgage bonds of both classes outstanding, will, after its proposed reconstruction, have only $5,000,000 first mortgage bonds outstanding, the refunding mortgage bonds being converted into ordinary shares. If the plan of reconstruction is successfully carried out, the company will have funds sufficient to complete the installation of a third generating unit and to carry on the business for two years.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ALBERTA ENGINEERING CO. (LTD.) (144,231.)—Reg. June 30, capital £10,000 in £1 shares, to acquire the Alberta Ammunition and Aluminium Works and the Premier Mfg. Co., and to adopt certain agreements. Private company. First directors are L. Chisogne and J. B. Garbe. Reg. office, 4, Copthall-chambers, E.C.

AUTOMATIC LOADING CO. (LTD.) (144,165)—Reg. June 23, capital £20,000 in £1 shares, to carry on in Great Britain or elsewhere the business indicated by the title and that of boiler makers, engineers, manufacturers of and dealers in electrical and other appliances, &c. Private company.

BRITISH ELECTRO-CHEMISTS (LTD.) (144,181).—Reg. June 24, capital of £10,000 in £1 shares (6,000 preference), to adopt an agreement with China and Metal Platers (Ltd.), and to carry on the business of engineers and contractors, chemists, galvanisers, electroplaters and refiners, &c. Private company. First directors are B. G. Clark, C. Bowen, E. D. Taylor and B. P. Crawshaw. The two first named have the right to appoint an additional director. Reg. office: 7, Ely-place, E.C.

BRITISH TUNGSTEN MINES (LTD.) (9,615.)—Reg. in Edinburgh on June 7, capital £40,000 in £1 shares, to take over, work and develop any mines, mining rights and metalliferous land in the U.K., and to adopt an agreement with King Bros. First directors are D. D. Binnie, G. McPherson and R. A. Murray. Reg. office, 175, W. George-st., Glasgow.

CHASE BROS. (LTD.) (144,107)—Reg. June 16, capital £2,000 in £1 shares, to adopt an agreement with A. A. Chase, to carry on the business of motor, electrical and general engineers, hardware merchants, dealers in motor and cycle accessories, &c. Private company. A. A. Chase is first managing director. Reg. office: 12A, Station-road, West Croydon.

ELECTRIC CONSULTING & SUPPLY CO. (LTD.) (9,631.)—Reg. in Edinburgh on June 26, capital £1,069 in £1 shares, to carry on the business of consulting electrical engineers, &c. Private company. First directors are J. S. A. Primrose and R. S. Smith. Reg. office, 199, Bath-street, Glasgow.

FILBAR ELECTRIC HEATER (LTD.) (144,237.)—Reg. June 30, capital £20,000 in £1 shares, to acquire from J. Fillans Barr, of Toronto, the benefit of certain inventions and patent rights relating to electric heaters, &c. Private company. First directors are J. W. M. Fry, F. Peterson and J. Fillans Barr. Reg. office, 24, Coleman-street, E.C.

JOSEPH R. HENSON (LTD.) (144,270.)—Reg. July 4, capital £500 in £1 shares, to take over the business of a general ironmonger, builders' merchant, electrical, gas and general engineer carried on by Joseph R. Henson. Private company. First directors are Capt. Heywood, W. Seton Karr, J. R. Henson (man. director), H. George Bowles and N. A. Heywood (all permanent).

L. WEEKES (LTD.) (144,093)—Reg. June 14, capital £10,000 in £1 shares (1,000 founders), to take over the businesses (1) of an electric fuse manufacturer carried on by A. L. Weekes as the British Electric Calibrated Fuse Co., and of electric switch manufacturers carried on by the "Safetec" Controlling Appliances Co. (Ltd.). Private company. First directors are A. L. Weekes (permanent chairman and sole governing director) and W. J. Coom. Reg. office: Langley-street, Luton.

ROBIN HOOD ENGINEERING WORKS (LTD.) (144,205.)—Reg. June 27, capital £10,000 in £1 shares, to carry on the business of manufacturers of and dealers in sparking plugs and other ignition apparatus for use in internal combustion engines, electrical mechanical and general engineers, machinists, manufacturers of and dealers in aeroplanes, motor cars, cycles, &c., and to adopt an agreement with K. E. L. Guinness. Private company. Reg. office, Newlands, Putney Vale, Surrey

STEVENS PETROL-ELECTRIC VEHICLES (LTD.) (144,236.)—Reg. June 27, capital £3,000 in £1 shares (1,500 "A" and 1,500 "B"), to carry into effect an agreement dated Aug. 19, 1915, between W. A. Stevens and Joseph Sankey & Sons (Ltd.), and to carry on the business indicated by the title, and that of agents for the sale of motor and other vehicles, &c. Private company. First directors are W. A. Stevens (managing director) and two others to be nominated by the holders of "A" shares.

VOLTA MAGNETO CO. (LTD.) (144,239.)—Reg. June 29, capital £5,000 in £1 shares, to carry on the business of manufacturers of and dealers in magnetos, sparking plugs and all kinds of machinery, appliances, accessories and fittings for ignition purposes, or capable of being used in connection with electric light, heat and power, manufacturers of and dealers in motor cars, motor boats, airships, aeroplanes, &c. Private company. First directors are C. T. B. Sangster and H. Jelley.

WEY ENGINEERING CO. (LTD.) (144,207.)—Reg. June 27, capital £6,000 in £1 shares, to carry on the business of electrical, consulting and electrical engineers, electrical experts, technical advisers, manufacturers, contractors, &c., and to adopt three agreements. Private company. First directors are H. J. Banister, R. P. Creagh and H. B. Ewbank (all permanent, and the two last named are joint managing directors). Reg. office, Baker-street, Weybridge, Surrey.

WILLIAM WARD & SON (SHEFFIELD) (LTD.) (144,146)—Reg. June 21, capital £2,000 in £1 shares, to take over the business carried on at Sheffield by J. Ward as Wm. Ward & Son, to carry on the business of mechanical, electrical, contructional, motor and general engineers, tool makers, machinists, &c. Private company. First directors are J. Ward (permanent managing director), Clement Ward, S. Ward and Clifford Ward. Secretary: Clement Ward. Reg. office: Surrey Works, 182, Broadfield-road, Sheffield.

MORTGAGES AND CHARGES.

ORFORD ELECTRIC LIGHT & POWER CO. (LTD.)—Particulars of £750 debentures, created June 5, 1916, have been filed, amount of present issue being £650. Property charged, company's undertaking and property, present and future. No trustees.

RECEIVERSHIP.

ELECTRO-FLEX STEEL CO. (LTD.)—Notice of appointment of W. Swan, 31, Mosley-street, Newcastle-on-Tyne, as receiver and manager on June 22, 1916, under powers contained in debenture dated Aug. 20, 1915, has been filed.

CITY NOTES.

MEMORANDA (July 12).—Bank rate 5 per cent. (since Aug. 8, 1914). Consols 60⅞. Consols Pay Day, Aug. 2. Stocks and Shares Ticket Days, July 27 and Aug. 15. Pay Days, July 28 and Aug. 16. Price of silver, 29½d.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The directors have declared an interim dividend for the quarter ended June 30 of 15s. per cent. on the ordinary stock and £1. 10s. per cent. on the preferred stock (less tax), payable on Aug. 1.

DIRECT UNITED STATES CABLE CO. (LTD.)—The board have resolved upon the payment of an interim dividend of 2s. per share (less tax at 5s.), being at rate of 4 per cent. per annum for the quarter ended 30th ult., such dividend to be payable on and after the 31st inst.

DUBLIN UNITED TRAMWAYS CO. (LTD.)—The directors announce an interim dividend for the half-year ended June 30 of 4 per cent. on the ordinary shares. The reduction by 1 per cent. per annum on the ordinary shares is caused by the loss of over £13,000 in receipts, due to the rebellion.

MADRAS ELECTRIC SUPPLY CORPN. (LTD. & REDUCED.)—A petition for confirming the proposed reduction of the capital from £500,000 to £380,000 will be heard by Mr. Justice Astbury on July 18.

J. STONE & CO. (LTD.)—The net profit for the past year was £133,157. A dividend of 10 per cent. and a bonus of 15 per cent. are proposed on the ordinary shares, leaving £207,147 to be carried forward.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date July 11, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	15d.
Solid Drawn Copper Tubes	18½d.
Brazed Copper Tubes	18½d.
Brazed Brass Tubes	17d.
Brass Wire	16½d.
Copper Wire	18½d.
Rolled Brass	15½d.
Brass Sheets	16½d.

	per ton.
Copper Sheets	£148 0 0
Spelter	£44 0 0

	per ton.
English Lead	£28 15 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£76 0 0
Clean Brass Scrap	£50 0 0
Braziery Copper Scrap	£70 0 0
Old Lead	£22 0 0
Old Zinc	£30 0 0
Hollow Pewter	£118 0 0
Black Pewter	£70 0 0
Gun Metal	£67 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date July 11, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£95 0 0
Clean Mixed Brass	£54 0 0
Clean Copper	£82 0 0
Braziery Copper	£70 0 0
Gun Metal	£72 0 0

	per ton.
Old Lead	£24 0 0
Tea Lead	£22 0 0
Old Zinc	£33 0 0
Hollow Pewter	£120 0 0
Shaped Black Pewter	£85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £86; Commercial Tinman's Solder, £112; Blowpipe Solder, £122.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, July 11. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., July 11.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	8⅞	5 11 8	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	10⅞	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅞	7 12 5	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	80	5 0 0	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 8	Jan, July
5	2/3	Do. 4½% Pref.	3½	7 4 0	..
5	5%	Do. Ord.	3½	7 2 10	Aug, Feb
5	4½%	Do. City Pref.	2⅛†	7 13 2	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3½	6 8 0	Mar, Sept
St.	4½%	Do. do. Deb.	87†	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12⅛	6 9 11	Feb, Aug
10	6/0	Do. 6% Pref.	10½	5 14 3	Mar, July
St.	5%	Do. 5% Deb. St.	97½†	4 17 6	Jun, Dec
St.	4½%	Do. 4½% Debs.	91†	5 11 1	Jun, Dec
10	7%	County of London Ord.	103	6 11 9	Mar, Sept
10	6%	Do. 6% Pref.	101	5 11 1	Feb, Aug
St.	4½%	Do. 1st Deb.	87½†	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	83½	5 7 4	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	75½	5 18 10	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6%	London Elec. Supp. 6% Pref.	4⅞	6 15 6	..
St.	4%	Do. 4% Mort. Debs.	80½	4 19 9	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2½	6 0 0	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80†	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St.	99†	5 1 0	Jan, July
..	6%	Newcastle & Dist. E L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E. S. 5% 2d Mt. Db. St.	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	2⅛	7 0 8	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., July 11.	Rate per cent, Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	5⅛	6 17 8	Feb, Aug
5	7%	Do. do. Pref.	5⅛	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74†	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	71½	6 5 10	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1	6 11 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6⅞	5 13 2	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4½†	5 5 11	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	83	6 0 6	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	79†	7 11 11	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	73½	5 9 4	..
St.	4%	Do. do. Assented Def. Ord.	72½	5 10 4	..
St.	4½%	Do. 4½% Pref.	81	5 7 2	Jan, July
St.	4%	Do. 4% Deb. St.	76	5 5 3	Jan, July
St.	4%	City & S. London Deb.	72	5 13 11	May, Nov
St.	5%	Do. Pref. 1896	70⅜	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅞	5 14 3	Jan, July
St.	4%	Do. 4% Pref.	69	5 16 1	Mar, Sept.
St.	4%	Do. 4% Debs.	75	5 5 3	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	27⅜	3 13 3	Feb, Aug
St.	3½%	Do. 3½% Pref.	66	5 6 1	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	62½	5 12 5	Feb, Aug
St.	3½%	Do. 3½% A Debs.	70½	4 19 3	Jan, July
St.	3½%	Do. 3½% Debs.	71	4 18 7	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19⅜	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	76½	5 4 7	May, Nov
St.	4½%	Do. 4½% First Pref.	74½	6 1 3	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	110	5 9 1	Jan, July
St.	4%	Do. 4% Debs.	77	5 3 11	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	77½	5 3 3	Jan, July
St.	4%	Do. 4% Guar. Stock	70	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2⅛	5 2 2	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅝	5 9 3	Mar
100	5%	Do. Prior Lien Debs.	92½†	5 8 0	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	11⅜	7 10 0	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅞	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref.	⅝	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91†	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2½	6 0 0	April
100	6%	Do. 6% Prior Lien Debs.	100½	5 19 5	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65½†	6 2 2	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅞	8 5 10	Jan, July
5	5%	Do. 5% Pref.	4†	6 5 0	Feb, Aug
St.	4½%	Do. 4½% Debs.	81†	5 7 2	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅝	7 2 3	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	¼	..	Feb, Aug
St.	4%	Do. 4% Deb.	59†	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	⅜	10 0 0	May
1	7%	Do. 7% Cum. Pref.	⅜	7 4 6	Jan, July
St.	4%	Do. 4% Debs.	71½	5 11 6	Jan, July
10	10%	General Electric Ord.	11⅛	8 11 1	July
10	6%	Do. 6% Pref.	10†	6 0 0	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15½	6 12 3	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4½	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	12⅛†	8 4 6	Feb, Aug
10	5%	Do. Pref.	8⅞†	6 1 8	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	40	6 0 0	Mar, July
100	4%	Do. 4% Debs.	95½†	4 6 0	Jan, July
1	7½%	Vickers Ord.	1⅛	4 1 4	May, Aug
1	6d.	Do. 5% Pref.	⅛	5 6 8	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 4	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 8	Jun, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40½	10 5 6	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	105½	5 14 2	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23	6 17 10	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	70†	5 14 3	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	8½	6 1 3	May, Nov
10	10%	Do. 10% Pref.	13½	7 5 5	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅜	7 16 10	Ja,Ap,Jly,O
St.	8%	Eastern Tel. Co. Ord.	150½	5 6 2	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	67	5 4 6	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	78½	5 1 7	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78½	5 2 3	Feb, Aug
10	8%	Do. Ord.	15⅞	5 6 3	Ja, Ap,Jly,O
10	22%	Gt. Northern Tel. Co. Ex. Coup. 10	37½	5 16 7	Ja, My, Jly
25	13%	Indo-European	47½	6 16 10	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3⅜	2 19 3	April
1	7%	Do. 7% Pref.	2⅛	2 9 9	July
10	10%	West India & Panama Ord.	1⅜	8 19 5	May, Nov
10	6%	Do. 1st Pref.	7⅛	7 17 5	May, Nov
10	8%	Western Telegh. Co.	14⅛†	5 8 0	Mr,Jly,O,Dec
St.	4%	Do. 4% Deb. St.	77½†	5 3 3	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½	4 10 10	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅝	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	2	5 0 0	Apl, Oct
St.	4%	Do. Db. St.	79½†	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Db. St	83†	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅛	5 18 0	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4½†	5 6 8	Jan, July
St.	4½%	Do. Deb. Stk.	85½†	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	13½	4 11 5	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	11	5 9 1	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	83½	5 19 9	Ja, Apl, Jly,O
..	4%	Do. $100 Pref	67	5 19 5	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	5	6 0 0	Mar, Sept
St.	5%	Do. 5% Debs.	94½	5 5 10	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10½	5 14 3	..
St.	4½%	Do. 4½% Debs.	85½†	5 4 11	Jan. July
5	9%	Calcutta E. S. Corp Ord	6⅛	7 6 11	May, Nov
5	5%	Do. 5% Pref.	4⅞	5 9 7	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,992. [No. 16. Vol. LXXVII.] **FRIDAY, JULY 21, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 519
Arrangements for the Week 521
Power Requirements and Resources of New South Wales. By William Corin. — *Concluded* 522
Oil Engines and Steam Engines in Combination. By Geoffrey Porter. Illustrated 524
Notes on Design of Electromagnetic Machines. By Stanley Parker Smith, D.Sc. Illus.—*Concluded* .. 528
National Physical Laboratory 532
The Effect of Vacuum-Fusion Upon the Magnetic Properties of Pure Open-Hearth Iron. By Trygve D. Yensen. Illustrated 533
Electric Undertakings in Japan 535
THE INEFFICIENT STATION .. 536
Instrument Transformers. By Chas. C. Garrard. Illus.—*Concluded* 537
Institution of Electrical Engineers 539
CORRESPONDENCE 540
S. P. Thompson (Charles Bright and John E. Raworth).
The Use of Carbon Tetrachloride (Benzinoform) with High-Tension Switches. By M. Vogelsang. Illustrated. 540
London County Council Tramways 541
PARLIAMENTARY INTELLIGENCE 542
LEGAL INTELLIGENCE 543
Educational 544
The "Electrician" Commercial and Industrial Section .. 545-552

NOTES.

Save Us From Our Friends.

LORD HALDANE'S advocacy of a more efficient system of English education must raise serious misgivings in the minds of persons really concerned with the preparation of our young people for their life work. Lord HALDANE'S action is likely to be extremely harmful for two reasons—firstly, because if he speaks of education at the present moment, education becomes automatically discredited with a considerable section of the public, and, secondly, because what he wants is likely to be bad in itself. The Report of the Royal Commission on London University, over which Lord HALDANE presided, shows the sort of system that he wants, and, just as the adoption of the recommendations of that Report would have a disastrous effect on the University, the putting into effect of his suggestions in the House of Lords would perpetuate the worst and destroy the best parts of our present system. What Lord HALDANE appears to want is a very limited number of special schools, both for the University and the Country, fortified with privilege, responsible to nobody except themselves, removed from the trouble of competition and accepted as perfect without test. What the public needs is a large number of schools, responsible for their work to a general directing organisation, working to a definite minimum standard, proved before being approved, and putting the best educational facilities within reach of all classes.

LORD HALDANE gives one the idea that the Secondary Schools are enough to make one weep. What does he mean? Are they inefficient? Do they produce the wrong type of man? Have they been given a reasonable chance? The method of assessing English Schools is a vicious circle of argument. Lord HALDANE and those who think with him begin by supposing that only a particular type of school can produce a man whose opinion is valuable. They then ask the men, whose opinions they value, what is the best type of school, and are confirmed in their original belief. Let us get back to proved facts, of which there are very few in English education. Lord HALDANE'S schemes for the University remove the Internal student from rude competition with men who are not Internal students. Sometimes one wonders whether he realises this, whether he understands how much the wind of the examination room is tempered for the Internal, whether he has taken the trouble to compare the searching test to which the External student is subjected with the lighter ordeal of that favoured candidate who is supposed to have had better teaching. Probably he has, as he seems to approve a similar system for all England. Before legislating for the schools let our masters ask whether a system of Internal and External students for the whole country is desirable. Whether it is desirable that there should be a limited number of schools from which the majority of public servants must come, or whether we need a system of schools in which the results are fairly tried, and the best material that can be obtained from every class is sorted out and hall-marked as being the best.

Vacuum Treatment of Iron.

FROM time to time we have given some account of the remarkable work of Prof. T. D. YENSEN upon the effect of vacuum fusion on the magnetic properties of iron. So far, these investigations have been carried out upon the purest iron, obtained by electrolysis, and they have been looked upon rather as of theoretical than of practical importance. In our present issue, however, we publish an article by Prof. YENSEN on the effect of this treatment on pure open-hearth iron, and it is interesting to note that a permeability exceeding 20,000 was obtained. Briefly, it may be said that by this treatment the maximum permeability was increased from two to three times, and the hysteresis loss was decreased by a corresponding amount. The conclusion is reached that nearly as good results are obtainable by the treatment of pure open-hearth iron as with pure electrolytic iron. There seems to be very little difference between the treated and untreated iron in other respects, though the treated iron was found to be slightly more dense and the crystals appeared to be larger. It cannot be said, however, that large crystals necessarily occur with high permeability. The present investigation is of great interest, as it serves to show that it may be worth while to apply vacuum fusion to the best grades of commercially pure iron, as distinct from iron which has been purified by special means, and consequently it may be that very high permeabilities so obtained will become of commercial importance.

"The Electrician" Monographs.

Earlier in the year when the last instalment of Mr. E. A. Biedermann's article on the "Dispersion of Induction Motors" was published, we announced that it was our intention to reprint the article as a pamphlet. In this issue Dr. Smith concludes the first of the important series of articles on the "Design of Electromagnetic Machinery." The article on "Continuous-current Machines," which has run through seven issues, will be re-issued shortly in pamphlet form for the benefit of students, as well as of those who are engaged in the design of such machinery. Our readers will remember that in this article an attempt has been made to illustrate the principles underlying the working of continuous-current machines, and the application of these principles to the design of continuous-current generators. The great importance of obtaining a good armature winding on all commutator machines has been emphasised, and rules have been given to enable the designer to obtain the best winding in a given case. In the illustrative design Dr. Smith chose an example where it was found best to use a four-circuit wave winding, and he applied the rules of symmetry to show how simple a problem it is to obtain the best winding in such cases. It has been decided to call these reprinted Papers "Monographs," in order that they shall not be confused either with the "Primers" we publish or with The Electrician Series of Books.

The L.C.C. Tramways.

From the statement which has been issued by the Highways Committee upon the working of the London County Council Tramways during the past financial year, it appears that there is a net deficit of £73,795. Considering that the estimated deficit was £61,160, and that during the year there was a very regrettable tramway strike which caused a loss amounting to over £100,000, it may be said that the result is more satisfactory than might have been expected. We need scarcely remark that the whole position is entirely abnormal, and for this reason it is difficult to criticise the figures. For example, war allowances have risen from £12,209 to £95,364. But among the most disquieting features of the position we may mention that the reserve fund now only amounts to £70,119, and in all probability at the end of the present financial year this fund will be completely wiped out by the estimated deficiency of £74,092. Moreover, the renewals fund has been stationary since the year 1912-13, and considering the fact that renewals cannot be fully carried out at the present time, the cost on this account is likely to be very heavy during the next few years. Having regard to the whole position, we are not surprised that both the Finance Committee and the Highways Committee view the situation with considerable anxiety.

The Postponement of the Holidays.

We imagine that the people at home will forego the August holiday with a good grace. Although it is relatively easy for us to forego holidays in face of the good news of the past fortnight, we hope that no more promises will be broken. In the past, for reasons that are not clear to us, a good deal of mud has been thrown at the munition worker, and it would be well for those who criticise to remember that the munition worker is neither better nor worse than themselves. Our reason for hoping that promises made by the Minister of Munitions will be kept is because many of our workers have reached the part of the curve close to the breakdown point. We know of munition factories in which men toil from 7 a.m. to 10 p.m., with a 15-mile journey to and from work. Cases, of which the Ministry of Munitions surely have knowledge, of men working from 7 a.m. on Friday till 1 p.m. on Saturday, with the customary breaks for meals, in order to increase the output, will convince clear-minded people that a holiday in the near future will be necessary to carry the munition worker over the winter. Failing this, it is likely that increasing the working time will reduce the output.

Nobel Prizes.—It is stated that the Swedish Government has decided to postpone the distribution of the Nobel prizes for physics, chemistry, medicine, and literature for 1916, together with those reserved from last year, until June 1, 1917.

Australian Commonwealth Traders' Commission.—The Commonwealth Government has agreed to the appointment of a Commission representing manufacturers and employés to investigate and report in six months upon various trades in America, including the engineering and iron trades.

Tasmanian Government Undertakings.—A Launceston syndicate has made an offer to the Government to construct a railway down the west bank of the Tamar to the cement and steel works, and to provide a main to transmit electrical energy from the Great Lake at a cost of £500,000.

Manufacture of Zinc.—At Drammen, Norway, new zinc works are about to be started for the extraction of zinc by an electric wet process, invented by a Belgian engineer, M. Sturbelle. Raw materials for the first year, about 10,000 tons, have been secured, and special attention will be paid to ores containing from 8 to 30 per cent. zinc, which have hitherto been considered as really worthless.

Electric Ranges.—An article by Mr. H. C. Hopkins in the "Electric Journal" on the above subject gives a table showing the weight of meat saved by electric cooking. Ribs of beef cooked by coal lose 21 per cent., as against 18·6 per cent. when cooked electrically. Mutton, 31·7 for coal, as against 15·8 electric. Shoulder of mutton, 25·7 by coal, as against 11·1 per cent. by electricity. A series of illustrations of ranges are given in the article, one of which is a combination Westinghouse gas and electric range.

Critical Shaft Speeds.—There has lately appeared in the "Engineer" several instructive articles on the above by Mr. W. M. Wallace, A.R.C.Sc. In the third of the articles Dr. Chree's and Dr. Stodola's theories are discussed, and a simple theory of gyroscopic action is worked out. As the articles are amply illustrated, this most difficult subject is made clearer than is usually the case. Formulæ are arrived at by means of a new and simpler method, which should be of interest to students.

Electric Railways in Sydney.—The "Engineer" states that the report on the new electric railways has now been published. The inner zone railways to Parramatta, Hornsby, Sutherland and Bankstown are to be changed from steam to electric traction, the city line is to be rebuilt, and lines laid to the eastern, western and northern suburbs. Two cantilever bridges are to be erected across the harbour, small branches electrified and an underground railway constructed. The total cost will be £20,000,000.

Trade After the War.—A committee has been appointed by the Prime Minister to consider the commercial and industrial policy to be followed after the war, and with special reference to the following questions:

(*a*) What industries are essential to the future safety of the nation: and what steps should be taken to maintain or establish them?

(*b*) What steps should be taken to recover home and foreign trade lost during the war, and to secure new markets?

(*c*) To what extent and by what means the resources of the Empire should and can be developed?

(*d*) To what extent and by what means the sources of supply within the Empire can be prevented from falling under foreign control?

The Committee is composed as follows: The Right Hon. Lord Balfour of Burleigh, K.T., G.C.M.G. (chairman); Mr. Arthur Balfour, Mr. H. Gosling, Mr. W. A. S. Hewins, M.P., Mr. A. H. Illingworth, M.P., Sir J. P. Maclay, Bart., The Right Hon. Sir A. Mond, Bart., M.P., Mr. Arthur Pease, Mr. R. E. Prothero, M.P., Sir Frederick H. Smith, Bart., Mr. G. J. Wardle, M.P., together with the following gentlemen, who are presiding over Board of Trade Committees on the position of important industries after the war: Sir H. Birchenough, K.C.M.G., Lord Faringdon, Sir C. G. Hyde, The Hon. Sir C. A. Parsons, K.C.B., F.R.S., Lord Rhondda and Mr. G. Scoby Smith. Mr. Percy Ashley, of the Board of Trade, and Mr. G. C. Upcott, of the Treasury, have been appointed secretaries to the Committee.

OBITUARY.

C. Lucey.—We regret to record the death of Mr. C. Lucey, who for some years was publicity manager of Crompton & Co., from whom he went to the Manchester office of the General Electric Co. He was with the latter firm at the time of his death, which took place at the Parkhill Sanatorium, near Liverpool, on the 9th inst. For many years Mr. Lucey was a sufferer from tuberculosis, to which he finally succumbed. We extend our sincere sympathies to his widow and children.

Killed in Action.—Amongst the deaths in action or as the result of wounds, or otherwise while on military service, which have been recorded during the past week, are the following :—

Lieut. W. C. M'Connell (Royal Irish Rifles), aged 36, who was killed on July 8. He was a partner in the firm of M'Connell & Bailey, mechanical and electrical engineers.

Lieut. R. P. Eason (Lincolnshire Regt.), aged 21, who was killed on July 1. Just before the outbreak of the war he passed the Inter B.Sc. Engineering) Exam. at University College, London.

Second-Lieut. C. W. Ellis (Yorkshire L. I.), aged 19, killed on July 2, was articled to Messrs. Marriott, Son & Shaw, civil engineers, Dewsbury.

Capt. R. D. Johnson (R. F.), aged 35, killed on July 7, was an inspecting engineer for the National Boiler & General Insurance Co.

Capt. N. Vaudrey (Manchester Regt.), aged 31, died on May 2, when with the Eastern Expeditionary Force. He was a civil engineer with Messrs. Edmund Nuttall & Co.

Capt. W. M. Johnson, M.A. (Manchester Regt.), killed in action on July 1, was formerly a member of the firm of Richard Johnson, Clapham & Morris.

Company Sergt. Major H. Gill (West Yorkshire Regt.), who was wounded a few days ago and died two days later, was an electrical engineer, of Leeds.

Capt. A. Lee Wood (Lancashire Fusiliers), aged 30, killed, was a B.Sc. of Manchester University and was connected with the Lancashire Dynamo & Motor Co., whom he had represented in India.

Second-Lieut. G. B. Hasler (Bedfordshire Regt.), aged 19, killed on June 26, was an engineering student at the City & Guilds Technical College.

Lieut. C. W. Fitch (Queen's W. Surrey Regt.), aged 20, who has been killed, was proceeding with his engineering diplomas at the City & Guilds Engineering College when the war broke out.

Second-Lieut. P. F. Murphy (R. E.) was killed recently. He was an Associate Member of the Institution of Civil Engineers and gave up an appointment in Canada when the war broke out.

Lieut. H. Lomas (Manchester Regt.), killed on July 1, was an engineer of Baltimore, U.S.A., and a graduate of Manchester University.

Lieut. H. M. McLellan (Manchester Regt.), killed on July 9, was an engineering student at the Manchester School of Technology and a pupil at Mather & Platt's works.

Gunner R. Wood and Gunner J. Riding (Lancashire County Palatine Artillery), formerly Burnley municipal tramwaymen, have been killed in action.

Capt. D. Horne (Northumberland Fusiliers), aged 40, has been killed in action. He was formerly assistant to his father, who was manager of Messrs. Cowans, Sheldon & Co.'s works at Carlisle, and subsequently he was the representative at Newcastle of Crompton & Co.

Private A. Meeson, of Leeds Gas, Water & Electric Light department, is reported killed.

Lieut. E. B. R. Scott (R.E.), aged 20, who was killed on July 11, joined the London Electrical Engineers at the outbreak of the war, and at the Front he acted as brigade signalling officer.

Second-Lieut. N. D. Edinborough (Middlesex Regt.), aged 22, was killed on July 1. He was an Associate of the Institution of Electrical Engineers.

Lance-Corporal P. J. Eldridge, who was recently killed in action, was 24 years, and a B.Sc. (Eng.) of the University of London. He graduated with first-class honours in physics in 1912. He went to the front in March last, and had been recommended for a commission.

The death of Lieut. Trevor Wilkins, of the Northumberland Fusiliers, is announced. Deceased graduated B.Sc. degree in mechanical engineering at Birmingham University, and was awarded a Bowen scholarship, time which he devoted to a research on the Diesel oil engine. He is reported to have obtained important results, which have not yet been published.

The death is announced of Capt. H. F. L. Sillars (A. & S.H.), a former student of electrical engineering in the Royal Technical College, Glasgow. The deceased officer was 21 years of age.

PERSONAL.

Mr. C. W. Shepherd, late general manager of the Edinburgh & District Tramways Co., and who has recently been acting as secretary, has been compelled by ill-health to resign his position with the company, and Mr. John Wiseman has been appointed secretary. Mr. Shepherd was appointed general manager in 1906.

At Sheffield Corporation Electric Power Station, Kelham Island, last week, Mr. J. R. Williams, power station superintendent, was presented with a silver flower stand and entree dish by the staff and employés of the electric supply department on the occasion of his marriage.

Two sons of Mr. W. G. T. Goodman, chief engineer and general manager of the Adelaide Municipal Tramways Trust, have enlisted for active service. The elder, Mr. C. W. Goodman, B.E., enlisted in December, and is now a Lieutenant in the Engineers. The younger, Mr. R. G. Goodman, medical student, went to Egypt as a private in the A.M.C. in November, and is now a Lieutenant in the 50th Battalion A.I.F.

Wounded.—We regret that during the past week the following officers and men have been reported wounded :—

Second-Lieut. R. S. Robertson (K.O.S.B.), aged 22, is reported wounded. He was an engineering student, is a B.Sc. of Glasgow University and an Associate of the Royal Technical College.

Corp. W. Hutchinson (18th W. Yorkshire Regt.), who was assistant engineer at Batley electricity works before the war, is reported wounded.

Private C. H. Long (W. Yorkshire Regt.), formerly employed at Bradford electricity works, has also been wounded.

Amongst others reported wounded are Privates H. H. J. Mason, G. W. Atkinson, N. Haddon and Lance-Corp. A. Hague, of the Leeds Gas, Water & Electric Light department.

Royal Engineers (T.F.)—The following appointments have been made :—

London Electrical Engineers : Sergt. C. L. Palmer (from R.E.) to be Second Lieutenant (on probation).

Tyne Electrical Engineers : Corpl. W. Dixon (from a Divisional Signal Company, R.E.) to be Second Lieutenant (on probation).

APPOINTMENTS VACANT.

An Assistant for junior technical work is required on the Editorial Staff of The Electrician.

A capable electrician is wanted, able to do repairs and familiar with upkeep and repairs of d.c. motors and generators. *See advertisement.*

Applications are invited for the position of senior shift engineer at the temporary station, Nechells, Birmingham. Commencing salary £130, rising to £200 per annum. Applications to the city electrical engineer, Mr. R. A. Chattock, 14, Dale-end, Birmingham, by July 29. *See also an advertisement.*

A firm of dry-cell manufacturers near London require a battery chemist. *See advertisement.*

A mechanic, used to microphone adjustments, is required by the Stolz Electrophone Co. (Ltd.). *See advertisement.*

Loughborough Electricity Committee invite applications for the post of engineer and manager of their undertaking. Salary £300 per annum. Applications to the Town Clerk by July 24.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for the week.

Officer for the week.—Platoon Commander A. Gerard.
Next for duty.—Platoon Commander W. J. A. Watkins.

Saturday, July 22nd.—Instructional Class, 2.30, Company Commander Fleming.

Monday, July 24th.—Technical for Platoon No. 9, 46, Regency-street, S.W. Squad and Platoon Drill, Platoon No. 10. Signalling Class and Recruits.

Tuesday, July 25th.—Officers' Instructional Class, 6—7. Recruits 7—8. Lecture 7.15. Lantern Lecture by Mr. W. Aitken : "Telephones."

Wednesday, July 26th.—Platoon Drill for No. 2 Platoon.

Thursday, July 27th.—Platoon Drill, No. 6 Platoon. Recruits 6.45—7.45. Instructional Class, 5.45.

Friday, July 28th.—Technical for No. 10 Platoon, 46, Regency-street, S.W. Squad and Platoon Drill, No. 9 Platoon.

Saturday, July 29th.—Parade Headquarters, 2.45, for Company Drill. Uniform.

Sunday, July 30th.—Entrenching at Otford. Parade Victoria (S.E. & C. Rly. Booking Office) 8.40 a.m. Uniform, haversacks, water bottles. Midday rations to be carried. Railway vouchers will be provided.

August Camp.—A Camp will be held under canvas or in billets at Otford from July 29th to August 31st. For particulars, *see* notice at Headquarters.

Musketry.—For all Companies, *see* notice and Tables A and B, at Headquarters

Note.—Unless otherwise indicated, all drill, &c., will take place at Chester House.

POWER REQUIREMENTS AND RESOURCES OF NEW SOUTH WALES.*

BY WILLIAM CORIN.

(*Concluded from page* 493.)

Summary.—This Paper is divided into three parts. In Part I. an inquiry is made as to the present total power in use in the State, and an attempt is made to forecast the extent to which power may reasonably be anticipated to be required in the immediate future. Part II. is a discussion of the resources available for meeting the anticipated demand; and in Part III. the author has attempted to indicate in what manner these resources should be developed in order best to provide for the requirements so as to supply power at the lowest rates, and in such a manner as to invite the establishment of new industries in New South Wales.

III.—Adaptation of the Power Resources of the State to Meet the Requirements.

Consideration of the requirements set forth in Part I. of this Paper added to the constantly increasing inquiries for power for pumping, for water supply, for sewage disposal and for lighting and manufacturing purposes from various parts of the State, suggest the question as to whether the catering for these requirements should be spasmodic or whether a well-considered, comprehensive scheme should be initiated.

That the resources of the State are ample for such a comprehensive scheme has been sufficiently shown in Part II. The author now wishes definitely to submit for discussion the consideration of the propriety of establishing a system or systems of power stations in suitable positions, interconnected where practicable by means of transmission mains, serving, firstly, those districts, including the larger cities and the South Coast, which are more particularly devoted to manufacturing industries; secondly, the larger towns; and thirdly, the intervening agricultural and pastoral areas. In the original Paper such a scheme is partially suggested and a power station on each of the northern, southern and western coal areas, with water power stations in some positions.

Assuming for such a system electrical transmission as a postulate—how to use to best advantage the available power resources; whether the coal should be borne to the locality where power is required or burnt at the mine; whether it should be burnt under boilers or distilled and the gas used under boilers or burnt direct in gas engines; if used for steam raising, the best class of prime mover to adopt; if distilled, whether the coke should be saved or consumed in the production of gas; and how best to develop a water-power, the most economical storage, the correct location and dimensions of race or pipe-line—these are questions of which consequently only the more important ones and bearing on the subject being considered are touched on.

A.—Development of the Coal Resources of the State for Power Production.

(i.) *Overall Steam Power Station Efficiencies.*—The efficiency of steam boilers at present in general use does not ordinarily exceed 80 per cent. Using boilers of this efficiency, and the best steam turbines of large size of ordinary construction, in a large power station with coal of 11,500 B.Th.U. per pound, the actual consumption under favourable conditions is as low as 1·8 lb. per unit sent out. With coal obtainable in New South Wales of calorific value of 11,500 B.Th.U. the best consumption obtainable, under present conditions is probably not less than 2·24 lb. per unit sent out, whence is derived the figure of 1,000 units per ton of coal used in Part I. of this Paper. Taking 1 kw. hour as equivalent to 3,413 B.Th.U., it is seen that the overall efficiency of the power station under these conditions is 3413/25760, or 13¼ per cent.

The increased efficiency already attained with the Ljungstrom turbine, and the possible added efficiency from Mr. W. C. R. Emmet's mercury turbine, may result in a considerable bettering of these figures in the future; and if gas fired boilers on the surface combustion principle are used, a still further increase of efficiency is likely.

For the several cases referred to, the overall power station efficiencies and the available units per ton of coal of average calorific value of 11,500 B.Th.U. per pound are given in the Table.

(ii.) *Gas Engines.*—Tests of large gas engines have shown 1 kw. hour to be produced with an expenditure of 10,000 B.Th.U. in the gas used, which averaged about 500 B.Th.U. per cubic foot. Allowing for these results to represent test conditions, and adding 10 per cent. for losses in normal everyday working, the B.Th.U. per kilowatt-hour sent out would amount to 12,000, giving an efficiency of 3413/12,000, or 28·4 per cent. Thus, in present-day practice, the large gas engine is more than twice as efficient as the steam engine, and without improvement it would still be 40 per cent. better even if the improved economy promised by the surface-combustion boiler and mercury turbine became an accomplished fact.

—	Overall efficiency. Per cent.	Units sent out per ton of N.S.W. coal.
Best modern practice	13·2	1,000
Probably obtainable with steam turbines	15·0	1,130
Possibly obtainable with mercury turbines	18·8	1,420
Possibly obtainable with mercury turbines and surface combustion boilers	20·0	...

The present difficulty as regards the gas engine is its enormous size for a given output. Whereas steam turbines of 35,000 kw. capacity in a single unit are at work, and up to 100,000 kw. contemplated, 5,000 kw. is about the largest gas engine plant that is manufactured, and this involves duplicate tandem double-acting horizontal sets requiring excessive floor space. This type has its home in Belgium and Germany. British makers are now manufacturing high-speed gas engines which are more promising; but at present these are unobtainable beyond 1,500 B.H.P.

In the Newcastle district, where coke-oven gas is largely used for power, the practice, so far as the Newcastle Electric Supply Co. is concerned, is to burn the gas, and, where available, to utilise waste heat under boilers, the steam turbine in this instance is preferred to the gas engine in spite of its lower efficiency.

If a successful gas turbine is at any time placed on the market, the chief hope for it lies less in the increase of range of temperature (which is an essential feature of the superiority of the steam turbine over the reciprocating steam engine), but rather in the possibility of the eventual provision of large high-speed units comparable with the present development of the steam turbine. This question is intimately connected with that of the utilisation of coke-oven gas, to which attention may next be directed.

(iii.) *Coke-oven Gas.*—In New South Wales 304,800 tons of coke were manufactured last year, of which 252,409 were made on the southern coalfields. At the new iron and steel works belonging to the Broken Hill Proprietary (Ltd.), at Port Waratah, 66 by-product ovens have been erected, and other examples of by-product recovery exist in the northern district; but so far as the south is concerned, with one exception, viz., the Corrimal mine, the whole of the coke-oven gas is wasted, and in no case is any attempt made to recover the valuable by-products. If coke-ovens were erected on a suitable site, with plant for the recovery of ammonia and tar, and possibly benzine, toluol, cyanide and other by-products, the whole of the South Coast coke could be produced therefrom, and in addition, there would be available from the gas no less than 140,000,000 units, which, if the industry be regarded as a whole, and the by-products be sold at market rates, could be supplied for less than ⅛d. per unit delivered. It need scarcely be pointed out that ammonia is being increasingly required for refrigeration, that sulphate of ammonia is a valuable fertiliser, and though more would be produced than is required at present in this country, its export would add to the material wealth of the State; that the large quantity of tar resulting would enable a supply to be furnished at low rates for improving the roads of the State; and that there is likely to be a large demand for toluol for the manufacture of tri-nitro-toluol (T.N.T.), if, as seems probable, Australia relies upon herself for her future supplies of explosives.

The figures given above are the result of careful consideration of the facts, and are based on actual quotations for coke ovens and subsidiary plant, with liberal estimates for generating machinery, transmission line, transformers and switchgear, the detail of which, however, is too considerable to allow of inclusion in this Paper. Suffice it to say that the author visited three works in Great Britain and three in Germany, where coke-oven gas was being successfully used for driving large gas-engine units for the generation of electricity.

Confidential figures were supplied to the author by several British coke-oven owners, showing conclusively the great profits which are being made from this industry

B.—Utilisation of the Water Power Resources of the State.

If the hydro-electric stations are to be self-contained conservation is necessary, and it becomes a question whether the high initial capital expense of such conservation is justified, or whether the necessary reserve to tide over periods of shortage should be provided in the shape of additional generators in the coal power stations. Each case arising will require separate investigation, and contracts may be arranged, as is frequent in America, so that consumers will

* Abstract of a Paper read before the Electrical Association of Australia.

take the risk of shortage, say, once in 10 years, and have the power at the lowest possible rate.

If, however, power stations are provided in connection with water conservation for irrigation purposes, such as the Burrinjuck scheme, it must be remembered that in ordinary years the reservoir will only be drawn upon for irrigation purposes for perhaps five or six months out of the 12; but in those years when there is a shortage of water, the greatest demand will be made upon the conserved waters, so that the irrigation reservoir power stations would in such case be, during the time of drought, working up to their maximum capacity, thus relieving the other power stations, and reducing the amount of reserve required in coal power stations.

Again, seeing that the hydraulic works which form so great a proportion of hydro-electric developments have already been constructed, the capital cost of the electric development of the available power in such a case is unusually low.

The question as to what proportion of the maximum fall available shall be utilised, and the amount of storage which shall be provided, requires special investigation in each case. As regards the height of off-take from dam, when an open canal is used, it is in general economical to sacrifice part of the storage in order to gain additional head, the economical height, *ceteris paribus*, being usually somewhere above the position where the ratio of increase of head to total head with off-let at bottom of dam is equal to the ratio of loss of storage capacity to total storage at off-let chosen. This is a point to which the author has not seen attention called previously, and examples have come under his notice where, owing to its not being attended to, increased cost has been incurred. The smaller water flow, and consequent smaller canal and pipes, favour the highest location, and the canals are generally more cheaply constructed at the higher levels.

C.—Electrical Transmission v. Railway Haulage.

(i.) *Influence of Transmission Line Design.*—In New South Wales wooden poles of good lasting quality are obtainable at reasonable prices, and where white ants are not specially to be provided against, their use is advisable. The cost of such a line to-day, using 4-chain spacing and 7/14 wire, may be roughly put at £250 per mile, though in at least one case the cost has been little more than half this figure.

The use of flexible poles was first advocated by Mr. Guido Semenza, now of Milan, in a Paper communicated to the Am.Inst.E.E., in 1904, wherein it was shown that the cost of a transmission line can be very materially reduced by designing the poles according to the direction of the stresses.

(ii.) *Large v. Small Power Stations.*—It is to be observed that the higher the class of coal and the more efficient the means of extracting the energy, the more effective is the argument in favour of railway haulage of coal as against electrical transmission. But, on the other hand, the energy can only be efficiently extracted in large power stations, and consequently, when a large power station has been constructed within reasonable distance of a town, it is in general cheaper to make use of power from this station than to construct a separate small station.

Although in Part II. of this Paper suction gas has been dismissed, as not to be seriously taken into consideration for large stations, yet it has a legitimate application for small power stations. Thus, in isolated districts far from a coalfield where wood is abundant and cheap, there will be a field for suction gas. The excessive cost of labour and stores at the small power station will inevitably bring the generating cost up to 2½d. or 3d. per unit under the most favourable circumstances.

(iii.) *Influence of Electrical System of Transmission.*—Reference is due here to the Thury system of high-tension continuous-current transmission, which has been described by Mr. J. S. Highfield in three Papers read before the Institution of Electrical Engineers ("Proc." I.E.E., Vol. XXXVIII., p. 471; Vol. XLIX., p. 848; Vol. LI., p. 640), in one of which he has asserted that in certain cases he has found the cost of underground mains for the Thury system not to exceed the cost of a three-phase overhead system of similar capacity.

During his recent tour the author made a special point of inspecting the system in operation, first in London at the Metropolitan Electric Supply Co.'s Willesden works, and later Mr. Thury himself was good enough to meet him at St. Maurice and show him over the power station there supplying power to Lausanne, and later took him to the St. Bridoire station, which is connected in series on the Lyon-Moutiers line. The beautiful simplicity of the system, the ease of regulation, together with the absence of those complications which characterise the three-phase syetem, cannot fail to excite admiration.

This method of transmission is not, of course, to be used indiscriminately; but there are instances in this State where its use would tend to considerable economy.

(iv.) *Use of Inferior Coals.*—The author has had occasion to investigate several cases in which it has been proved beyond doubt that electrical transmission is cheaper than haulage by rail. Not only is this so in transmitting very large quantities of energy in bulk, say, for the supply of the metropolis from the southern coalfields, but also for more moderate powers there are towns situated a few miles back from the sea coast to which the direct line is very much shorter than the route taken by the railway; and in such case the advantage of electric transmission is still more strongly evident.

If the inferior coals of the State of lower calorific value than those assumed in these investigations be utilised the superior advantage of electrical transmission as against railway haulage is still accentuated.

D.—Examples from Other Countries.

During his tour the author visited a large number of power stations, including many of the chief ones in Great Britain, and many on the Continent and in America. Reference is made below, however, only to those inspected which have a distinct bearing on the subject of power supply in bulk. These are as follows:—

(i.) *Company-owned Schemes.*—The author deals next with various well-known British schemes.

The South Swedish Power Co. has four power stations, totalling 20,000 kw., and supplies a large district from Engleholm to Trolleborg. Fifty-one million units were sold in 1913, the average price being 0·3d. per unit.

At the two mines visited near Aix-la-Chapelle, belonging to the Eschweiler Bergwerks Verein, were some of the large gas engines supplied with coke-oven gas referred to above in Part II. In October, 1913, the gas engines, totalling 14,200 H.P., produced 3,746,000,000 kw.-hours, at a cost of 0·26d. per unit, largely used for mining purposes, but partly sold as bulk supply for all use.

The Rheinisch-Wesphälisches Station at Essen was one of four totalling 127,500 kw., belonging to the company which supplies the whole of the provinces of Rhineland and Westphalia, about 2,200 square miles, with a total connection of 225,000 kw., the tariff being 3·6d. per unit for light, and 1·7d. for power, with rebates up to 25 per cent. for large consumers.

Both the Bonifacius and Prinz Regent Mines visited, in the neighbourhood of Essen, had gas-engine stations, the former of 6,000 kw. and the latter 16,000 kw. They supply power for their own uses, including winding machinery, and sell for local tramways at 0·6d. per unit, surplus energy being sold to the Rheinisch-Wesphälisches Electricitats Gesellschaft at 0·3d. per unit, or in case of need they buy from this company at an enhanced price.

These gas-engine stations are all in connection with coke ovens, having complete recovery plants, benzol, and toluol being amongst the valuable by-products.

The Lauchhammer transmission is noteworthy in that the fuel used is peat, and the power is transmitted at 110,000 volts (the highest pressure in use in Europe) to Gröditz (20 miles), and to Riesa (31 miles), where two of the company's works are respectively situated.

Power stations visited at Wyhlen and Rheinfelden, and another in construction at Lauffenburg on the Rhine, just across the boundary from Switzerland, are controlled by German banks, who construct new works and get them on to a paying footing before forming subsidiary companies to take them over and work them, a method of financing new schemes which has its advantages, but which is unknown in Australia.

The Loentsch Station in Switzerland, with 1,180 ft. head of water, supplies 25,000 kw., is tied in with another station of 14,000 kw. at Beznau, and transmits at 45,000 volts a maximum distance of 85 miles to the Canton of Aargau, and a number of large manufacturing cities.

Robbia and Campo Cologno are in Italian Switzerland, the Robbia Power Station being notable on account of the high head, no less than 1,968 ft. being used for driving the turbines. This, with the stations at Campo Cologno and at Malero, in Northern Italy, are fine examples of water power work.

Malero Power Station in Italy, in conjunction with the two stations just referred to in Switzerland, and a number of others in Northern Italy, supplies the Societa Lombarda per Distribuzione di Energia Elettrica, whose system is indicated on the map of Northern Italy, which also shows how very dense is the network supply the country to the north-east of Milan. The prices charged over this area are for lighting from 4d. to 6d., for power to small users 2d. to 4d., whilst for bulk supply to large customers from ½d. to 1d. is charged. Mr. Semenza, whom the author met at Milan, stated that 30 years ago this district was as noted for its poverty as it is now for the well-being of its inhabitants, the improvements being entirely due to the people being now provided with an abundant and cheap supply of power.

Keoknk Power Station in the United States, is designed to be the largest in the world. It is intended ultimately that 230,000 kw. shall be lodged under one roof. Plant to half this capacity is already at work, and power is transmitted 144 miles to St. Louis. The station is a fine example of work of the highest class.

In the neighbourhood of Denver, steam and water power stations are tied together. As a contrast to Keokuk, the Boulder Water Power Station was an example of how 100,000 volts may be handled in an inexpensive and rough-and-ready fashion, though all essential requirements had been cared for.

(ii.) *State and Municipally-Owned Schemes.*—At Trollhättan, in Sweden, the government have 72,000 kw. developed, and sell in the immediate neighbourhood 18,000 kw. for the electrical smelting of Australian zinc ores, 8,000 kw. for iron smelting and 6,000 kw. for the manufacture of ferro-silicon, a fixed price of from £2. 10s. to £2. 16s. per kilowatt-year being charged. Power is also transmitted to Gothenburg at 50,000 volts, where the bulk charges are £2. 16s. per kilowatt-year, based on the four maximum weekly readings, plus 0·07d. per unit; 120,000,000 units were supplied from Trollhättan in 1912.

At Elfkarleby, North of Stockholm, the government is developing 65,000 H.P., the works when visited being under construction.

The State Coal Mines at Heerlen, in Holland, are extremely interesting, especially on account of the care taken in providing for the comfort of the workmen, who change completely and bathe in well-appointed bathrooms before proceeding to their homes.

At Nymegen is a station owned by the municipality, which supplies parts of the three Provinces of Limburg, N. Brabant and S. Gelderland, 9,000 kw. being in use, and the charges varying from £4. 8s. to £3 per kilowatt-year, plus 0·5d. per unit.

The State Coal Mines near Gladbeck, in Germany, were interesting for the use of waste heat from coke ovens for raising steam, and of exhaust steam from winding engines for low-pressure turbines. The usual by-products were being collected.

The Albula Station belonging to the Zurich municipality was a beautiful example of well-designed work, 20,000 kw. being transmitted 90 miles at 40,000 volts.

This Paper would be incomplete without reference to the operations of the Hydro-Electric Power Commission of Ontario, the most notable example of State enterprise in the direction referred to yet attempted in the world's history. The Commission, which started operations in 1908, has its headquarters in Toronto, and the author had an opportunity of seeing something of its work at both ends of the transmission line. Power is bought at Niagara from the Electrical Development Co., of Ontario, and delivered thence over a large portion of the province of Ontario, the contract being for 100,000 H.P. at £2. 3s. per horse-power year.

In 1913 no less than 52 municipalities were served at rates varying from £3 to £8 per horse-power year for power, the smallest township served having a population of only 400 inhabitants. The rates devised by the Commission for charging individual consumers are interesting. For domestic lighting they include a charge of 2d. per month per 100 sq. ft. of floor area, counting all the rooms in the house, whether they are lighted or not, plus a charge varying from 1½d. to 3d. per kilowatt-hour. Commercial rates vary from 3d. to 6d. per unit for the first 30 hours' use per month of the installed capacity, and for each unit thereafter from 1½d. to 2½d. in most instances (in two instances to 3d., and in one instance 5d.). Discounts of from 10 per cent. to 25 per cent. are allowed for prompt payment. For street lighting, the municipalities are charged from £1 to £3 per annum for ordinary lamps of from 60 to 100 watts, and proportionately higher charges for larger incandescent lamps or arc lamps.

Apart from the 52 municipalities actually supplied, investigations were in progress in 1913 with reference to the supply of more than 100 other municipalities, townships, or districts, many of which were, no doubt, supplied during 1914.

Work in connection with rural distribution is next referred to, and it is stated that near Toronto there are no less than 200 farms connected with the mains.

A detail as regards the transmission mains is that the Commission has been using aluminium cable provided with a central steel core, which enables aluminium to be used on long spans with considerably less sags than would otherwise be possible.

E. Solution of the Power Supply Problem in New South Wales.

Dr. Ferranti has recently said that electricity supply is a matter of national economy, and that properly carried out to its logical issue, it is the greatest labour-saving factor with which we have any prospect of dealing.

In Part I. of this Paper it has been shown that the anticipated requirements within the next five years of the State are an increase of 106,000 kw., and 312,000,000 of units per annum. In Part II. it is proved that the coal and water power resources of the State are ample for all requirements, and in Part III. an attempt has been made to indicate the best method of proceeding to provide for the State's requirements.

The analysis of the problem leads one to the inevitable conclusion that the initial step to be taken in the solution of the power problem to-day is the establishment of a larger power station on the southern coalfield, in conjunction with coke ovens, and recovery plant for tar, ammonia, and possibly benzol, toluol and cyanide, this station to be tied in with a water-power station established on the Shoalhaven or Snowy Rivers.

Coming to the question of ownership, the tendency in Australia has been for such schemes to be nationally owned; and it would seem probable that under existing conditions the venture is not one such as a private company would undertake.

Consequently, the author submits that it is quite within the bounds of legitimate State enterprise for this important matter to be taken up by the Government, and as the demand is increasing at such a considerable rate, it needs to be taken in hand at once. There is no doubt that the conclusion of the war will find Australia very much more self-contained in the future than in the past in respect of all those supplies which her natural resources enable her to produce, and in the economic struggle for existence the universal provision of cheap power will be one of the factors enabling her to succeed in that struggle.

OIL ENGINES AND STEAM ENGINES IN COMBINATION.*

BY GEOFFREY PORTER.

Summary.—The author gives figures from his own experience showing the economy that can be effected by running Diesel plant in combination with steam plant in existing stations.

May I, in the first place, ask you to accept this Paper with a generous allowance for the difficulties under which it has been prepared. Time has been extremely short, and though some of my friends have been most kind in furnishing a good deal of the necessary data, I should have preferred a longer time for criticism and comparison of the figures than has been at my disposal.

My object is to discuss some of the problems met with in extending a comparatively—and in some instances, an extremely—inefficient generating station of the "lighting load" order with a plant capacity round about 1,500 kw., and equipped with steam engines, some with condensers and some without. There are dozens of such stations dotted about the country, from 12 to 20 years old, none of them with any great future so far as can be seen at present, and most of them having difficulty to make ends meet financially.

In Table I. I set out various data relating to three generating stations, A, B, and C; A being my own, a small one on the South Coast; B a London station of considerable capacity; and C a riverside station in the provinces.

It is not proposed to elaborate an ideal situation in this Paper, but to deal with established facts and to leave out of account all methods of providing additional plant except that of Diesel engines. The combination of steam and Diesel engines is now pretty well established, and reliable data are available.

Some five or six years ago several Papers were read before Societies of standing in the engineering world, in which were discussed the advantages to be gained by the use of the Diesel engine. Some of the writers, I think, rather over-stated their claims, and all conclusions were based chiefly on results obtained on the Continent with plant manufactured by Continental firms. This was natural under the then circumstances, as few sources of information were available at the time in this country. The arguments, good as they were on the whole, fell on somewhat stony ground, for, with the Englishman's native scepticism of things foreign, engineers waited cautiously for an object lesson in their own land.

Apart from this aspect of the case, it was felt rather strongly that the best coal in the world is mined in the British Islands, while a residual petroleum fuel oil (with the exception of a limited supply of shale oil) is an imported commodity; hence, with a growing demand, the price of fuel oil would rise in a greater degree than would the price of coal. Further, from a business man's point of view, the Diesel engine requires a greater capital expenditure per unit of power than does an equivalent steam plant.

The question of reliability in operation arose also, though I think it was used rather as an excuse than as a genuine argument in disfavour of the Diesel engine; for engineers cheerfully bought steam turbines in the early and middle stages of their development and

* Paper read before the Diesel Engine Users' Association.

Table I.

Item.	Station A, 1,048 kw. D.C.				Station B, 3,700 kw. D.C.				Station C, 1,400 kw. A.C.			
	Last completed financial year.		Last completed financial year before starting Diesel engines.		Last completed financial year.		Last completed financial year before starting Diesel engines.		Last completed financial year.		Last completed financial year before starting Diesel engines.	
	£	£ per kw.	£	£ per kw.	£	£ per kw.	£	£ per kw.	£	£ per kw.	£	£ per kw.
1. Capital cost of Diesel engines and dynamos	8,301	16·28	...	...	12,300	20·5	...	...	8,450	15·35	...	...
2. ,, ,, ,, ,, foundations	200	0·39	...	...	2,500	4·2	...	...	1,277	2·37	...	...
3. ,, ,, ,, ,, accessories	747	1·46	...	...	1,200	2·0	...	...	506	0·94	...	...
4. Total ,, ,, ,,	9,248	18·13	...	...	16,000	26·7	...	...	10,233	18·66	...	...
5. Total kilowatts—Diesel plant	510 kw.	...	...	...	600 kw.	...	...	...	540 kw.	...	...	...
6. Capital cost of steam plant (engines, boilers, accessories, including foundations)	15,698	29·1	15,698	29·1	87,100	28·0	87,100	28·0	34,292	39·8	34,292	39·8
7. Total kilowatts—steam plant	538 kw.	...	538	...	3,100 kw.	...	3,500 kw.	...	860 kw.	...	860	...
8. Capital cost per kilowatt of combined plant	...	23·9	...	...	...	27·8	...	...	...	31·8	...	...
9. Annual insurance against breakdown—Diesel plant	77	0·15	...	...	142	0·24	...	...	...	...	...	...
10. ,, ,, ,, ,, steam plant	58	0·11	58	0·11	103*	0·033	103	0·033	...	...	...	...
11. Annual capital charges (interest and redemption)	...	1·95 Per kw.-hour generated.	...	2·23 Per kw.-hour generated.	...	... Per kw.-hour generated	...	... Per kw.-hour generated	...	...	...	... Per kw.-hour generated
12. Units generated Diesel plant	591,584	...	...	...	2,429,148	...	...	...	1,127,557	...	...	...
13. ,, ,, steam plant	11,312	...	609,609	...	2,133,214	...	5,024,127	...	403,431	...	1,332,851	...
14. ,, ,, total	602,896	...	609,609	...	4,562,362	...	5,024,127	...	1,530,988	...	1,332,851	...
15. Cost of fuel per unit generated—Combined plant	...	0·296d.	...	0·570d.	...	0·459d.	...	0·537d.	Oil 0·32 / Coal 1·36	0·594d.	...	0·869d.
16. ,, lubricating oil, waste stores and water	...	0·106d.	...	0·092d.	...	0·032d.	...	0·028d.	...	0·075d.	...	0·048d.
17. ,, wages (running staff)	...	0·139d.	...	0·206d.	...	0·194d.	...	0·150d.	...	0·204d.	...	0·199d. (*a*)
18. ,, repairs and maintenance of generating plant	...	0·073d.	...	0·105d.	...	0·090d.	...	0·106d.	...	0·068d.	...	0·060d.
19. ,, proportion of salaries	...	0·069d.	...	0·068d.	...	...	...	...	...	...	...	...
20. ,, total running charges	...	0·683d.	...	1·041d.	...	0·775d.	...	0·821d.	...	0·941d.	...	1·176d.
21. Average price of fuel oil, per ton	64/0	...	...	...	67/2	...	...	...	65/0	...	...	...
22. ,, ,, coal ,,	29/8	...	18/3	...	30/9	...	23/9	...	17/0	...	16/2	...
23. Units generated by steam plant, per cent of total	2%	...	100%	...	47/2%	...	100%	...	26·4%	...	100%	...
24. ,, ,, oil ,, ,, ,,	98%	...	...	...	52·8%	...	...	...	73·6%	...	...	...
25. Units generated per ton of coal	176	...	388	...	553	...	560	...	150	...	...	...
26. ,, ,, ,, oil	3,200	...	...	...	3,615	...	...	...	2,435	...	...	...
27. Thermal efficiency $\frac{\text{B.T.U.'s in units generated} \times 100}{\text{B.T.U.'s in fuel used}}$	22·6%	...	4·93%	...	10·5% (approx.)	...	6·1% (approx.)	...	6·5% (approx.)	...	2·6% (approx.)	...
28. Coal used per unit generated	12·8 lb.	...	5·8 lb.	...	4·05 lb.	...	4 lb.	...	14·9 lb.	...	10·1 lb.	...
29. Fuel oil ,, ,, ...	0·67	...	...	...	0·62	...	...	...	0·92	...	...	...
30. Running plant—load factor ... Steam	69·4%	...	66·2%	...	...	...	...	...	...	...	...	...
30. Running plant—load factor ... Oil	56·9%	...	...	...	...	...	...	...	...	...	...	...
31. Annual load factor	15·6%	...	14·19%	...	19·9%	...	17·7%	...	...	...	19·63%	...
32. Ratio price of oil to price of coal	2·14	...	...	...	2·16	...	...	...	3·82	...	...	...

* Boiler and steam pipes only.

(*a*) B and C include proportion of salaries (*see* lines 17 and 19).

experienced a good deal of trouble with them—thus repeating the former experiences with electrical machinery.

Now, however, the Diesel engine is making good headway; manufacturers and users have gained experience; the fuel oil question is in a fair way of being solved by utilising the products of the distillation of coal; and though the capital cost is and will probably continue to be high, the essence of the problem, *i.e.*, the balance in hand to credit of net revenue account in the annual balance-sheet is found to improve in proportion to the use of the Diesel engine. The mixed stations have justified the wisdom of their engineers during the present extremely difficult times; but for their efficient oil engines many of them would be in a bankrupt condition to-day.

In Table I. will be found the figures of the capital outlay on generating plant of the three stations already mentioned. The Diesel figures (capital costs) are stated in some detail, but time has not permitted the division of the steam plant costs under separate heads; they have, therefore, been taken as a gross total. (In my own station, A, such sub-division has been possible, as the figures were got out for another purpose some time ago). The items taken into consideration are engines and their dynamos, foundations, boilers, boiler settings, flues, chimney shafts, condensing plants, exhaust steam and other feed-water heaters, feed pumps, oil separators and the like. Left out of account are storage batteries, boosters, balancers, and all plant outside the works, as a comparison is sought only in the generating department.

It will be seen that the capital cost per kilowatt is high. This is due not only to the higher cost of plant at the beginning of the century and even earlier, than in more recent years, but also to the piecemeal way in which generating plant has been added to from time to time. The engineer has always been overweighted with the bulk of annual payments of interest and principal, and was compelled to arrange them in such a manner that the annual increments of such charges did not grow too disproportionately to the annual increments of income, which he could estimate fairly closely. The result has been the pursuit of a rather hand-to-mouth policy. When making

extensions it would have been preferable in the long run to put down additional plant sufficient to supply the requirements of 10 years or so, from the ultimate financial point of view. However desirous one may be of taking and adopting long views, circumstances are often too strong for us. The progress of an electric lighting undertaking lies along a strait and narrow way.

The capital expenditure on the three stations up to the time when Diesel engines were put down was (for generating plant only) as follows, viz. :—

Station A	£29·1	per kilowatt.
„ B	£28·0	„
„ C	£39·8	„

Stations A and C condense the exhaust steam; station B is a non-condensing station.

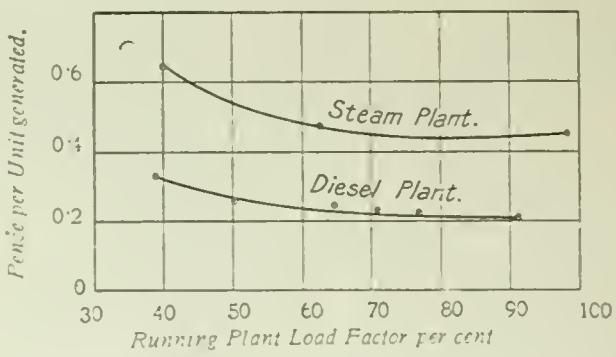
As the result of this large outlay the overall thermal efficiency of the three steam plants in the year prior to the adoption of Diesel engines was :—

Station A	4·93	per cent.
„ B	6·1	„
„ C	2·6	„

These results are not very encouraging when one considers the money that has been put into the plant in each case. Nevertheless, the figures are typical in stations of their class.

This thermal efficiency is arrived at by calculating the British Thermal Units equivalent to the units generated at the dynamo terminals (taking 3,412 B.Th.U.s per B.O.T. unit) and working out the total as a percentage of the B.Th.U.s in the quantity of coal consumed. The figures given are not absolutely accurate owing to the heat values of the coals used not being certain, but I do not think they are very far wrong.

As one can speak most fully from one's own experience, I trust I may be forgiven if I analyse the various figures tabulated for station



A. In 1911 extensions of plant became imperative: what had been done in the past and the possibilities of the future were very carefully considered.

The capital expenditure on generating plant up to the end of the financial year 1910-11 was as under :—

Engine Room Plant.

Engines, dynamos and foundations	£4,690	£15·2 per kilowatt.
Condensing plant and pipework	£3,506	

Boiler House Plant.

Boilers and their brick settings..... (nominal evaporation 36,000 lb. per hour)	£3,602	£13·9 per kilowatt.
Feed pump, injectors and pipework	£1,500	
Chimney, economiser and flues	£2,400	
Gross Capital Expenditure.....	£29·1	„

On this outlay the annual charges for interest and redemption of capital amounted to approximately £1,200, or £2·23 per kilowatt installed.

On the other side of the account 1 kw. of maximum load on feeders produced (in 1910-11) 1,243 units, equivalent to about £21. Hence the capital charges on the steam raising and using plant alone absorbed as much as 10 per cent. of the earnings. (Annual load factor 14·2 per cent.) Table II., line 18, shows a series of these figures. All the figures (except fuel figures) for 1915-16 are abnormal owing to the various restrictions in force due to the state of war on which we find ourselves. The same remark would apply in a less degree to those of 1914-15.

After very careful consideration it was decided to extend the plant with Diesel engines. At the time an addition of 250 kw. was required. I decided to divide this capacity between two engines: firstly, because a better "running plant" load-factor could be obtained in this way; and, secondly, from motives of caution. The type of engine was new to the staff, and I argued that it would be very unlikely for both engines to collapse at the same time should they prove

Table II.—*Station "A."*

Item.	1910–11. Steam only.	1912–13. Steam and oil.	1913–14. Steam and oil.	1915–16. Steam and oil.	Estm. steam extension.*
1. Fuel	0·570d.	0·454d.	0·42d.	0·296d.	0·46d.
2. Wages (running staff)	0·206d.	0·134d.	0·12d.	0·139d.	0·20d.
3. Lubricating oil, waste stores, water	0·092d.	0·074d.	0·06d.	0·106d.	0·09d.
4. Repairs, maint'n'nce, plant	0·105d.	0·041d.	0·07d.	0·073d.	0·10d.
5. Proportion of salaries	0.068d.	0·055d.	0.05d.	0·069d.	0.06d.
6. Total cost per unit gen.	1·041d.	0·758d.	0·72d.	0·683d.	0·91d.
7. Percentage of total units by steam plant	100%	17·8%	20%	2%	100%
8. Percentage of total units by Diesel plant	...	82·2%	80%	98%	...
9. Units per ton of coal	388	248	334	176	500
10. .. .. fuel oil	...	3,350	3,180	3,200	...
11. Thermal efficiency, %	4·93	12·34	12·78	22·6	6·5†
12. Fuel per unit generated Coal	5·8 lb.	7·9 lb.	6·7 lb.	12·8 lb.	...
13. .. Oil	...	0·67 lb.	0·70 lb.	0·69 lb.	...
13a .. Combined	...	1·94 lb.	1·84 lb.	0·89 lb.	...
14. Price of coal per ton (av.)	18 3	23 6	23 0	29 8	...
15. .. oil fuel ..	...	69 0	80 0	64 0	...
16. Water consumption per unit generated	45 lb.	...	...	...	36 lb.
17. Water consumption per 1 lb. coal	8·5 lb.	from and at 212 °F.			10 lb.
18. Units sold per an. per kw. of max. load on feeders	1,243 =£22	1,270 =£21	1,331 =£21·8	1,363 =£19·5	... ...
19. Running plant load factor Steam	66·2%	62·2%	56·7%	69·4%	...
Diesel	...	71·0%	66·4%	56·9%	65%
20. Annual load factor	14·19%	15·19%	15·30%	15·58%	...

unreliable in operation. I am glad to say that my caution turned out to be superfluous. Better and more consistent running could not be desired.

Station B has provided me with figures relating to the hours lost through defects in the year 1914-15 as follows :—

No. 1 engine ...	12 hours ...	piston trouble.
No. 2 engine ...	12 hours ...	high-pressure cooling coil worn.
No. 3 engine ...	36 hours ...	compressor trouble.

The capital cost of the extension worked out at £16·95 per kilowatt. Two years later a third engine was obtained coupled to a 260 kw. dynamo at a capital cost of £19·27 per kilowatt. In all, a capital expenditure of £18·13 per kilowatt for 510 kw. capacity.

If you turn again to Table I. you will see that station B spent £26·7 per kilowatt for 600 kw.; and station C a sum of £18·66 per kilowatt for 540 kw. of plant. Local circumstances entailed a very heavy expense for foundations in the case of B, while plant was more expensive in first cost than at the time when I was in the market. B profited by other people's experience in the matter of "accessories," and wisely spent rather more money on them—notably on fuel oil storage tanks. C adopted engines and dynamos which required large foundations, with the result that the gross capital outlay was rather greater than it was in station A.

An equivalent steam plant for A would have necessitated an outlay of £7,450, equivalent to £14·8 per kilowatt. The annual charges for interest and repayment of principal would have been £177 less for a steam plant than for a Diesel plant.

On a "running plant" load factor of 65 per cent., and with coal at about 13,000 B.T.U.s per pound, I expected to produce 500 units, more or less, to a ton of coal, taking the whole steam plant into consideration. Inquiries in several quarters lead me to expect confidently that a Diesel engine under the same load factor conditions would deliver 3,200 units per ton of fuel oil of 17,500 B.T.U.s per pound. Assuming a price ratio of 2½ to 1 between oil and coal (as it was approximately for A in 1910 to 1911), there was a large margin in the earning capabilities of the two types of plant to cover the difference in the annual charges.

The figures shown in lines 9 and 10 in Table II. give a series of actual results for A. The figures in lines 25 and 26 in Table I. show the actual results obtained in stations B and C as well. The low figure in the records of C is accounted for by the fact that one of the pair of engines put down was a two-stroke cycle machine. All engines in A and B were vertical four-stroke cycle engines.

So much for a direct comparison between steam and oil.

The problem was, however, complicated by the existence of the

* The last column of this table is an estimate of the probable results had steam plant been adopted instead of oil plant.

† Maximum observed with oil plant alone—28·73% over one week.

original steam plant, in conjunction with which the Diesel engines would be required to work. Undoubtedly the boldest course to adopt would have been to write off a part at least of the steam equipment. This plan was considered, but, in view of the very long loan period (which had still 15 years to run), the sum required for the purpose was too great for the finances of the undertaking to bear.

Had more steam plant been added to the old, and allowing for a much shorter load period and a higher rate of interest, the annual combined capital charges would have amounted to £1·62 per kilowatt of plant. The earning powers of 1 kw. were not expected to increase. The total capital cost would have become £22·1 per kilowatt.

The following returns give some important figures for A :—

Year.	Revenue per kw. of max. load.	Gross profit per kw. of max. load.	——
1910-11	£21·2	£11·3	Steam plant only.
1911-12	20·4	10·4	Part Diesel about two months.
1912-13	19·1	11·1	Diesel plant 82·2 per cent. of output.
1913-14	20·0	11·8	,, ,, 80 ,, ,,
1914-15	27·3	14·9	,, ,, 91·7 ,, ,,
1915-16	23·2	14·1	,, ,, 98 ,, ,,

In the first column the revenue per kilowatt of maximum demand on feeders was artificially increased by the fact of the maximum output falling off during the last two periods owing to restrictions more rapidly than did the number of units sold. In the second column the figures of gross profit were adversely affected by the steam "stand-by" charges, two boilers being kept up for the greater part of the time in case of Diesel engine failures. During the last two years in the table the boiler house was entirely shut up, except for a month or so. There is no doubt that the efficient working of the Diesel engines effected a marked increase in the gross profit per kilowatt of maximum demand on the plant. In the year 1912-13 the tendency of the gross profit had begun to counteract the downward trend of the revenue curve.

An examination of the figures quoted show that the lower cost of operating a Diesel engine plant quickly extinguishes the higher annual charges for capital, although in the case of A the steam plant has an advantage of £0·33 per kilowatt in respect of capital charges.

Five years ago opinions differed as to the functions of a Diesel engine in a "mixed" station. Some said "work it for all it is worth and use the steam plant for peak load and emergencies"; others said "run your steam plant all the time in order to keep down the preparation charge proportion and use your oil plant for the peaks and emergencies, when its quick starting and high efficiency characteristics will be of the greatest advantage." I think it is now the general practice to work the Diesel engines "for all they are worth," and to keep the steam engines in reserve. At any rate, that is my own practice. In Table II., lines 6, 7 and 8 illustrate the point fairly clearly, and may be read in conjunction with the thermal efficiencies given in line 11. Lines 12 and 13*a* indicate the effect of keeping boilers under steam for stand-by purposes.

In Table I. a comparison of the generating costs of the three stations before and after adopting Diesel engines is instructive.

A shows a reduction of 0·358d. per unit generated ;
B ,, ,, 0·046d. ,, ,,
C ,, ,, 0·276d. ,, ,,

these figures being obtained in the face of rising fuel prices. Similarly the overall thermal efficiencies have improved as under :—

A—Thermal efficiency rose from 4·93 per cent. to 22·6 per cent.
B ,, ,, ,, 6·1 ,, 10·5 ,,
C ,, ,, ,, 2·6 ,, 6·5 ,,

These figures depend, of course, on the proportion of the units generated by oil as a percentage of the total units generated. B having a steam plant of five times the capacity of its oil installation was obviously unable to make so great a reduction as was A, where the proportion was roughly 1 to 1 ; and C 1·6 to 1. The greatest reductions are in the items fuel, wages and repairs.

It should be pointed out that stations B and C include in the "wages" item the proportion of "salaries" of the engineering staff which is stated separately in line 19 of Table I. for station A.

I refer you at this point to Table III., which shows the cost of fuel per unit generated for station A at various load factors for the steam and oil sections of the plant. A pair of curves below the table shows the comparison graphically. Coal cost 18s. 3d. per ton, fuel oil was 64s. per ton. The figures are taken from the ordinary weekly records, and are the result of everyday running conditions.

From approximately full load down to half load there is a drop of 6·3 per cent. in the steam figures, and over a corresponding series there is one of 20 per cent. in the oil figures.

A statement of some of the "vital statistics" of eight generating stations having both steam and oil plants may be of interest ; it shows a general tendency towards improvement in the financial position since the Diesel engine was adopted.

Station.	Reduction in fuel cost per unit sold.	Gross profit per kw. of max. load before oil plant.	Gross profit per kw. max. load after adopting oil plant.
1	0·31d.	£11·3	£14·1
2	0·23d.	9·9	10·5
3	0·20d.	8·8	14·3
4	0·18d.	11·1	15·2
5	0·20d.	3·37	6·9
6	0·21d.	8·4	10·2
7	0·11d.	9·8	11·5
8	0·06d.	13·4	15·1

I regret that the figures in this table are not arranged on quite the same lines as are the figures in the other tables. In the time available I was unable to obtain the number of units generated in each case, hence the unit "sold" is here the basis of the calculation.

The Diesel engine has this important advantage over the steam equipment. If valves are leaking and adjustments are not in order the fact becomes quickly obvious. The indications on the gauges (and there are not many of them) draw one's attention to irregularities.

But a steam engine may run beautifully to the outward eye and ear, although piston valves and piston rings may leak, and the valve settings may be wrong owing to eccentric strap wear ; the boiler settings may be drawing many cubic feet of air into the flues ; the fires may be too thick or too thin. In very many cases, provided the main steam gauge is showing about the correct steam pressure, there is a general feeling of satisfaction with the aspect of affairs.

Personally, I managed to improve the steam costs of A by 20 per cent. or so by the aid of flue thermometers, draught gauges, flue gas analysers and graduated staffs in the boiler feed water tanks ; but even at that the benefit was but a fraction of that gained by purchasing plant that was inherently more efficient from the thermal point of view. Putting the three things together, capital charges, running costs and gross profits, the advantage accruing from the use of the Diesel engine for installations within the limits of those indicated in this Paper is manifest. The figures quoted for A showed the combined annual capital charges for interest and redemption to be £1·95 for a mixed steam and oil plant, and £1·62 for a steam plant only. The difference being one of 20 per cent. Taking the running costs for the last completed financial year, the reduction in running costs from those obtained in pre-oil days was no less than 34·4 per cent.

In concluding this section of the Paper I should like to urge on all Diesel engine users the great value of the indicator diagram as a quick and ready means of testing the condition of an engine. The "hand-drawn" cards are particularly valuable as showing the distribution of the fuel oil among the cylinders. If cards are taken and filed for reference and comparison, it is not difficult to keep an engine well up to its test results. The outlay of £10 to £15 on an indicator set is a small matter in comparison with the losses that may occur if an engine is not periodically checked.

The choice of the most suitable Diesel engine to accept when confronted with a number of them is not easy. All members of this Association are now acquainted with the features which are and are not desirable in an engine. But when taking the plunge in the first instance the choice was difficult. Some engineers embraced the lowest tender with the affection frequently accorded to that interesting hybrid, others did not. Manufacturers' representatives were very kind, but exhibited a considerable admiration for the merits of their own particular variety of Diesel engine, and in this respect no other attitude could be looked for.

The attractions of the lowest tender are, of course, almost irresistible. In my judgment the lowest tender is suspect if it be more than 5 per cent. below the average of the other tenders. Being certain that this difficulty would surely arise I attached a schedule to my specifications in which the manufacturer filled in sundry dimensions and other

Table III.—*Comparative Fuel Costs per Unit Generated on a Load Factor Basis, extracted from the Weekly Records—Station A.*

Running plant load factor %	38·9	40·0	50·1	62·5	64·5	70·3	76·8	91·5	98·0
Steam plant (d.)	...	0·625	...	0·48	...	...	...	...	0·45
Diesel plant (d.)	0·332	...	0·260	...	0·255	0·223	0·220	0·208	...

Coal at 18s. 3d. per ton ; fuel oil at 64s. per ton.

Table IV.—*Schedule of Particulars Obtained from Manufacturers in Submitting Tenders for Diesel Engines.*

Tender 1.	B.H.P.	No. of cylinders.	B.H.P. per cylinder.	Revs. per min.	M.E.P. from full load card.	Cylinder diam. (Inches.)	Length of stroke (Inches.)	Piston speed per min. (Feet.)	Ratio stroke bore.	Ratio of price accepted to lowest tender.
A	400	3	133⅓	187	82	20	28·4	885	1·42	1·64
B	400	4	100	175	99	18	26·0	758	1·44	1·26
C	375	3	125	200	95	18	26·0	866	1·44	1·20
D	375	3	125	200	84	20	24·0	800	1·20	1·20
E	400	4	100	175	72	17¾	24·75	721	1·40	1·18
F	400	4	100	187	72	17	25·25	786	1·48	1·18
G	400	4	100	180	92	17¾	26	780	1·46	1·04
H	385·8	3	128·6	175	95	18¾	28	815	1·49	1·00
I	400	4	100	175	95	17½	26½	773	1·51	1·04
						Average		798·2		
Tender 2.	I.H.P.			I.H.P. per cyl.						
A	256	4	64	250	100	12	18·1	755	1·51	1·00
B	260	4	65	250	100	12	18·25	761	1·52	1·159
C	266	4	66·5	250	88·8	13⅜	16⅞	700	1·26	1·165
D	296·1	3	98·7	300	98·7	13⅜	16⅞	842	1·36	1·00
E	266·1	3	88·7	190	104·7	14¼	22⅛	700	1·55	1·186
F	210	3	70	210	82	13⅞	18⅞	661	1·36	1·294
						Average		735		

particulars of the engine offered. Table IV. gives a list of such particulars for engines of two capacities and may interest you. You will notice a good many differences in corresponding items. I do not venture to lay down any rule for the guidance of anyone in this matter, but I will go so far as to say that my own preference is for (1) a low piston speed, (2) a low mean effective pressure from the full load card, and (3) a low piston and crank-pin loading. The general design of the crankshaft and its bearings, the gudgeon-pins and the lubricating arrangements throughout must, of course, be examined also. A schedule of this sort enables one to discover a "speeded-up" engine, of which several have proved to be unfortunate speculations.

The transition from the paper stage to the practical one of operating the Diesel engine not unnaturally brought to light a number of occurrences with which engineers were not familiar. Many were trivial in their nature, others were serious. Many engineers solved their problems by means of their own skill, others grumbled and lost heart and interest. In course of time it was felt that a central body competent to collect and compile records and to act as a standardising authority to some extent was a necessity. In this way the Diesel Engine Users Association came into being. From a very modest and quite informal beginning this Association is growing steadily, and will, I trust, one day assume a very important position in the domain of the internal-combustion engine.

I notice that, in some quarters, our Association is regarded as being a species of coroner's inquest with a permanent jury. It is delicately insinuated that a number of disgruntled and disheartened individuals meet once a month to weep in company over the latest smash-up.

That this view, where it is held, is a misrepresentation of our activities goes almost without saying. It is a fact that we discuss breakdowns. Of course we do; we want to learn how to avoid them in future; but their number is not large enough to prevent our attention being taken up by many other and more important matters of general interest to the industry. As a whole, I can say with confidence that we do obtain the greatest satisfaction in the working of our Diesel engines.

The *tu quoque* type of retort is possibly an exhibition of bad manners, but at times it is permissible and necessary. A study of accident insurance company reports leads one to wonder if all is as well as it is said to be with our old and tried friend the steam plant.

A recapitulation of all the subjects we have discussed at our meetings would be wearisome, and indeed impossible, within the scope of this Paper. I should like, however, to draw your attention to three subjects which have been of great interest and which are far from being exhausted. The first is the problem of the lubrication of Diesel engines. We collected a large amount of information and data on this subject and discovered a series of remarkable discrepancies in the course of our investigations. An endeavour to lay down any definite pronouncement in the matter of how much or how little oil should be used for various engines was found to be impossible at the time. Mr. C. O. Milton, one of our most energetic members, gave us a communication on the subject and contrived to establish some relations between the lubrication of engines and the conditions under which they are used; but even here he lighted upon two series which did not agree and for whose disagreement there did not appear to be any reason. We had hoped that Mr. G. E. Windeler would have given us some useful hints on the subject this evening, and doubtless he would have done so had he been able to read his Paper on "Methods and Difficulties of Lubrication in Diesel Engines." The actual rate of the destruction of lubricating oil in the cylinder of a Diesel engine is a matter which would, I am sure, well repay a careful investigation. I trust we shall return to this subject in the not too distant future.

We are at present engaged in investigating the vagaries of air compressors. In general they work well; but occasionally they show bad habits. The Committee of the Association have a report on the subject in hand and hope to bring it before the Association before long. There are differences of opinion among our members, and not unnaturally so. We are not a "mutual admiration society," and the happy mean will doubtless be struck. One feature, however, emerges as being of paramount importance, and that is the behaviour of oil-impreganted vapours under the influence of high pressures and temperatures. I think it is a line of investigation eminently suited to the labours and talents of the National Physical Laboratory. I trust that Institution may be persuaded to take it up in the future. Users, manufacturers and Government officers unite in recognising the necessity for the discovery of the real properties of these vapours.

Last, and perhaps of the greatest importance, is the question of fuel oil supplies. This is a matter of vital importance to the whole industry. The present state of war has opened our eyes in many instances to the manner in which this great and rich country has become dependent on other communities for absolute necessities. The fuel oil question can be and will be solved by our own chemists and engineers. The matter is of more than a sectional interest; it is a national interest.

Our engines will work well on the products of the distillation of coal—British coal—that coal which is used to-day so uneconomically that at the best but 15 per cent. to 20 per cent. of its available energy value is actually utilised. Continental users and manufacturers have used tar oils and tars with the greatest success for many years in their Diesel engines, and we can do so too. The cost of adapting an existing engine for the purpose is not excessive, and under present conditions, at any rate, such cost will be abundantly repaid.

There is an opening for a new market for the by-products of gas works, blast furnaces, gas producers and low-temperature coal distillers which should be well worth cultivating. When that is established we shall be, in one direction at least, an independent people.

England's greatest commercial asset is her coal: her position in the trade of the world is chiefly due to this gift of the gods. It is the business of manufacturers and users of power plants in particular that it should be adequately conserved. In working our coal deposits we are indeed living on our capital: the greater the reason, then, to use it to the best advantage.

With these remarks I will bring this Paper to a close, and trust that the figures I have put before you have been sufficiently interesting to merit your attention.

NOTES ON DESIGN OF ELECTROMAGNETIC MACHINES.

I. CONTINUOUS-CURRENT MACHINES.

BY STANLEY PARKER SMITH, D.Sc.

(*Concluded from page* 496.)

Summary.—In the first part of the article the author deals with the principles underlying the design of continuous-current machines, and in the second part he applies these principles to the design of a 350 kw., 500-volt generator running at 200 revs. per min.

The Field System.

The Magnetic Circuit.—Before the magnetisation can be calculated, the dimensions of the field system must be settled, and we must now decide how the poles and yoke are to be made. It is certainly good practice, with regard to economy in copper, to use round poles, since for a given area a circle has the least perimeter. On the other hand, the available space does not always permit of this construction, especially when there are interpoles, and it becomes

necessary to use rectangular poles. Nevertheless, it is best to use round poles, where possible, even if the coils have to be tapered somewhat. Another advantage of using round poles, when the poles are made separate from the yoke, is that they can be cut from standard bar, which usually is cheap, and can be delivered quickly. Rectangular poles can be made either solid or laminated ; in the latter case, no extra shoes are needed.

For the yoke, we can use either cast iron or cast steel. Since steel can be worked up to densities of the order of 14,000 lines per cm.^{2}, whilst iron is seldom pushed beyond 6,000, the weight of steel required is less than one-half that of iron, and with the densities given, the steel only needs some 75 per cent. of the ampere-turns taken by the iron. Also the price of cast steel is by no means double that of cast iron, so that taken all in all it would seem preferable to use the former from a commercial standpoint. The cost of transport also favours the use of steel. The objections to steel, however, are often important to the competing manufacturer. Chief among these is the question of delivery, for he has almost invariably to rely on outside firms, and experience has shown this to be serious, whatever the reason may be. Then again, steel castings are not so reliably uniform as iron castings and usually need more attention. Nevertheless, most of the objections to cast steel are remediable, and modern tendencies certainly point to the increased use of steel for yokes.

In the present case, the yoke will be made of steel and the poles will be cast with the yoke, facings being left for the interpoles. The main pole-shoes are laminated, and serve as a support for the exciting coils. The dimensions of the yoke and poles are shown in the drawing, and have been found suitable by trial. The poles are 33 cm. diameter, and the yoke is 12×45 cm.

The length and cross-section of the different parts of the magnetic path can now be found. These have already been determined for the core and teeth, in connection with the iron losses. The length of a pole $l_p=33$ cm., and its cross-section $a_p=0{\cdot}785\times33^2=855$ cm^2. The cross-section of the yoke $a_y=12\times45=540$ cm.^{2}, whilst the mean length of the path through the yoke is estimated at $l_y=75$ cm.

There only remains the *air-gap*, and this is the most important of all, since most of the ampere-turns in the circuit are expended here. Owing to the presence of the slots and ventilating ducts, the reluctance of the air-gap is increased due to the contraction of the flux. In the case of continuous-current machines, the curve is usually flat-topped over a wide range of arc. This uniform density B_g is greater than it would be if there were no slots and ducts, and we must now see how its value can be calculated. With a smooth core and concentric air-gap, the flux-density in the gap, ignoring fringing, would be simply Φ/bL; actually the effective arc b_g is less than pole-arc b, owing to the slots, and the effective length L_g is less than the core-length L, owing to ducts. Thus $B_g=\Phi/b_gL_g$, so that we must now find b_g and L_g.

The reduction of the pole-arc or core-length is a function of the ratio of the width of the opening of the slot or duct to the length of the gap. If we denote this function opening/gap by y:

$y'=f$ (slot-opening/gap) and $y''=f$ (duct/gap)

then we have

effective polar-arc : $b_g=b-s_o\dfrac{b}{y_s}y'$

effective core-length : $L_g=L-n_vd_v\,.\,y''$

where s_ob/y_s=total slot-openings under one pole (s_o=slot-opening) and n_vd_v=total width of vent ducts (n_v ducts each d_v wide). The function y is called the contraction coefficient, and can be calculated mathematically. This has been done by Carter—*see* "Electrical World," 1901, Vol. XXXVIII., p. 884—and the coefficient is therefore often referred to by his name. Carter's results are usually plotted in the form of a curve with y as a function of the opening/air-gap. The figures for this curve are given in the following table :—

$y=$	0	0·16	0·28	0·37	0·44	0·55	0·64	0·70	0·75	0·78
$\frac{\text{opening}}{\text{air-gap}}=$	0	1	2	3	4	6	9	12	16	20

Some designers prefer to apply Carter's results to increase the length of the gap instead of reducing its area, but this is chiefly a matter of taste.

Before applying this to the present case, we have to choose a length for the air-gap. In an interpole machine the length of the gap largely depends on mechanical considerations, for there is no need to make the field ampere-turns greater than the armature ampere-turns. A gap of 6 mm. will be quite suitable for the present machine.

With a slot-opening of 14 mm. and a gap $l_g=6$ mm., $s_o/l_g=14/6=2{\cdot}34$; whence we get from Carter's curve $y'=0{\cdot}31$, so that

$$b_g=37-1{\cdot}4\,\frac{37}{3{\cdot}6}\,0{\cdot}31=37-4{\cdot}5=32{\cdot}5\text{ cm.}$$

Similarly with 10 mm. ventilation ducts, $d_v/l_g=10/6=1{\cdot}67$, for which ratio, $y''=0{\cdot}24$, and the effective core-length is

$$L_g=35-4\times1{\cdot}0\times0{\cdot}24=35-0{\cdot}96=34\text{ cm.}$$

Hence the effective gap area $b_gL_g=32{\cdot}5\times34=1{,}100$ cm.^{2} This is 85 per cent. of the area bL—a very average figure for machines with open slots.

To find the densities in the poles and yoke we must know the *leakage* flux which these parts have to carry in addition to the main flux. There are various ways of estimating this, and it is usually found that the leakage flux is from 10-25 per cent. of the useful flux. Many designers are contented to add a percentage which they know by experience is sufficient to cover leakage, and this rough method is often quite good enough in normal machines provided the poles and yoke are not highly saturated. It is not an easy matter, on the other hand, to calculate accurately the amount and distribution of the leakage flux, especially in machines with interpoles, and we do not intend to attempt such a calculation, as the matter is of no particular interest or importance in the present design. We shall simply add a safe figure of 20 per cent. on to the useful flux and assume that this flux passes through the yoke and the whole length of the poles—an assumption which certainly gives us a result on the safe side.

Magnetisation.—Since there are no particular requirements to be fulfilled by the machine there is no need to calculate the whole of the magnetisation curve, and we shall only work out the ampere-turns needed on no-load and on full-load.

The no-load flux to produce 500 volts at no-load speed is

$$\Phi_o=\frac{a}{p}\,\frac{E}{Zn_o}\,10^8=\frac{2}{4}\,\frac{60}{684\times206}\,500\,.\,10^8=10\,.\,6\times10^6$$

At full-load the induced pressure E must be increased to maintain $V=500$ volts at the terminals, owing to the drop in the windings. Summing up the different drops, we find the pressure induce on load must be about 520 volts. At a speed of 200 revs. per min. this requires a flux of 11·4 lines.

The magnetisation is best entered up in the form of a table, as shown below. For the *ampere-turns for the teeth* where the density varies on account of the taper, it is sufficient to take the maximum, mean and minimum densities, provided $B_{max.}$ does not exceed 20,000. When the density exceeds this value, μ becomes fairly small—of the order of 50—so that an appreciable amount of flux goes through air, and this must be taken into account. Calculating the ampere-turns for the teeth when the machine is on load, the maximum and minimum areas for the teeth are 670 cm.^{2} and 600 cm.^{2} respectively. Corresponding with these for a flux of $11{\cdot}4\times10^6$, $B_{min.}=17{,}000$ and $B_{max.}=19{,}000$, whence $B_{mean}=18{,}000$. For $B=19{,}000$, the ampere-turns per centimetre $AT/cm=160$; for $B=18{,}000$, $AT/cm=100$; for $B=17{,}000$, $AT/cm=62$. Applying Simpson's rule under the assumption that these points lie on a parabola, we get the mean ampere-turns per centimetre needed for the teeth $=(160+4\times100+62)/6=104$. The iron curves used are those given by Prof. Walker in his book on "The Design and Specification of Electrical Machinery." The curve used for sheet steel is on p. 42, and for cast steel on p. 37 (marked "average cast steel").

In addition to the ampere-turns needed for the iron and air, the effect of armature reaction has to be compensated. This depends on the brush position—with a backward shift armature reaction strengthens the main flux, with a forward shift it

weakens it. With the brushes in the geometrical neutral zone, 10 to 15 per cent. of the armature ampere-turns have to be added to the field ampere-turns to make up for weakening due to distortion, &c. The exact percentage is not important in an interpole machine, because the brushes can be rocked slightly if necessary, and the interpoles then act on the main field in the same sense as the armature ampere-turns.

			No-load AT			Full-load AT		
Part of circuit.	Area.	Length.	B.	AT per cm.	AT	B.	AT per cm.	AT
Core.....	2×385	35	13,700	10·5	370	14,700	17	600
Teeth $B_{max.}$	600	2×4·2	17,700	57	480	19,000	104	870
Air-gap	1,100	2×0·6	9,650	...	9,250	10,350	...	9,950
Poles	855	2×33	14,900	29	1,900	16,000	45	2,970
Yoke	2×540	75	11,800	12	900	12,700	14	1,050

Total AT on no-load.....12,900 Total..... 15,440
Arm. reaction (11 %) 1,660

Total AT on full-load..... =17,100

It will be seen that the ampere-turns are calculated for a complete magnetic path, that is, for a pole-pair, and not for one pole, as preferred by some designers.

Hence, we can express the section a in terms of the known quantities :—

$$a=\frac{0{\cdot}02l_t}{R_e}=\frac{0{\cdot}02(p\,.\,T\,.\,l\,.\,10^{-2})I_e}{V_e}.$$
$$=\frac{l\,.\,p\,.\,AT}{5{,}000\ V_e},$$

where $T\,.\,I_e=AT$=ampere-turns per pole-pair, and is taken for full-load.

The exciting pressure V_e is usually 70 to 80 per cent. of the terminal pressure V. We shall assume $V_e=0{\cdot}75\times V=375$ volts. To find the length of mean turn we can assume a winding depth of 35 mm. and the inside diameter of the coil 34·5 cm. (increased from 33 cm., to allow for slack and insulation), so that $l=\pi(34{\cdot}5+3{\cdot}5)=120$ cm.

The required section of wire is then :—

$$a=\frac{120.4\,.\,17{,}100}{5{,}000.375}=4{\cdot}4\ \text{mm.}^2.$$

The nearest S.W.G. to this is No. 13, for which $a=4{\cdot}3$ mm.^{2}, with a diameter 2·7 mm. when insulated with 14 mils d.c.c.

If, now, we assume a figure for the current density in the shunt winding we get the exciting current I_e. The current density in shunt windings usually lies between 1·5 and 2

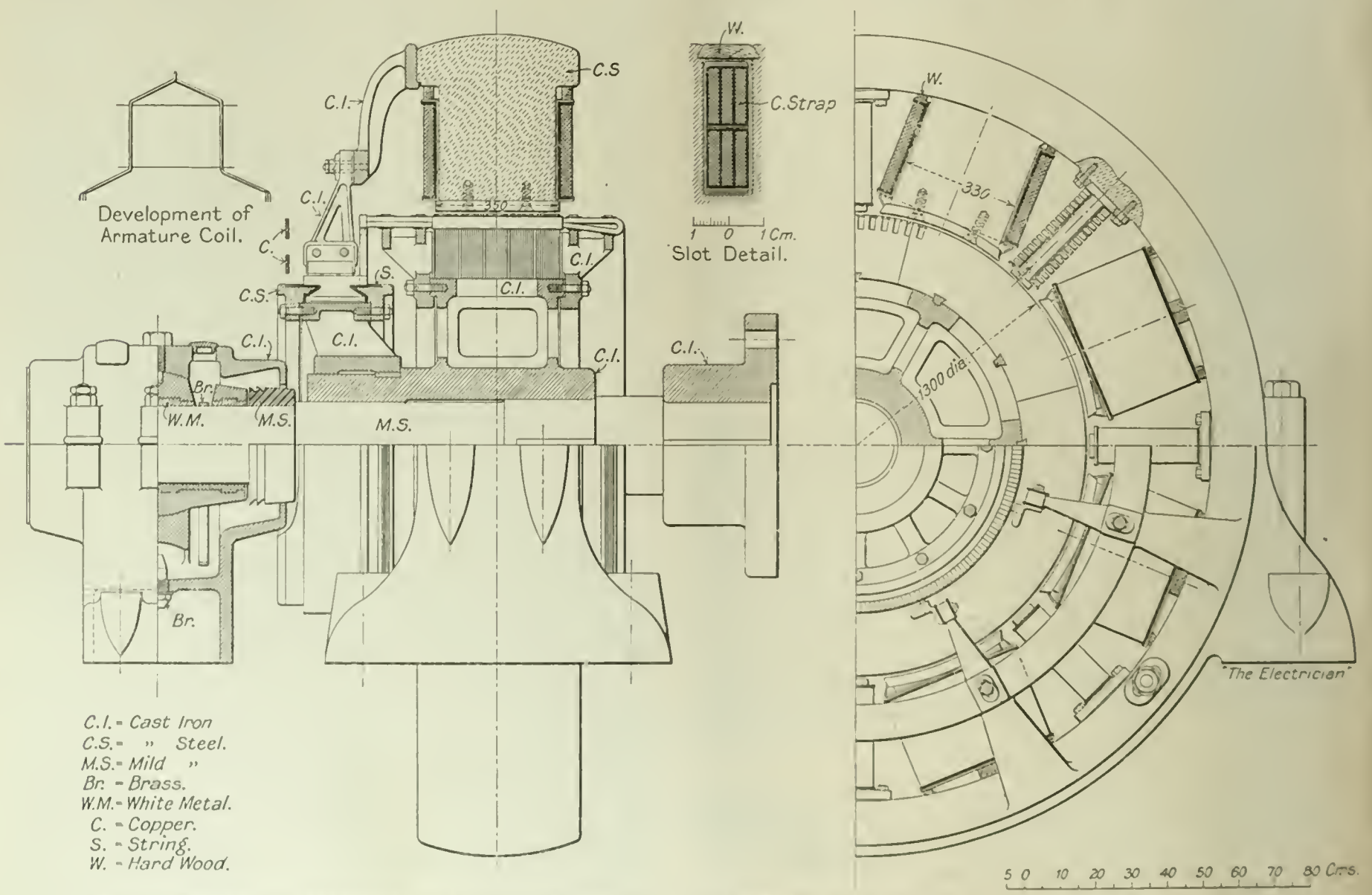


Fig. 10.—General Arrangement of 350 kw. Generator. 700 amps., 500 volts, 200 r.p.m. Dimensions in millimetres.

For the benefit of students it may be as well to remark that it is no use trying to calculate a magnetisation curve with the accuracy demanded in a balance-sheet. Judicious guessing and correct arithmetic are much more important for the designer than blind faith in empirical data.

Shunt Winding.—Knowing the ampere-turns required per pole, the shunt winding can be calculated as follows : Let V_e denote the exciting pressure and I_e the exciting current, then from Ohm's law, the resistance of the exciting winding $R_e=V_e/I_e$, where $R_e=0{\cdot}02\,l_t/a$; l_t is the total length in metres of wire in the shunt winding, and a its section in mm.^{2}.

Now, the total length $l_t=p\,.\,T\,.\,l\,.\,10^{-2}$ metres, where T is the number of turns per pole-pair, and l the length of a mean turn in centimetres. l can be estimated pretty accurately.

amperes per mm.^{2} ; taking 1·7 amperes/mm.^{2} as a suitable figure, we get $I_e=1{\cdot}7\times 4{\cdot}3=7{\cdot}3$ amperes. Hence, for 17,100 ampere-turns per pole-pair the turns needed per pole will be $17{,}100/2\times 7{\cdot}3=1{,}170$.

We must now arrange these on the pole. From the drawing we see that the available winding length, after allowing for spool and insulation, is 265 mm. It is possible to fill about 95 per cent. of this, or 250 mm., with wire, so that in each layer there will be $250/2{\cdot}7=92$ turns. To get 1,170 turns per pole we then need nearly 13 layers ; taking 13 full layers of 92 turns per layer, the turns per pole will be $92\times 13=1{,}196$, which is quite near enough to the figure 1,170 we started from. The depth of 13 layers is $13\times 2{\cdot}7=3{\cdot}5$ cm., which agrees with what we assumed in estimating the length of mean turn.

With 1,196 turns per pole having a mean length of 120 cm., the total length of wire $l_t=8(1{,}196\times1{\cdot}2)=11{,}500$ metres, and the weight of copper in the shunt winding=970 lb. net.

The resistance of the shunt winding (hot):

$$R_e=0{\cdot}02\times11{,}500/4{\cdot}3=53{\cdot}5 \text{ ohms.}$$

The exciting current at full-load:

$$I_e=17{,}100/2\times1{,}196=7{\cdot}15 \text{ amperes.}$$

The exciting pressure:

$$V_e=R_eI_e=53{\cdot}5\times7{\cdot}15=383 \text{ volts (77 per cent.).}$$

The loss in the shunt winding:

$$I_eV_e=7{\cdot}15\times383=2{,}740 \text{ watts.}$$

To check whether this loss can be dissipated without the permissible temperature rise being exceeded there are various factors to help us, but actual experience is the only safe guide. From the current density, which is quite normal, we should expect the temperature rise to be all right provided the ventilation is satisfactory. Another simple check is the loss per unit surface of the outside part of the coil. The cylindrical surface of all the coils=$8\times2{\cdot}65\times\pi4{\cdot}15=277$ dm.^{2}. Hence, the watts per dm.^{2}=2,740/277=9·9. For normal temperature rise a safe limit for this figure is 10 watts/dm.^{2}, so that the present machine should be all right. For the effect of the speed on cooling, and on heating of machines in general, the reader can consult the books by Mr. Hawkins and Prof. Walker, already referred to.

The Interpole Winding.—For the commutating flux the calculated ampere-turns per magnetic circuit were 21,000, or 10,500 ampere-turns per pole. With an exciting current of 700 amperes (the full-load current of the machine) there will be 15 turns per pole. For the interpole winding, the writer prefers, if possible, to use a spiral of bare copper, leaving a cooling space between adjacent turns. The cooling properties of such coils are very good, and it is safe to work at densities of 2–3 amperes per mm.^{2} for a temperature rise of 45°C. Allowing about 2·3 amperes per mm.^{2}, we need a copper section of 700/2·3=300 mm.^{2}. The winding length on the interpole, after deducting for the shoe and insulation (*see* drawing), is 275mm., so that for each turn there is a space of 275/16=17mm. (allowing one extra turn for the spiral). With a cooling space of 5 mm. between turns we have 12 mm. for copper, so that the depth of copper needed will be 300/12=25 mm. It is possible to use a solid strip 12×25, but it is much easier to wind the coil if we split up the section into, say, 5 parts. We, therefore, use 5 strips 12×5 mm. in parallel. Since there is no insulation between the strips the cooling is about the same as if the section were solid.

Using rounded ends for the interpoles, and allowing 1 cm. for the pole insulation, the inside dimensions of the coil will be 5×21 cm., so that the length of mean turn=$2(21-5)+\pi(5+2{\cdot}5)=55{\cdot}5$ cm.

The total length of copper is then $8\times15\times0{\cdot}555=67$ m.

The weight of copper on the interpoles is 400 lb. net.

The resistance of the interpole winding (hot)=$0{\cdot}02\times67/300=0{\cdot}0045$ ohm, and the pressure drop=$700\times0{\cdot}0045=3{\cdot}15$ volts.

The loss in the interpole winding is then=$700\times3{\cdot}15=2{,}200$ watts.

Efficiency.

It only remains now to calculate the efficiency of the generator we have just designed. Most of the losses have been calculated already for full load, and it is a simple matter to estimate them at other loads. We need only work in round numbers. The iron loss in the core and teeth at full load was found to be 3,600 watts. This falls off slightly with the load, owing to the decrease in the flux. The loss in the armature copper varies as the square of the load, except for the changes in the temperature rise. The loss due to shunt excitation falls from 2,750 watts at full load to about 1,500 watts at no-load. The copper loss in the interpole winding follows the same law as the copper loss in the armature winding.

On the commutator the losses are of two kinds, the electrical loss due to the contact resistance between the carbons and the copper and the mechanical loss due to rubbing friction between carbon and copper. If we assume a P.D. of 1 volt between the brushes and the commutator at all loads, then at any load this loss will be $2I$ watts. The commutator loss due to friction can be calculated from the formula—

Brush friction loss $=9{\cdot}81\mu\,.\,\rho\,.\,a_b\,.\,v_c$ watts,

where μ=coefficient of friction=0·1—0·2 for carbon brushes,

ρ=specific pressure of brushes on commutator in kilogrammes per cm.^{2}. This usually lies between 0·1 and 0·2, or, say, 1½ lb. to 2½ lb. per square inch.

a_b=total brush surface in cm.^{2}.

v_c=peripheral speed of commutator in metres per second.

Taking $\mu=0{\cdot}15$, $\rho=0{\cdot}15$ kg. per cm.^{2}; $a_b=8\times3/8{\cdot}0=192$ cm.^{2}; and $v_c=10$ m./sec., then

Brush friction loss$=9{\cdot}81\times0{\cdot}15\times0{\cdot}15\times192\times10$,
$=500$ watts, say.

The only remaining loss we shall take into account is windage and friction. At ordinary speeds this loss might amount to 1 per cent. or more of the output, but in the present low-speed machine it is not likely to exceed one-half of 1 per cent., or, say, 2,000 watts.

Table of Efficiencies.

Load	5/4	4/4	3/4	2/4	1/4
Iron loss, core+teeth	3,800	3,600	3,400	3,200	3,000
Copper loss, armature	16,000	9,550	5,350	2,200	550
,, shunt	3,150	2,750	2,400	2,100	1,800
,, interpole	3,500	2,200	1,200	500	100
,, commutator	1,750	1,400	1,050	700	350
Mech. loss, commutator	500	500	500	500	500
,, wind. & friction	2,000	2,000	2,000	2,000	2,000
Total losses	30,700	22,000	15,900	11,300	8,300
Output	437,500	350,000	262,500	175,000	87,500
Input	468,200	372,000	278,400	186,300	95,800
Efficiency in per cent.	93·5	94·1	94·2	93·8	91·3

It is seen that the maximum efficiency is reached somewhat below full-load. This is due to the fact that the constant losses are relatively small owing to the low speed, maximum efficiency being reached of course when the variable and constant losses are equal.

SCHEDULE OF LEADING PARTICULARS OF DESIGN.

SLOW-SPEED CONTINUOUS-CURRENT GENERATOR.

Shunt-wound, with Commutating Poles.

Output	350 kw.
Pressure, V	500 volts, constant at all loads.
Current I	700 amperes
Speed, no-load n_o	206 R.P.M.
,, full-load, n	200 ,,
Temperature rise not to exceed 45°C. after continuous run on full-load.	

Main Dimensions.

Number of poles, $2p$	8
Armature diameter, D	130 cm.
,, periphery	408 ,,
Pole-pitch, Y	51 ,,
Air-gap	0·6 ,,
Total core-length, L	35 ,,
Vent. ducts	4, each of 1 ,,
Net core-length, L_i	28 ,,
Thickness of plates	0·5 mm.
Diameter of spider	94 cm.
Peripheral speed of armature	13·6 m. per sec.
Frequency, f_r	13·3 cycles per sec.

Output coefficient $C=\dfrac{350\times10^5}{130^2\times35\times3{\cdot}33}=17{\cdot}8$

Yoke.

Cast steel	12×45 cm.

Main Poles.

Cast steel, cast with yoke	33 cm. diam.
Shoes: Arc×length	37×35 cm., laminated.

Commutating Poles.

Poles	20×4 cm. rounded ends.
Shoes	20×7 cm., laminated.

Armature Slots.

Number of slots	114
Slot-pitch	3·58 cm.
Size of slot	42×14 mm., open

Specific Loading.

Total ampere-conductors, $Z.I_a$	120,000
Ampere-conductors per slot, $u.I_a$	1,050
Specific electric loading, ac	294
Armature ampere-turns per pole-pair, $Y.ac$	15,000
Flux per pole when $E=500$ and $n=200$	$11{\cdot}0\times10^6$
Specific magnetic loading, B_{mean}	6,150
Output coefficient $C=\pi^2.6{,}150.294.10^{-6}=17{\cdot}8$	

Armature Winding.

Type of winding	4-circuit wave ($a=2$)
Current per circuit, I_a	175 amperes
Number of active conductors, Z	684
,, idle ,,	None.
Turns per coil, T_c	1
Number of coils or com. bars, C	342
,, slots, S	114
Segments per slot	3
Coil-sides per slot, u	6
Commutator pitch, y_c	85 bars.
Coil-span (back pitch), y_b	85 coil-sides.
Front pitch, y_f	85 ,,
Slot insulation	1 mm.
Conductor, section A	44mm².
,, made of strip	3×15 mm.
,, taped to	$3{\cdot}7\times15{\cdot}7$ mm.
Current density	4 amp. per mm²
Length of conductor	100 cm.
Resistance of winding, cold	0·017 ohm.
,, ,, ,, hot	0·0195 ohm.
Ohmic drop	13·7 volts.
Copper loss	9,550 watts.

Commutator.

Diameter, D_c	95 cm.
Periphery, πD_c	298 cm.
Peripheral speed of commutator	10 m. per sec.
Active length	15 cm.
Number of segments, C	342
Pitch of segments, y_1	8·7 mm.
Mean pressure between bars	11·7 volts.

Equalising Rings.

Potential pitch, y_p	171 segments
Number of rings	9
Section of rings	20 mm.²

Brushes.

Number of spindles	8
Carbons per spindle	3
Size of carbon	20×40 mm.
Quality of carbon	Medium hard.
Brush surface per spindle	24 cm.²
Current per spindle	175 amperes.
Current density	7·3 amp. per cm.²
Segments per brush	2·3

Shunt Winding.

Ampere-turns per pole-pair	17,100
Diameter of pole, insulated	34·5 cm.
Depth of coil	26·5 cm.
Thickness of coil	3·5 ,,
Length of mean turn, l	120 ,,
Conductor, section a	4·3 mm.²
,, insulated to 2·7 mm.	
,, made of No. 13 S.W.G.	
Number of layers	13
Turns per layer	92
,, pole	1,196
Exciting current, I_e	7·15 amperes.
Current density	1·66 amp. per mm.²
Resistance, cold	46·3 ohms
,, hot, R_e	53·5 ,,
Exciting pressure, V_e	383 volts (77 %).
Loss in exciting winding	2,740 watts.

Commutating Pole Winding.

Type of winding	Spiral.
Ampere-turns per pole-pair	21,000
Length of mean turn	55·5 cm.
Conductor, section	300 mm.²
,, made of 5 strips	5×12 mm.
Number of layers	1
Turns per layer	15
,, pole	15
Exciting current	700 amp.
Current density	2·33 amp. per mm.²
Resistance, cold	0·0039 ohm.
,, hot	0·0045 ,,
Ohmic drop in interpole winding	3·15 volts.
Loss ,, ,, ,,	2,200 watts.

This article was written at the City and Guilds (Engineering) College, and the drawing was made by Mr. J. W. Sims.

NATIONAL PHYSICAL LABORATORY.

The annual report of the Executive Committee of the National Physical Laboratory was submitted to the General Board last month. In what follows we reproduce those parts of the report which are of general physical and electrical interest :—

Reference is first made to the death of Sir Andrew Noble and of Sir Arthur Rücker, and to losses sustained by the Laboratory staff through casualties in the war. Since a large amount of Government work is now carried out at the Laboratory, war badges have been issued to the staff by the Ministry of Munitions.

Owing to the great increase in the work during the past 12 months, it has been necessary temporarily to augment the staff considerably. The work in practically all departments of the Laboratory has been very heavy throughout the year, and the committee are indebted to the staff for the readiness with which the additional burdens imposed on them by the circumstances prevailing have been undertaken. The committee are satisfied that in many ways the work done has been of great value and importance to the nation.

A large amount of work has been done during the year for the Ministry of Munitions, including the Munitions Inventions Department, and for the Board of Invention and Research. On the formation of the Ministry of Munitions, the Director was appointed scientific adviser on physical questions to the Ministry. He has also acted on the advisory panel of the Munitions Inventions Department, has served on a number of committees and sub-committees of this department, as well as of the B.I.R., and has acted as chairman of the Instruments Committee. By request of the Ministry, the Laboratory undertook the testing of gauges required in the manufacture of fuses and shells, for which it has been necessary to organise a special staff, under the superintendence of Mr. Sears, the head of the Metrology Division. The Director has acted as chairman of the Gauges Sub-committee of the Committee on Munitions Supply.

By desire of the Committee of the Privy Council for Scientific and Industrial Research, particulars have been laid before them as to various researches in which the Laboratory could be of assistance to British industries. The equipment of the Laboratory has been provided with special reference to such work, and during the past year help has been given to a number of firms who have undertaken the manufacture of goods formerly only obtainable from German sources. It is gratifying to be able to record that in several directions the efforts of these firms have been successful. A grant has been received from the Privy Council Committee for the research on optical glass, which is now in progress. The Laboratory has also been asked to give assistance in connection with one or two researches undertaken by the great technical institutions under grants from the Privy Council Committee. It is probable that the Laboratory will be asked by the committee to undertake other work of similar character.

Additional buildings have been provided during the year in connection with the aeronautics research carried out under the control of the Advisory Committee for Aeronautics. Provision has also been made for an extension of the work carried out in the Tank for the Advisory Committee for Aeronautics. The additions to the staff necessary for the above purposes have been sanctioned by the Treasury, and the appointments were made early in the year.

In the Physics Department, the electrical standards division has been largely occupied with the investigation for the Admiralty and the War Office of some special problems in connection with wireless telegraphy. In the division for general electrical measurements a number of special questions have been investigated, and at the same time it has been found possible to continue some of the research work, which has assumed increased importance during the war. The research on magnet steels for the Institution of Electrical Engineers has been continued, and methods of magnet testing have been improved.

In the Electrotechnics Division, Mr. Paterson has made arrangements for a new branch of test work, and has given assistance in various special matters. Mr. Rayner's services have during the past few months been lent to the Inventions Department of the Ministry of Munitions, where his detailed knowledge of instruments and instrument design has been found of great value. Mr. Melsom has been largely occupied with the testing of instruments for the Admiralty, the numbers dealt with, with a weakened staff, being more than treble those tested in the year previous to the war.

In the Heat Department, the absence of Dr. Kaye and Mr. Blackie has been severely felt, but progress has been made with some of the investigations of most immediate importance. These relate chiefly to heat loss from surfaces and heat transmission through refractory and non-conducting materials. Investigatory work has been in progress with regard to optical pyrometers for high-temperature furnace measurements, and assistance has been given to manufacturers in the investigation of porcelains for the sheathing of pyrometer tubes.

In the absence of Dr. Kaye, Mr. Higgins has successfully taken charge of the thermometer testing, and of the radium tests. Arrangements are being made, at the request of the Röntgen Society, for the examination of materials employed for the protection of X-ray workers. The equipment has been installed and the conditions of test are being determined in conjunction with the Council of the Röntgen Society.

The Metrology Division has been mainly occupied with the work of gauge testing, undertaken for the Ministry of Munitions.

The Optics Division has dealt with a largely increased volume of test work for the Admiralty, while special arrangements were made for the

examination for the Ministry of Munitions of instruments collected under an order in Council. By desire of the Ministry also tables have been prepared giving the curvatures required in achromatic lenses for small telescopes made from various glasses. These have been published, and have been found of good service. A considerable number of special questions have been investigated, and some useful Papers have been contributed to the Physical Society and other bodies.

In the Engineering Department, Dr. Stanton has been able to continue some of the research work which had already been undertaken. The work on the fatigue resistance of materials under combined torsion and bending, carried out for the B.A. Committee on Complex Stress, has been advanced, and some interesting results obtained. The examination for the Engineering Standards Committee into the application of the methods of notched bar impact testing recommended by the International Association for Testing Materials has made good progress. In connection with the Hardness Tests Research Committee of the Institution of Mechanical Engineers, improved methods of determining the resistance to wear of various materials have been developed, which avoid some of the difficulties experienced earlier. A standard tensile impact test of railway carriage couplings has been arranged. Some interesting fatigue tests of timber for aeroplane construction, and of wires subjected to vibration have been made. The measurements of the growth of cracks in the buildings of the Tower of London, mentioned last year, have been continued.

The Metallurgy Department has been greatly occupied with special questions. The alloys research has been continued, and special attention has been given to the production of light alloys under manufacturing conditions, in which considerable success has been attained.

The following table gives a summary of the tests carried out at the Laboratory during the last three years :—

	1914.		1915.		1916.
Electrical measurements...	259	...	191	...	140
Electrotechnics.....	3,828	...	5,080	...	10,444
Photometry	1,142	...	410	...	3,053
Heat.....	28,136	...	24,017	...	20,289
Radium	7	...	72	...	68
Optics	7,846	...	10,579	...	19,542
Metrology	4,799	...	5,797	...	8,214
Taximeter Testing	18,184	...	15,539	...	12,957
Engineering Department .	453	...	617	...	640
William Froude National Tank	67	...	61	...	18

The accounts have been audited, and will be presented to the Treasury in due course. They show a credit balance on the year's working of £1,568. 2s. 3d. Both the expenditure and receipts have increased by large amounts, due to the work done for Government departments, mainly the Ministry of Munitions. The rise in income has been £11,718. 15s. 1d. from £39,653. 5s. 6d. in 1914-15, to £51,372. 0s. 7d. in 1915-16. This is due mainly to an increase in the Treasury grant for aeronautics, which has risen from £7,474. 10s. 8d. to £9,175. 8s. 9d., and to the payments from the Ministry of Munitions. On the other hand, the receipts from fees for the ordinary test work has fallen from £20,017. 8s. 5d. to £19,141. 18s. 3d., and the payments for special investigations from £1,612. 8s. 7d. to £1,125. 15s. 9d. The number of instruments tested has increased greatly, and the increase has been specially marked in the optical and electrical divisions ; the increase in fees arising from this has, however, been counterbalanced by a fall in the work done for the India Office.

The total expenditure has increased from £39,572. 11s. 10d. to £49,803. 18s. 4d., the main item of increase being salaries and wages, which have grown from £29,623. 0s. 6d. to £36,397. 9s. 5d. This large increase is due practically entirely to the growth of the staff required to carry out the Government work, and to the necessity for increasing the salaries of the junior staff and the weekly wages. The staff has grown from 217 in April, 1915, to 337 in April, 1916. The administration expenses for coal, gas, power supply, have increased considerably, partly in consequence of the higher prices, partly as a result of longer hours ; the departmental expenses, on the other hand, are in nearly all cases less than usual. This is due to the reduction in the research work.

At the commencement of the year the sum to the credit of the general fund was £2,347. 5s. 3d. Adding £1,568. 2s. 3d., the credit balance for the year, it now stands at £3,915. 7s. 6d. Against this must be set the liability of £1,660. 14s. 4d., balance on the loan for the completion of the William Froude National Tank.

(*To be continued.*)

Grain Size in Metals.—Mr. Z. Jeffries, in a Paper read recently before the Faraday Society, described a method for measuring grain size. This consisted of counting the grains completely and partly included in the circular part of an image at standard magnification of the specimen ; and by means of an empirical formula finding the number of whole grains in the area. The President, commenting on the method, mentioned that a 0·58 carbon steel contained 5,540 grains per square inch when forged, and if forged and annealed 4,500. When the steel was water quenched and re-heated the number rose to 330,000.

THE EFFECT OF VACUUM-FUSION UPON THE MAGNETIC PROPERTIES OF PURE OPEN-HEARTH IRON.

BY TRYGVE D. YENSEN
(Research Assistant Professor, University of Illinois).

In a number of articles* during the last two years the writer has described the remarkable magnetic properties obtained by melting electrolytically refined iron *in vacuo*. It has been shown that it is possible by this process to obtain magnetic permeabilities ($\mu=B/H$) as high as 50,000, accompanied by hysteresis losses of one-fifth to one-eighth that of the best commercial transformer steels in use at the present time. The question has naturally arisen, What effect will the vacuum treatment have upon commercial grades of iron ? In order to answer this question, one of the purest grades of commercial iron obtainable was selected for an investigation. The composition of this iron, which was made by the open-hearth process according to the most approved method, is as follows† :—

S	0·025	per cent
P	0·005	,,
C	0·010	,,
Mn	0·025	,,
Si	0·005	,,
Cu	0·050	,,
O	0·035	,,
N	0·004	,,
H	0·001	,,
Fe (by diff.)	99·84	,,
	100·00	,,

Test pieces were prepared from this iron as it was received from the manufacturer, and others were prepared from the

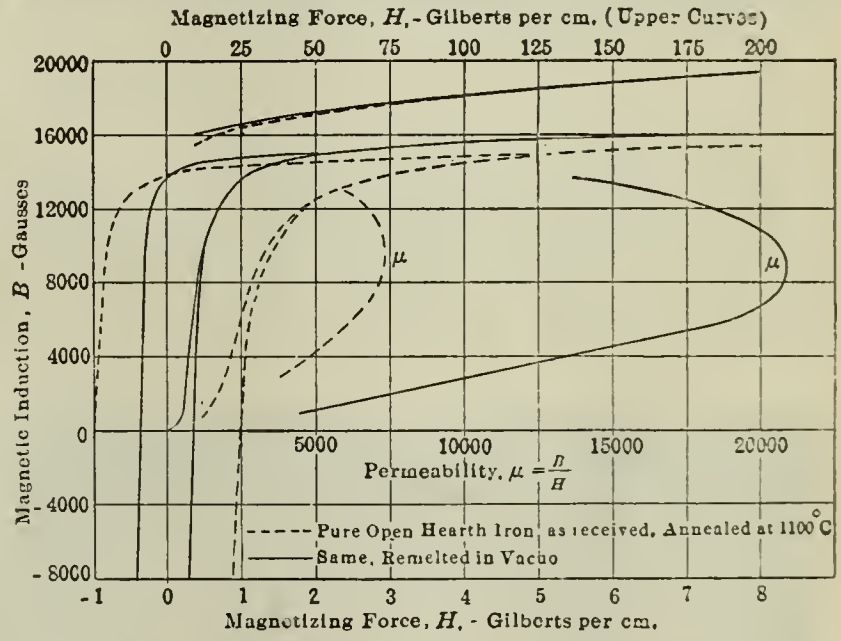


FIG. 1.—MAGNETIC TEST CURVES OF PURE OPEN-HEARTH IRON AS RECEIVED AND REMELTED IN VACUO.

iron after being re-melted *in vacuo*. The test pieces consist of rods 1 cm. by 36 cm., used in connection with Burrows' compensated double bar and yoke method, and of rings 4·2 cm. outside diameter by 3·8 cm. inside diameter, tested by the ordinary ballistic method. These test pieces before the final testing were annealed at 1,100 °C. *in vacuo* and cooled at the rate of 30°C. per hour to room temperature.

The results obtained are given in the accompanying table and in Fig. 1. It is seen that the vacuum treatment has increased the maximum permeability from two to three times and decreased the hysteresis loss by a corresponding amount.‡ For the sake of comparison there has been included in the table the results previously obtained with electrolytic iron—with

* "Bulletins" Nos. 72, 77 and 83, Eng. Exp. Sta., Univ. of Ill. "Transact." A.I.E.E., 1914, Vol. XXXIII., Part I., p. 451. "Proc." A.I.E.E., October, 1915, p. 2455. "Proc." A.I.M.E., February, 1916, p. 483.[Abstracts of these have appeared in THE ELECTRICIAN.—EDS.]

† These figures have been supplied by the manufacturer, and are said to be representative of the iron. Analysis made by the chemistry department of the University of Illinois check these figures satisfactorily.

‡ A similar improvement has been obtained with Swedish charcoal iron. *See* "Bull." 72, Eng. Exp. Sta., Univ. of Ill., pp. 28 and 33.

and without additions of silicon—melted *in vacuo*. This comparison shows plainly that *nearly* as good results are obtainable using pure open-hearth iron as a base as with the pure electrolytic iron.

As far as the chemical analysis is concerned, it is difficult to point out any material difference between the open-hearth iron before and after the vacuum treatment. Only, as far as the CO and CO_2 gases are concerned, it may be stated that there has been a material reduction by the vacuum treatment. In order to obtain further information regarding possible differences, samples were examined for density and under the microscope. The density tests showed very slight differences between the treated and untreated iron; but out of a number of tests under different conditions and by different persons, the density of the vacuum-treated iron was in every case found to be higher, the average difference being about 0·1 per cent.

Figs. 2 and 3 show the photomicrographs obtained for the two samples examined. In Figs. 2A and 2B it is seen that in the untreated iron, while it is remarkably free from slag or other impurities, such as are generally met with in commercial iron, there appear a large number of minute spots, evidently cavities caused by dispelled gases. The vacuum-treated iron is practically free from such cavities, as seen by Figs. 3A and 3B. Furthermore, the crystals of the treated iron are much larger than those of the untreated iron.



FIG. 2A.—60 DIAMETERS.



FIG. 2B.—360 DIAMETERS.

PURE IRON MADE IN OPEN-HEARTH FURNACE.

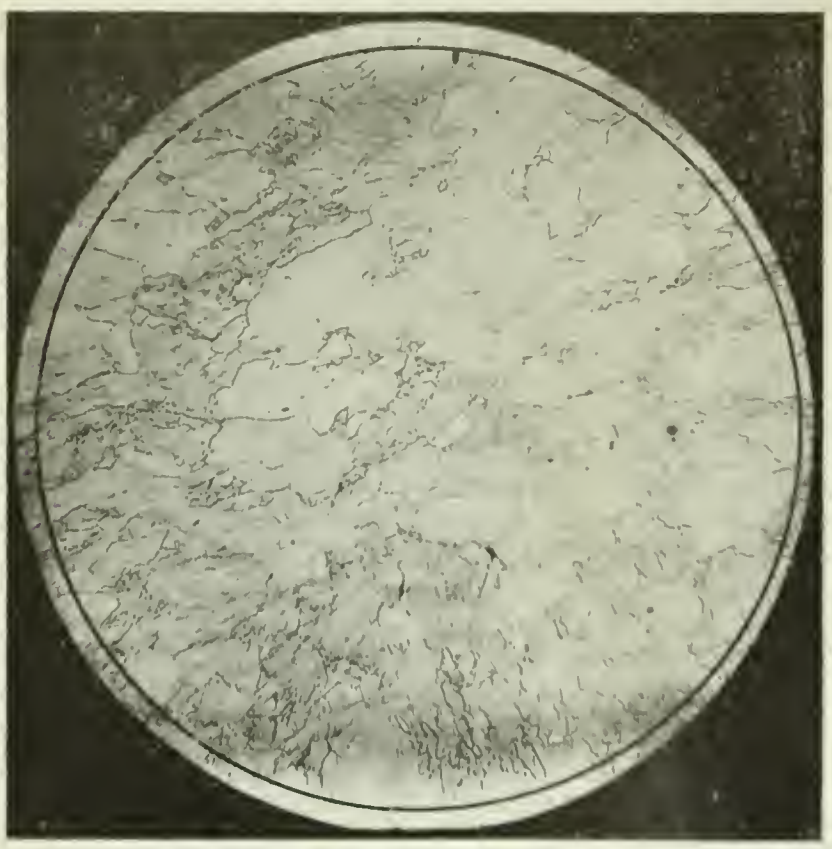


FIG. 3A.—60 DIAMETERS.

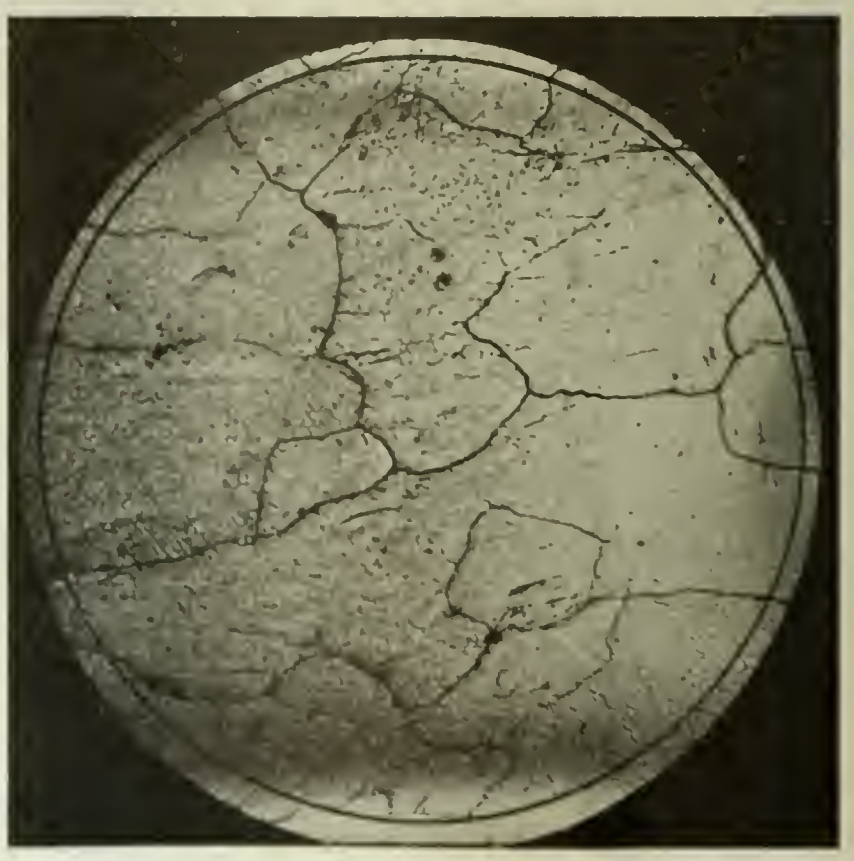


FIG. 3B.—360 DIAMETERS.

OPEN-HEARTH IRON REMELTED IN VACUO.

The results thus far obtained seem to indicate that the purer the iron the larger are the crystals. Previous results also point towards a possible connection between high magnetic per-

A Comparison between the Magnetic Properties of Open-hearth Iron Before and After being Re-melted in Vacuo. Also Compared with Electrolytic Iron.

Specimen No.	Kind of specimen.	Max. perm.	Density for max. perm.	Permeability.		Hysteresis loss, ergs per cub. cm. per cycle.		Retentivity, gausses.		Coercive force, gilberts per cm.		Spec. elec. resist., microhms.
				$B=10{,}000$.	$B=15{,}000$.	$B=10{,}000$.	$B=15{,}000$.	$B=10{,}000$.	$B=15{,}000$.	$B=16{,}000$.	$B=15{,}000$.	
			Open-hearth iron, as purchased, machined from ½ in. rod, annealed at 1,100°C.									
1. AR ...	Rod ...	7,250	10,000	7,250	2,710	...	5,050	9,000	13,000	0·85	1·0	10·15
			Open-hearth iron re-melted in vacuo, annealed at 1,100°C.									
2. 4–01 .	Ring ...	14,300	8,500	13,700	5,700	986	2,063	8,400	12,300	0·33	0·39	...
4–01 .	Rod ...	14,180	8,500	13,200	5,350	1,080	2,190	8,700	12,300	0·37	0·40	10·05
4–02 .	Ring ...	16,500	9,500	16,450	6,400	935	2,010	8,700	13,900	0·30	0·35	...
4–03 .	Ring ...	17,000	9,000	16,700	8,250	852	1,755	8,400	12,600	0·28	0·33	...
4–03 .	Rod ...	20,900	9,000	20,200	7,500	865	1,760	9,300	13,600	0·30	0·34	10·20
4–04 .	Ring ...	16,300	10,000	16,300	6,000	870	1,880	8,400	13,300	0·30	0·35	...
			Electrolytic-iron melted in vacuo, annealed at 1,100°C.									
3. 3–54 .	Rod ...	22,800	8,000	21,300	1,365	665	1,860	9,300	13,300	0·20	0·24	9·84
3–55 .	Rod ...	25,800	9,000	25,600	1,365	707	1,451	9,300	12,700	0·23	0·28	9·85
			Electrolytic-iron with 0·15 per cent. Si, melted in vacuo, annealed at 1,100°C.									
4. 3 Si 06	Rod ...	66,500	6,500	41,700	6,000	286	916	9,080	12,000	0·09	0·165	11·80
			Electrolytic-iron with 3 per cent. Si, melted in vacuo, annealed at 1,100°C.									
5. 3 Si 40	Ring ...	36,200	8,000	31,300	790	337	757	7,700	11,000	0·09	0·10	...
3 Si 40	Rod ...	72,600	9,000	69,500	2,500	254	926	9,400	13,700	0·09	0·16	44·75

meability and large crystals when comparing irons of the same general composition having received the same mechanical and heat treatment. It may be a question, however, whether magnetic permeability has anything to do with the crystal size, as it may depend solely upon the purity of the iron. In favour of this contention may be cited the fact that when pure iron has been annealed at temperatures above 900°C., followed by slow cooling, the resulting crystals are much smaller than after annealing at or below 900 deg., and yet the magnetic permeability is generally increased by annealing at the higher temperatures.

From these facts and indications the only safe conclusion that may be drawn is that the open-hearth iron has been purified by the vacuum treatment to a degree not obtainable by any ordinary process of manufacture, and, furthermore, that this purification has resulted in marked improvements in the magnetic properties. Together with the results previously obtained with Swedish charcoal iron,* these results show definitely that it is possible to obtain magnetic properties with commercial grades of iron by vacuum fusion that are comparable with those obtainable with electrolytic iron.

ELECTRIC UNDERTAKINGS IN JAPAN.†

The first electric undertaking in Japan was only directed towards the supply of electric lighting in Tokyo, by the Tokyo Electric Light Co. in November, 1887, with one home-made 75-lamp dynamo (afterwards replaced by two 200-lamp Edison dynamos) installed at Nihonbashi. In the following year the company constructed three more power stations, while the Kobe Electric Light Co. installed four 20 kw. Edison dynamos and commenced the supply of lights in Kobe. The aggregate capacity of generating stations in Japan at the end of 1888 came to about 500 kw.

In May, 1889, the Osaka Light Co. adopted the high-tension alternating-current system for the first time, and opened its business in Osaka with one 30 kw. dynamo (1,040 volts) of the Thomson-Houston type.

In the following year an electric light supply business was started in Kyoto, Nagoya and Yokohama, and thus the total capacity of generating stations reached 1,500 kw. at the end of 1890.

Thereafter the electric business made a steady progress, and the first electric traction undertaking in Japan was the electric tramway which was opened in Kyoto in 1895.

The electric undertakings in Japan continued to increase their electric power, and at the same time the method of transmitting power to a long distance was considered. In 1899 an enterprise was opened in the town of Koriyama for the transmission of electric power over a distance of 15 miles at a pressure of 10,000 volts, the electric power concerned being 300 kw. This having proved a success, the voltage was increased and the distance of transmission extended.

Towards the end of 1907 the Tokyo Electric Co. established a hydro-electric power station at Komahashi, Yamanashi, Prefecture, the capacity of which is 15,000 kw., transmitting that power at an extra-high tension of 55,000 volts to Tokyo over a distance of 50 miles, to supply electric lighting in Tokyo. In view of this successful undertaking of the Tokyo Electric Light Co., similar undertakings have been contemplated at various places, availing themselves of the water power abundant in this country. Among those undertakings the enterprise of the Inawashiro Hydro-Electric Co. is the largest one established in Japan. In October, 1914, the Company completed the work of the first hydro-electric generating station in the neighbourhood of Lake Inawashiro, the output of which is 14,000 kw., transmitting the power to Tokyo over a distance of 140 miles at an extra-high tension of 115,000 volts.

Electric undertakings in Japan are showing a rapidly progressive tendency; at the end of 1914 the total capacity of generating stations (exclusive of those under construction) amounted to 608,554 kw., and the length of tracks of the electric traction systems reached 822 miles at the end of 1914, whereas it was only 72 miles at the end of 1903.

In 1910 the Hydraulic Power Investigation Bureau which was continued to 1913, was organised for the purpose of investigating hydraulic power suitable for generating electric power. The available hydraulic power in Japan estimated by the said bureau reached 2,295,223 H.P.

The report includes a series of tables, from which it appears that there are 1,940 plants, 1,366 of them being isolated. There are 390 electricity supply undertakings, and 24 electric traction undertakings. Forty-seven concerns supply both light and power for traction. Of the plants mentioned there are 695 driven by water and 457 by gas, the remainder being steam plants. The plants in question work at various voltages, 1,297 being below 600 volts continuous-current system, 578 at pressures below 3,500 volts, and the remaining 125 at still higher pressures. The total capacity of all the above plants in 1914 is given above. In 1903 the total horse-power was 4,107, whereas in 1914 it was 148,702. The rate of increase of horse-power in 1913 was 56 per cent. per annum, and in 1914 was 45 per cent. It is evident from the tables that Japan is going ahead in the electrical direction, the length of electric lines having increased from 1,655 miles in 1903 to 22,670 in 1914. Tramway lines in the same period have increased 344 cars in 1903 to 4,287 cars. The report should prove interesting to manufacturers.

Thermo-Electric Method of Studying Allotropic Changes in Iron or Other Metals.—Prof. C. Benedicks, in a recent Paper before the Iron and Steel Institute, gives an experimental method for determining an effect of thermo-electrical hysteresis in metals characterised by allotropy. The metal in the form of a wire is moved at constant speed through a small furnace, the maximum temperature T of which is known; between the free ends of the wire an E.M.F. may appear if molecular changes occur in the metal at temperatures below T. The effect shows a marked discontinuity at a certain point, and is stronger in iron with 0·10 per cent. carbon than with carbonless iron. The results support the theory of the allotropy of iron as expounded by the author, but their accuracy is not very high, and it is desirable they should be repeated, especially with pure iron.

* A similar improvement has been obtained with Swedish charcoal iron. *See* "Bull." 72, Eng. Exp. Sta., Univ. of Ill., pp. 28 and 33.

† Statistical Report of Electric Undertakings in Japan, Department of Communications, Tokyo.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.

Published every Friday, Price Sixpence, Post Free, Sevenpence.

Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.

(ONLY ADDRESS.)

Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* and has an influential circulation all over the World. *This statement is guaranteed. Advertisement Rates, &c., forwarded on application.*

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF

Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Ready in a few days.* 15s. nett, post free 15s. 6d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

ELECTROMAGNETIC THEORY. By Oliver Heaviside. Vol. I. Price 12s. 6d. Vol. II. Price 12s 6d. Vol. III. 21s. nett.

ELECTRIC CRANES: THEIR DESIGN, CONSTRUCTION AND APPLICATION. By H. H. Broughton, M.I.E.E. Price 25s. nett, postage 9d. (abroad, 1s. 8d.)

ELECTRICAL TESTING FOR TELEGRAPH ENGINEERS. By J. Elton Young. Price 10s. 6d. nett, post free 11s

STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Price 7s. 6d nett.

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie, A.M.Inst.C.E. *New Edition in preparation.*

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation.*

"THE ELECTRICIAN" PRIMERS (84 Primers in all, and a GLOSSARY). Single Primers 3d. each post free. *In One Complete Vol.*, 10s. 6d. *nett, or Three Separate Vols. (Vol. I.* 3s. 6d. *nett ; Vol. II.*, 6s. *nett ; Vol. III.*, 4s. 6d. *nett*). Prospectus free. The Primers are revised or re-written as new printings are called for, and new Primers are added from time to time. Five New Primers: Gas Engines (No. 52), Oil Engines (No. 52A), Common Battery Telegraphs (No. 60A), Electric Clocks (No. 79), Electric Impulse Dials (No.79A), now ready. Revised Primers, 1914 and 1915: No. 29 (Management of Dynamos and Electric Machinery); No. 46 (House Wiring for Electric Light); No. 63 (Repairing Submarine Telegraph Cables); No. 42 (Electric Ignition); No. 49 (Steam Engines); No. 54 (Comparative Advantages of Steam and Producer Gas for Power Production); No. 59 (Diplex and Quadruplex Telegraphy); No. 61 (Automatic Telegraphic Apparatus).

ELECTRIC TRACTION ON RAILWAYS. By Philip Dawson, M.I.C.E., M.I.E.E., &c. Handsomely bound ; fully illustrated. Price 25s. nett, postage 6d. U.K., abroad, 1s. 6d

SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson, M.I.E.E. *New Edition in preparation.*

ELECTRICAL LABORATORY NOTES AND FORMS. Arranged by Dr. J. A. Fleming, M.A., F.R.S. Single copies 4d. nett, or in dozens at 3s. 6d. nett. Complete Sets of 50 Notes and Forms, 12s. 6d. nett, or in strong portfolio, 14s. nett ; or bound in strong cloth, 15s. nett. Spare Copies of Tabular Sheets, 1s. per dozen. Portfolios, 1s. 6d. each. Sectional paper, 1s. per dozen sheets. *Complete Prospectus post free on request.* These Notes and Forms are kept revised as new printings are required.

A VALUABLE WORK.

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE.
By W. R. COOPER, M.A., B.Sc.

NEW EDITION: Price **10s. 6d.** nett, post free.

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

THE INEFFICIENT STATION.

In surveying the position of electricity supply at the present time one comes to the conclusion that, although the quite small station may be run on economical lines, and though there is, of course, no question that the larger station, if properly designed, sets the ideal in efficiency, there are numerous stations which are neither large nor small, and which are very distinctly unsatisfactory in their working. We refer to stations having a capacity of about 500 kw.-1,000 kw. These stations have probably been working for some 12 years or so. Their prospects are not good, there is very little in the way of power load, and the capital expenditure per kilowatt is high.

Some excellent examples of this class of station are given by Mr. GEOFFREY PORTER in a Paper on "Oil Engines and Steam Engines in Combination," which was read recently before the Diesel Engine Users' Association. This Paper is reproduced elsewhere in our present issue. The first station that is cited has a capacity of 510 kw., the capital expenditure on the station itself is at the rate of £29·1 per kilowatt, the fuel consumption is 12·8 lb. per unit, and the overall thermal efficiency is only 4·93 per cent. Another station has a capacity of 540 kw., with a capital expenditure of £39·8 per kilowatt, the fuel consumption is at the rate of 14·9 lb. per unit, and the overall thermal efficiency is only 2·6 per cent. It is a difficult problem to decide what is the best course to follow in order to improve these unsatisfactory figures. From the financial point of view it is impracticable to scrap all the plant. On the other hand, such a station is not large enough to benefit by the use of steam turbine plant, and although further extension on ordinary steam lines would doubtless prove beneficial, the benefit would not be such as to bring about a very marked improvement.

Mr. PORTER, who is President of the Diesel Engine Users' Association, shows the improvements which have been effected by the use of Diesel engines for extensions. The method of working that has been adopted is to use the efficient Diesel engine plant as much as possible, and to use the inefficient steam plant for taking the peak parts of the load. It appears to us that this is the proper method to adopt rather than the converse arrangement. In the case of plant which is used for peak load work the efficiency is comparatively unimportant, as this part of the load accounts for only a small part of the output. The effect of working the Diesel plant as much as possible is shown in a marked way by the improved overall thermal efficiency of the stations. In the case of the two stations which we have mentioned this efficiency has risen from 4·93 per cent. to 22·6 per cent. in the first case, and from 2·6 per cent. to 6·5 per cent. in the case of the second station. It must be admitted that this is a very marked improvement.

Some engineers may feel that it is a somewhat serious disadvantage to be dependent on oil fuel which so far has been imported into this country, and which may rise considerably in price for one reason or another. This objection, however, is losing its weight through the fact that oil obtained from the distillation of coal in this country is now being used, and is stated to give quite satisfactory results.

Another question that should be considered is the ultimate character of such stations. As they become larger will they continue with Diesel plant, and thus displace the original

steam plant? Or will it be worth while, when a more extensive load comes upon the mains, to increase their steam plant so as to obtain the most efficient results in this direction? The third alternative, which is no doubt the ideal where it is feasible, is to take a bulk supply and to convert such stations into sub-stations. Whatever may be the ultimate solution, there is no doubt that Mr. PORTER's Paper forms a very interesting and practical contribution to the subject of economy in the smaller class of electricity supply station, and will be of assistance to those engineers who are considering what steps they should take to meet the increasing load in stations of this type.

INSTRUMENT TRANSFORMERS.*

BY CHAS. C. GARRARD.

(*Concluded from page page* 501.)

Data for the Design of Current Transformers.—The magnetic density used in current transformers is very small, and therefore the usual particulars which are available as to core loss, permeability, &c., are not applicable. Wild, however (*see* ELECTRICIAN, Vol. LVI., 1906, page 705), has gone into the matter fully, and reference to his article will show how it is possible to secure a great degree of accuracy with a properly

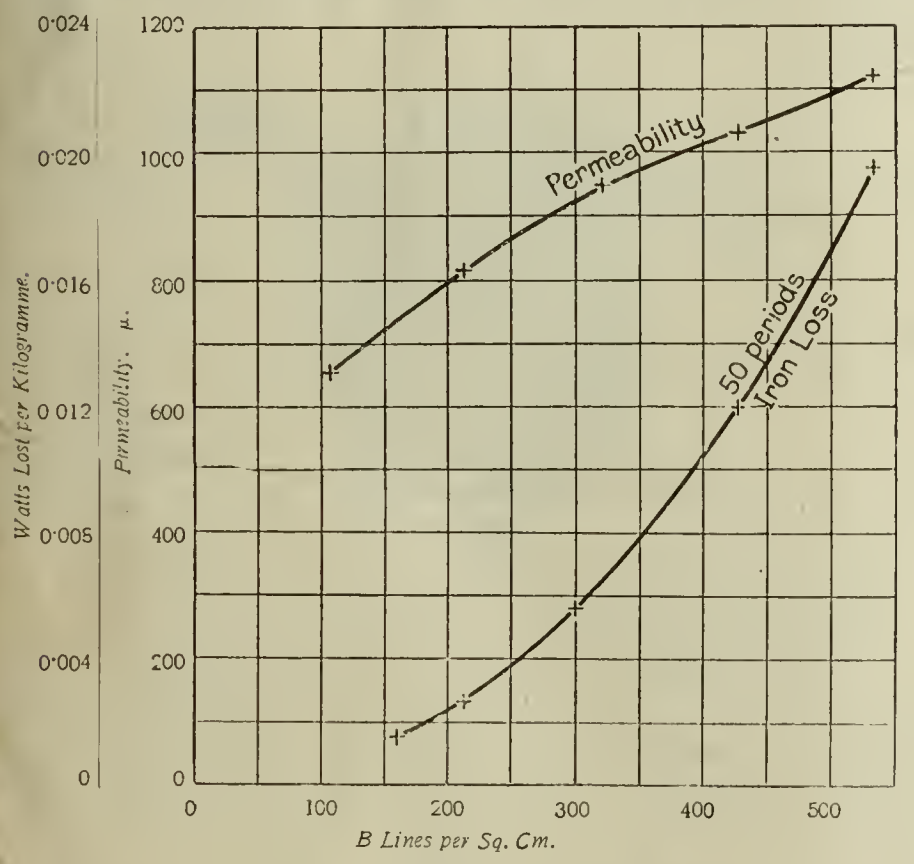


FIG. 6.—CURVES OF WATTS LOST PER KILOGRAMME AND OF PERMEABILITY CALCULATED FROM WILD'S CURRENT TRANSFORMER. TRANSFORMER IRON 0·013 IN. THICK. TWO JOINTS IN THE MAGNETIC CIRCUIT.

designed series transformer. From Wild's figures one can calculate the permeability and core loss of the core used by him, and the figures are given in Fig. 6, as they will be useful to other designers. By using stalloy, which has a higher permeability at these low flux densities, and also a lower watt loss than ordinary transformer iron, still better results may be obtained.

It may be remarked that Wild's figures show that between $B_{max.}$ of 200 and 400 per square centimetre the core loss increases by about the 2·7th power of the $B_{max.}$; instead of the 1·6th (Steinmetz Rule) power, which is the case with densities of 2,000 to 8,000 $B_{max.}$.

Types and Characteristics of Current Transformers.—The first consideration in the design of current transformers is to avoid magnetic leakage between the secondary and primary. For this reason those types consisting of a core upon one leg of which the primary is wound, and upon the other leg of which the secondary is wound, are, as a rule, to be avoided. The best arrangement is to wind the secondary next the core with the primary on top of it. By this means the length of mean turn of the secondary is kept as short as possible, and therefore its resistance will be a minimum. When cheapness of construction is all important, then the primary and secondary may be wound side by side upon the same leg of the core. A transformer constructed upon this principle is illustrated in Fig. 7. This only has 300 ampere-turns per winding at full load, and is suitable for working a single ammeter. A similar

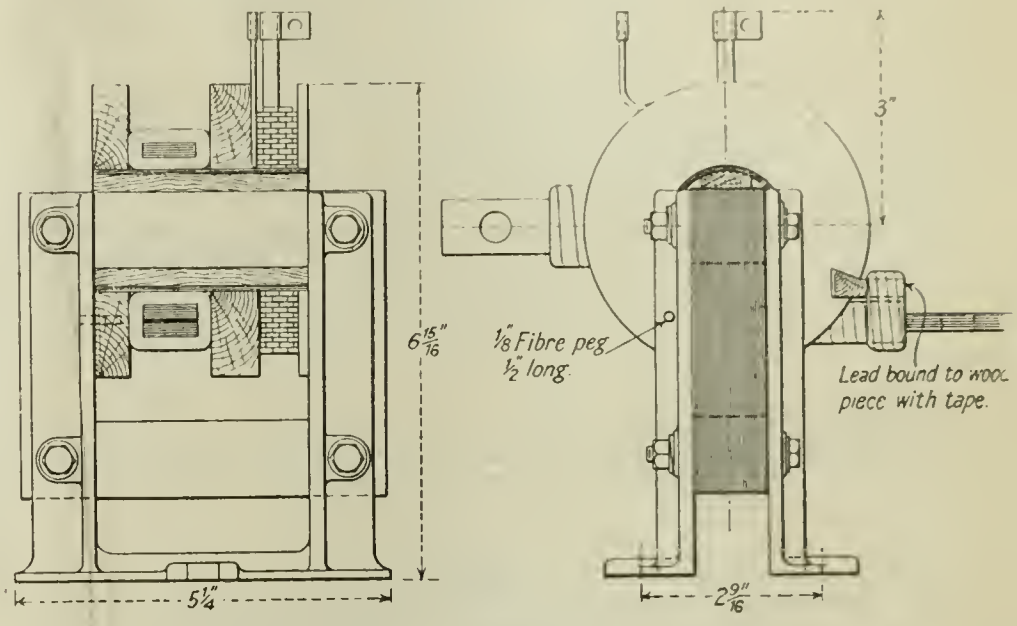


FIG. 7.—OPEN TYPE, 5,000-VOLT, 150-AMPERE CURRENT TRANSFORMER HAVING 300 PRIMARY AMPERE-TURNS.

transformer with a bar primary is shown in Fig. 8. It will be seen that this transformer has the fault mentioned in the beginning of this paragraph—viz., considerable magnetic leakage. Everything has been sacrificed to cheapness; nevertheless, it is suitable for use with a single ammeter. It is necessary with this type to determine the number of turns in the secondary for any particular ratio, load and periodicity, experimentally. The secondary leads should always be placed coming out as shown in the figure, and it must be remembered that the effective number of turns is the number crossing the section AA.

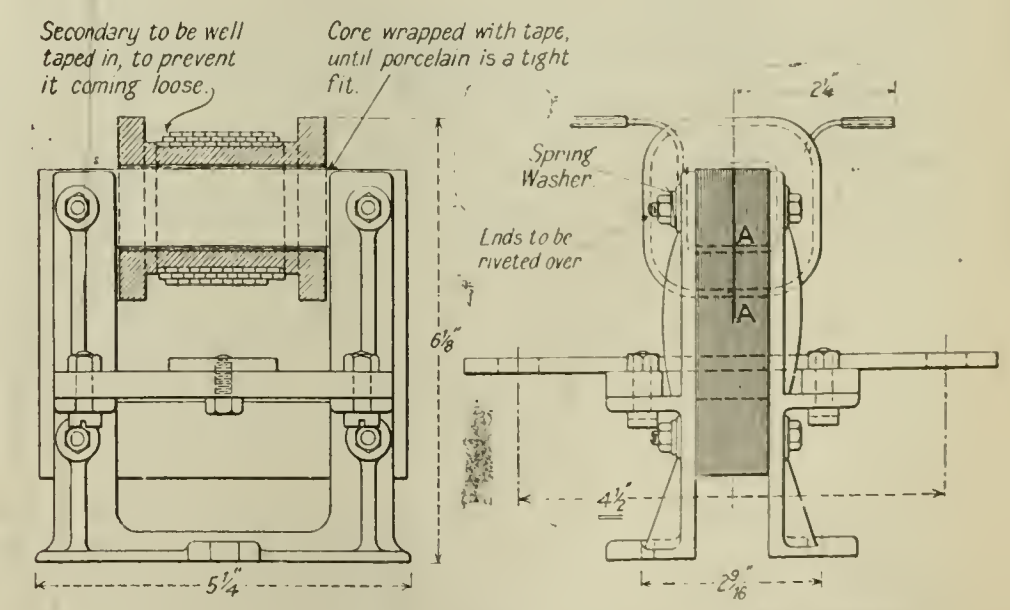


FIG. 8.—OPEN TYPE, 5,000-VOLT CURRENT TRANSFORMER, 300 AMPERES, WITH BAR PRIMARY.

The transformers illustrated in Figs. 7 and 8 are of the core type. Fig. 10 illustrates a shell type which has been used extensively. It is somewhat magnetically leaky.

Bar primaries as illustrated in Figs. 8 and 9 are extremely convenient in switchboard work, as in many instances the actual switchboard conductor may be used without any special primary at all. That is to say, the core with the secondary winding is slipped over the switchboard connection.

* From a forthcoming book on "Electric Switch and Controlling Gear." Copyright. All rights reserved.

Bar types of transformers are further illustrated in Figs. 9 and 11. Fig. 11 has 400 ampere-turns at full load current. Its core consists of circular stampings with the secondary wound (necessarily by hand) over it. The primary goes through an

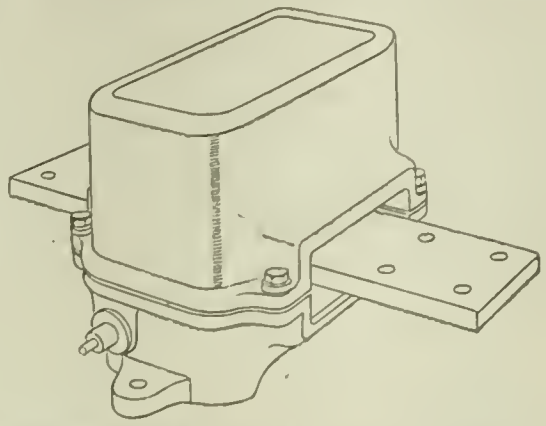


Fig. 9.—Current Transformer having Single Turn Bar Primary.

insulating tube in the centre. This method of construction (circular core discs) is expensive, and does not give any corresponding advantage. Built up cores are to be preferred. Curves showing the performance of this transformer (Fig. 11)

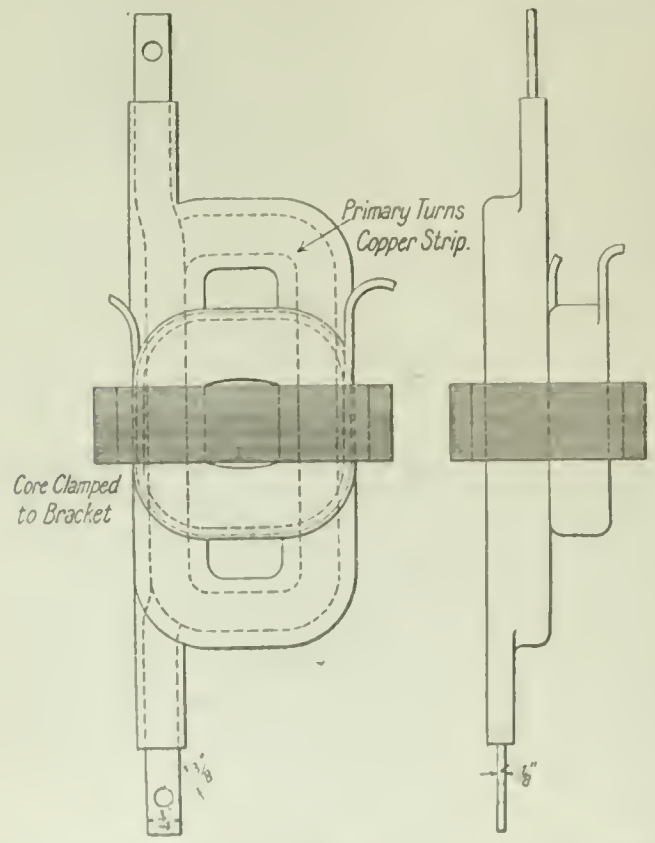


Fig. 10.—Westinghouse Current Transformer. Shell Type.

compared with one constructed on the same lines as Fig. 11 are shown in Fig. 12. The variations in the lower curve from a straight line are to be traced to experimental errors. Fig. 9 is a transformer for much larger currents. The upper portion of the lid should be made of some non-magnetic metal to prevent eddy currents and heating occurring.

A very good form of current transformer is illustrated in



Fig. 11.—Current Transformer (having 400 ampere-turns) for slipping over Switchboard Conductor and having Circular Core Discs.

Fig. 11. It will be seen that the core is designed on generous lines, and that the size is large compared with the usual run of series transformers. It has 1,600 ampere-turns per winding, and the curves in Fig. 13 show the excellent result it is possible to attain with it. It will be seen that the ratio remains constant in spite of change of frequency and very wide fluctuations of the primary current and of the resistance in the secondary circuit. Fig. 15 shows the same type of trans-

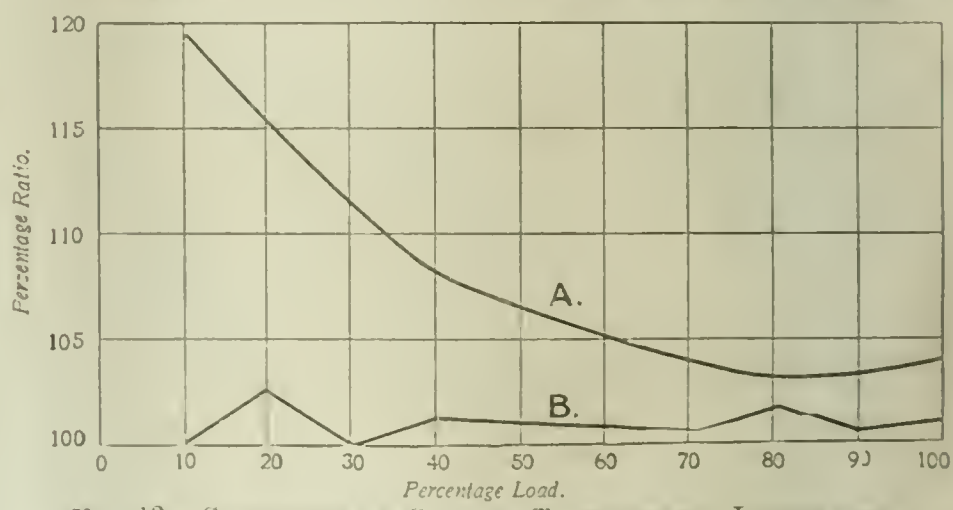


Fig. 12.—Comparison of Current Transformers Illustrated in Figs. 11 and 14.

A=current transformer as in Fig. 11 (400 ampere-turns).
B=current transformer as in Fig. 14 (1,600 ampere-turns).
50 ~ .

former, but for 2000 amperes, primary. In these last two types the secondary consists of two coils in series, one on each limb.

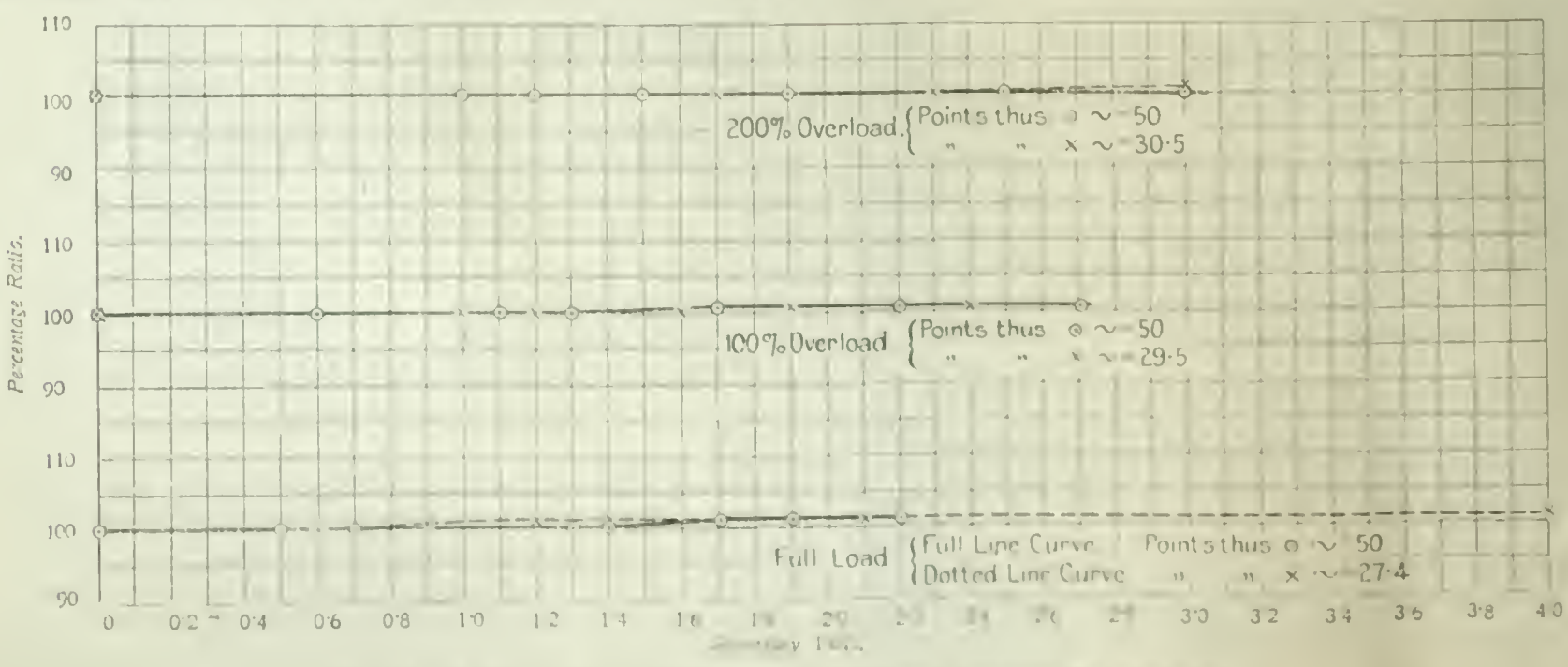


Fig. 13.—Results obtained with well-designed Current Transformer.
Full load secondary current 10 amperes.

The effect of frequency on a current transformer of middling quality is illustrated in Fig. 16.

The curves in Fig. 17, taken from a transformer as illustrated

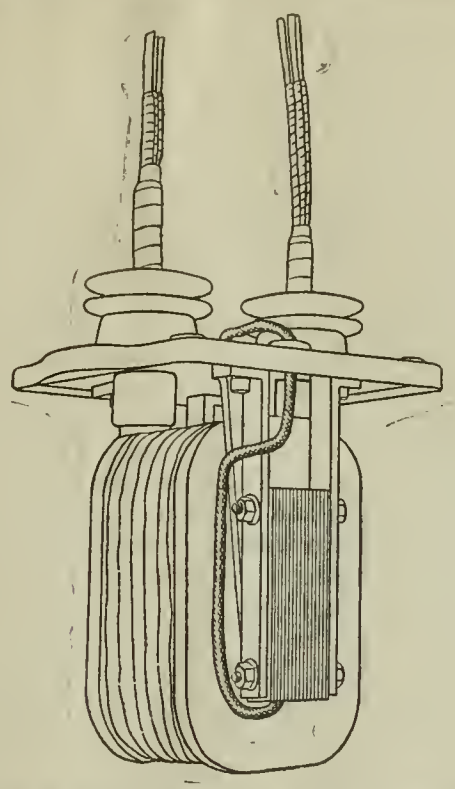


Fig. 14.—Current Transformer for use on 2,000-volt Circuit, and having 1,600 ampere-turns per Winding, with Tank Removed.

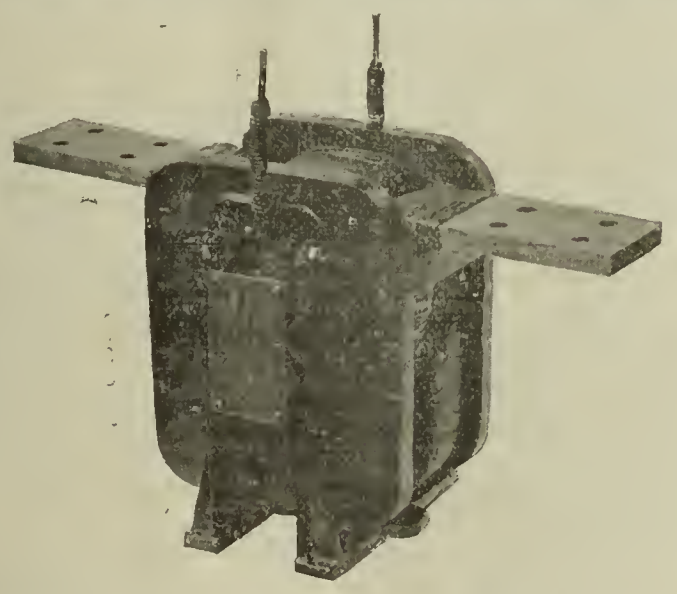


Fig. 15.—Current Transformer having 2,000 ampere-turns per Winding and constructed with Minimum Magnetic Leakage.

in Fig. 8, show the variation in ratio with varying current. This transformer is, of course, a cheaply designed one. With such a transformer it is necessary to take the variation of ratio

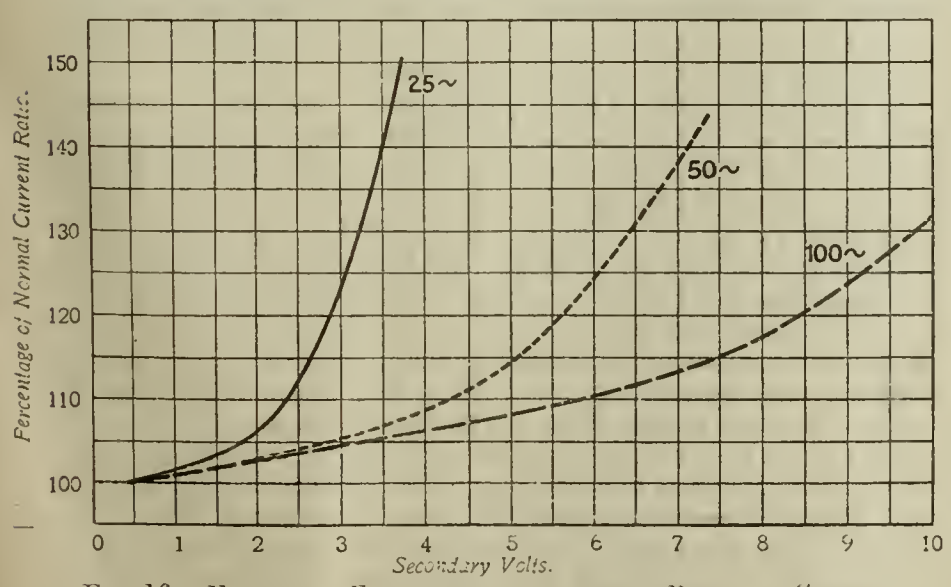


Fig. 16.—Effect of Frequency in altering Ratio of Current Transformer.

Variation of current ratio with secondary volts for constant full load primary current. Secondary load, non-inductive.

into account when marking off the scales of the ammeters. It is, however, not necessary to calibrate each ammeter with its own transformer if the latter are all made alike. For important work it is not advisable to use transformers which have such a variable ratio as this. It is much better to spend the extra money (which is, after all, not a great deal) and have transformers which are constant in ratio under all the varied conditions of their use. The moral which the switchboard designer should extract from the illustrations given in this section is to examine the current transformers offered him critically, and

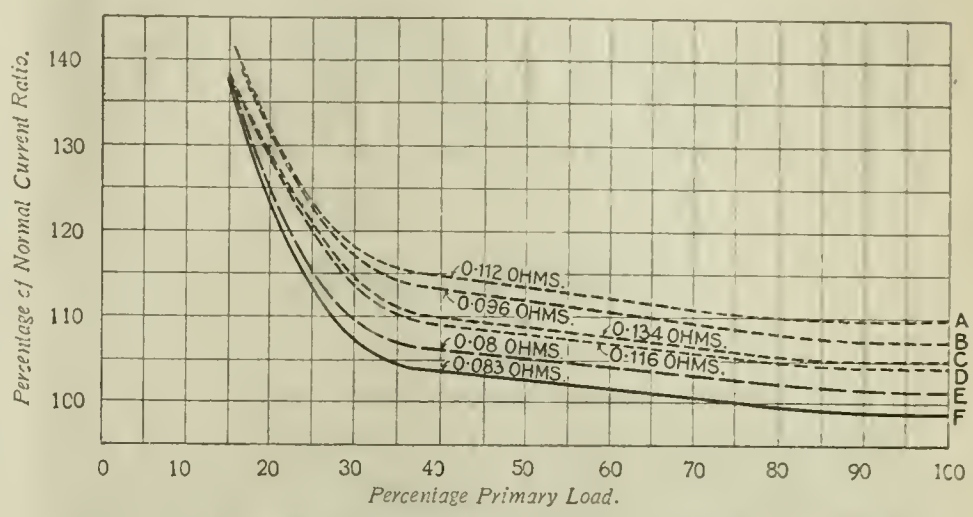


Fig. 17.—Current Transformer illustrated in Fig. 8, 300 to 10 amperes.

Variation of current ratio from $\frac{1}{10}$ to full load with different inductive resistances in secondary. Curves marked A B E = 25 ∼. Curves marked C D F = 50 ∼. The secondary load was inductive, corresponding to the usual instrument and relay load.

by demanding curves of performance such as herein illustrated, satisfy himself that appreciable errors will not be introduced into the metering by the use of the same.

INSTITUTION OF ELECTRICAL ENGINEERS.

TRADE POLICY.

In the current issue of the "Journal" of the Institution of Electrical Engineers the following notes appear, showing that the Council is taking up a new attitude in regard to trade :—

A Committee of the whole Council recently had under consideration certain matters affecting the electrical engineering profession, but shortly before the Committee presented their report to the Council the attention of the latter was drawn to an announcement in the Press that the Board of Trade had decided to appoint Committees to consider the position of certain important British industries after the war, especially in relation to international competition, and to report what measures, if any, are necessary or desirable in order to safeguard that position. It was also announced that two Committees had already been appointed for (*a*) the iron, steel and engineering industries, and (*b*) the shipping and shipbuilding industries.

It was thereupon decided by the Council that a letter be sent to the Board of Trade urging the appointment of a separate Committee on the above lines for the electrical trades, and an announcement appeared in the Press on April 26, 1916, to the effect that such a Committee had been appointed by the Board.

The President of the Institution having been recently invited to give evidence before the Electrical Trades Committee, it was resolved by the Council that the following recommendations, based upon the conclusions reached by the above-mentioned Committee of the whole Council, be submitted by him to the Board of Trade Committee on behalf of the Council :—

1. Some combination of British electrical firms, especially with regard to overseas trade, is desirable.

2. A Government Tribunal of the most independent character that can be devised to be appointed to control the electricity supply industry of the country, and also to prevent indiscriminate addition or extension of power stations or systems undesirable from the point of view of size, locality or system.

3. In view of the necessity of securing the home market and that none other than British electrical apparatus be purchased in the United Kingdom, a protective tariff to be set up, notwithstanding such benefits as will in any case result from patriotism.

4. A permanent Advisory Committee to be appointed to ensure that as far as possible raw materials and parts, as well as whole apparatus, necessary to the trade of the British Empire shall be produced within the Empire.

5. (i.) British-born Electrical Attachés to help in the Consular service ; and (ii.) Trade Commissioners (scientific and technical commissioners, as

suggested by Mr. Pollard Digby, I.E.E. "Journal," Vol. LIII., p. 799, 1915), to be appointed.

6. British engineering standards to be adopted throughout the Empire.

7. The use of the metric system to be made compulsory after a reasonable period; and during this period all trade catalogues to make use of both the British and metric systems.

8. The Institution to be granted a charter, so as to improve the status and training of electrical engineers.

9. A Central Engineering Board, consisting of representatives nominated by all the important institutions, to be established whom all engineers (other than mechanics) would be required to satisfy as to the sufficiency of their technical training and general education before they could be recognised as proficient, so as to ensure that every engineer shall qualify for his profession in the same manner as a doctor or solicitor.

10. Closer co-operation of manufacturers and other employers of electrical engineers with the technical colleges is desirable to ensure that students are trained to meet the future need of the industry.

CORRESPONDENCE.

S. P. THOMPSON.

TO THE EDITORS OF THE ELECTRICIAN.

Referring to Mr. Eborall's appreciative letter, I do not think that the practical realisation of a memorial to our dear and distinguished friend would be suitably set afoot by myself, but rather by some wide embracing organisation with which he was prominently associated—the Institution of Electrical Engineers, for example.

My little effort was only by way of adding a personal tribute of admiration and affection to his memory, incited, in fact, by the altogether admirable article of Dr. Russell.

Westminster, July 17. CHARLES BRIGHT.

TO THE EDITORS OF THE ELECTRICIAN.

With reference to the correspondence which has appeared in your columns concerning a memorial to the late Prof. Silvanus P. Thompson, I have to inform you that the Finsbury Technical College Old Students' Association had already taken the matter up and are now engaged on the formulation of a scheme to enable all those interested to perpetuate the memory of the deceased in a suitable manner.

Westminster, July 19. JOHN E. RAWORTH,
President, the Finsbury Technical College Old Students' Association.

[We are glad to note that action is being taken with a view to a comprehensive scheme.—EDS. *E.*]

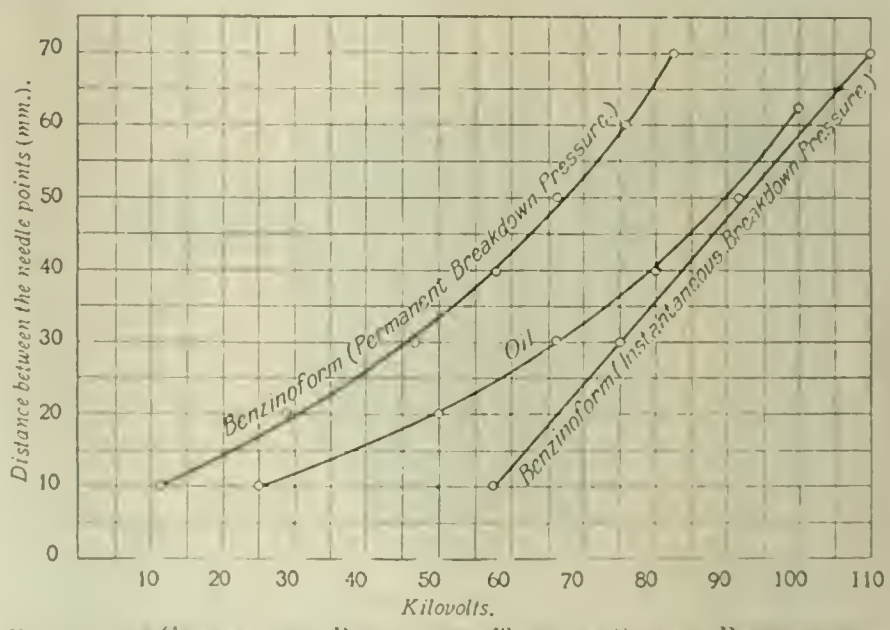
THE USE OF CARBON TETRACHLORIDE (BENZINOFORM) WITH HIGH-TENSION SWITCHES.*

BY M. VOGELSANG.

Although it may be possible by proper design to prevent an explosion in an oil switch, the inflammable nature of the oil is a constant source of danger. Moreover, if a fire should be started, the presence of a considerable quantity of burning oil might cause serious trouble. The firm of Voigt & Haeffner has lately made experiments with a view to providing a substitute for the oil commonly used, and has investigated the properties of carbon tetrachloride, which is known in the trade under the name of benzinoform. The results of the preliminary tests are now known, and though the new proposed fluid has some unfortunate properties and peculiarities, it may be of interest to describe what has been done. The possible use of benzinoform was originally suggested by E. Peyrusson, of Paris, in his German patent 218,399, dated December, 1908, but this patent has since expired. Peyrusson described the nature and properties of benzinoform, and laid stress upon its characteristics as an insulating medium. It was proposed to prevent volatilisation by covering it with a layer of water or glycerine, or, better still, by a mixture of equal volumes of the two. The author began experiments on the subject in 1911, without any knowledge of the existence of this patent. This was continued after the war began, as oil became very scarce; but the conditions soon became reversed, oil was fairly plentiful, benzinoform was hardly to be obtained, as the raw materials were not to be had, and there was no glycerine on the market.

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 12, 1916.

As for benzinoform itself, it may be said that carbon tetrachloride is a fluid of specific gravity 1·63, boiling at 76·5°C., and solidifying at —26·7°C. It volatilises easily when exposed to the air. The specific gravity of the oil, ordinarily used in switches, is 0·91; the difference in this respect is therefore very great. With regard to volatilisation, it was found that an ordinary closed oil-switch lost 1 mm. of fluid a day. A packing of felt was then introduced, and this reduced the loss to 0·5 mm. But this plan would have introduced other difficulties. Another suggestion was to cover the surface to some extent with a kind of float; but this produced practically no effect at all. The affinity of benzinoform for other substances is an important matter. Various samples were immersed in the fluid for more than a year. Copper was scarcely attacked at all at normal temperatures; at 45°C. it was gradually covered with a white slimy layer, which sank deeply into the metal. Aluminium, silver, and lead were scarcely attacked at all; but the best results were given by tin, and the tinning of metallic parts, exposed to the fluid, seemed, therefore, the best solution. Rubber, vulcanite, pertinax, and micanite were found to be completely useless. Fibre and mica were free from any signs of attack. Tests were then carried out as to its insulating properties, and there was found to be a great difference according as the breakdown voltage was applied permanently or momentarily. The results are shown in the Figure. The spark passed between needle-points. One curve shows the breakdown voltage required to break down the medium at once—*i.e.*, within two seconds; the other shows the breakdown voltage which just suffices to produce the effect in 20 minutes. The fluid was brown, as it had been used on short-circuiting tests, but this scarcely affected its insulating properties. The tests were scarcely exhaustive, as too much time would have been required, and this in war-time was not available. But sufficient was done to establish the fact that the



RESULTS OF COMPARATIVE BREAKDOWN TESTS IN OIL AND BENZINOFORM.

fluid was quite suitable for use on high voltages. The fact that it behaves very well on momentary surges is very useful; in practice, surges of this character constitute the real danger. Electrification causes a considerable commotion in the fluid. This is also the case with oil, but not to the same extent, and this may explain the differences in the breakdown voltages noticed above.

In September, 1914, a switch, filled with benzinoform, was put into steady use in the test room. It was covered with a layer of glycerine. It was kept under steady observation through a glass window. The first important fact that was noted was of a decidedly unsatisfactory nature. Within a month all the copper parts were covered with a slimy green layer. But this was found to be due to the glycerine, and to have nothing to do with the insulating fluid itself. The ordinary type of oil switch cannot therefore be used with benzinoform, if a layer of glycerine is used. This switch was used on very different pressures up to 10,000 volts: the ordinary pressure was about 5,000 volts. After six weeks, there was a flash-over on 5,000 volts, which took place between the copper and the glycerine. The switch was then replaced by another, in which the insulators were deeper immersed in the fluid. Up to the end of 1914, short-circuits were made daily, and nothing happened till the end of March, 1915, when another accident occurred. It was then found that the level of the fluid had fallen 26 mm. in consequence of a slight leakage in the case, and it may be remarked that such leakages cannot be noticed from the outside, on account of the volatility of the fluid. This is quite different from oil: there the leakage of a few drops always causes an oily patch, which is easily noticed. The tests with this old type of oil switch were of interest, as it was very frequently used on very different pressures. It was used in con-

nection with a transformer, which took about 50 k.v.a., but it was not connected immediately to the network. It was therefore considered desirable to connect it to the 3,000-volt single-phase supply from the central station at Frankfort. The works were supplied with direct current through a group of converters. Four switches for the converters were filled with benzinoform in the spring of 1915. The switch connected to a 220 kw. transformer was most frequently used; and it was also the one with which most of the trouble took place. After some days, it refused to work; this was found to be due to defective lubrication; ordinarily the oil lubricates the contacts. The strength of the springs was adjusted; but the same thing happened again soon after. The strength of the cut-out coil was increased, and the trouble ceased. One night the whole room was filled with vapour, and this was thought to be due to the glycerine. The switch was then cleaned out, but the same thing happened again, and was doubtless due to the frequent use of the switch and the consequent agitation of the layer of glycerine.

It naturally seemed desirable to see how a switch of this type could deal with a serious short circuit, and arrangements were made to carry out a test on a machine giving 1,100 kw. single-phase power at 3,000 volts; it was driven by steam power with a reciprocating engine. The test was made as severe as possible, in view of the fact that the voltage was not very high. The switch chamber contained 75 litres of fluid, the distance from the contacts to the surface of the glycerine was 195 mm., and the depth of the layer of glycerine was 18 mm. The precise nature of the adjustments and arrangements are described by the author in some detail. Suffice it to say that a three-pole switch was adapted unsymmetrically to the purpose, and that the tests were fairly satisfactory in their results up to pressures of 3,250 volts. There was a considerable excess of vapour pressure in the box when the switch operated, and the metallic parts were in places attacked by the arc. The contact pieces were in some measure covered partially with a black deposit which could be easily removed by the finger. But more particularly was there a sign of defective lubrication of the contacts, which was very noticeable when compared with oil; and this effect has been already noticed. It is therefore necessary to increase the strength of the springs, if the switch is to operate with certainty on a short-circuit.

Thus we see that these preliminary tests do not seem to indicate that benzinoform is in all respects a satisfactory substitute for oil. The volatile nature of the fluid and the probable necessity of using glycerine to prevent it seems likely to cause trouble in practice. A closed type of switch seem most suitable, in which the leading-in insulators are at the bottom. This kind can generally be so designed that the moving parts, which pass through the layer of glycerine, can be limited to a rod; and this diminishes the difficulties due to the glycerine. Thus a practical form of switch, capable of being used with benzinoform, could be supplied, if it were found that there was any demand for it.

The question can, of course, be dealt with in another way, if the requirements are not set too high. Benzinoform mixes with oil in all proportions; such a mixture of the two can be had, which volatilises very slightly, and which, as compared with oil, inflames with some difficulty. Some preliminary trials were made with a view to getting a suitable mixture, and it was found that a mixture of one volume of benzinoform with three of oil seemed likely to work. If this mixture is kept at a temperature of 100°C. for three hours, only 5 per cent. volatilises; this is a great improvement on benzinoform, which boils at 76·5 deg. In such a mixture, the volatility of benzinoform may be a positive advantage; but lengthy tests have not yet been carried out. Such a mixture of benzinoform with oil may constitute an improvement on the use of oil alone, but it cannot be regarded as doing away with the risk of fire entirely, or even more than very partially. Some time before the war a "non-inflammable switch oil" was on the market, and it seems probable that this was a mixture of benzinoform and oil. The whole problem is, perhaps largely a chemical one, and may be recommended to those chemists who have an interest in such things. It has long been supposed that inflammability and insulating capacity must necessarily go together in an oil, and thus it seemed that any oil, suitable for a high-tension switch, must expose the installation to a certain fire-risk. But the above facts and experiments seem to show that this is not the case, and that a practical solution of the problem is quite within the bounds of possibility.

Midland Railway (London, Tilbury & Southend Railway).—The Midland Railway Co. has applied to the Board of Trade for an extension until the 1917 session of the period limited by their Act of 1914 for the powers for working by electric traction the company's railway by the direct route from Fenchurch-street to Southend-on-Sea.

LONDON COUNTY COUNCIL TRAMWAYS.

At the Council meeting on Tuesday the annual report and accounts of the tramways department for the year ended March 31, 1916, were submitted and adopted. The following details are taken from the statement which appears in the minutes:—

The system on March 31, 1916, extended over 150¼ street miles, being 144½ miles electric and 5¾ miles horse lines, but the services on the horse lines have been withdrawn. Income was £2,339,291 and working expenses (including war service allowances) were £1,683,660, surplus on working being £655,631. Interest (gross) required £326,476 and redemption £425,907, rent drawbacks, &c., £6,797, income tax (schedule D), in addition to property tax included in working expenses £40,000, Parliamentary expenses £2,260; total £801,442. Added to the above-mentioned surplus (£655,631) is £72,016, made up as follows: Tax deducted and retained from interest on debt, £48,971; interest on cash balances, &c., £5,372; rents from surplus property, £11,461; debt charges on moneys advanced to London United Tramways for reconstruction of tracks, £4,494; debt charges on cars and car sheds in respect of excess mileage run by Council on behalf of Metropolitan Electric Tramways, £1,704; surplus on Drake-buildings (re-housing obligation, Greenwich generating station), £11, so that there was a total of £729,426 to set against the amount of total expenses (£801,442), leaving a deficiency to be met out of the general reserve fund of £73,795. Renewals fund amounts to £329,967. There has been no payment into this fund since 1912-13. General reserve fund, after meeting the deficiency of £73,795 on the year's working, amounts to £70,118. In the case of both funds the balances stated take no account of the depreciation of investments, which on present prices amounts to about 20 per cent. Operating expenses were £1,588,295 (excluding war service allowances of £95,364). Passengers carried were 545,423,397; car-miles run were 47,879,675. The corresponding figures for 1914-15 were 550,497,993 and 58,978,792.

The tramway strike, involving a loss of over £100,000, occurred in the second month of the financial year. Further, there is the special charge of £10,000 for the removal of the old horse lines in Liverpool-road. It is not possible to draw conclusions as to the financial prospects of the undertaking from the position under the existing abnormal conditions. Capital expenditure amounts to £13,516,576, an increase of £200,853 during the year. Debt incurred to March 31, 1916, was £13,930,659, and net debt, less the sinking fund in hand, and less £120,216 in respect of the value of surplus land, was £9,580,991. Capital expenditure becom ng obsolete owing to the electrification of horse tramways was £2,024,687. Deducting the amount provided for the redemption of the debt in respect of such capital and the proceeds of the sale of horses and old materials, the amount still to be provided for in respect of the debt under this head is £971,877. Certain other expenditure amounting to £84,788, incurred in connection with electric traction, has also been rendered obsolete, and the amount still to be provided in respect of the debt thereon is £12,094. The sum pa'd as rates on the permanent way was £82,927. The saving to the road authorities in consequence of the obligation of the Council to maintain the paving along the tramway routes is estimated by the Council's officers at about £140,000 a year, this estimate being based, of course, on the normal standard of maintenance. The amount chargeable to tramways account in respect of the cost of effecting street improvements carried out along tramway routes is £800,252, of which £689,317 had already been so charged, whilst in addition the amount estimated to have been paid to tramway companies (as part of the purchase money for their undertakings) in respect of the expenditure incurred by them on street improvements is £40,576. The whole of the latter amount has been charged to the tramways account, making a total charge of £729,893.9s.9d.

With regard to the steps taken to improve the position of the undertaking, the Highways Committee say they have frequently drawn attention to the serious extent to which the tramways suffer through not being able on many of the routes to carry passengers to their desired destination. The difficulty would be to a large extent met as regards many routes if the present termini could be linked up with one another or the tramways extended to better recognised traffic points. On Nov. 10, 1914, the Committee submitted the first portion of a comprehensive scheme of development for submission to Parliament. Having regard, however, to difficulties arising out of the war, the Council decided not to proceed with any schemes to which the road authorities offered opposition, with the result that Parliamentary authority was obtained only for one short connecting line. The third turbo-generator for the Greenwich generating station is now in course of manufacture, but by arrangement with H.M. Treasury no arrangements for the supply of the fourth will be made until after the war. The delay in the delivery of the second and third turbines owing to the requirements of the Government necessitated the purchase of power at enhanced rates. The tramways system has been linked up with another source of electrical supply so as to ensure against the complete stoppage of the tramways services in the event of a failure of the Council's own power supply. Inquiries are now being made whether further steps can usefully be taken in the direction of inter-connection for reciprocal supplies of power. Additional cables have been laid, particularly in the Woolwich district, in order to augment the supply of current and thus allow of increase in the car services. 150 trailers have been ordered and 120 are now in service. Greater progress would have been made with the work of electrification but for the war. For instance, the construction of the Lee Green to Eltham tramways, which would have linked up two dead-end termini, was commenced in January, 1915, but the work had to be stopped in

consequence of the war. Through running and through bookings are in operation on various routes partly within and partly without the Council's tramways system.

Owing to shortage of staff, car services have had to be reduced, and much overtime has had to be worked, including the employment of men in excess of the normal six days a week, at overtime rates. It was not until October, 1915, that the Commissioner of Police of the Metropolis agreed to license women as conductors on tramcars in the metropolitan area, and since then a large number of women have been trained to act in this capacity on the Council's cars, the number of such women now employed being 1,150. There is still, however, a shortage in the number of motormen required to enable a full service of cars to be maintained. Again, the speed of cars after dark has had to be appreciably reduced owing to the lighting restriction orders. A considerable increase has taken place in the cost of materials, particularly coal. If the price paid for coal had been that quoted in the contracts entered into before the war the expenditure during the year would have been £74,293 less.

The annual estimates of the Highways Committee in respect of tramways for the financial year 1916-17 were also submitted and adopted by the Council. The amount of the capital estimate appearing in the volume of capital estimates was £132,055, but on June 6, 1916, a revised estimate of £134,805 was submitted so as to provide for expenditure of £2,750 proposed to be incurred in respect of the doubling of further sections of the Woolwich tramways, and the Council on that date approved, for the purpose of obtaining borrowing powers in the L.C.C. (Money) Bill, 1916, the supplemental estimate of £2,750. The following is a summary of the estimated results for 1916-17 : Surplus on working, £655,355 ; interest on bank balances and sundry rents, &c., £19,110 ; total working surplus, £674,465. Charges against working surplus : Debt charges (including £429,851 for repayment of capital and £313,273 for interest on capital expenditure), £743,124 ; income tax (less tax deducted and retained from interest paid), expenditure on surplus property and sundry items, £5,433 ; total, £748,557. Net estimated deficiency, £74,092. The general reserve fund will in the first instance be used to meet the estimated deficiency. Passenger traffic receipts are estimated at 11·50d. per car-mile, compared with 11·42d. a car-mile, the actual receipts for 1915-16. It is estimated that the total rates payable in 1916-17 will amount to £113,735. The estimates include a provision of £23,420 for interest on capital outlay and £12,461 for repayment of debt ; total £35,881. The estimates contemplate no sum being available for addition to the renewals fund in 1916-17. The balance of the fund at March 31, 1917, is estimated at £241,761 ; but this figure takes no account of the depreciation (about 20 per cent. below purchase price) of investments. The amount which it is estimated will be expended during 1916-17 out of this fund is £96,300.

On the basis of the transfer of £74,092 referred to above to meet the estimated deficiency, the balance of the general reserve fund at March 31, 1917, is estimated at £6,798. The accounts for 1915-16 show that the actual deficiency of that year is £9,635 more than appeared probable when the estimates for 1916-17 were framed. Taking this into account, the general reserve fund will be more than absorbed by the estimated deficiency of 1916-17 should such be realised. In arriving at the balance of £6,798, the value of investments has been taken at cost price, and if these investments had to be realised at present market prices the amount left to be found from some other source to meet the estimated deficiency on the current year's working would be still further increased.

The Finance Committee stated that they view with anxiety the probable continuation of the deficit as a result of the current year's working of the tramways, but the undertaking is being worked under abnormal and adverse conditions arising out of the war.

The estimated expenditure on capital account is £134,805, including reconstruction of tramways for electric traction and construction of authorised new tramways (£53,105) and power generating station, Greenwich (substitution of reciprocating engines by turbines and incidental works) (£81,700) ; and on revenue account £1,914,640, including power expenses (£338,665), traffic expenses (£751,800), advertisement expenses (£5,450), repairs (£336,800), general expenses (£196,075), special charges (£13,000), war service allowances (£122,500), income tax (£51,000), expenses of temporary investments (£50), renewal of special trackwork, rails, tee rails, &c. (£96,300).

PARLIAMENTARY INTELLIGENCE.

TECHNICAL EDUCATION.

In the House of Lords last week Viscount Haldane rose "to call attention to the training of the nation and to the necessity of preparing for the future." He said we had been lacking in the scientific direction of our abundant energy. Some aptitudes lay in the realm of science, and it was necessary to take account of different aptitudes and train men according to their aptitudes. Science and the application of science were increasingly becoming a necessity for the training of a very large number of our people, but they were discouraged because nearly all the scholarships in the universities were allocated to the professions. It was not enough to do anything short of reforms which would improve our training system itself—the quantity and quality of the teachers—and make education more interesting and comprehensive, so that when boys wished to go forward to a particular industry and science, they might go with their minds so trained that they might be able to take up and absorb the scientific ideas which they were to put in practice.

We suffered in this country from want of experts. There were only 1,500 trained chemists in this country, although four German chemical firms employed 1,000 chemists. By proper means we could produce in this country the whole of the motor power which we used from one-third of the coal we actually consumed in doing so. In the various stages of consumption and of the making of by-products we wasted as much coal as would pay the interest on 500 millions after the war. We had men of the highest science and knowledge, but we had not enough to go round. Since the beginning of the century 10 new teaching universities had been called into existence. That was a great step forward, and, given some improvement in the system of secondary schools, we should get an immense deal out of it.

The Earl of Cromer said it would be deplorable if the result of the interest now being taken in educational subjects was that the discussion degenerated into an undignified wrangle between the advocates of science and the humanities. He agreed with Prof. Freeman that the classics should be the objects of a reasonable homage and not of an exclusive superstition. But when he observed that some of the extreme advocates of science were prepared to deny the classics any claim to be formative of character, he must enter an earnest protest. He could conceive nothing more disastrous than to place the whole education of the country on a strictly utilitarian basis.

The total moral collapse of Germany was one of the most tragic events recorded in history. He could not help feeling that one of the causes of that deterioration was that the atmosphere created by humanistic study having lost its hold upon German public opinion, the whole national mind of Germany had apparently become materialised. On the question of university reform he thought the present moment was singularly opportune for taking it up. He was told that the governing bodies of the older universities would be inclined to adopt reasonable and liberal reforms but that they would object to drastic changes. He hoped the Government would introduce legislation on the subject. As to financial considerations, he held that it would be false economy to stint education, but he feared that our financial situation at the end of the war would be such as would render it impossible for us to spend as much money on education as many of them would certainly like.

Viscount Bryce agreed that this was the time when, if ever, we must consider what should be done to set our house in order in every way. He believed that the English universities performed the function of teaching people to think as well as any universities in the world, though he did not deny that they were capable of improvement. At present money was not so much wanted in education as its proper application. What did need improving was the teaching ; and that could not be done without making the teacher's career more attractive. The Germans did not exclude literature in favour of science ; indeed, he had often heard it stated that German experience had been that boys who had gone through the classical side of their schools did better in after-life than those who had received direct scientific instruction in the schools. He did not share the view that there was a lack of scientific experts in this country. There would be more experts if there were more demand for them ; but the business community in Great Britain, unlike the business communities in America and Germany, did not appreciate sufficiently the important effects which scientific discovery and the application of science to their industries might have upon their business. After some further discussion the debate was adjourned.

In the course of the discussion in the House of Commons on the Education Vote on Tuesday, Mr. A. Henderson, President of the Board of Education, said the services rendered by the technical schools in munition work and the training of munition workers had been of the highest possible value, and this applied in even greater measure to the universities. Their services to the State during the war had been of incalculable value, but not, he thought, greater than the services they would render when peace came. There was, he believed, a growing recognition on the part of manufacturers of the importance of applying science to all industrial problems, and there was a growing intimacy between the universities and the industrial workers. One of the three Committees appointed to deal with education would inquire into the position of science in our system of education.

Sir Philip Magnus said he regretted the closing down of some of the evening technical schools. Some of the literary or historical classes might to greater advantage have been closed down than those connected with instruction in the application of science to industry. He hoped that in any reform of education it would be provided that science masters should be regarded as being in an equal position with the classical masters and should have the same opportunities of advancement and be paid equal salaries.

Mr. R. Macdonald hoped the Board of Education would not encourage those scientific gentlemen who demanded that the humanities should be cleared out of our schools. He was not satisfied, however, with the present position of scientific training in this country. It must be a part of a liberal education. Standing apart it could not be considered as an education. He hoped the programme of educational reconstruction would begin with a Royal Commission to inquire into university education.

Sir H. Hibbert thought the time necessary to learn Greek would be far better employed on modern languages and science so far as the youth intended for commerce was concerned.

Mr. A. Henderson said he had come to the conclusion that a Royal Commission would not be the best machinery to adopt. In addition to the three Committees he had mentioned there would be a fourth selected from the Prime Minister's Reconstruction Committee. The others would not be Cabinet Committees but Committees of experts appointed by the Prime Minister in consultation with the Board of Education.

REGISTRATION OF FIRMS BILL.

A Select Committee of the House of Lords state in their report on this Bill that it was not thought necessary to call much evidence as to the existence of a public demand for the Bill, as the commercial community throughout the country has for a long time made that clear. The Committee invited observations from the General Council of the Bar, and received from it valuable suggestions. The Committee think the title of the Bill should be "Registration of Business Names," as the Bill is not confined to trading firms, but includes professional partnerships. It is proposed that anyone coming within the Act who does not register shall be disabled from suing on a contract made while he is in default, but that the Court in proper cases shall be able to give relief from this disability. The Committee anticipate that the Board of Trade will issue a simple form to be obtained and filled up at any post office. The proposed fee for registration is 5s. The Committee submit the Bill to the House as one which ought to be pressed forward without delay.

EXCESS PROFITS TAX.

On the report stage of the Finance Bill in the House of Commons last week Mr. McKenna agreed to introduce a new clause making a concession to controlled munition establishments, allowing them for the income-tax assessment to include under the heading of expenses of the business sums spent on building or plant provided for the purposes of the Ministry of Munitions. The buildings would be assessed at the post-war value.

Telegraph (Construction) Bill.—In the House of Commons on Tuesday the Postmaster-General (Sir Joseph Pease) introduced this Bill to amend the Telegraph Acts, 1863 to 1915, with respect to the construction and maintenance of telegraph lines.

LEGAL INTELLIGENCE.

Alien Enemy Patents.

On the 13th inst. the Suffolk Electricity Supply Co. applied for a licence under Aust's patent, No. 4,909 of 1909.

It was stated that the application was made by the Suffolk Electricity Co. (Ltd.) through its secretary (Mr. Napier Prentice), and was for a licence to use patent 4,908 of 1909 in the name of Konrad Aust, of Berlin, for a device for employing tar oil instead of American oil fuel in Diesel engines. The company desired to use it especially in connection with their plant for supplying Felixstowe with electricity. The invention provides for an arrangement whereby in an internal combustion engine of the Diesel type, in which the fuel is injected by a gas under pressure through an atomiser, a small portion of fuel is supplied directly to the admission part of the cylinder without passing through the atomiser through a separate duct, this duct being cut off from the chamber only during the ignition period. The appliance, in substance, is an auxiliary pump, which injects oil of lower ignition temperature in advance of the main fuel oil. It was explained that by this contrivance the temperature of the air is raised for the ignition period by a small injection of petrol, giving sufficient temperature to vaporise the tar oil.

The application was opposed by Messrs. Mirrlees, Bickerton & Day (Ltd.), of Hazel Grove, Stockport, the sole British licensees, for whom Mr. Courtney Tirrell appeared.

Mr. NAPIER PRENTICE stated that the Suffolk Electricity Co. hoped, with the aid of the device, to cut down their fuel bill by half. He was not attracted, however, by the tenders he had received from manufacturers whom he had approached for making and fitting the appliance. He had been asked £363 for fixing it to two engines. He understood that this was because of the price fixed by the British licensees from the German, Mirrlees, Bickerton & Day. If the Board of Trade would give him a licence to make that auxiliary pump—and he asked for it in the public interest—he was confident, as an experienced engineer, that he could fit the thing for £60 to two engines. For 112 tons of oil, which the company used last year, at the present price the cost would be £960. By using tar oil for a similar amount of work the cost would be brought down to £576. But if it cost £363 to fit this apparatus for 470 H.P. to only two engines, it could hardly be worth while to makers of electricity, unless it were guaranteed that the war would last more than another year. The purchase of American oil was against the national interest to-day; it was to the national interest to encourage the use of tar oils in Diesel engines. There was no patent to hinder the manufacture of Diesel engines here, and there was no difficulty in getting them. The wide use of that special apparatus would be to the advantage of the general electricity supply of the country. Personally he should take an ordinary engine and make an alteration in it.

Counsel for the opponents said the firm paid a large sum for the licence—£1,500 down. They had the equipment and plans for making, and could meet the entire demand. If there was anything they could not cover they were ready to issue licences to sub-licensees.

Mr. TEMPLE FRANKS: Legal opinion as to your licence would be that it is suspended during the war. If that is so we may treat your licence as non-existent. I am not sure you ought not to come here to get a licence yourself.

Mr. TIRRELL: It may be that is what we ought to do. However, we have either supplied or contracted to supply 22 firms with a total horse-power of over 4 000.

Mr. TEMPLE FRANKS: I gather that electrical firms cannot readily get the other oils. Tar oils they can only employ economically if they use this improvement. You are the only people who can supply this improvement at present, and you can charge what you like. If you charge a reasonable price I admit there is something to be said for maintaining your position; but the Board of Trade must supervise, and here comes the opportunity for us to exercise that oversight.

Mr. CHARLES DAY, managing director of the opposing firm, said that on Nov. 29, 1912, they entered into agreement with the patentee by which they paid £1,500 in cash and agreed to pay a royalty of 2s. 6d. per horse-power on all engines fitted. They experimented to ascertain how many varieties of tar oil could be used with these engines, and had to set up an installation for distilling tar oil. In the beginning they found as great difficulty in getting tar oil as the Suffolk Electricity Supply Co. now found in getting petrol. They engaged a chemist who had been chemist for a tar distillery, and had to use their distillery for the supply of tar oil to their customers. Including payment for the patent, their preliminary expenses came to £3,000. In their price they added the 2s. 6d. royalty for the patentee and 2s. 6d. for themselves, to go to a sinking fund to recoup themselves for the preliminary outlay. The price of fuel oil began to mount up a year after the outbreak of the war. It had been from £3 to £4 a ton. In January last it was £8 to £9. Tar oil cost £3 or £3. 10s. Mr. Prentice said he hoped to get it at £4. It varied according to the district. That complicated and delicate piece of apparatus required considerable skill to install. Personally he should object to any stranger fitting it to an engine he had anything to do with. The £360 price cited was not unreasonable. He read a Paper before the Diesel Users' Association in January, drawing attention to the apparatus and the national importance of using tar oil. His firm were pioneers in the matter, yet he found the Suffolk Electricity Supply Co. proposing, after that interval, to go into the business without so much as asking them for an estimate for manufacture. They had not had an inquiry from them. He said in the Paper that the cost to the buyer would be in the neighbourhood of £1 per horse-power. He thought he could bring that figure down, but the thing required superior and special workmanship, and they desired to maintain the reputation of the apparatus and of the Diesel engine. To everyone who made that type of engine they had offered a licence to make that special apparatus, too, giving the benefit of their experience as to details of manufacture and drawings. Those auxiliary pumps had to be watched after fitting, and taking into account all the risks the manufacturer ran the price was not excessive.

Mr. FRANKS: You would have been rather in a hole with that tar oil apparatus if it had not been for the war.

The WITNESS: I had no idea the war was coming, but I was quite convinced tar oil was coming. Petrol prices were bound to go up in a year or two, and the Diesel business was likely to suffer unless we placed ourselves in a position to use other kinds of oil.

Mr. FRANKS: If the war had not come and prices had remained as before, you would not have had much opportunity of getting in. Do you not think that, like so many more people in a similar situation, you were rather "done" by this agreement with the German firm?

The WITNESS gave an emphatic negative. For every engine the firm on the other side sold in this country his firm should sell a hundred or two hundred.

Mr. HUGHES, of Messrs. Willans & Robinson, said he thought Messrs. Mirrlees, Bickerton & Day's prices were reasonable and fair. His own firm at Rugby built the Suffolk Company's engines, and they had practically concluded arrangements to receive a sub-licence from the Stockport firm, so that they could quite readily make the patented part.

Mr. TEMPLE FRANKS asked how Mr. Prentice made up his £60 for fitting two engines.

Mr. PRENTICE: It is a simple affair, sir—£10 for making the pump, £10 for fitting to the engines and running the pipes to the valves, and £10 for sundries, a small distributor, &c. It is nothing more than a pipe conveying the tar oil to another position. I simply want to put in oil in position to enter in advance of the main charge, and that I can quite easily do for the sum I have mentioned.

Mr. DAY: Mr. Prentice apparently proposes one pump for three cylinders. One is needed for each of the three, according to our experience.

The CONTROLLER observed that the Suffolk Company might find now that they could get what they wanted at a reasonable price from the makers of their engines. He would report on the hearing to the Board of Trade, who would communicate with the applicants in due course.

Wm. Bates, Sons & Co. v. W. & R. K. Rea (Ltd.)

Last week Mr. Justice Neville had before him an action by plaintiffs, manufacturers of cloth finishing machinery, of Sowerby Bridge, against W. & R. K. Rea (Ltd.), of Manchester, for an injunction to restrain defendants from obstructing the flow of the River Calder and for damages. Plaintiffs' case was that defendants by their new works at Lock Hall Mills, Sowerby Bridge, had obstructed the flow of the Calder and thus reduced the power obtainable by plaintiffs to drive their turbines, thus reducing the speed of their electrical plant and materially reducing their output. It was alleged by defendants that the rise in the river complained of was not due to defendants' works but to debris from buildings destroyed by fire which had fallen into the river.

His LORDSHIP said he was not satisfied by the evidence that the obstruction complained of was due to defendants' works and dismissed the action, with costs.

Damages for Electric Shock.

At Swansea County Court recently William Power, boilermaker, claimed £47. 17s. 6d. damages from the Prince of Wales Dry Dock Co. for electric shock

For plaintiff it was said that he was employed by the Oxy-Acetylene Welding Co., who had a sub-contract with defendant company to do certain work on the ss. "Lille," and on March 13 last he was working in the engine-room of the ship. While bringing a gas cylinder from the stokehold to the engine-room he received a "tremendous electric shock" which rendered him unconscious for a time. He was incapacitated from work for some weeks. A number of the Prince of Wales Dry Dock men were working an electric drill in the engine-room at the time, and it appeared that an electric cable which was laid on to the engine-room, had its insulation cut by the cylinder, as it was trundled along the alley-way. As a result the current escaped on to the steel casing round the engine causing the shock to plaintiff.

Evidence was given by plaintiff and others, who said the voltage of the electric current used was 240.

Geo. Dennis, electrical engineer with defendants, said the voltage at the spot where plaintiff received the shock could not have been more than 175. He had made tests, and there was no danger with that voltage.

David Fulton, chief electrical engineer of the Swansea Harbour Trust, said he had never heard of 250 volts direct current having any serious effect upon a person under circumstances similar to that case. If a person fell across the two poles of a generator, then a much less voltage than that would have serious effects. It depended to some extent upon the physique of the person.

His Honour gave judgment for plaintiff for £23.

Electro-Flex and Steel Co. (Ltd.)

In the Chancery Division on Friday last Mr. Lavington, on behalf of plaintiff in the action Newall *v.* Electro-Flex & Steel Co. (Ltd.), applied to Mr. Justice Astbury for the appointment of a receiver and manager of defendant company. Counsel said the debentures had become payable, the company having passed a resolution for voluntary winding up. The company consented to the application. Counsel also asked leave for the receiver to borrow up to £5,000. The company had to purchase machinery and plant, and money was also required to pay wages.

His Lordship appointed a receiver and manager, but referred the application for leave to borrow £5,000 to chambers. In the meantime he gave leave to borrow £500 for wages.

EDUCATIONAL.

City and Guilds Technical College, Finsbury.—The training at this College is adapted to the needs of various students, including pupils above 15 from secondary schools, who desire a practical and scientific training bearing upon their future industry or profession, and young men who, having previously served a pupilage or apprenticeship in works, desire a more systematic training in engineering and applied chemistry. The College has well-equipped laboratories and workshops for practical work. The entrance examination will be held on Sept. 19. The programme of the College has just been issued, and gives full particulars of the courses of instruction, fees, time-tables, &c. Further particulars, syllabuses of instruction, &c., may be obtained from the Registrar of the College, Leonard-street, Finsbury, London, E.C.

Technical College of Middlesbrough.—Nearly £75,000 has been collected for the proposed new technical college at Middlesbrough, and the Cleveland & Durham Electric Power Co. has offered to supply £100 worth of electrical power per annum.

University of Birmingham.—At this University there are courses in mechanical, civil and electrical engineering. The full courses extend over four years, and students who enter after matriculation and pass the examinations at the end of each year will be entitled to the degree of Bachelor of Science in Engineering. The next session commences on Tuesday, Oct. 3. Syllabus, with particulars of courses, fees, &c., can be obtained from the Secretary.

Heriot-Watt College, Edinburgh.—At this College there are complete courses of training for mechanical, electrical and mining engineers. The diploma course in engineering lasts for three years, and arrangements exist for shortened apprenticeships with local firms. An entrance bursary of £25 is offered for competition on Sept. 26th. Particulars from the Principal. Information regarding the new scheme for engineering degrees in civil, mechanical and electrical engineering are given in the Calendars of Edinburgh University and the Heriot-Watt College.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by Messrs. Mewburn, Ellis & Pryor, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914 Specifications.

7,591 A.B.C. Schriftlampen Ges. Electric incandescent lamps (20/11/13.)

7,890 Maitre & Martin. Use of interrupted current as method of effecting an initial quivering in the vibration of bodies by electricity, more especially the strings of musical instruments such as the piano.

1915 Specifications.

1,950 Swyers. Switches for use in ignition systems for internal-combustion engines.

4,222 Akt.-Ges. Brown, Boveri et Cie. Means for controlling electric and other motors. (19/3/14.)

7,341 Landis & Gyr Akt.-Ges. Apparatus for measuring electric current. (18/5/14. addition to 3,856/15.)

7,457 Cole. Electrical distributing system.

8,826 Bardeloni. Telephone systems.

8,926 Marconi's Wireless Telegraph Co. & Wright. Wireless telegraph receivers. The employment of a vacuous tube containing an anode, a grid and a filament, which is only heated to such a degree that there is no magnification.

9,054 Pedersen. Magnetos.

9,097 Marks. (Walker.) Electric hot water storage installations.

9,111, 9,112 Varley Duplex Magnet Co. & Varley. Systems for producing electrical discharges from a source of energy. (Addition to 17,607/13. Convention date not granted.)

9,293 Relay Automatic Telephone Co. (Botulander.) Automatic or semi-automatic telephone systems.

9,396 Automatic Telephone Mfg. Co. Telephone systems. (27/6/14.)

10,137 Wilkinson. Primary cells.

10,605 Nelson. Electrolysis. (17/8/14.)

11,708 B.T.-H. Co. (G.E. Co.) Systems of control for electric motors. Consists in the use in a series-parallel system of control, of a plurality of series-motors and connections whereby the motors are first connected in series with full field, a bridge connection across intermediate points in the fields being subsequently established to weaken the fields, and this connection finally broken when the motors are connected in parallel.

14,895 Pedersen. Magnets for/of magnetos. (Divided application on 9,054/15. June 21.)

14,896 Pedersen. Make-and-break mechanism for/of magnetos. (Divided application on 9,054/15. June 21.)

14,893 Pedersen. Armatures of magnetos. (Divided application on 9,054/15. June 21.)

16,933 Pieper & Pieper. Electric rotary converters.

17,022 Aktiebolaget Elektriska Ugnar. Current regulators for electric furnaces. (16/12/14.)

17,580 Nicolson & Hull. Electron emitting cathodes and process of manufacturing the same. (26/12/14.) Consists in applying to a platinum or other suitable electrical conductor, which becomes the heating element of the cathode, a coating consisting of an organic compound of a metal of the alkaline earth group, and then raising said coating to the ignition temperature.

APPLICATIONS FOR PATENTS

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

June 19, 1916.

8,607 Hancock & Wintle. Electrodes of secondary batteries.

8,620 Granville. Electrical conductors.

8,625 Holland & Morgan Crucible Co. Distributors for high-tension magneto.

8,633 British Westinghouse Electric & Mfg. Co. Alternating-current commutator motors. (19/6/15, U.S.)

8,639 Marks & Soc. Anon. Italiana G. Ansaldo & Co. Arrangement of electric storage batteries in submarines, and construction of submarines for that purpose

June 20, 1916.

8,669 Mercer. Assisting adjustment of trolley pole of tramcar, &c.

8,685 B.T.-H. Co. (G.E. Co., U.S.) Nozzle plugs.

8,691 Grahn, Herink & Relay Automatic Telephone Co. Telephone systems.

8,698 Akt.-Ges. Brown, Boveri et Cie. Varying pressure in electro-magnetically operated carbon-pressure regulators. (25/6/15, Germany.)

June 21, 1916.

8,733 Beaver & Clarement. Electric cable.

8,736 Casotti. Electric circuit-breakers.

8,740 Anderson & Ellison. Protective devices for dynamo-electric motors.

8,754 Cutler-Hammer Mfg. Co. & Igranic Electric Co. Controlling and regulating electric motors.

8,756 Brooke. Control of alternating electric current induction motors.

June 22, 1916.

8,792 Bergonie. Electromagnet for localising foreign substances embedded in human body. (22/6/15 France.)

8,795 Chryst & Kettering. Electrical systems for engines. (16/7/14, U.S.)

8,796 B.T.-H. Co. & G.E. Co. (U.S.) Controlling electric motors.

8,797 Hellfen. Electric lamps.

8,810 Oldham. Means for electric safety lamps.

8,811 Kribs. Battery lamps.

8,814 Marris. Electrical influence machines.

8,815 Morris. Electrical precipitation of solid and liquid particles.

8,821 Herink & Relay Automatic Telephone Co. Timing devices for telephone systems, &c.

June 23, 1916.

8,831 Hall. Electrically-welded wire fabric, &c.

8,845 Burton & Siemens & Halske Akt.-Ges. Electromagnetic relays.

8,858 Cutler-Hammer Mfg. Co. & Igranic Electric Co. Varying resistance of electric current.

June 24, 1916.

8,893 Ryan. Magneto-generator.

June 26, 1916.

8,957 Wright. Electrical arrangements for conversion of functions, for use with calculating apparatus, &c.

8,959 Brandwood & Callender's Cable & Construction Co. Electrical bonding [illegible] armoured cables and wires, &c.

8,961 Wood & Callender's Cable & Construction Co. Apparatus for indentifying individual lengths of submarine cables.

8,992 Fenton. Electric automatic switch controllers.

June 27, 1916.

9,003 Emmett. Signalling devices.

9,070 Crompton & Co. & Parsons. Dynamo-electric machines.

9,032 Sykes, Ltd. & Railway Signal Co. & Tarrant. Electric relays.

9,036 B.T.-H. Co. (G.E. Co., U.S.) Electric welding systems.

9,037 Sowden & Walker. Automatic device for registering telephone calls.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	545	New "Aurora" Cooking Apparatus. Illustrated	108
Imports and Exports of Electrical Manufactures	546	Elder's Cable Hangers and Clips. Illustrated	110
Business Notices	546	The Turbo-Generation of Continuous Current. Illustrated	112
Electricity Supply	546		
Lighting and Power Notes	547	Tenders Invited	549
Traction Notes	547	Tenders Received & Accepted	549
Telegraph and Telephone Notes	547	Municipal Accounts	549
Empire Notes	547	Companies' Meetings and Reports	550
Foreign Notes	548	City Notes	551
Miscellaneous Notes	548	Electrical Companies' Share List	552
The Round Table	107		

COMMERCIAL TOPICS.

Capital and Labour. At the Trades Union Congress, which will be held in Birmingham in September, various resolutions affecting the relations of capital and labour will be submitted.

The London Society of Compositors will urge that, in view of the importance of maintaining the trade and commerce of the country in the period immediately following the declaration of peace, every effort should be put forth to preserve industrial peace and thereby assist to secure the material prosperity of the nation after the war. That for the purpose of removing causes of friction likely to lead to industrial disturbance the Parliamentary Committee is hereby instructed to approach the Government and the Employers' Parliamentary Association with the object of discussing terms that will secure the end in view for a period of three years, such terms to include the acceptance of the following proposals :—

(1) Membership of a Trade Union to be compulsory upon all workers ; (2) compulsory 48-hour working week in every occupation ; (3) compulsory minimum wage of 30s. for all adult workers ; (4) no reduction of present wages or increase in working hours ; (5) complete recognition by employers of Trade Unions and all agreements entered into between the Unions and employers' associations ; (6) State unemployment pay for men and women out of work ; and (7) settlement by the Unions of the conditions of women's labour after the war.

The Parliamentary Committee will submit also a resolution to the effect that the war has proved beyond all doubt the national weakness and danger of our pre-war industrial system and the immediate need for reform, and claims that our vital industries should no longer be left in the hands of capitalists but should be controlled by the State. The resolution suggests the appointment of a Minister of Labour and Industry, whose duties should include :—

(1) The provision of adequate housing for the workers ; (2) national standard of sanitation in all factories ensuring the safety of the workers ; (3) national control of direction of all land, with security of tenure for tenants ; (4) State to have first claim on all British shipping at rates to yield a fixed national standard of profit ; (5) establishment of national storehouses for grain, frozen meat, dried fish, and all kinds of necessary storeable foods ; (6) complete national ownership and production of all war materials and ships of war ; (7) national ownership and control of all railways, waterways and mines.

The Parliamentary Committee asks for authority to demand the *status quo ante* when peace is declared in regard to Trade Union rules and customs.

With some of the above demands we have sympathy, but if the whole of them are persisted in we are afraid that we shall have a period of industrial agitation and uncertainty after the war, instead of the peace and co-operation between labour and capital which are so essential if we are to maintain our leading position as manufacturers and exporters. Artificial attempts to limit output, to introduce a universal 48-hour week, to enforce the payment of a minimum wage to *all* adults, &c., are doomed to failure, because they seem to us to be in conflict with natural and economic laws and to be opposed to progress. Instead of shorter hours everyone will have to work harder and longer, and it is a pity that desirable and possible demands are mixed up with the impossible.

* * * *

Day Wages v. Piece Work. At the annual conference of the Miners' Federation last week a resolution declaring the time to be opportune for the substitution of day wage rates for piece rates for all coal getters was passed.

Mr. J. E. Sutton, M.P., who moved the resolution, said piecework was a matter of one man competing with another, and he hoped some day a reasonable day's wage would be given to a man for a reasonable day's work, and the damnable piece system would be abolished.

Mr. Frank Hodges (South Wales) said the introduction of coal-cutting machines to do the work formerly done by the pick was putting men on an equality of production, and was a strong reason for the payment of a regular wage.

* * * *

Australian Metal Scheme. It is announced that the Mount Morgan Gold Mining, the Electrolytic Refining & Smelting of Australia and the British Insulated & Helsby Cables (Ltd.) have formed a new company called Metal Manufacturers (Ltd.), with a capital of £200,000, for the purpose of establishing a new Australian industry, the manufacture of copper wire, sheets and tubes. The new company has received assurances of support from the Commonwealth authorities to justify the establishment of the industry. It is stated that there is an increasing demand for the goods which it is proposed to manufacture, and which have hitherto been imported, largely from Germany.

* * * *

United States Trade With South America. At present the capture of the South American trade forms one of the most fruitful topics of discussion in commercial and export circles of the United States. Various reports have been issued and investigations made by mercantile associations and others in the United States, and at a recent meeting of the New York State Bankers' Association at Atlantic City Senor Carlos A. Tornquist made an interesting speech on the subject.

According to the "Electrical World," Senor Tornquist said there is no reason why the United States should not be placed on a footing of equality with Europe in relation to Argentine finance and business if the necessary modifications of your federal banking and trade laws are made along lines which would more largely facilitate banking and commercial operations between the United States and the Argentine. Financial credits naturally strengthen the exchange of the country which grants them. The experience of the foreign banks in the Argentine Republic has exploded the theory that "*trade follows the flag.*" The results obtained there show that *trade follows capital ;* and even in these early days of the investment of American capital in Argentine issues and enterprises there is ample evidence of the truth and soundness of the latter theory. But in order to convert this theory into practical form there are other essentials to be considered. There must be closer personal contact between Americans and Argentines. I want to see the inauguration of the first necessity of increased trade relations, and that is the establishment of a service of first-class, comfortable and fast steamships that will make the trip from New York to Buenos Ayres, and vice versa, in 12 to 14 days. Extended intercourse between the leaders of the respective communities—not of their secretaries and employés—would do more good to foster and augment international commerce than any number of conferences or publications. We are seeing the extraordinary proportions reached lately in the trade between the two countries ; and, although much of it doubtless owes its existence to war conditions, a great part of the advance has been the result of closer personal investigation and of the exercise of more vigorous efforts on the part of American manufacturers than were previously put forth. Still, since my stay in the United States I have seen in the columns of the Press an undercurrent of suspicion and mistrust, with more than open reference to the necessity for official protection, even by force, for American investors in South American countries. Speaking for my own country, let me say, gentlemen, that the great and close relations built up by Europe with the Argentine Republic have been established principally on the basis of mutual confidence ; and unless the Americans are prepared to show the same confidence as has been shown by the financial and mercantile communities of Europe—a confidence justified by long experience—they had better not waste their time or their money in the effort to capture a larger share of our trade.

* * * *

Trade Products of the Empire. The annual July Trade Products Supplement of the London Chamber of Commerce contains interesting information concerning the resources and capabilities of the oversea countries of the Empire. Certain Empire products have become especially prominent during the last few months, and among these are metals, oilseeds and sugar.

Arrangements have been completed whereby the zinc production of Australia shall be in future under British control, instead of being exploited by the Germans. Steps have been taken also to ensure that other mineral resources of the Empire, such as the tungsten ores of Burma and the silver-lead production of Australia, shall be worked primarily in the interests of the Empire as a whole. The aim and scope of the annual supplement are to present, in a concise form for ready and frequent reference, a statistical review of the import trade of the United Kingdom in food products and raw materials for industries, special attention being

given to the trade sources of these imports within the British Empire. The extent and importance of the production in each part of the Empire are indicated and the condition of development in such production is mentioned. The figures relating to trade and production in British colonies and possessions are quoted mainly from official publications of the countries concerned. In this way many opportunities for expansion and investment of capital in promising agricultural, planting and mining enterprises are revealed, whilst attention is drawn to new sources of supply within the Empire of products in which British importers, merchants and manufacturers are interested, and to directions in which extension of business may be possible. The annual "Trade Products Supplement," consisting of 46 foolscap pages, is published at 1s., post paid 1s. 4d.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From July 8, 1916, *to* July 14, 1916.

IMPORTS.

HULL.—*Sweden:* Elec. machinery, 57 cases.

LONDON.—*U.S.A.:* Elec. lamps, £26; telephone material, £78; carbon candles, £293 12 cases; unenumerated, £5,439 1,189 cases. *Holland:* Elec. lamps, £9,104 811 pkgs; unenumerated, £1,596. *Japan:* Elec. torch parts, 9 cases; unenumerated, £2,116 18 cases. *France:* Elec. meters, 66 cases; unenumerated, £22. *Switzerland:* Unenumerated, £253. *Denmark:* Unenumerated, £371.

SOUTHAMPTON.—*France:* Elec. cable, 23 pkgs.; unenumerated, £527 6 cases.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Elec. machinery, £40; unenumerated, £716. *Melbourne:* Wire and cable, £1,305; elec. glow lamps, £470; elec. machinery, £1,665; unenumerated, £1,937. *Sydney:* Elec. machinery, £848; elec. glow lamps, 18,350 no.; wire and cable, £1,334; unenumerated, £4,045. *Wellington:* elec. lamps, 7,756 no.; wire and cable, £490; unenumerated, £687. *Christchurch:* Unenumerated, £80; *Lyttelton:* Unenumerated, £246. *Dunedin:* Unenumerated, £175. *Adelaide:* Unenumerated, £931. *Brisbane:* Wire and cable, £247; unenumerated, £404. *Invercargill:* Unenumerated, £63. *Bluff:* Wire and cable, £212; unenumerated, £160. *Launceston:* Elec. machinery, £72. *Wanganui:* Unenumerated, £42. *Newcastle:* Elec. machinery, £876. *Perth:* Unenumerated, £46.

AFRICA.—*Durban:* Elec. machinery, £650; wire and cable, £335; unenumerated, £150. *Cape Town:* Elec. machinery, £403; unenumerated, £271. *Port Elizabeth:* Wire and cable, £495; unenumerated, £157. *East London:* Elec. machinery, £18; unenumerated, £50.

EGYPT.—*Alexandria:* Unenumerated, £39. *Suez:* Unenumerated, £30.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Elec. machinery, £648; unenumerated, £1,888. *Penang:* Telegraph material, £300. *Singapore:* Elec. machinery, £160; glow lamps, £382 n.o; wire and cable, £141; unenumerated, £758. *Calcutta:* Elec. machinery, £214; wire and cable, £64; unenumerated, £1,174. *Madras:* Elec. machinery, £142; unenumerated, £1,760. *Colombo:* Elec. machinery, £3,705; wire and cable, £31; unenumerated, £209. *Port Swettenham:* Elec. machinery, £367; telegraph material, £26. *Karachi:* Unenumerated, £23.

CHINA.—*Shanghai:* Unenumerated, £135. *Hong Kong:* Wire and cable, £85; unenumerated, £692. *Tientsin:* Unenumerated, £42.

U.S.A.—*New York:* Elec. machinery, £127; unenumerated, £884.

CANADA.—*Montreal:* Telegraph material, £30; unenumerated, £28. *Halifax:* Telegraph material, £54; unenumerated, £141.

SOUTH AND CENTRAL AMERICA.—*Buenos Ayres:* Telegraph material, £150; unenumerated, £180. *Punta Arenas:* Unenumerated, £47. *Rosario:* Unenumerated, £348. *Mejillones:* Unenumerated, £119.

HOLLAND.—*Amsterdam:* Wire and cable, £2 125; unenumerated, £948. *Rotterdam:* Wire and cable, £318; unenumerated, £153.

FRANCE.—*Dieppe:* Elec. machinery, £50; unenumerated, £64. *Paris:* Elec. machinery, £148; unenumerated, £178. *Bordeaux:* Elec. machinery, £195. *Nantes:* Unenumerated, £170. *Boulogne:* Wire and cable, £66. *St. Nazaire:* Elec. machinery, £133.

SWEDEN.—*Gothenburgh:* Wire and cable £149.

NORWAY.—*Christiana:* Wire and cable, £165; unenumerated, £3 664.

GIBRALTAR.—Wire and cable £84.

MALTA.—Telegraph material £37; unenumerated, £41.

RUSSIA.—*Petrograd:* Elec. machinery, £40. *Vladivostok:* Wire and cable, £60; unenumerated, £484.

FINLAND.—*Helsingfors:* Unenumerated £153.

JAPAN.—*Yokohama:* Unenumerated, £251 *Tokio:* Unenumerated, £128. *Kobe:* Elec. machinery, £709; unenumerated £270.

CORFU.—*Corfu:* Elec. machinery, £104.

FOREIGN GOODS (duty paid and free).

Singapore Unenumerated, £46. *Wellington* Unenumerated, £40. *Sydney*, Unenumerated, £16. *Melbourne* Unenumerated, £5. *Cape Town*, Unenumerated, £156. Christiana: Unenumerated £20. *Paris* Unenumerated, £104.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

The Dominion Electric Co., manufacturers' agents and wholesalers of electrical material, announce that they recently commenced business at 33, High street, Walsall. Telegrams: "Dominant Walsall."

Commonwealth Edison Co.—We have received from the Commonwealth Edison Co., of Chicago, a booklet of Rules and Information pertaining to Electric Service Meters, Wiring and Motors. We notice that electric energy is distributed at 115 to 230 volts for light and power both on alternating current and direct current, and three-phase at 230 volts for power, the frequency being 60 per second. Energy at 110 volts is only supplied when there is an aggregate rated motor capacity of 250 h.p. or more. There are a considerable number of tables in the book giving sizes of wires for connecting motors, sizes of meters, and other useful practical information.

ELECTRICITY SUPPLY.

GENERAL.

Aylesbury.—An unopposed L.G. Board inquiry was held last week into the Council's application for sanction to borrow £600 for batteries, £160 for house services, £75 for meters and £780 for expenditure in excess of estimates for the electricity department.

Evidence was given by the engineer (Mr. W. A. Turnbull) and others and the Inspector subsequently visited the works.

Barnes.—The Council have authorised their Electrical Engineer to represent them on the Joint Advisory (Engineers') Board which is being formed to consider the best means of taking concerted action regarding the future development of the electric supply undertakings in the Western Metropolitan area.

A request from a neighbouring authority for terms upon which the Council would be prepared to supply current in bulk has been referred to the Engineer.

Belfast.—The existing regulations as to "stand-by" supply of electric current have been cancelled, and a "restricted-hour stand-by supply" will be given on the following terms:—

A person requiring a supply of power to any circuit, cable or current-consuming device, while same can be supplied as an alternative from a private source, shall be charged a flat rate of 1½d. per unit, and the supply shall be cut off by time switch between the following hours: 4.30 p.m. and 7.30 p.m. in October, 3.30 p.m. and 7.30 p.m. in November, 3.30 p.m. and 7.30 p.m. in December, 3.30 p.m. and 7.30 p.m. in January, 4.30 p.m. and 7.30 p.m. in February, and 5.30 p.m. and 7.30 p.m. in March. The consumer must consume or, failing consumption, must pay for a minimum quantity of electricity each quarter, (determined by multiplying three-fourths of his possible maximum demand in kilowatts by one-fourth of the number of unrestricted working hours per annum—namely, 2,288. The consumer shall not be entitled to require or receive a supply of electricity during the restricted hours, and in the event of the consumer forcing a supply during the restricted hours, he shall pay to the Corporation as and for liquidated damages a sum to be determined by multiplying his maximum demand in kilowatts by £5 for each occasion on which the supply is so forced.

The purchase of four chain-grate stokers, the renewal of the furnaces and of dismantling old stokers, at a cost of £2,090, has been referred back.

Bradford.—At the City Council meeting last week Mr. Barraclough, in submitting the minutes of the Gas Committee, gave the following information in reply to questions by Mr. Sutcliffe.

The number of firms who had introduced gas engines since July, 1913, was 138. Fifty firms had substituted electric motors for gas engines, and the gas used by these firms previously was 19,075,700 cubic ft. per annum. A few had given up electric motors for gas. No efforts had been made by the department to prevent a gas engine being replaced by an electric motor when the latter had been obviously more suitable for the particular purpose required. The duty of the Corporation was to oblige the ratepayers, and to supply them with electricity if it suited their purpose better than gas. The Gas Committee had themselves installed at Birkshall gasworks 13 electric motors.

Carnarvon.—The Accountant has reported that his efforts to obtain repayment from the Treasury of the income tax deducted from the electricity works sinking fund instalments by the National Electric Construction Co. had not been successful.

The Surbiton Urban Council had only been able to get out of the same difficulty by selling their works to the company which was running them, but at Carnarvon a similar course did not meet with any support from the Finance Committee, although the National Electric Construction Co. had expressed their willingness to consider such a proposal.

The report has been handed to the Town Clerk to consider, and the whole question will be again considered at the next meeting of the Finance Committee.

Finchley.—It is proposed to erect an overhead cable, at a cost of £75, to supply certain blocks of workmen's dwellings with electric current.

Holmfirth.—On Saturday last the Holmfirth electricity supply was formally inaugurated by Com. E. Overend, chairman of the Electricity Committee. Mr. A. B. Memtain, of Huddersfield, is consulting engineer, and Messrs. T. W. Proadbent (Ltd.) supplied the plant. The streets are to be lighted electrically, and there are 31 private customers to start with.

Hull.—The Corporation are applying for an order to empower them to supply electric current to the new sanatorium at Cottingham.

Increase of Charges for Electrical Energy.—The following have decided to increase their charges during the past week:—

Ingleby Council has increased the charge for current for lighting from 6d. to 7d., and for power and heating the charge is increased by 10 per cent.

Taunton Council has increased the charges by a further 10 per cent. for both light and power, making a total increase of 25 per cent.

The Urban Electric Supply Co. has notified Redruth Guardians that the cost of lighting will be increased by 10 per cent.

Hornsey Council is increasing its prices by a further 10 per cent.' making 25 per cent. in all.

Belfast Corporation has increased the prices of current for power and lighting by ¼d. per unit as from April 1.

At Grantham the Urban Electric Supply Co. has increased its charges by 10 per cent., making 20 per cent. since the commencement of the war.

Halifax Electricity Committee recommends the Council to increase its charge for current for power by 17½ per cent. from Oct. 1 next.

Barnstaple Council is increasing the maximum charge for current for lighting from 5d. to 6d. per unit.

At Aberystwyth the Chiswick Electricity Corpn. is increasing its charges by a further 10 per cent.

Twickenham & Teddington Electric Supply Co. is increasing its charges for current for all purposes by a further 10 per cent., making 20 per cent. in all.

Lynn Council is increasing its charge for current for lighting by ½d. per unit, and the increase in the charge for current for power is also to be ½d. per unit instead of the 10 per cent. previously decided upon.

Kingstown.—The Urban Council have made arrangements for raising a loan of £6,000 to cover the preliminary expenses of their electric lighting scheme.

Sheffield.—At its meeting last week the Council discussed the recommendation of the Electric Supply Committee (*see* p. 512 of our last issue) to increase the charges for electrical energy.

Mr. T. G. Evans, chairman of the committee, moved the adoption of the minutes of the committee, which included the recommendation referred to. He said in view of the fact that there was an increase in cost of coal and labour of over £87,000 it became a serious question as to whether they were to increase the charges or not. If they did not the department would very likely make a serious loss, and they would have to make up the deficit from the rates. As they made a very favourable contract for coal they had not made a loss for the year ending March, 1916, but if they did not do something they would have a serious loss at the end of the next year. As to the £62,500 more for machinery, he had great faith that the Government would give financial help. Having put down machinery solely to provide current for the Government's purposes, the department could hardly be expected to pay the piper. He suggested that the contract with the Tramways Department made in 1914, though it was made for three years, might not be strictly adhered to, and that that department should be asked to bear part of the extra expense that the department would be put to.

Mr. A. J. Blanchard moved that consideration of the matter should be deferred until the Council had the full accounts before them. It was not a question as to whether certain users of electric current should pay a little more, but one of determining the whole policy of the committee, which he had understood to be that they would supply current to manufacturers at near cost price as was practicable with sound financial working.

Mr. A. Neal said the tramways undertaking was the one department from which they received funds in relief of rates, and if the contract with the electric supply department was to be altered it would simply reduce the amount available to relieve rates, and would only be another way of making ratepayers pay for the benefit of the users of electricity.

Ultimately the discussion was adjourned until August.

Woodford.—The County of London Electric Supply Co. have given notice of intention to apply for a provisional electric lighting order for Woodford.

LIGHTING & POWER NOTES.

Burton.—The Council have decided to resume a modified system of lighting by suspended electric lamps on the tramway routes during the coming dark evenings at a cost of £350.

The Chairman of the Electricity Committee (Ald. Lowe) said the lamps would be lighted from the tramways main, and would be extinguished simultaneously with the cutting off of the traction current. A more expensive scheme was rejected, because of the extended time which would be involved in cutting off the current.

Dromore (Ireland).—A special meeting of the Council is to be held to consider tenders for street lighting by electricity and gas.

Electricity in Mines.—At the annual conference of the Miners Federation last week a resolution was adopted in favour of amending regulation 131 of the Coal Mines Act be so as to make it illegal for a person in charge of an electrical coal-cutter, whose wages depend upon the amount of mineral gotten, to be appointed as the responsible person to supervise, examine or adjust the electrical apparatus.

It is reported that Mr. G. W. Charlwood, who was recently elected chairman of Talbot Alluvials (Ltd.), is studying the question of the application of electricity to mining work, and particularly for pumping.

Southend.—The Council have asked the Highways and Works Committee to consider the question of substituting electricity for gas for street lighting.

Proposals to dispense with the services of the tramway traffic superintendent and the canvasser for electric light consumers were defeated.

TRACTION NOTES.

Edgware and Hampstead Railway.—The London Electric Railway Co. has applied to the Board of Trade for an order to extend for one year from Nov. 18, 1916, the time limited by the Edgware and Hampstead Railway Act, 1912, for the completion of railway No. 1; to extend for one year from Oct. 20, 1916, the time limited by the same Act for compulsory purchase of lands and easements and for the completion of the deviation railway authorised by Edgware and Hampstead Railway Act, 1909; and to extend for one year from Aug. 12 the time limited by Edgware and Hampstead Railway Act, 1912, for compulsory purchase of lands and easements.

Middlesex.—The County Surveyor has reported to the County Council on the bad condition of the track of the lines of the London United Tramways (Ltd.).

It is stated that in several places the joints of the rails have given way, whilst in others portions of the rails are missing altogether, and the track paving is below the surface level of the roads. The attention of the representatives of the areas directly concerned had been called to the matter, who had informed him that owing to the war it was impossible for the company to proceed with a complete renewal of the tracks (which is badly required), owing to their inability to obtain new rails. He had pointed out to the authorities concerned their obligations under sec. II. of the Local Government Act, 1888, and that, as they were the authorities in whom the roads were vested they were responsible for the satisfactory state of same from fence to fence. It was imperatively necessary that some steps should be taken in connection with the tramways as soon as possible. He should, undoubtedly, be justified in withholding his certificates for the annual maintenance of the roads affected, but as there were such abnormal conditions prevailing he proposed to issue them this year in the usual way. It did not follow, however, that the same procedure would be followed next year should the present deplorable state of things continue in connection with the tracks. In High-street, Brentford, there were many places along the tramway track which required relaying. Under the Local Government Act the supervision of the road throughout its width was vested in the District Council, and it was their duty to see that both road and tramway tracks were kept in a proper condition.

TELEGRAPH & TELEPHONE NOTES.

Hull Municipal Telephone System.—The accounts of the working of the Corporation telephone undertakings for the year ended March 31 were presented to the Telephones Committee on Monday.

It will be remembered that Hull is the only city in the kingdom in which the Municipality controls the telephone service. Income on revenue account for the year was £56,228 and expenditure £32,978. Gross profit was £23,250, compared with an estimate of £24,000. The expenditure included a war bonus of £1,300 and special charges for works protection. Capital charges amounted to £18,879 and the net profit was £3,645.

The Chairman of the Committee (Ald. Brown) said he considered the balance-sheet very satisfactory, especially in view of the exceptional conditions. The effect of the war had been to increase the cost of maintenance and to decrease the revenue.

New Automatic Telephone Exchange at Paisley.—The new automatic exchange at Paisley Post Office was opened on Saturday. The apparatus was made and installed by the Automatic Telephone Mfg. Co. (Ltd.).

EMPIRE NOTES.

Australasia.—A licence has been granted to the Borough Council of Wairoa to use water from the Wairoa river (near Te Reinga Falls) for generating electrical energy, and also to erect electric lines for lighting, power and heating. purposes.

The Public Works Committee of the State of New South Wales has been requested to report upon the expediency of carrying out schemes of hydro-electric development. The estimated cost of the Snowy River scheme is £5,000,000, of the Shoalhaven River scheme £770,000, Tumut River scheme £600,000, Cataract Cordeaux scheme £306,800, Burrenjuck Dam scheme £100,000, Gilmore Creek scheme £44,400, and Nymboida River scheme £35,000. The power house proposed to be constructed in connection with the Snowy River scheme is to have generators capable of generating 750,000,000 units per annum (86,758 kw.). In connection with the Gilmore Creek scheme an electric railway from Gilmore to Batlow is proposed to be constructed at an estimated cost of £160,500.

FOREIGN NOTES.

Colombia.—The municipality of Frontino (Department of Antioquia) has been authorised to raise a loan up to 10,000 pesos gold (£2,000) for the installation of electric power plant, and Amalfi municipality, in the same Department, has been authorised to borrow 6,000 pesos gold (£1,200) for a similar purpose.

Electric Smelting in Norway.—A company was recently formed in Stavenger with a capital of 1,000,000 kroner for utilising the Florli waterfall near Lysefjordin for electrical smelting.

The necessary capital is said to have been secured from Norwegian banks, and the company will proceed with the erection of works. The waterfall is calculated to produce 12,000 H.P.

Holland.—A report by the British Consul-General at Rotterdam on the trade of the Netherlands in 1915, states that the year was the most profitable the Netherlands has experienced.

The increase in the national wealth since the war commenced is estimated at between £160,000,000 and £200,000,000. Manufacturers began early in 1915 to make good any losses they had suffered in the disorganisation of trade in 1914, while shipping companies made unprecedented profits. The Netherlands Oversea Trust has been indispensable to Dutch trade, inasmuch as through its agency the importation of many articles which would otherwise have been unobtainable has been possible. Imports of coal fell off considerably, and the war brought home to the Government and people of the Netherlands that they need no longer be mainly dependent upon their neighbours for supplies. The coal fields of the Netherlands, which are all in the province of Limburg, have an output of 2,000,000 tons per annum; it is stated that this can be increased considerably, and that only the unfavourable position of the fields in relation to the industrial districts of the country has caused this national source of supply to be neglected. The coal market in the Netherlands has been practically governed by the German Coal Syndicate, the unswerving policy of which during the last 10 years has enabled it to monopolise more than five-sixths of the entire coal consumption of the country, and British coal, in spite of its natural advantages, has been almost ousted, except from gas works, where the special quality of British gas coal has made it indispensable. The normal consumption of the country is about 12,000,000 tons per annum.

Imports included 1,429,595 tons of metal articles in 1913, 1,040,073 in 1914 and 299,192 in 1915; metals (unmanufactured) imported in the same years respectively were 2,719,382, 1,887,638 and 837,439 tons; and rails imported 39,975, 49,286 and 26,222 tons. Exports of metal articles were 1,186,665 tons in 1913, 804,688 tons in 1914 and 152,479 tons in 1915; metals (unmanufactured) exported were 2,182,125, 1,410,604 and 419,167 tons. If British firms adapt themselves to the requirements of the market there should be an opening for materials and appliances for electricians and for agricultural machinery. There is a good opening in the Bois-le-Duc district for British goods, and business relations might be opened up with the weaving and spinning mills in Tilburg, which at present deals almost exclusively with Germany. There is an increase in the use of motors on small farms in the Netherlands, and such motors should find a good market.

An era of unparalleled prosperity for the Netherlands is expected to set in after the cessation of hostilities, and there is no reason why British trade should not share in this prosperity if British traders can be induced to enter into provisional arrangements with Netherlands firms at once. Large British firms would be well advised to appoint resident British agents in the Netherlands, instead of entrusting their interests to local firms. One of the principal causes of the commercial success of Germany was to be found in the fact that well-trained and competent agents of German nationality represented important German firms abroad.

Italy.—A decree has been issued approving a convention between the Italian Government and the Roma Nord Tramway & Railway Co. for the construction and working of an electric railway from Rome to Viterbo via Civitacastellana.

Morocco.—The Cherifian "Bulletin Officiel" of May 15 gives the text of the annex to the Franco-Moorish Postal Convention of Oct. 1, 1913 (signed on March 28 last) relating to the telegraphic service between Morocco and Algeria and Tunis. The Act provides for laying a submarine cable and for the erection of a land line between Tangier and Algeria, which will pass through the Spanish zone.

Platinum Deposits in Spain.—The Minister of Fomento has been authorised to present to the Cortes a new Bill suspending for two years the right of public search for platinum in a certain area in the Ronda district of the Province of Malaga, where important platinum deposits have been found.

The Minister urged this course in view of the importance of platinum in connection with modern military requirements. The State will either exploit the reserved deposits or sell or lease the right of working.

Portugal.—The Legislature has authorised the municipality of Amarante to borrow £18,500 for a hydro-electric installation, water supply, &c., and the municipality of Guimaraes to borrow £75,500 for an electric tramway system, &c.

MISCELLANEOUS NOTES.

Defence of the Realm Regulations.—Attention is called to regulation 41A of the Defence of the Realm Regulations and D.R. Form 17 issued thereunder, by which lists of male employés between 18 and 41 must be exhibited in a conspicuous place on the premises where such men are employed.

The official forms for this purpose can be obtained from any post office. The Military Representative for the City of London Tribunal is arranging for officers to go round and inspect these lists during the course of the next few months.

His Majesty in Council has ordered that the Defence of the Realm Regulations be amended by the addition of Regulation 8E, which provides that the Minister of Munitions may by order prohibit or restrict the carrying on of building and construction work other than by licence from the Minister. Such works include buildings, railways, docks, harbours, canals, bridges, tunnels and other works of construction or engineering.

"Directory of Manufacturers."—The success of previous issues of the Directory of Manufacturers, &c., has led the Commercial Agent of the North Eastern Railway Company to publish the third (1916) edition of the volume, and in view of the new trade conditions which are certain to obtain after the war, including no doubt much heavier demands for British products, the book must prove of great utility alike to the manufacturer and the consumer, as well as the exporter and the importer.

The Directory contains over 36,000 entries, split up under more than 1,200 separate trade headings, to which there is a special index. These figures show a great advance on the previous editions, whilst the value of the entries has been further enhanced by the inclusion of registered telegraphic addresses in addition to amplified telephonic information. Another feature of the new issue is a map of the North Eastern Railway system, showing in distinctive colours the principal natural products of the different districts it serves, also at a glance the wide range of Continental and "Overseas" Sailings which in normal times are maintained from the North East Coast Ports. 15,000 copies of the volume have been prepared for purely gratuitous distribution, and not only will traders throughout this country receive the book, but it will be supplied to H.M. Consuls all over the world, to British Colonial and Foreign Chambers of Commerce, &c. The securing of the right markets for both buying and selling, and of the most suitable channels of exchange, is so necessary to modern commercial success, that the great value of a Directory containing the names and addresses of the principal manufacturers and wholesale importers and exporters, classified respectively under their particular trades, and in town order, will be apparent.

Enemy Firms Wound Up.—The Board of Trade have ordered the winding up of 252 businesses controlled by alien enemies.

Included in the latest list are Phitte Scheele & Co. (Ltd.), 18-19 Queenhithe, London, E.C., merchants and agents for electrical goods. (Controller: G. W. Roberts, 133, Wool Exchange, E.C., to whom claims by Sept. 30.); Gerhard & Hey, Great St. Thomas Apostle, Queen-street, London, E.C., forwarding and shipping agents. (Controller: J. D. Pattullo, 65, London-wall, E.C.); A. Barson & Co., 57, Scrutton-street, London, E.C., engineers' tool manufacturers. (Controller: Adam Turquand Young, 41, Coleman-street, E.C.); British Hulm Metallic Packing Co. (Ltd.), Snowdon's Wharf, Millwall, E., manufacturers of metallic packing for steam engines, &c. (Controller: J. E. Wilson, 28, Basinghall-street, E.C.); Poldi Steel Works, Napier-street, Sheffield, steel manufacturers. (Controller: A. Duncan Barber, Sheffield Telegraph-buildings, High-street, Sheffield); Phenotas Co. (Ltd.), 125, High Holborn, London, W.C., system for cleaning telephones.

Military Tribunal Cases.—At Southwark (London) Tribunal B. E. White, electrical engineer, applied for exemption. He stated before the war he employed from eight to 12 men, but now had only one man and a boy. He had to work double time himself on electric motor repairing. Granted conditional exemption on joining a V.T.C.

At the same Tribunal the Imperial Lighting Co. (Implitico) (Ltd.) applied for the exemption of a general and electrical engineer. Out of 42 hands 12 had joined up. They had only one engineer left out of eight. Granted three months' extension on joining V.T.C.

At Battersea Mr. Pope (trading as F. Williams), electrician, appealed for exemption. He said he was an electrical contractor. His partner was in the Army, and he allowed him 10s. a week, and did all the work himself. Granted a month's final extension.

At St. Anne's, Mr. H. W. Laing, manager of Blackpool, St. Anne's & Lytham Tramways Co., appealed on behalf of the foreman of the track repairing staff and two motor men. He had lost 110 men of the traffic staff out of 125. Conditional exemptions granted.

At Gosport Mr. J. Fereday Glenn, manager of Gosport & Fareham Tramways Co., applied on behalf of 27 men in the employ of the company, whom he said were quite indispensable. Three months' exemption granted in six cases, one month in one case, and conditional exemption for all the others, except one, in which exemption was refused.

TENDERS INVITED.

Batten Holders, Ceiling Roses, &c.

The COMMISSIONERS OF H.M. WORKS, &c., invite tenders for the supply of Batten Holders, Ceiling Roses, Plugs and Cut-outs. Forms of tender, conditions of contract, &c., from the Controller of Supplies, H.M. Office of Works, King Charles-street, Westminster, S.W. Tenders by 11 a.m. July 26, to the Secretary, H.M. Office of Works, &c., Storey's-gate, London, S.W. *See advertisement.*

Telegraph and Telephone Material.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. Aug. 8 for the supply and delivery in Melbourne, Sydney, Brisbane, Adelaide, Perth and Hobart of Standard Battery Material, including Pots, Porous Jars, Zinc, Carbon Rods, Chemicals, &c., for the AUSTRALIAN COMMONWEALTH, Postmaster-General's department. (Schedule 1,327.) Specifications, &c., from the Deputy Postmaster-General.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

Rotary or Motor Converter and Switchgear.

WALTHAMSTOW Urban Council require tenders by noon July 26 for supply and erection of 500 kw. Rotary or Motor Converter, e.h.t. l.t. Switchgear. Specifications from Mr. G. R. Spurr, Electricity Dept., Priory-avenue, Walthamstow.

Motors, Starters, &c.

The VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

The Town Clerk, INVERCARGILL (N.Z.) will receive tenders until 4 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 40). Specification, &c., from the Town Clerk.

Wiring and Fittings.

Tenders are required by July 28 for Wiring the BASINGSTOKE Conservative Club. Particulars from the Secretary.

Street Lighting.

CASTLEBAR Urban Council require tenders by 2 p.m. Aug. 5 for Electric, Gas or other lighting from Sept. 15 to April 1 next.

Signal Lighting Transformers.

The VICTORIAN RAILWAY COMMISSIONERS want tenders by 11 a.m. July 26 for 400 Signal Lighting Transformers (contract No. 29,997). Specifications from the Commissioners' Offices, Spencer-street, Melbourne, Victoria.

TENDERS RECEIVED AND ACCEPTED.

LONDON COUNTY COUNCIL.—The Council has accepted the tender of the Chloride Electrical Storage Co. for the supply and erection of a storage battery at Woolwich Tunnel, at £122. 7s.

STAFFORD.—The Corporation has accepted the tenders of Siemens Bros. Dynamo Works for 500 kw. d.c. turbo-generator, £995; and Westinghouse Electric & Mfg. Co., 500 kw. geared turbine and condensing plant, £4,335.

BARROWFORD.—The Urban Council have accepted the tender of Adams Hydraulic (Ltd.) for the supply and erection of automatic control electric screening gear for sewage disposal works.

MANCHESTER.—The following tenders have been accepted by the Corporation :—

Pirelli General Cable Works, Western Electric Co., W. T. Glover & Co., Callender's Cable & Construction Co., British Insulated & Helsby Cables and C. Macintosh & Co., cables; Sir W. G. Armstrong, Whitworth & Co., three electric capstans; and Fraser & Chalmers, coal stacker with 420-volt three-phase motor.

SOUTHEND.—The Corporation is recommended by the Lighting Committee to place contracts with Venners' Time Switches (Ltd.) for 200 current limiters, with Callender's Cable & Construction Co. for the supply of cables during six months, and with British Insulated & Helsby Cables for about 100 pairs of cut-outs (6s. 8d. per pair).

SHIPLEY.—The Council has accepted the British Electric Transformer Co.'s tender for a 50 kw. transformer.

WATFORD.—The Council has accepted the tender of Marshall & Plumtree for the supply of a motor, gearing, &c., at £755.

New Zealand Government Contracts.—The New Zealand Public Service Stores Tender Board has accepted the following tenders:—A. D. Riley & Co., 3,000 bridle rings, £27, 4,000 ditto, £52, 4,000 ditto, £56; Lawrence & Hanson, 35,000 yds. jumper wire, £168.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Hampstead (London).—On the electricity department at March 31 the gross capital expenditure was £477,571 (increase £4,362), of which £207,038 is outstanding.

Revenue was £69,332, and working and general expenses were £45,624, leaving gross profit £23,707. Interest required £8,355 and instalment of loan £22,062, year's net deficit being £6,709. Average price obtained per unit sold was 2·91d. (2·88d.). Fuel per unit sold cost 0·79d. (0·48d.), and total costs (exclusive of capital charges) were 2·08d. (1·59d.). Units generated were 6,279,680 and sold 5,069,397 (compared with 5,550,078 in previous year). Total maximum supply demanded was 3,128 kw.

In his report Mr. W. Wyld (chief engineer and manager) says the war has had a very serious effect on the year's working. The deficit of £6,709 (compared with a net profit of £2,766 in previous year) is the first deficit in the history of the undertaking, except that for the first 15 months' working (ended Dec., 1895). Average price of coal was 20s. 10½d. (against 13s. 6½d.) per ton, the decrease in receipts from lighting was £4,252, the total net income decreased £2,205, and the embargo placed by the Treasury upon capital expenditure on mains and services arrested the natural increase in business. The price for current for private lighting was increased in November last. With a view to greater reliability of supply, safety to the staff, and upon the urgent recommendation of the Home Office electrical inspector, it was decided to replace the existing h.t. switchboard; tenders were obtained for modern mechanical remote control cubicle switchgear, and the contract was given to the British Thomson-Houston Co. Owing to stress of war work, the contractors for a 1,500 kw. turbo-alternator were not able to make delivery of the alternator to complete the set during the year. It has been delivered since the end of the financial year, and is now on load. The contract for condensing plant, pipework, &c., has been completed by the Mirrlees, Watson Co. (Ltd.). A contract for an additional cooling tower has been entered into with Witting & Partners, and the work is now in progress. Motors connected are 275=1,468 H.P. (an increase of 192 H.P.). Apparatus on hire includes 327 (200) heaters, 59 (55) cookers,

33 (18) motors, and 42 (28) miscellaneous (hotplates, &c.). 52 members of the staff (=37·14 per cent.) have joined H.M. Forces, and 36 members of the staff have war service badges.

Islington (London).—The accounts of the electricity department for the year ended March 31 show gross capital expenditure £568.432 (increase £6,624), of which £409,223 is outstanding.

Revenue was £69,660 (compared with £65,655 in previous year), and working expenses were £39,051 (£35,133), leaving gross profit £30,609 (£30,522). Interest required £14,227 (£14,386) and repayment £13,559 (£12,898), the net profit being £2,117 (£2,807). Coal cost 0·44d. (0·38d.) per unit sold, works costs were 0·68d. (0·66d.), total running costs 1d. (0·98d.), and total costs, including capital charges, &c. 1·79d. (1·82d.). Units generated were 10,652,980 (9,569,260) and sold 8,552,729 (7,831,593). Maximum load was 4,989 kw. (4,429 kw.) and load factor 19·57 (20·19) per cent.

Mr. Albert Gay (borough electrical engineer) says in his report more than half the 8½ million units sold were for power, the increased use of power having been over 1,000,000 units. Lighting, however, has shown a further decrease, but with regard to lighting the rock-bottom effect of the war conditions upon this class of consumer has probably been reached, as the restrictions have become more and more stringent during the year. The "Daylight Saving" Act, it is estimated, will have no serious effect upon the undertaking. Charges for current were increased 15 per cent. at the end of 1915. Owing to having favourable coal contracts up to the end of December, the serious increase in the cost of coal has not materially affected the year's accounts, although the effect can be realised by the fact that for three months of the year the cost of coal per ton was increased by about 9s. to 10s., thus accounting for the increased cost of coal per unit generated, increasing from 0·38d. to 0·44d. (According to the contracts for 1916, the average price is 21s. 8d., compared with 12s. 8d. for 1915. There are 1,293 motors connected to the mains, totalling 6,975 H.P., and applications waiting for connection of 1,766 H.P.

Sheffield.—The accounts of the tramways department for the year ended March 25, show total capital expenditure £1,554,201 (increase £9,941) or £1,420,046, after deducting depreciation on horse traction systems, and total amount of sinking fund is £562,783.

Revenue was £455,608 (compared with £396,229 in previous year), working expenses were £270,939 (£246,829), war allowances to employes' dependents £11,209 (£5,706), income tax was £13,861 (£5,566), and interest and sinking fund required £63,818 (£73,893), leaving net balance £95,779 (£69,939). After making contributions for improvements, renewals, special purposes, surplus fund, capital outlay, and a grant of £5,000 to Sheffield University, £41,855 (£22,876) has been devoted to aid of district rate. Average total revenue was 12·236d., and working expenses, including power, but excluding war allowances, were 7·333d. (6·568d.) Average fare charged per mile was 0·371d. (as in previous year). Passengers carried were 123,429,410 (107,023,195), car-miles run 8,867,726 (8,810,252), and units used 19,566,818 (18,329,775) = 2·173 (1·979) per car-mile.

The Committee's report states that the length of (equivalent) single track is 79 miles, the number of cars 339, and of motor 'buses 21, besides water, stores and other cars 13. 426 of the employés have joined H.M. Forces. The expenditure on renewals of permanent way (track and rails) was £10,833, a reduction of £12,739, but certain renewals work, which would have been done in the ordinary course of events at a cost of approximately £10,000, has been postponed on account of the war. The saving is, therefore, only temporary, as the amount of track renewal to be carried out at the end of the war will be considerable. Total length of trolley wire in use is 88 miles. During the year 10 miles of this has been renewed. Improvements have been carried out by altering the position of poles, by planting additional poles and installing additional automatic point controllers which are operated from the car without the motorman leaving the platform. Automatic trolley reversers have been fitted at the termini of several of the routes to enable the trolleys of cars to be automatically reversed without leaving the wire, and thus obviating the necessity of employes removing the trolley from the wire by means of bamboo canes. All that is required of the motorman is that the car shall be driven very slowly over the portion of the line where these are fixed so that the trolley does not race. One great advantage of the arrangement is that the car is never required to be in darkness, which removes the cause of complaint against an impetuous motorman or conductor who will not wait in the evenings until passengers have left the car before removing the trolley from the wire. The number of automatic reversers will be increased until all terminal points are so fitted. During the year the department's resources have been severely taxed to meet the demands for increases in car services required in consequence of the large number of extra hands employed in factories. On the Tinsley service there was an increase in mileage of 180,000 miles, on the Firth Park (Brightside Lane) service an increase of 20,000 miles, and on the Walkley service an increase of 28,000 miles. On the Tinsley cars alone 16,408,000 passengers were carried, being an increase of 1,677,000 or 10 per cent. for the year. To enable the department to carry on in spite of the serious shortage of men it was necessary to get the assistance of women as car conductors, and the only men remaining as conductors are those unfit for motormen and not eligible for the Army. Women are also engaged at the car depots on the work of car cleaning and are gradually replacing men on this work. There are now 706 women employed on the tramways. The gross profit on the working of the motor 'buses was £5,516, and the net surplus after paying capital charges, income tax, &c., was £3,816.

COMPANIES' MEETINGS AND REPORTS.

Chili Telephone Co. (Ltd.)

The twenty-seventh ordinary general meeting was held on Tuesday last, Mr. GEORGE KEITH, the Chairman and Managing Director, presiding.

The SECRETARY (Mr. W. G. Mare) having read the notice convening the meeting and the auditors' certificate,

The CHAIRMAN said: Gentlemen, I have now to propose the adoption of the report and accounts for the year ended March 31 last. Our business has again passed through a very abnormal year, and, all things considered, I think you will find the results of the year's working satisfactory. Chili suffered badly in consequence of the war, closing her principal markets for the export of nitrate, her chief source of revenue. Since the commencement of the year under review the demand, principally by the United States, for nitrate to manufacture explosives, has in a measure covered the loss of the European markets. The oficinas which were closed at the end of 1914 have been re-opened, and the output shipped to the United States and other neutral countries. High prices also benefited mining and agriculture, increasing the export of these products. Then came the stoppage of the Panama Canal and with it lack of shipping and dear freights, greatly delaying and restricting Chili's exports and imports, which reacted badly upon the general economic condition of the country and our business in particular. A large number of subscribers was connected up during the year, but, unfortunately, the net increase was much reduced by those who had to give up their telephones in consequence of necessary economy or bad business. The revenue increase from this source was thereby much reduced. There was, however, a large increase in fee message and miscellaneous receipts, and the whole sterling income was also considerably enhanced by the higher value of the Chilian currency in which it was collected during the year. Altogether the revenue in Chili from all sources shows an increase of £9,577, and the total revenue, including interest on investments and transfer fees, amounts to £121,973, or £9,612 more than it was last year. The working expenditure in Chili also shows an increase of £5,439, and absorbs 52 per cent. of the revenue, or about the same as last year. The high price of materials, and the cost of repairing the damage done to the overhead plant by the large fires which occurred in Concepcion, Talcahuano and Valparaiso, added considerably to the year's maintenance expenses. The London expenses are £174 less, but income tax shows a large increase of £2,727. Altogether the total expenditure amounts to £72,388, or £7,992 more than it was last year. The result of the year's working is a credit balance of £49,585, of which the sum of £2,644 was expended in Chili during the year on replacements of plant. An interim dividend of 3 per cent. was paid in January, and after carrying £18,577 to the general reserve and £2,000 to the reserve against loss by depreciation on investments, the Directors now recommend the payment of a final dividend of 5 per cent., making, with the interim payment, a total distribution for the year of 8 per cent. on the share capital, free of income tax, the same as last year, and carrying forward £4,302, as compared with £4,338 last year.

Amongst the new works carried out during the year I may mention the purchase of a site at Vergara, in the Vina del Mar district, upon which a new exchange building has been erected. A house has also been purchased for the exchange at Melipilla. New offices have been opened and equipped at Diaguitas, Chanaral, Alto, and Vilcun, and several inter-town lines have been erected in the Central and Southern districts. A new switchboard has been imported for Santiago, and is being installed.

Since the commencement of the current year the demand for nitrate and metals continues, and production in Chili is now as large, if not larger, than it was before the war, and is now being exported principally to the United States, the Panama Canal being again open. Our business up to the present is making steady progress, and the outlook for the current year is very promising. The Company is being ably represented and managed in Chili. The property and plant are being maintained in a high state of efficiency, and every attention is paid to give a good and satisfactory service.

The report was adopted unanimously, and the dividend approved. The retiring director (Mr. Keith) was re-elected, the auditors re-appointed, and the proceedings terminated with a hearty vote of thanks to the chairman, directors and the staff at home and abroad.

CROMPTON & CO. (LTD.) The directors' report for the year ended March 31 states that the gross profit was £63,117. 17s. 5d. After deducting general charges, depreciation, interest on debentures and other items, there remains, with the sum brought forward from previous year, an available balance of £37,950. 8s. 1d., which the directors recommend be disposed of as follows: General reserve fund £6,500, special depreciation account £10,000, to writing off balance of preliminary expenses £1,608. 1s. 2d., dividend on the preference shares at the rate of 7 per cent. per annum £9,363. 1s., balance carried forward (subject to excess profits tax and assessment under the Ministry of Munitions Act, 1915) £10,479. 2s. 11d. In view of the company's liability in respect of the excess profits tax and under the Ministry of Munitions Act, the directors do not deem it prudent to recommend a dividend on the ordinary shares. On Aug. 18, 1915, the company's works were declared a controlled establishment under the Ministry of Munitions Act. Mr. Thomas Britten, manager of the works at Chelmsford, has been elected to a seat on the board. The retiring directors, Mr. J. A. Reeve and Mr. A. A. Campbell Swinton, F.R.S., offer themselves for re-election.

ELECTRIC & GENERAL INVESTMENT CO. (LTD.)—The directors' report for the year ended May 31, 1916, states that the gross profit for the year was £7,336. 10s. 11d. After deducting general charges and interest on

debenture stock and adding £5,222. 5s. 7d., brought forward from last year, there remained a balance of £10,194. 10s. 1d., which is carried forward. Mr. J. Cecil Bull retires by rotation and offers himself for re-election as a director.

GENERAL ELECTRIC CO. (LTD.)—The annual general meeting of this company was held on Monday, Mr. H. Hirst (chairman and managing director) presiding. The chairman said the company had made a net increased profit of nearly £31,000, had spent roughly £80,000 in works extensions, and had been able to keep £252,000 invested in War Loan and Treasury bills. The proposed appropriation provided for an increase to the reserve fund of £40,000 and an increased carry forward of £11,000. The distribution on the ordinary shares was the same as last year. Dividends absorbed £92,000 (compared with £87,000). Grants to dependents of men on active service reached a total of £12,960. The advance shown was all the more remarkable as a great portion of the previous year's output was for Government requirements, and the prices charged were, almost without exception, the same as those ruling prior to the war; only in certain cases had they asked for advances, and then only in proportion to the increased prices of raw material and labour. The higher profits were mainly due to the fact that under present conditions they had obtained more repetition work than one could expect in normal times. Their large reserve stock of standard lines had benefited by the general rise in prices, and this had been a contributory factor to the success of the year. Above all, the results were mainly due to the loyalty, co-operation and resource of the staff and the majority of the work-people, a goodly number of whom would not be lured away into concerns started since the war which temporarily were offering tempting and abnormal wages. Many of their people had been able to advise and give useful assistance to Government Departments and Committees in experiments and in the evolution of scientific problems which the conditions of war had created. The shareholders would agree that this was not a time for thinking of larger dividends. With the ever-increasing difficulty of obtaining raw material the probable further diminution in the supply of labour and the necessary limitation to imports and exports, it was impossible to forecast what surprises might be ahead of them. They must persevere in conserving their strength and keeping their assets liquid. A big task confronted the electrical industry. Much was expected of them, and the company were anxious to fulfil those expectations. As soon as they had the slightest indication as to the Government policy after the war they would be willing to open up in new fields and avenues which had hitherto been closed to the manufacturers of this country. Their sales organisations overseas were so unique and firmly established that they were prepared for any challenge. It was just this desire to keep their oversea branches alive and well organised that was causing them anxiety, as export business was now rendered so difficult due to lack of tonnage. If a portion of the past profits was always available for pioneer work, for testing, sounding and studying new inventions, and investigating fresh fields of inquiry, one had the greatest chance of remaining at the top of the industry. The investment account was likely to be still further increased next year. He presumed, however, that so long as this account showed a handsome yield the shareholders would encourage the board to go ahead. Through one of their associated companies, the Peel-Conner Telephone Works, they had established a magneto factory near Coventry. Under the title of the Conner Magneto Ignition (Ltd.), that company had evolved a magneto for which Government contracts had already been secured. Their labour and resources were being used to the utmost to further the end they all had in view—namely, complete victory. Of their 1,500 people who had laid aside their tools in order to fight for British liberty, 52 had made the supreme sacrifice, 133 had been wounded, 61 invalided and four were missing or prisoners of war. The company had a scheme for regularly communicating with and supplying comforts to those serving at the Front, and they fervently hoped that, at a not far distant date, they might see them back again at their old places in the firm. He proposed that the report and accounts for the year ended March 31, 1916, be approved and adopted.

Mr. E. G. Byng (vice-chairman) seconded the resolution.

Mr. Frederick Walker asked what was going to happen in view of the fact that roughly £80,000 had been expended in works extensions. If capital was being sunk in works extensions in order to place a company like this in a position to do good work for the Empire, it seemed unreasonable that they should be told that losses made in times of peace should not be made up in times of war. The Government said 50 per cent. of the profit was to go into the hands of the Chancellor of the Exchequer, to be increased to 60 per cent., and, according to gossip, probably to 95 per cent. If the Government were to so discourage companies and individuals who placed at the disposal of the Empire the means of protecting it the effect would be to drive those industries to America and other neutral countries.

The Chairman said he sympathised with the remarks of Mr. Walker, but the question which he had raised was not such a burning one for them as for many other companies. Electrical apparatus and appliances were works both of peace and of war, and he believed a large proportion of the amount they had spent would again be useful in the natural development of the company's business in peace time. The principle involved would be fought out by firms which were much more affected than themselves.

The report and accounts were adopted, and the dividend of 10 per cent. on the ordinary shares approved.

The appointments of Mr. M. F. Armstrong, Mr. G. H. Ide and Mr. M. Solomon as directors were then confirmed, and Mr. E. G. Byng (vice-chairman of the company) was re-elected as a director. A vote of thanks to the chairman, directors and staff concluded the proceedings.

ST. JOHN DEL REY MINING CO. (LTD.)—At the recent meeting, Mr. H. Percy Harris, M.P., who presided, said that they hoped to work the mine profitably below horizon 20, and in order to do that they must have (among other things) an additional supply of power. As regarded power, a dam had been constructed by which water was accumulated which could be used when the River Peixe, which was their main source of power, ran low. Then a considerable amount of tunnelling and other work had been done in connection with what was called the Peixe E scheme, by which it was proposed to supply themselves with a considerable amount of additional power.

VENTURE TRUST (LTD.)—At the meeting on Friday last the chairman (Mr. Arthur Baumann), in moving the adoption of the report (abstracted in our last issue), said the real point of interest in the report was the formation of the British Electrolytic Zinc Co. (Isherwood Process), (Ltd.), of the capital of £62,500 in shares and £25,000 in debentures authorised, there had been issued £42,400 in shares and £21,200 in debentures. The Fresh Issues Committee has sanctioned this issue which indicated that the Treasury recognise that this company was promoting, or helping to promote, an industry of national benefit and importance. They had reserved for the Venture Trust £12,000 of the debentures, carrying interest at 7 per cent., and they had received a bonus in shares of £14,400. The directors subscribed £2,000 of the debentures, the vendors of the patent process, the Refractory Zinc Ore Treatment Co., have subscribed £4,000 of them, and the other £3,200 had been placed among individual friends. The company has acquired the Isherwood process for the electrolytic treatment of zinc in Great Britain and Ireland, and it had also acquired an 84 per cent. interest in all the foreign and Colonial patents outside the United States. They had acquired a plant at Widnes, Lancashire, and he hoped in a few weeks' time they would be producing electrolytic zinc. If their anticipations were realised the patents in Great Britain and the Colonies would be very valuable, and the 14,400 shares which they had would also be valuable, and a welcome addition to the company's assets. They were entitled to assume that spelter and electrolytic zinc would range at prices between £25 and £40 a ton for some years to come. The annual production of spelter of the world was just short of 1,000,000 tons, of which Great Britain consumed 200,000 tons. About 58,000 tons of spelter out of 200,000 tons were smelted within the British Empire. After the war the Australian Colonies would be turning out zinc-lead ore to the amount of over 500,000 tons per annum. This would have to go to the United States to be smelted or treated electrolytically, unless the British Colonies and Great Britain herself exerted themselves to erect smelting plant. It would take some £2,000,000 or £3,000,000 of capital to erect the plant necessary to deal with these concentrates. That capital will be forthcoming, provided the producers of spelter of electrolytic zinc could be assured that they would be protected by their Government from German methods of competition. The spelter industry could be protected by a bounty on production, by a prohibitive import duty, or by an export duty. Allowing the metal trade to pass entirely into the hands of German producers was a great blunder. The report was adopted.

CITY NOTES.

MEMORANDA (July 19).—**Bank rate 6 per cent. (since July 13, 1916). Consols 59. Consols Pay Day, Aug. 2. Stocks and Shares Ticket Days, July 27 and Aug. 15. Pay Days, July 28 and Aug. 16. Price of silver, 29⅝d.**

AMERICAN TELEPHONE & TELEGRAPH CO.—This company's earnings (six months) to June were $25,184,000, against $23,150,000, the surplus, after payment of interest and dividends, being $3,746,000, against $2,701,099.

BRAZILIAN TRACTION, LIGHT & POWER CO.—A dividend of 1 per cent. on ordinary stock has been declared.

BRITISH NORTH BORNEO CO.—In the report for 1915 it is stated that the year's net capital expenditure in respect of railways, telegraphs, works, &c., was £133,224.

COMPANIES TO BE STRUCK OFF THE REGISTER.—The following companies will be struck off the Register of Joint Stock Companies unless cause to the contrary is shown before Sept. 30 next: Australasian Vacuum Cleaner Synd., British Motobloc Synd., British Tungsten Lamp Co., Compagnie Generale Electrique de la Champagne, Doncaster Electrical Co., Electra House (Belfast) Electrical Advertising Co., Electric Safety Boiler Cleaner, Ernest Scott & Mountain, Kevan Electric Co., Mica Mfg. Co., Molybdenite, National Lighting Corpn., Platinum Corpn., Signs.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.) The interest on this company's 4 per cent. mortgage debenture stock for the half-year ending July 31, due on 1st prox., will be paid by warrant on that date. The 4 per cent. mortgage debenture stock register will be closed from 27th to 31st inst., inclusive.

HADFIELDS (LTD.)—The directors have declared an interim dividend of 1s. per share (tax free) on the ordinary shares.

LIVERPOOL OVERHEAD RAILWAY CO.—The directors have declared an interim dividend to June 30 on account of the year ending Dec. 31, 1916, at the rate of 5 per cent. per annum on the preference shares, and 2½ per cent. per annum on the ordinary shares (less tax).

MONTREAL WATER & POWER CO.—The gross profits of this company for the year ended April 29 were $454,340, against $444,968, and the net

profit was $204,067, against $195,727. This has been disposed of by providing for depreciation, $60,000; bad debts, &c., $14,159; year's proportion of discount on sales of bonds and addition and interest for premium at maturity on prior lien bonds, $27,340, leaving to be carried forward, $102,567, which, with the balance brought forward from previous year, makes a total of $415,232.

RIO DE JANEIRO TRAMWAY LIGHT & POWER CO.—A dividend of 1¼ per cent. on capital stock has been declared.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—The share transfer books of this company will be closed from July 22 to Aug. 4, inclusive, preparatory to the payment of dividends for the half-year ended June 30.

SAO PAULO TRAMWAY, LIGHT & POWER CO.—A dividend of 2½ per cent. on the common stock has been declared.

VERITY'S (LTD.)—Meetings of holders of ordinary and management shares are to be held on July 25 at 31, King-street, Covent Garden, London, W.C., to consider a scheme of arrangement proposed to be made between the company and the holders of such shares.

VICKERS (LTD.)—The company has issued to the shareholders a circular stating that owing to the time required for preparing the accounts and statements to comply with the Finance (No. 2) Act, 1915 (Excess Profits) and of the Munitions of War Act, it will not be possible to get the accounts and balance-sheet ready to present at the annual meeting that must be held within 15 months from the date of the last annual meeting. The meeting will be held on 26th inst., and a resolution will be proposed that it be adjourned until the accounts are ready.

WESTERN UNION TELEGRAPH CO.—This company's revenue for the half-year ended June 30 was $29,125,269, and expenses, including maintenance and reserve, were $22,278,592. Interest on bonds required $665,925, leaving net income $6,180,752 (increase $2,068,315).

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date July 18, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	14¼d.
Solid Drawn Copper Tubes	17¼d.
Brazed Copper Tubes	17¼d.
Brazed Brass Tubes	16¼d.
Brass Wire	15¼d.
Copper Wire	18¼d.
Rolled Brass	15¼d.
Brass Sheets	16¼d.

	per ton.
Copper Sheets	£146 0 0
Spelter	£48 0 0

	per ton.
English Lead	£29 5 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£80 0 0
Clean Brass Scrap	£56 0 0
Braziery Copper Scrap	£70 0 0
Old Lead	£22 0 0
Old Zinc	£35 0 0
Hollow Pewter	£118 0 0
Black Pewter	£80 0 0
Gun Metal	£72 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date July 18, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£95 0 0
Clean Mixed Brass	£56 0 0
Clean Copper	£84 0 0
Braziery Copper	£70 0 0
Gun Metal	£74 0 0

	per ton.
Old Lead, Tea Lead	£3. 10s. under price of English lead
Old Zinc	£37 0 0
Hollow Pewter	£120 0 0
Shaped Black Pewter	£85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £97; Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, July 18. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	NAME.	Price, Tues., July 18.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅝	6 10 2	Mar, Sept
10	4¼%	Do. 4¼% Cum. Pref.	8⅞	5 11 8	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	10⅞	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅝	7 12 5	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. C. Deb. St	80	5 0 0	..
St.	4%	Charing Cross West End & City Debs.	82†	4 17 7	Jan, July
5	2/3	Do. 4¼% Pref.	3½	7 4 0	..
5	5%	Do. Ord.	3½	6 13 4	Aug, Feb
5	4¼%	Do. City Pref.	2⅛	7 13 2	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3½	6 8 0	Mar, Sept
St.	4¼%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12½	6 8 0	Feb, Aug
10	6/0	Do. 6% Pref.	10½	5 14 3	Mar, July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun, Dec
St.	4¼%	Do. 4¼% Debs.	80	5 2 6	Jun, Dec
10	7%	County of London Ord.	10⅛	6 11 9	Mar, Sept
10	6%	Do. 6% Pref.	10½	5 14 1	Feb, Aug
St.	4¼%	Do. 1st Deb.	87½	5 4 2	Jan, July
St.	4¼%	Do. 2nd Deb.	83½	5 7 4	My, Nov
St.	4¼%	Edmundson's Elec. Supp. 4¼% Debs.	75½†	5 18 10	July
5	7%	Kensington and Knightsbridge Ord.	5	7 0 0	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6%	London Elec. Supp. 6% Pref.	4⅛	6 1 6	..
St.	4%	Do. 4% Mort. Debs.	80½	4 12 5	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅜	7 [illegible] 11	Mar, Aug
St.	4¼%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	2⅞	7 0 8	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	NAME.	Price, Tues., July 18.	Rate per cent Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	6	6 13 4	Feb, Aug
5	7%	Do. do. Pref.	5⅞	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	73	6 3 3	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1½	6 8 0	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6⅝	5 9 10	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4½	5 5 11	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	83½	6 0 1	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	81	7 8 2	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	74	5 8 1	..
St.	4%	Do. do. Assented Def. Ord.	72⅜	5 10 6	..
St.	4½%	Do. 4½% Pref.	84†	5 7 2	Jan, July
St.	4%	Do. 4% Deb. St.	76†	5 5 3	Jan, July
St.	4%	City & S. London Deb.	74⅞	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70½	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅛	5 14 3	Jan, July
St.	4%	Do. 4% Pref.	69	5 15 1	Mar, Sept.
St.	4%	Do. 4% Debs.	76	5 5 3	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25⅛	3 17 1	Feb, Aug
St.	3½%	Do. 3½% Pref.	65⅝	5 6 8	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	61½	5 14 3	Feb, Aug
St.	3½%	Do. 3½% A Debs.	69½†	5 0 9	Jan, July
St.	3½%	Do. 3½% Debs.	68½†	5 2 2	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	19½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	76	5 5 3	May, Nov
St.	4½%	Do. 4½% First Pref.	73½	6 2 4	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	109	5 10 1	Jan, July
St.	4%	Do. 4% Debs.	77	5 3 11	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	77½	5 3 3	Jan, July
St.	4%	Do. 4% Guar. Stock	70	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	3	5 0 0	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1½	5 12 0	Mar
100	5%	Do. Prior Lien Debs.	92⅞	5 7 11	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	11⅝	7 9 4	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	⅝	6 12 5	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	5 18 6	April
100	6%	Do. 6% Prior Lien Debs.	101½	5 18 3	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65½	6 2 2	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅛	8 12 7	Jan, July
5	5%	Do. 5% Pref.	4	6 5 0	Feb, Aug
St.	4½%	Do. 4½% Debs.	84	5 7 2	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	[illegible]	7 2 3	Sept
5	..	Edison & Swan U.Elec.Lt.A. £3 pd.	½	..	Feb, Aug
St.	4%	Do. 4% Deb.	59	5 4 3	Jun, Dec
1	7½%	Elec. Construction Ord.	[illegible]	8 17 9	May
1	7%	Do. 7% Cum. Pref.	[illegible]	7 4 6	Jan, July
St.	4%	Do. 4% Debs.	71⅜†	5 11 6	Jan, July
..	10%	General Electric Ord.	11⅛	8 11 1	July
10	6%	Do. 6% Pref.	10	6 0 0	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15½	6 7 0	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4⅛	4 14 9	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	12	8 6 8	Feb, Aug
10	5%	Do. Pref.	8⅞	6 1 8	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39†	6 3 1	Mar, July
100	4%	Do. 4% Debs.	95½	4 4 1	Jan, July
1	7½%	Vickers Ord.	1⅜	4 1 4	May, Aug
1	6d.	Do. 5% Pref.	[illegible]	5 3 3	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 4	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 8	Jan, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40½	10 6 9	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	104†	5 15 5	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23⅛	6 17 1	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	70	5 14 3	Ja,Ap,Jly,O
10	5%	Cuba Submarine Ord.	8½	6 1 3	May, Nov
10	10%	Do. 10% Pref.	13⅛	7 5 5	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅛†	6 9 4	Ja,Ap,Jly,O
St.	8%	Eastern Tel. Co. Ord.	148	5 7 7	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	67†	5 4 6	Ja,My,Jly,O
St.	4%	Do. 4% Debs.	78½	5 1 7	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78½	5 2 3	Feb, Aug
10	8%	Do. Ord.	15†	5 6 8	Ja, Ap, Jly,O
10	22%	Gt. Northern Tel. Co. With Coup 11	37½	5 16 2	Ja, My, Jly
25	13%	Indo-European	48	6 15 5	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3⅜	3 4 8	April
1	7%	Do. 7% Pref.	2⅛	2 14 9	July
10	1%	West India & Panama Ord.	1⅜	8 19 5	May, Nov
10	6%	Do. 1st Pref.	7⅞	7 16 1	May, Nov
10	8%	Western Telegh. Co.	14⅛	5 8 0	Mr,Jly,O,Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 3	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99⅛	4 10 10	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅛	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	2	5 0 0	Apl, Oct
St.	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Do. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅛	5 15 4	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅛	5 6 8	Jan, July
St.	4½%	Do. Deb. Stk.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12⅛†	4 13 8	Sp,De,Mr,Je
10	6%	Do. 6% Pr.	10⅛†	5 11 8	Sp,De,Mr,Je
100	5%	Mackay Companies' Common	83½	5 19 9	Ja, Apl, Jly,O
..	4%	Do. $100 Pref	70	5 14 3	Ja,Ap,Jly,O
100	6%	Submarine Cable Trust Certs	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	5	6 0 0	Mar, Sept
St.	5%	Do. 5% Debs.	94½	5 5 10	Jun, Dec
10	6/-	Bombay E. S. & T 6% Pref.	10½	5 14 3	..
St.	4½%	Do. 4½% Debs.	83	5 8 5	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6½	7 6 11	May, Nov
5	5%	Do. 5% Pref	4⅝	5 9 7	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,993. [No. 17. Vol. LXXVII.] **FRIDAY, JULY 28, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 553
Arrangements for the Week.. 555
Some Mechanical Analogies in Electricity and Magnetism. By W. S. Franklin. Illustrated 556
Treatment of Silver Furnace Fume by the Cottrell Process. By Charles H. Aldrich 559
Two Notable Floating Cranes. By H. H. Broughton. Illus. 561
National Physical Laboratory. *Continued* 565
Properties of Reactor with Iron Core and Air-Gap. By S. Sano. Illustrated..... 567
The Bettington Boiler. Illus. 568
New Galvanometer Lamp and Scale. Illustrated..... 569
ANALOGIES AND MODELS 570
Recent Patents in Radiotelegraphy and Radiotelephony. By W. Eccles, D.Sc. Illustrated 574
CORRESPONDENCE..... 574
Abacs for Electrical Calculations (C. Howard).
Engineering Education and Research (J. C. Maxwell Garnett).
Neglect of Science (Alfred S. E. Ackermann).
Patent Law Reform.—*Discussion*..... 575
LEGAL INTELLIGENCE 576
PARLIAMENTARY INTELLIGENCE 576
The "Electrician" Commercial and Industrial Section .. 577–581

NOTES.

Technical Education for Apprentices.

WE are glad to see that the St. Marylebone Council are taking steps to facilitate the technical instruction of the apprentices in their Electricity Department. Arrangements have been made with the Education Department of the London County Council, and a special class is to be set up exclusively for the instruction of these apprentices at the Marylebone Central Institute, classes being provided on three evenings per week and two hours per evening. The time is divided up so as to give two hours to practical science, two to technical drawing, one to mathematics and one to English. This first, course covers two years and costs quite a nominal fee of 2s. if the number of attendances is 75 per cent. or above. Afterwards the apprentice is passed to the Senior Department at the Polytechnic, Regent-street, where students showing an average ability have opportunities at the end of the second session of winning exhibitions which would provide them with a means of acquiring the necessary text-books and instruments. The senior part of the tuition lasts for three years and is divided equally between electrotechnology, technical drawing and mathematics. This scheme is certainly a move in the right direction, and we hope that it will be copied by other bodies. There is only one point which is a little uncertain in the details which have been published, and that is how far these evening classes are provided in the working hours. It is too much to expect apprentices to attend technical classes for three evenings a week if this course is to be taken as additional to their normal daily work. We hope that it is otherwise, as the best results can only be obtained by training the mind when the body is not fatigued.

The National Physical Laboratory.

THE Annual Report of the National Physical Laboratory this year is somewhat shorter than usual and is not of quite such general interest, as indeed would be expected owing to war conditions. Nevertheless, a good deal of instructive information is given, and the investigations are, perhaps, of a more practical interest than is often the case. As an example, we may take the question of the transmission of heat through roofing materials. During recent years there has come into somewhat extensive use a roofing material consisting of cement made up with fibrous material. This is a competitor of sheet iron for certain classes of building, and as its thermal conductivity is something like one-seventieth that of iron, the very natural assumption would be that it would prove superior from the point of view of keeping heat within a building, or equally from keeping a building from getting too hot in summer time. Owing to the fact that the amount of heat to be provided in the heating of factories depends upon the amount of heat that is dissipated by the roof and walls led to this problem being placed in the hands of the National Physical Laboratory by a firm of consulting engineers. It is interesting to note that the results of actual tests on a model building show that preconceived ideas were quite wrong. It appears that the heat loss per square foot of the composite material is about 20 per cent. greater than it is through galvanised iron. The explanation of this result lies in the difference of surface emissivity of the two materials. If the surface of the iron is painted black the heat transmission becomes equal to that of the composite material, and conversely if the external surface of the composite material is coated with aluminium paint the transmission becomes practically identical with that obtained with galvanised iron. Although the fundamental laws on which such phenomena depend are exceedingly well known, it often happens that they are entirely disregarded in practical work through the lack of actual measurements.

Fas est ab Hoste doceri.

THE attitude of a section of the lay Press towards higher technical education is to be deplored. Some of the ultra patriots have now started the cry that we will not "Germanise" our system of education. Although we are second to none in our detestation of the methods of what we hope to be a small section of the German people, it must not be forgotten that most of the social reforms that have been introduced into this country during the last 20 years were first made in Germany. There is, therefore, no more disgrace in applying some of the German methods to our educational system than there is in allowing certain of the social reforms to remain on the Statute Book. Furthermore, it is well to remember that, had we not availed ourselves during the present war of the advantages which technical training and research alone afford, we should, long ere this, have been either degraded or annihilated. By some it is thought that the purpose of science is to make war frightful, but if such people study the question they will find that civilisation and science are synonymous. To argue that because man is base enough to misuse science, science must

per se be bad is about as absurd as to argue that a ban should be put on all literature because degenerates write immoral books. It were better for the lay Press to stick to the subjects of popular interest, and to use their columns for the discussion of the idiosyncrasies of the " flapper " rather than decry that to which they owe not only their existence but also their circulation.

A Question of Royalties.

THE application by the Suffolk Electricity Co. for a compulsory licence to use a German patent raises a somewhat delicate point as to what is and what is not reasonable in royalties. In the present instance it is not a question of obtaining a compulsory licence to use a patent which is not already being worked in this country. The patent in question, which is of some importance, relates to the fitting of a subsidiary pump to the cylinders of Diesel engines, so that a small proportion of petrol may be used for ignition purposes, thus enabling tar oil to be used for the bulk of the work. A licence is already held by Messrs. Mirrlees, Bickerton & Day, but the contention is that in a particular instance the cost of the apparatus under this licence would be £363, whereas the work involved would only account for £60, according to the estimate of the Suffolk Electricity Co. On the face of it this seems to be a very great difference between the two prices. In the defence it was pointed out by Messrs. Mirrlees, Bickerton & Day that they had paid a sum of £1,500 for the licence, and that in addition to this there was a royalty of 2s. 6d. per horse-power of engine to which the device was fitted. Moreover, the actual expenses, owing to experimental work, had amounted to £3,000, and consequently the price could not be regarded as excessive for a piece of apparatus which was actually considerably more costly to make than had been suggested. The matter has not yet been concluded, but it appears to us that there are two points of view. The first is that it is highly undesirable to arrange royalty terms on so high a basis that the price at which the piece of apparatus must be sold is unduly high, for high prices inevitably defeat the object in view. The other point is that it is undesirable to interfere with a licensee who has already incurred considerable expenses, unless the prices at which he is willing to supply the product are obviously exorbitant. Very possibly the result of the action, as suggested by the Comptroller, will be that the applicants will be able to come to some satisfactory arrangements with the licensees.

Wiring Rules of the I.E.E. — ERRATA.— We have received for publication the following errata in the seventh edition of the Wiring Rules :—

Rule 117 (*b*) line 1, for " fitted with " read " controlled by." Rule 121 (*b*) applies to lighting circuits only. Page 42, line 30, for " decks " read " desks."

Petrol-Electric Car. — The " Engineer " refers to a new type of car used in America. A four-cylinder petrol engine drives an electric generator which charges accumulators. These supply current to a motor coupled to the back axle. Control is similar to that of the electric car, there being no clutch or gear box. It may be used either as an electric car for short distances, as a petrol car only, or as a combined arrangement, giving a direct top gear.

Ignition of Petrol by Electric Spark. — The " Insurance Observer " refers to several cases of ignition of petrol vapour, of which the following is an example :—

A chauffeur desiring to fill the tank of a large limousine car, which was standing on a cement floor, took an ordinary 5 gallon can with a wooden handle on the bail, and hung it by this wooden handle on the hook of a self-measuring petrol pump, connected with an underground tank in the yard outside. He had drawn off about one gallon when he heard a snapping sound and saw the can burst into flame. The door of the garage happened to be open at the time, and the chauffeur seized the can around the lower part and threw it out upon the concrete walk in front of the building, where it upset. The burning fluid ran down to the side walk, but nobody was hurt. The chauffeur had no other can, and as this one was intact he carefully washed it out, wiped it dry, and hung it on the hook again by the same wooden handle, which was only charred by the fire. This time he had drawn about two gallons when the contents of the can took fire once more, whereupon he repeated the act of throwing it out of the door, and refused to use the can again.

On account of these accidents regulations have been framed by the State of Massachusetts in regard to earthing.

Electric Hammer Drills —" Engineering " refers to a bulletin issued by the Chicago Pneumatic Tool Co. regarding the Demtley portable electric hammer drill.

These tools are suitable for drilling holes up to 1 in. in diameter in stone or concrete, and also for light chipping, are operated by a small electric motor, which runs equally well on either continuous or single-phase current. The hammer blow is delivered on to the drilling-bit, or chisel, by a piston operated by pneumatic power from the motor, which is controlled by a thumb-switch on the handle of the tool. Ball-bearings are used throughout for the rotating parts, and provision is made for the thorough lubrication of all moving parts. A special feature of the tool is the use of compressed air for blowing dust and chippings out of the hole during the process of drilling. For this purpose the drilling-bits are made hollow, and the air is delivered through them close to the cutting edges. This arrangement not only ensures the full force of the blow being delivered directly on to the stone or concrete, but also enables the drilling-bit to be easily withdrawn, when the hold is finished, by removing the chippings, which might otherwise cause it to jam. The weight of the tool is 21 lb., and its over-all length is 17½ in.

Magnetic Shielding.—At a recent meeting of the Royal Society a Paper on " The Magnetic Shielding of Large Spaces and its Experimental Measurement " was read by Prof. E. Wilson and Prof. J. W. Nicholson. It appears that (*a*) the magnetic shielding of a large space is a problem wholly different in practice from that of a small space, and in view of important applications the efficiency to which such shielding can be raised is a matter of importance. Considerations of mobility of the apparatus and weight of iron required necessitate the solution of the problem of maximum shielding for a given weight of iron and more than two shells, together with an examination of the limitations of utility of lamination. These problems are discussed in the Paper. (*b*) A field of order as low as 3×10^{-3} has been obtained in a space of radius 30 cm. by the use of 1,273 kilos of high permeability dynamo magnetic steel, and an accurate method designed for the measurement of fields of lower order. (*c*) The leakage through air spaces in a magnetic shield has been studied. (*d*) It is now possible to examine the behaviour of iron under practically no magnetic force.

OBITUARY.

SIR WILLIAM RAMSAY.—With great regret we record the death on the 23rd inst. of Sir William Ramsay, K.C.B., F.R.S., Sc.D., &c., Emeritus Professor of Chemistry at University College, London. Sir William Ramsay was educated at Glasgow Academy, and at the Universities of Glasgow and Tübingen. After acting for two years as assistant to the " Young " Chair of Technical Chemistry in Anderson's College, Glasgow, he was, until 1880, " tutorial assistant " in the Chemical Department of Glasgow University. In 1880 he was appointed to the Chair of Chemistry in University College, Bristol, and in 1881 was made Principal of the College. In 1887 he succeeded Prof. A. W. Williamson as Professor of Chemistry in University College, London, and in 1907 was made a Professor in the University of London. He was President of the British Association in 1911, a past-President of the Society of Chemical Industry and a past-President of the Chemical Society. He was President of the International Congress of Applied Chemistry at its meeting in London in 1909. He was an Officer of the Legion of Honour of France and foreign member of the French Institute, and of the Royal Academies of Berlin, Petrograd, Vienna, Stockholm, Copenhagen, &c., as well as honorary fellow of the Chemical Societies of Germany and America. Sir William published the results of numerous researches, the chief of which relate to the molecular volumes of liquids, the thermal properties of alcohols, ether and water, the experimental proof of the existence of a triple point for water, ice and steam, and the behaviour of dissociating substances; also of the variation of capillarity with temperature, which affords a means of determining the molecular weights of liquids and the degree of association of certain liquids; the adiabatics of ether and the condition of hydrides of platinum and palladium. In 1894, in conjunction with Lord Rayleigh, he discovered " argon, a new constituent of the atmosphere,"

and in 1895, terrestrial helium. These discoveries were followed in 1898 by that of neon, krypton and xenon, in conjunction with Dr. M. W. Travers; the properties of these new elements were investigated and an account of the research published in the "Phil. Trans." in 1900. The existence of a complete group of non-active elements was then established, which form transition numbers between the electro-negative group of chlorine elements on the one hand, and those of the electro-positive sodium group on the other. In conjunction with Prof. Fred. Soddy, he investigated the nature of the gas emitted by radium, and proved that it decomposes spontaneously, giving helium as a product, thus opening the question of the transmutation of elements. With Dr. Gray, he determined the properties of radium emanation; and with Mr. Cameron and Mr. Usher, the probability that in contact with radium emanation elements of the carbon group are transmuted into carbon. Sir William Ramsay shared the Hodgkins Prize and the Prix Leconte with Lord Rayleigh in 1895; he was also awarded the Davy Medal of the Royal Society, the Longstaff Medal of the Chemical Society, the Le Blanc Medal of the French Chemical Society, the Hofmann Medal of the German Chemical Society, the Gold Medal of the French Association for the Advancement of Science, and in 1904 he was awarded the Nobel prize for chemistry, Lord Rayleigh being the recipient of that for physics. Sir William Ramsay resigned the Chair of Chemistry at University College in 1912. In recognition of his scientific work he was made a K.C.B. in 1902. He was the author of a number of books, including "System of Inorganic Chemistry" (1891), "The Gases of the Atmosphere" (1896), "Modern Chemistry" (1902), and "Essays Biographical and Chemical" (1908). He married, in 1881, Margaret, daughter of the late G. S. Buchanan, who survives him, together with a son and a daughter. The funeral took place at Hazlemere Church on Wednesday.

KILLED IN ACTION.—The following deaths in action or of wounds are reported :—

Second-Lieut. J. M. Bain, M.A., B.Sc. (Scottish Rifles), who was killed recently, was a graduate of Edinburgh University and Science Master at Juniper-street school, Hawick.

Lieut. N. J. Wragg (S. Staffs Regt.), who has died of wounds, was born in 1890. He graduated with honours in the mechanical science tripos at Cambridge University in 1912, and was afterwards engaged with John Taylor & Sons, civil engineers. He was an A.M.Inst.C.E.

Capt. H. K. Turner (Suffolk Regt.), was killed on July 16, after returning to the front following recovery from a previous wound. He was about 27 years of age and a director of E. R. & F. Turner (Ltd.), gas and oil engine makers.

Second-Lieut. C. R. Ward (R.E.), aged 32, killed on July 14, was on the staff of the British Westinghouse Co., Trafford Park.

Second-Lieut. F. R. Hoggett (Queen's W. Surrey Regt.), who has died in London of wounds, was an A.M.I.E.E., was trained in engineering at Faraday House and was subsequently in the service of the Lancashire Electric Power Co. and Callender's Cable & Construction Co.

Lieut. W. H. Milburn (Suffolk Regt.), killed in action, was a B.A. of Cambridge and science master at Framlingham College, Suffolk.

Lieut. Basil Withy (Liverpool Regt.), reported to have died of wounds on July 2, was a naval architect in the scientific department of Denny & Bros., Dumbarton.

Second-Lieut. L. R. Davies (Liverpool Regt.), who has died of wounds, was a graduate in science of Liverpool University and a science-master at Worksop College.

Lieut. Gilbert Fyfe (H.L.I.), who has been killed in action, was about 19 years of age, and was an electrical engineering pupil with a Glasgow firm.

Second-Lieut. C. S. Coombes (W. Kent Regt.), who died of wounds on July 6, was educated at the City and Guilds Technical College (Finsbury), and was a student of the Institution of Electrical Engineers.

Private Harry Burniston (W. Yorks. Regt.), 26 years of age, killed on July 1, was a draughtsman at Leeds Corporation electricity works.

H. Noble, late of the Halifax & Bermudas Cable Co., and a private in the Bermuda Rifle Volunteer Contingent (attached 1st Lincolnshire Regt.) was killed in France on the 3rd July.

Second Lieut. O. Colin Harvey (attached to S. Lancs. Reg.), 21 years of age, who was killed on July 4, was an engineering student at the McGill University, Montreal, prior to the war.

Second Lieut. J. N. Pickering-Clarke (Leicester Reg.), 22 years of age, who was killed in action on July 14, was a student of marine electrical engineering at Glasgow when the war commenced.

Capt. L. A. P. Harris (Welsh Regt.), 24 years of age, who has been killed, was an engineering apprentice in the Rhymney Railway Co.'s Caerphilly works and an engineering student at Cardiff College.

PERSONAL.

We are pleased to learn that Major W. A. Vignoles (Borough electrical engineer of Grimsby) is progressing satisfactorily. Major Vignoles was recently wounded in the left hand while on active service.

Mr. S. R. Mullard, A.M.I.E.E., of the Research Laboratory, Edison & Swan United Electric Light Co., Ltd., Ponder's End, has been granted a temporary commission as Lieutenant R.N.V.R. attached to the R.N.A.S. It will be remembered that Mr. Mullard has been actively employed in connection with research work on the Ediswan "Pointolite" (nitrog[illegible] arc lamp). Lieut. Mullard is being retained by the Ediswan Co[illegible]ny, which will enable him to keep in touch with his laboratory work.

Mr. Francis H. Davies, assistant engineer, Weston Electrical Instrument Co., was gazetted on July 21 Lieut. in the Army Ordnance Dept.

Mr. W. Bell, electrical engineer to the Municipal Board of Mussoorie, has been appointed to act as Electrical Inspector to Government, United Provinces, India, vice Mr. H. C. C. Tufnell on military duty.

WAR CASUALTIES.—The following casualties are announced :—

Second-Lieut. Ralph N. Lodge (Lancs Fusiliers), who is reported missing, is a son of Mr. C. S. Lodge and a nephew of Sir Oliver Lodge, and was in the employ of the General Electric Co.

Lieut. A. R. Bedey, reported missing, believed killed, on June 28, went to Cambridge University in 1913 as a Salomons engineering scholar and took a first class in the mathematical tripos, part I., the following year.

ROYAL ENGINEERS (T.F.)—The following appointments have been made :—

London Electrical Engineers: Lieut. W. B. Odham (from Seaforth Highlanders) to be second-lieutenant. Petty officer C. S. Hann (R.N. Div.), L.-Corp. A. C. Stacey and L.-Corp. H. L. Mann to be second-lieutenants (on probation).

Tyne Electrical Engineers: Capt. (temporary major) A. K. Tasker to be major. C. B. L. Fernandes to be second-lieutenant (on probation).

APPOINTMENTS VACANT AND FILLED.

A capable electrician is wanted, able to do repairs and familiar with upkeep and repairs of d.c. motors and generators. *See advertisement.*

Applications are invited for the position of senior shift engineer at the temporary station, Nechells, Birmingham. Commencing salary £130, rising to £200 per annum. Applications to the city electrical engineer, Mr. R. A. Chattock, 14, Dale-end, Birmingham, by July 29.

The Executive Committee of the City and Guilds of London Institute have appointed Mr. W. Eccles, D.Sc., A.R.C.S., M.I.E.E., to the Professorship of Electrical Engineering and Applied Physics at the Institute's Technical College, Finsbury, rendered vacant by the recent death of the late Prof. Silvanus P. Thompson, F.R.S. Dr. Eccles, who was for some time on the editorial staff of THE ELECTRICIAN, is at present University Reader of Graphics at University College, and is the author of "Wireless Telegraphy and Telephony" in "The Electrician" series of standard electrical books. He has contributed numerous articles to the columns of this and other journals, and he has read many Papers before the Physical Society, of which he is one of the honorary secretaries. He is also the author of many inventions connected with electrical engineering.

Mr. James S. D. Moffett, manager of the West Ham Corporation tramways, has been appointed general manager of Belfast Corporation tramways at a salary of £800, rising to £1,000, per annum.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. CLAY, V.D.

Orders for August.

Headquarters and Range.—The headquarters will be closed during August, except on Tuesday evenings. The range will be open on Thursday evenings only. On these evenings the Sergeant-Major will take charge and be responsible for the maintenance of order and discipline. Recruits are urged to take advantage of this arrangement for drill and shooting.

Instruction Classes.—Instruction classes at Regency-street will be held as usual for Platoons Nos. 9 and 10.

Camp.—The camp at Otford will be available until Aug. 31. Members wishing to attend should enter their names at headquarters on the sheet provided for the purpose. The cost will be about 3s. per day. Members should provide themselves with two blankets, knife, fork spoon, plate, mug and a spare pair of boots.

Entrenching.—As many members as possible should endeavour to attend the Sunday entrenching parades, in order that the work to be done may be completed as expeditiously as possible. Parade in uniform as usual at Victoria Station (S.E. & C. Railway) Booking Office, 8.45 a.m. Members are reminded that this work is of national importance, and therefore all who are able to put in Saturdays or occasional week days are urged to do so. They are reminded that they can obtain railway vouchers from the booking clerk by showing their cap badges.

SOME MECHANICAL ANALOGIES IN ELECTRICITY AND MAGNETISM.*

BY W. S. FRANKLIN.

Certain fundamental equations in the elementary theory of electricity and magnetism are identical to equations in mechanics,† and this identity of mathematical forms carries with it a group of complete analogies between mechanics and electricity and magnetism. These analogies are familiar to everyone in a vague and incomplete way. The object of this article is to show the use of these analogies in their precise forms, especially in their bearing on alternating-current phenomena.

Consider a heavy body which moves without friction. The effect of a force on such a body is to make its velocity increase at a certain rate. Indeed—

$$F=M\frac{dv}{dt}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where F is the force (expressed in suitable units), M is the mass of the body, and dv/dt is the rate of increase of the velocity of the body.

Consider an electric circuit or coil which has no resistance. The effect of an E.M.F. on such a circuit would be to make the current in the circuit increase at a certain rate. Indeed—

$$E=L\frac{di}{dt}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where E is the E.M.F., L is what is called the inductance of the circuit, and di/dt is the rate of increase of the current i in the circuit.

From equations (1) and (2) it is evident that electric current i corresponds to velocity v in mechanics, and that what is called the inductance L of a circuit is exactly analogous to mass M in mechanics. Also it is evident that E.M.F. E is analogous to mechanical force F.

Consider a helical spring. The effect of a force, F, is to stretch the spring; and the elongation q' is proportional to the stretching force F, so that we may write—

$$q'=C'F, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where C' is a proportionality factor having a definite value for a given spring.

Consider a thin layer of insulating material between two large sheets of metal. Such an arrangement is called a condenser. The effect of an E.M.F. E on such an arrangement is to draw a certain amount of electric charge q out of one metal plate and push it into the other metal plate, and q is proportional to E. Therefore, we may write—

$$q=CE, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where C is a proportionality constant which is called the capacity of the condenser.

From equations (3) and (4) it is evident that the electric charge q which has passed through a circuit is the analogue of distance moved, and that the capacity C of a condenser is the analogue of the elastic or yield constant C' of a spring.

The Functions of the Choke Coil in the Lightning Arrester.

The hammer exerts very large force on the ball for a very short time, and this force sets the heavy ball in motion very quickly. The ball then continues to move for a relatively long time, slowly compressing the elastic cushion and exerting a comparatively small force on the wall for a comparatively long time.

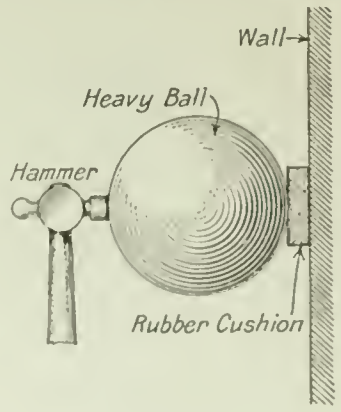


Fig. 1.

Thus the ball and cushion convert the very large and short-time force of the hammer blow into a comparatively small and long-time force as exerted against the wall.

If the cushion is replaced by a rigid block, and if ball and wall are assumed to be entirely rigid then the force exerted on the wall would be exactly as if the ball were not there.

When lightning strikes the trolley wire a very large E.M.F. acts for a very short time between trolley wire and ground. This E.M.F. sets up a current through the choke coil (an inductance) and this current continues to flow for a relatively long time, slowly charging the condenser and building up a comparatively small E.M.F. across the condenser terminals and across the generator terminals. Thus the choke coil and condenser convert the very large and short-time E.M.F. due to the lightning

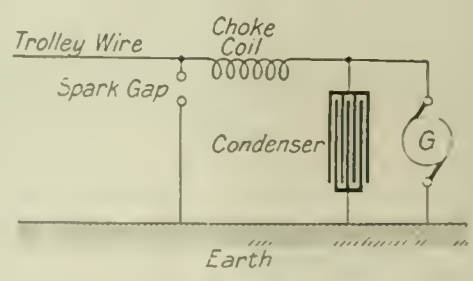


Fig. 2.

stroke into a comparatively small E.M.F. of long duration, as acting across the generator terminals.

If the condenser is disconnected, if there is no condenser effect in the end turns of the generator, and if the generator inductance is very large, then the E.M.F. exerted across the generator terminals would be exactly as if the choke coil were not there.

Analogue of Leading Wattless Current in a Condenser.

A flat spring is clamped in a vice, and the free end of the spring is moved back and forth by the hand. *The end of the spring moves at its maximum velocity in the positive direction one-quarter of a cycle before the maximum pull in the positive direction is exerted upon it.* Similarly, the maximum positive value of current in a condenser occurs one-quarter of a cycle before the maximum positive value of alternating E.M.F. is exerted on the condenser.‡

Analogue of Lagging Wattless Current in an Inductive Circuit.

A heavy weight is attached to the free end of a flat spring the other end of which is clamped in a vice. The weight is set oscillating back and forth and the spring by its bending serves to visualize the force (alternating force) which acts on the oscillating weight. *The weight moves at its maximum velocity in the positive direction one-quarter of a cycle after the maximum force in the positive direction is exerted upon it.*

Receiver of High Power-factor.—A light spoon is used to stir stiff pancake batter by a rapid to-and-fro motion. The force exerted on the spoon by the cook's arm is nearly all used in overcoming the resistance of the batter thus doing useful work, and only a negligible portion of the force exerted by the cook's arm is used to start and stop (accelerate and decelerate) the spoon.

Receiver of Low Power-factor.—Imagine a cook trying to stir pancake batter with a heavy iron coupling pin by a rapid to-and-fro motion. The force exerted on the receiver (the coupling pin) would be nearly all used to accelerate and decelerate the pin, and only a small part of the force would be used to overcome the resistance of the batter.

Alternator with High Internal Inductance.—The spoon (or coupling pin) is the receiving device in the above examples, and the cook's arm is the alternator. If the spoon were to fly out of the cook's hand we would have the analogue of dead short-circuit on the alternator (perfect freedom of movement corresponds to perfect freedom of flow of current). Why, under such conditions does not the cook's

* From the "General Electric Review."

† A partial list of these equations is given in Franklin and Williamson's "Elements of Alternating Currents," pp. 15-16.

‡ The student of physics who is content with a verbal statement is hopeless. Let the thing be actually done. The above statement in italics is not to be taken on authority: get a spring and see for yourself. If this article is to be understood all of the experiments must be seen, or, what is infinitely better, done by the reader.

hand move back and forth with indefinitely large velocity values corresponding to the very large current values in a short-circuited alternator and wreck the kitchen ?

Because, even supposing the muscular effort to be entirely unaltered by the " short-circuit " condition, the mass of the cook's arm limits the velocity values in the same way that the internal inductance of an alternator limits the current values on short-circuit even if the E.M.F. induced in the armature windings were to be entirely unaltered by the short-circuit condition.

A Horse that Can be Fed by Driving Him Down Hill.—One of the most troublesome things in mechanics is to understand the work or energy aspects of the stirring of pancake batter with a heavy coupling pin. Anyone can understand that very little work is done on the batter, but everyone knows that a great deal of work is done by the cook. The case of the alternator, however, is different ; very little work is done by a low power-factor receiver, and *correspondingly little work is done by the alternator.* The important difference between the cook and the alternator is that the cook is not a pure mechanism. The cook's arm cannot be put into condition to do work by forcibly bending it. Or, in other words, forcibly to bend a man's arm is not equivalent to giving the man food. To understand completely the energy relationship between an alternator and a low-power-factor receiver one must get far enough away from homely experience to realise that there is a kind of horse that can be fed by driving him down hill. Let our coupling pin be connected to a spring of proper stiffness to accelerate and decelerate the pin, and let the cook exert only the force necessary to overcome the resistance of the batter, then all forcible bending of the cook's arm is eliminated and taken care of by the spring, and the spring *can* be " fed " by forcible bending.

Inductance and Capacity in Parallel.

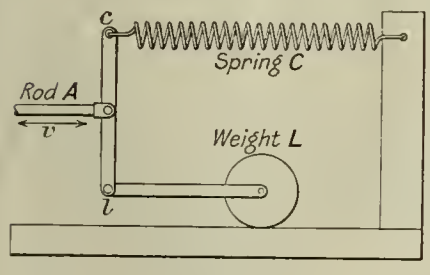


Fig. 3.

An alternating force is applied to the rod A, so as to give to it a to-and fro velocity v.

This velocity divides between the ends c and l of the lever.

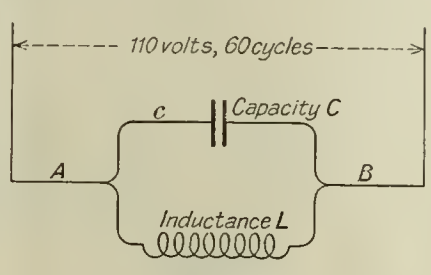


Fig. 4.

An alternating electromotive force produces an alternating current i through A and B.

This current divides between the two branches C and L of the circuit.

The following experiments can be performed with the mechanism shown in Fig. 3 :—

1. Move the rod A back and forth at low frequency ; then the weight L will move, but the end c of the lever will not move perceptibly. *Low-frequency alternating-current will flow almost wholly through the inductance L in Fig.* 4.

2. Move the rod A back and forth at high frequency ; then the end c of the lever will move, but the weight will not move perceptibly. High-frequency alternating-current will flow almost wholly through the condenser *C in Fig.* 4.

3. Move the rod A back and forth at a low frequency with a high-frequency movement superposed thereon. The low-frequency movement will show itself almost wholly in the movement of the weight, and the high-frequency movement will show itself almost wholly in the movement of the end c of the lever. This action corresponds exactly to the action of the arrangement for using a single telegraph wire for telegraph and telephone service simultaneously.*

4. At a certain critical frequency a very small to-and-fro movement of rod A sets up and maintains very large rocking movement of the lever, so that the to-and-fro velocity of end c and the to-and-fro velocity of end l are both very much larger than the to-and-fro velocity of rod A. *A small alternating-current of critical frequency at A and B in Fig.* 4 *divides between the two branches C and L, and the current in each branch is much larger than the current at A and B.* This effect is called the multiplication of current by resonance.

5. Hold end c of the lever so that it cannot move, and move rod A back and forth (preferably at the resonance frequency as described under 4, above). Then release end c of lever and note great reduction of motion of rod A for given to-and-fro movement of weight. This experiment shows how the alternating-current in a transmission line (movement of rod A) can be reduced by connecting a condenser in parallel with a low power-factor (inductive) receiver.

* *See* Franklin's " Electric Lighting and Miscellaneous Applications of Electricity," page 245.

Inductance and Capacity in Series.

A weight attached to the end of a flat spring, the other end of the spring being clamped in a vice, is exactly analogous to inductance and capacity in series. Take hold of the weight and move it back and forth thus bending the spring. Then :

1. At low frequency nearly the whole of the force exerted by the hand is used to bend the spring, the force required to accelerate and decelerate the weight is very small in comparison.

2. At high frequency nearly the whole of the force exerted by the hand is used to accelerate and decelerate the weight, the force required to bend the spring is very small in comparison.

3. If a low-frequency alternator is connected in series with a high-frequency alternator we get from the combination a high-frequency E.M.F. superposed on a low-frequency E.M.F. If such an E.M.F. be connected to an inductance and capacity in series, the low-frequency voltage will show itself across the capacity and the high-frequency voltage will show itself across the inductance.

4. At a certain critical frequency the force exerted by the hand overcomes the resistance only ; the force required to bend the spring is at each instant supplied by the inertia reaction due to acceleration and deceleration of the weight, and the force required to produce acceleration and deceleration is at each instant supplied by the reaction of the bent spring. It is correct to say that the alternating force exerted by the hand divides into two parts (one acting on the weight and the other acting on the spring), each of which may be much larger than the whole force exerted by the hand. This phenomenon is called the multiplication of E.M.F. by resonance.

Use a strip of window glass as a spring, clamp it in a vice and attach a weight to its free end. Touch the weight with a feather repeatedly at a frequency equal to the frequency of free oscillation of the weight and a violent state of oscillation will be slowly built up. Eventually the force action on the strip of glass by the inertia reaction of the weight will be large enough to break the glass. This is exactly analogous to the building up of a high voltage across a capacity by resonance so as to break down the insulation of the condenser (capacity).

5. The use of a stiff spring to accelerate and decelerate a coupling pin which is used to stir batter, so that the cook need only exert the force necessary to overcome the resistance of the batter, is an example of power-factor correction (reduction of low power-factor to unity power-factor) by connecting a condenser in series with an inductance. This arrangement is not used in practice.

The Transformer.

Every student of electrical engineering has no doubt wondered what might possibly be the relation between the familiar devices for multiplying force in mechanics and the devices for multiplying E.M.F. A steady force of 110 lb. is easily " transformed " into a steady force of 1,100 lb. or 11,000 lb. by means of a lever ; but a steady E.M.F. of 110 volts cannot be converted into a steady E.M.F. of 1,100 or 11,000 volts by a transformer. Therefore, it would seem that the lever and the transformer are wholly unrelated. However, a lever with a heavy weight instead of a fixed fulcrum is entirely analogous to a transformer ; and the equations of motion of such a lever can be reduced to forms identical to the equations of a transformer including such complications as magnetising current and magnetic leakage.

An ideal lever consisting of a weightless bar with an indefinitely large mass as a fulcrum is the exact equivalent of the ideal simple transformer. The to-and-fro velocities of the ends of the lever correspond to primary and secondary currents, the force (alternating) applied to one end of the lever corresponds to the voltage applied to the primary of a transformer, and the force (alternating) exerted by the other end of the lever corresponds to the secondary terminal voltage of a transformer. The velocity values are directly as the lengths of the two arms of the lever (this corresponds to the fact that the primary and secondary currents of an ideal transformer are inversely as the respective numbers of turns of wire), and the two forces are inversely as the lengths of the two arms of the lever (this corresponds to the fact that the primary and secondary voltages of an ideal transformer are directly as the respective numbers of turns of wire).

When the working end of the lever is rigidly fixed, we have a condition corresponding to open-circuited secondary. In this case the hand-end of the lever will not move perceptibly if the fulcrum mass is very great ; but if the fulcrum mass is moderate, the hand-end of the lever will move as the fulcrum mass is accelerated and

decelerated. This motion of the hand-end of the lever corresponds exactly to the magnetising current of a transformer.

If the beam of the lever were without mass the forces at the ends of the lever would be in exact inverse proportion to the lengths of the arms of the lever; but if the mass of the lever beam is considerable or if there are weights attached to the ends of the lever then the lever acts like a transformer with magnetic leakage. Part of the force exerted by the hand is used to accelerate and decelerate the weight at the hand end, the remainder of the force exerted by the hand is transmitted to the other end of the lever (being multiplied in exact inverse proportion to the lengths of arms of lever); a portion of the force so developed at the working end of the lever is used to accelerate and decelerate the weight at the working end, and the remainder is exerted on the receiving device.

In all of the above the lever is supposed to be frictionless and the transformer coils are assumed to have zero resistance. There is no need to trace out the analogies between mechanical friction and electrical resistance, because, to make the analogy complete, one has to assume that the force of friction is proportional to the velocity of the moving body.

Loose and Close Coupling.

Fig. 5 shows a mechanism which is exactly analogous to the inductively coupled (transformer connected) circuits in Fig. 6. Two cars, S and P, in Fig. 5 are each tied by coiled springs $C'C'$ and CC as shown, and the cars are free to oscillate back and forth on friction rollers. The cars are connected by the vertical lever ll' as shown. Car P with its connecting springs represents the primary circuit in Fig. 6, and Car S with its connecting springs represents the secondary circuit in Fig. 6.*

If the weight (mass) W is large as compared with the mass of either

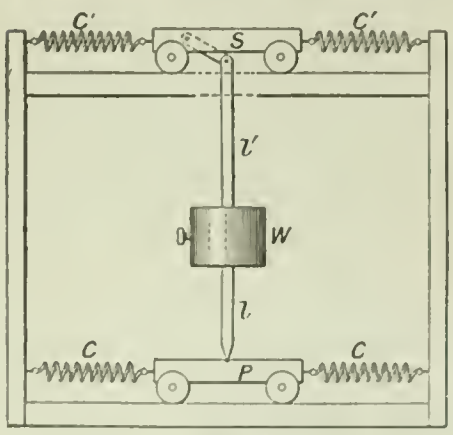


Fig. 5.

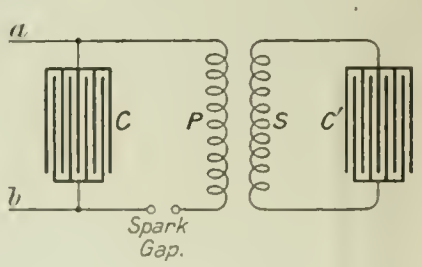


Fig. 6.

car we have what is called *close coupling*. If the mass W is small as compared with the mass of either car we have what is called *loose coupling*.

If either car in Fig. 5 is held fast so that it cannot move, we have what is equivalent to open-circuited primary or open-circuited secondary, as the case may be.

Four modes of oscillation are to be distinguished in the mechanism shown in Fig. 5 (or in the electrical arrangement in Fig. 6) as follows:

Part of system held fast—

(a) Oscillation of car P (primary) when car S is held fast (when secondary is open).

(b) Oscillation of car S (secondary) when car P is held fast (when primary is open).

Entire system free—

(c) Steady oscillation of entire system at high frequency c with velocities of cars opposite at each instant (primary and secondary currents opposite in phase).

(d) Steady oscillation of entire system at low frequency d with velocities of cars in same direction at each instant (primary and secondary currents coincident in phase).

These four modes of oscillation are easily shown by the mechanism of Fig. 5.

The most general type of motion of the system consists of modes c and d together; and in this general type of motion the two circuits oscillate by turns, and the energy is handed back and forth from one circuit to the other repeatedly. This is easily shown by the mechanism of Fig. 5.

In order that all of the energy of the system may be handed back and forth, from primary to secondary and back again, the two frequencies a and b must be equal. The adjustment for bringing these frequencies to equality is called tuning. Tuning may be accomplished in the mechanism of Fig. 5 by placing weights on car P or on car S. With this adjustment made, car P may be set oscillating and it quickly comes to rest because it gives all its energy to S; then S quickly comes to rest because it gives all its energy back to P; and so on.

If frequencies a and b are not equal and car P is set oscillating, it quickly loses part of its energy as it sets S oscillating; then it takes all of the energy back again and S comes to rest; and so on repeatedly.

In the coupled circuits of the older type of wireless telegraphy, it is desired to get all of the energy from the primary into the secondary. Therefore, the primary and secondary should be adjusted to make frequencies a and b equal. When the energy has been handed over to the secondary it must be prevented from being handed back to the primary by open circuiting the primary by means of the quenched spark. The effect of the quenched spark may be shown by tuning the system in Fig. 5, setting car P oscillating, and suddenly grabbing car P and holding it fast the moment it loses all its energy and comes to rest.

The above discussion takes no account of friction and resistance.

The Electric Doubler.

Two tin cans, C and D open at top, are supported on insulating stands, as shown in Fig. 7. Can C has a small amount of positive charge and can D an equal amount of negative charge, as indicated by the 10 lines of force which diverge from C and converge upon D. Two metal balls A and B with insulating handles are placed in contact with each other between C and D as shown, and *a certain fraction of the lines of force from C to D converge upon A and diverge from B, as shown.* This fraction is equal to 1/2 in the figure.

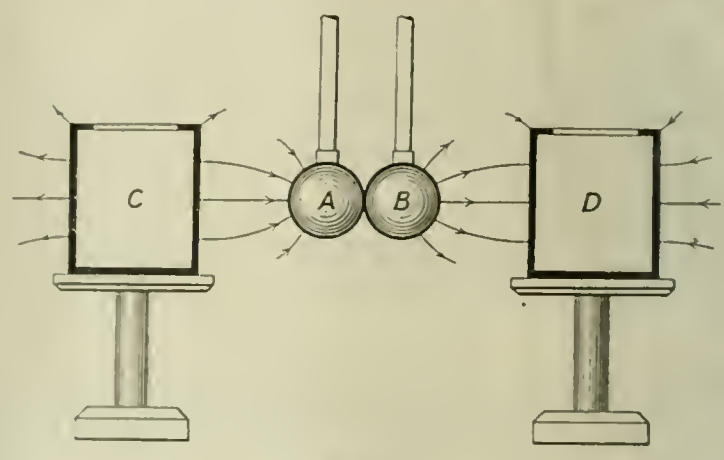


Fig. 7.

The balls A and B are separated from each other and (1) ball A is carried to and into can D and touched to the interior of D, and (2) ball B is carried to and into can C and touched to the interior of C. The result of operation (1) is to string the five lines of force from C to A clear across from C to D, and the result of operation (2) is to string the five lines of force from B to D clear across from C to D: balls A and B being left in neutral condition. The original 10 lines of force from C to D have evidently been increased to 15, that is, the charges on C and D have been multiplied by 1·5 by the above-described operation, and by repeating the operation over and over again the charges on C and D can be multiplied by 1·5 over and over again (leakage on account of imperfect insulation being ignored). Therefore, extremely minute initial charges on C and D can be quickly brought up to very large values by 50 or 60 repetitions of the above-described operation, because, if the insulation is good, 60 repetitions will multiply the initial charges about one hundred-thousand-million times, and, of course, the initial voltage between C and D is multiplied to the same extent.

This experiment must be seen to be appreciated. Support the two cans C and D on clean blocks of paraffin in a warm dry room. Use best hard rubber or quartz tubes (closed at one end) for insulating handles for balls A and B. Attach a vertical strip of metal to the outer face of each can C and D, and hang several strands of fine cotton thread over the top edges of these strips of metal. These threads will stand approximately vertical at first, but as the charges on C and D increase they will stand out more and more nearly horizontal.

There is, perhaps, no mechanism which multiplies mechanical force in a manner strictly analogous to the multiplication of E.M.F. by the electric doubler. A slight modification of the doubler to give a series of increasing charges (and voltages) which constitute an arithmetical progression instead of a geometrical progression is shown in Fig. 8. The opposite charges on plate A and hollow vessel B are to be multiplied (and thus the voltage between A and B multiplied). A metal ball with an insulating handle is touched to the battery terminal as shown in Fig. 1 and a certain number of lines of

* The double pendulum arrangement which is described by Prof. F. R. Lyle in the "Philosophical Magazine", Vol. XXV., pp. 567-592, is the exact equivalent of two circuits inductively coupled, but the details of the correspondence are not so simple. The usual double pendulum arrangement is not theoretically exact as a representation of coupled circuits.

force form from ball to plate. Four lines are shown in the figure. These lines are then strung across from A to B by carrying the ball to and into B and touching it to the interior of B as shown in Figs. 2, 3 and 4.

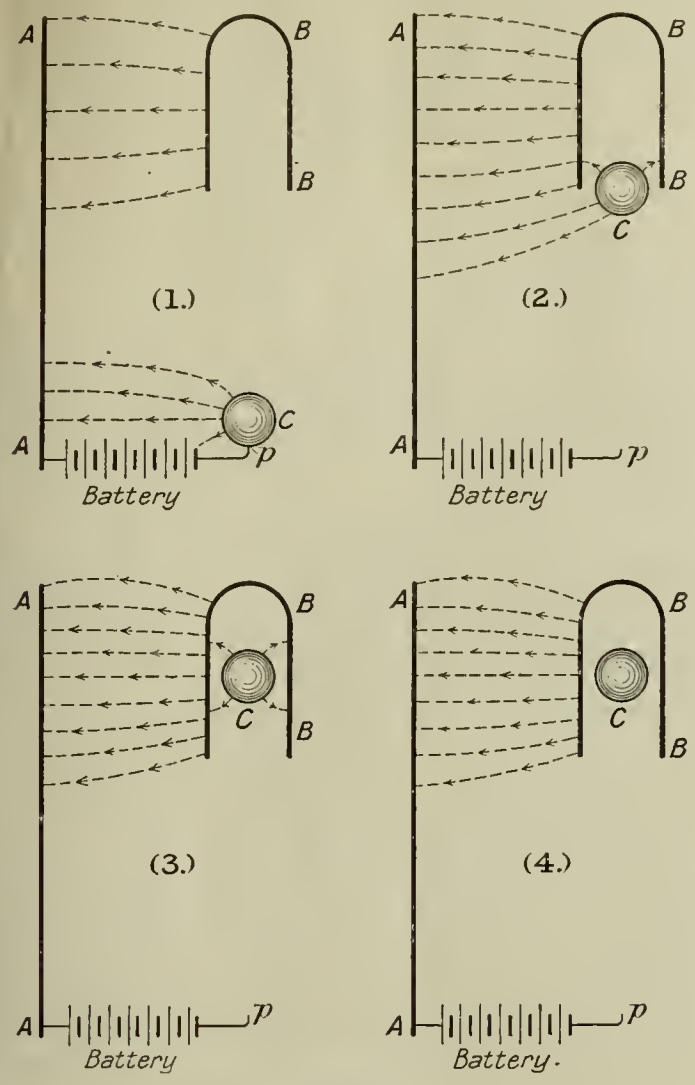


Fig. 8.

The nearest approach to a mechanical analogue of the doubler as shown in Fig. 8 is to produce an increasing compression on a pack of cards by winding around the pack a string under tension.

Electricity or Energy: Which?

When water is pumped through a pipe it is usually the amount of water delivered in a given time that is important, whereas the amount of power represented by the stream of water is not important, except that it must be enough to carry the water where it is needed. But one might conceivably use a pump to drive water through a pipe for the sake of the heating effect of the moving water in the pipe or to drive a water motor placed somewhere in the circuit of pipe. In such a case one would be interested primarily in the amount of power represented by the stream of water because the desired effect (heating or motor driving) would depend upon the amount of power.

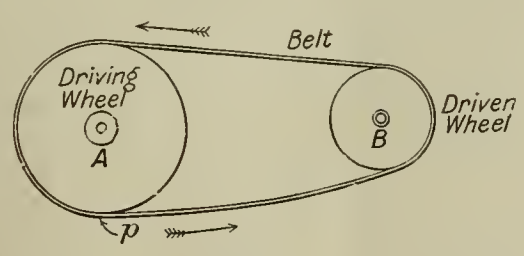


Fig. 9.

So it is in the use of the electric current. It is not electricity (whatever that is) that one uses, it is work or energy; and the important thing about an electric generator (such as a battery or dynamo) is its power output. The almost universal misunderstanding of the matter may be beautifully illustrated by considering the mechanism shown in Fig. 9. A wheel A drives another wheel B by belt. A person knowing nothing at all about machinery, and *especially a person having no available words to use in describing such an arrangement*, might look at the continuous stream of leather coming off wheel A at point p and decide to call wheel A a leather generator, and wheel B a leather motor. Everyone knows, however, that a driving wheel does not generate leather; it gives off work or energy, and the work is transmitted to the driven wheel by the belt.

It seems very ridiculous to speak of a belt wheel as a generator of leather, and it is equally absurd to speak of a battery or dynamo as a generator of electricity. One must be careful not to take electrical terms and phrases too literally.

To speak of a dynamo as an electric generator is common usage and it is therefore not seriously objectionable, but to speak of electricity as a motive power indicates a very serious misunderstanding. When it is proposed to drive a machine by a leather belt it is always understood that something must drive the belt, but when it is proposed to drive a machine by "electricity," it is not always understood that something must drive the "electricity." Electricity as applied in the arts is merely a go-between like a leather belt, and no one ever thinks of leather as a motive power, at least not in the engineering sense, however vivid our memories may be of the motive power of leather in homely sense.

The discussion of mechanical analogies is intended to illustrate the important use of sense material in the building-up of physical ideas; indeed, the understanding of any principle or relation in physics is a structure which is built up in the mind out of just stuff, like a house is built of wood or stone. Many teachers, especially teachers of mathematics, seem to think that ideas can be built up in a young man's mind by a sort of hocus-pocus, out of nothing; but ideas, like everything else in this world must be made of something, and the problem of the science teacher is, by suggestion or by manipulation and experiment, to drag sense material into the young man's field of consciousness where it may be organised into a structure of ideas.

TREATMENT OF SILVER FURNACE FUME BY THE COTTRELL PROCESS.*

BY CHARLES H. ALDRICH.

Summary.—Reference is made to the experimental work at the Raritan Copper Works, and the apparatus finally adopted, and results obtained with it are deseribed.

In the past many tons of valuable materials have been lost through volatilisation and dissipation with furnace gases, and, although the subject of metallurgical fume has received a great deal of attention of late, yet there is no doubt that in many instances fume losses are occurring daily that are entirely unsuspected by those in charge of the operations.

During the past four years considerable work has been done at the Raritan Copper Works on treatment of gases from Doré refining furnaces, and we believe that we are in a position to state that the problem of the recovery of practically all metal values from these gases has been solved by the application of the Cottrell process.

Since this plant was the first one to use this process in connection with silver refining, a description of the methods used and results obtained will, perhaps, be of interest.

Prior to the year 1907 the only method in use for recovering values from silver furnace gases was a system of brick flues, about 12 sq. ft. in cross-section and 250 ft. long, leading to a brick stack 90 ft. high.

When a large addition to the plant was constructed in 1906 the silver refinery was remodelled and enlarged, and it was decided to install a water scrubber on the end of the flue system, based on results obtained at the Baltimore Copper Smelting & Rolling Co. with a similar apparatus. This consisted of a lead-lined tank filled with water, into which dipped 336 5 in. lead pipes, projecting about 5 in. below the surface and communicating with a cast-iron gas chamber above. The furnace gases were drawn from the flues by means of a 6 ft. centrifugal blower and forced through the pipes, bubbling through the water and passing out of a lead stack connected to one end of the tank.

The results obtained with this apparatus amply justified the considerable expense involved in its installation and maintenance, and during its operation it has saved values averaging about £10 per day.

It seemed evident, both from the appearance of the gases passing out and from the nature of the treatment, that no dust could be escaping, and for some time it was thought that no values of importance were being lost, the escaping cloud being apparently mostly steam. However, it was observed that if a metal sheet was suspended in the gases a deposit would form upon it which often carried several hundred ounces of silver per ton.

Early in 1911 tests were started to determine the advisability of constructing a settling flue through which the gases could be passed after leaving the scrubber and not until then was the true nature of the fume or the importance of its recovery realised.

It was found that, as had been supposed, practically all dust had

* Paper read before the American Electrochemical Society, slightly abbreviated.

been removed from the gases by the scrubber, the material remaining all being in the form of particles so fine that they formed a fog, which, when placed in a closed vessel, required from 2½ to 3 hours to clear up. Obviously, no practical settling flue could be constructed to accomplish this. Violent agitation with water, it was found, would clear up the gas. Accordingly, the installation of various mechanical gas-washers was considered. The problem of acid proofing appeared serious and, as these gases contained large proportions of nitric sulphuric acids, it will be seen that this was of importance.

A device in which the gases were to be forced through a series of lead screens in contact with running water appeared to be the most practical, and some working drawings of this were made. There were many points about this, however, which were not satisfactory. Consequently, when Dr. Cottrell's Paper upon "The Electrical Precipitation of Suspended Particles" * appeared in the "Journal of Industrial and Engineering Chemistry," it seemed likely that the process described would perhaps accomplish the desired result upon our gases. Dr. Cottrell was communicated with, and shortly afterwards arrangements were made with him to conduct tests and, if favourable results were obtained, to construct a treater of sufficient capacity to handle the gases.

Electrical apparatus for converting 220-volt direct-current up to about 45,000-volt direct-current was obtained, and during the summer of 1912 a series of tests was conducted by Mr. Linn Bradley,† representing the Research Corpn., and the writer, which gave such encouraging results that it was decided to go ahead with the construction of the treater.

With regard to the details of these tests, little need be said. Briefly, the method used was the aspiration of a definite proportion of the gases, measured by a Pitot tube, through a treater composed of a 10 ft. length of 6 in. pipe provided with a central electrode of No. 20 copper or iron wire. Clearance was determined by aspirating equal volumes of gases simultaneously through Brady filters, located at the inlet and outlet ends of the treater pipe, and assaying the filter thimbles for silver and gold.

The electrical apparatus used in the preliminary work was far from practical. It was designed for X-ray work, and included a multiplicity of condensers and inductance coils, together with a transformer impregnated with beeswax but without provision for cooling; consequently, as might be expected, a large proportion of time was occupied in repairing punctured condenser plates and scooping up the beeswax that ran out of the transformer.

The apparatus finally secured for the commercial treater, which has now been running continuously for nearly two years, consisted of a 3-kw. 220-volt direct-current to 154-volt alternating-current 60-cycle "Hill" rotary converter, a 7·5 kw. 154-500,000-volt American Transformer Co. oil-cooled transformer, and a rotary rectifying switch, designed jointly by the Research Corpn. and the Raritan Copper Works. Shortly after starting the commercial treater, on account of experiences at some other plants, air choke-coils were placed in circuit with the high-tension terminals of the transformer to protect the windings from puncture caused by excessive voltages due to surges.

At that time the plate treater was considered the most practical for our work, and designs were made along these lines. It was decided to use cast-iron as far as possible in the construction, but the question of the most suitable material to use for discharge wires furnished a perplexing problem. Finally, the solution of the problem was the employment of lead strips, 1 in. wide, sharpened on the edges and set transversely between each pair of collecting plates. These have been perfectly satisfactory, the original strips still being in use.

The treater, as constructed, consisted of a rectangular cast-iron chamber, 8 ft. wide by 6 ft. high by 16 ft. long, set over a lead-lined hopper connecting with a sludge tank through a launder. Collecting electrodes consisting of 6 in. lead strips, were hung parallel with the gas flow, through cast-iron bars, which also carried the cover plates. The lower ends of the strips were guided by slotted iron bars resting on flanges cast on the lower edges of the frame end plates. Cast-iron I-beams, carried on each side of the treater on high-tension pedestal insulators, formed the high-tension 'bus bars, and these carried four cast-iron channels running transversely through openings in the sides of the treater, which supported the discharge electrode frames.

As to durability, cast-iron has proved very satisfactory in the sides and top; however, wherever there has been an intense electrical discharge, as from the discharge electrode frames, the iron has been quickly corroded. Lead, however, has proved entirely satisfactory under all conditions, and all iron discharge frames and guide bars have been replaced by lead-covered wrought-iron.

In our operation, the gases leaving the Doré furnaces pass first into a 4 ft. diameter sheet-iron flue about 40 ft. long, then into a brick flue 6 ft. wide by 7 ft. 6 in. by 80 ft. long. A centrifugal fan, operated by a 40 H.P. motor, is placed on the end of this flue. This draws the gases out and forces them through iron connecting flues tangentially into the base of a circular brick settling chamber, 16 ft. in diameter by 17 ft. high. The whirling motion imparted to the gases in this chamber assists materially in depositing the particles of dust. An iron flue, 3 ft. in diameter, leads from the centre of the top of this chamber into a horizontal brick flue, which, in turn, opens into the scrubbers, the treater being connected to the scrubber outlet. It will thus be seen that enough settling is secured in this system to remove practically all the values that are present in the form of dust, before the treater is reached, the only material passing to the treater being true fume.

The average analysis of the dust deposited in the treater shows that there is 800 oz. of silver per ton and 1 oz. of gold per ton.

The total recovery averages 29·2 per cent. of the silver and 6·6 per cent. of the gold caught in the whole flue dust system. Of the total amount treated in the furnaces, this is 0·24 per cent. of the silver and 0·022 per cent. of the gold.

All elements are highly oxidised, and silver and gold are combined with the base metals present in extremely insoluble forms, all attempts to remove them by acid treatment having been unsuccessful. It is also interesting to note that the silver in treater sludge runs about twice as high as in scrubber sludge. Gold runs about the same.

The cost of operating has been very low. The volume of gas treated will average about 6,000 cubic ft. per minute. The power required is about 2·5 kw., at a voltage of 35,000 to 40,000. As to labour, one man working one or two hours per day can keep the treater clean and in good running condition. Apart from the substitution of lead-covered frames for the cast-iron previously mentioned, very few repairs have been necessary.

It will be noted that the gases having previously passed through a system of flues and a water scrubber, are comparatively cool and saturated with moisture. Attempts have been made at times to treat the dry gases coming from the flues directly, cutting out the scrubber. The results obtained under these conditions are much poorer than when the scrubber is in circuit. The temperature is, of course, much higher, being about 300°F. in the former case to 150°F. in the latter. The deposit is extremely dry and light, so that particles falling off the electrodes are carried out by the moving gases. The corona is not so good when dry gas is used, and if the voltage is raised there is much more sparking-over than when wet gas is passing.

In our case the presence of suspended moisture appears to be a very desirable condition to satisfactory precipitation of the fume. The injection of steam has been tried, but did not give satisfactory results.

Recently a system of sprays has been placed transversely in the lead flue leading to the treater inlet through which the gases are forced to pass, and with this arrangement we have secured better results than with any other, a number of tests having given silver escaping as low as 2 oz. or 3 oz. per day. This, however, is while operating at less than the full furnace capacity.

The results obtained with the first installation have, on the whole, been so satisfactory that it was recently decided to build a second treater of sufficient capacity to give us practically complete precipitation of fume with additional furnaces operating.

For a number of reasons, among them being better insulation, more substantial construction, greater economy of space and ease of cleaning, it was decided to build the new treater of the tube type. From results obtained in numerous tests on pipes of varying dimensions, lead pipes, 18 in. in diameter by 12 ft. long, containing a single central discharge electrode, were found to be the most satisfactory.

The discharge electrodes, to be used in these pipes, are made of ⅜ in. steel shafting covered by extrusion with a star-shaped layer of lead. These electrodes are supported firmly over the pipes, and as they are stiff they require no steadying inside the treater. Most of the discharge at the start takes place from the sharp ridges extending the length of the electrode. However, when they have become coated with a deposit of dust the discharge is very uniform over the whole surface. With these pipes and a voltage of from 85,000 to 90,000 it has been possible to get over 99 per cent. precipitation efficiency, at a gas velocity of 4·5 ft. per second.

The electrical apparatus secured for the new treater consists of two 10-kw. Fort Wayne direct-connected rotary converters, so arranged that they can be used interchangeably as a motor-generator set or as rotary converters. As a rule, they will be operated as a motor-generator, in which case the generator is separately excited by the regular 220-volt lighting current. Alternating-current at 25 cycles and up to 200 volts can be obtained from these machines.

The transformer was made by the American Transformer Co.,

* *See* also THE ELECTRICIAN, July 16, 1915.
† *See* THE ELECTRICIAN May 5, 1916.

and is of 10 k.v.a. capacity. It is oil-cooled and has five taps giving 50,000, 62,500, 75,000, 87,500, 100,000 volts at a primary voltage of 200. By means of these taps, together with rheostats in the generator field and in series with the low-tension alternating current, it is possible to secure extremely fine regulation of the high-tension voltage. An arm-type rectifier of Research Corpn. design is used, and has proved very satisfactory in all the tests which have been made. With this complete installation we expect to be able to treat up to 12,000 cubic ft. per minute of silver furnace gases and to recover 99 per cent. of all the silver and gold which they contain.

TWO NOTABLE FLOATING CRANES.*

BY H. H. BROUGHTON.

Summary.—In this article descriptions are given of two 150-ton electrically-driven floating cranes, one of the non-revolving bridge type and the other of the revolving type. The latter is said to be the first heavy revolving floating crane constructed in America, and is an excellent example of a modern crane.

Floating cranes may be subdivided into two main types: (*a*) Non-revolving; (*b*) revolving. Such cranes are generally used where there is only a short length of quay for the moving of vessels, or when the form of the quay is very irregular. Mr. R. Boyle† has given the following summary of the advantages and disadvantages as compared with giant cantilever cranes.

The principal advantages of floating cranes are :—

(*a*) They are independent of the difficulty of obtaining a good foundation, except as regards anchorage.

(*b*) They may be used where the wharf or quay space for berthing is limited.

(*c*) When not in use they may be let out on hire to smaller firms, which do not possess a crane, or to larger firms in an emergency.

(*d*) They may be propelled or towed to a vessel whether alongside the quay or in open water.

(*e*) Ships are not only served and fitted out, but the material may be brought to them from the quay, saving the expense and difficulty of heavy haulage.

(*f*) The crane hooks can reach every point of the deck of the vessel.

(*g*) The jib may be derricked to a small radius, allowing masts and other long objects to be dealt with at the extremity of the cantilever arm.

(*h*) One floating crane can be moved about to serve any number of vessels under construction at the same time.

(*j*) The skill required to operate a floating crane is no greater than that for any other crane.

(*k*) The cost of maintenance is moderate, and will not exceed that for a fixed cantilever crane.

The main disadvantages as compared with giant cantilever cranes are :—

(*a*) Loads are handled less rapidly.

(*b*) For the largest loads at comparatively small radii, the range of height above water level is more limited without greatly increasing the height of the crane.

(*c*) When the load is being dropped or adjusted to position, the righting of the pontoon causes jerking, making adjustment to position much more difficult. By many this is considered a rather serious defect.

(*d*) The waves from a passing vessel may disturb the pontoon at an important moment when precision of movement is required.

(*e*) Unless of the self-propelling type, tugs are required to move the crane about. Moorings are also necessary.

(*f*) They may not be so readily used in rough weather.

As examples of non-revolving floating cranes the derrick and bridge types may be given. A revolving crane is much more costly than a non-revolving crane, but the advantages of the former over the latter are such as to lead many users to pay the increased cost.

Till comparatively recently, steam was generally used as a motive power for floating cranes, but during the past five or six years a number of heavy electrically-driven cranes have been constructed, and it is not unlikely that most new cranes will be electrically driven, as electrical energy is now generally admitted to be the motive-power *par excellence* for operating cranes of all types.

* Copyright. All rights reserved.

† "Transactions," Inst. of Engineers and Shipbuilders in Scotland, April 18, 1911.

The three methods of furnishing the motive power are: (*a*) From a flexible cable connection to the shore; (*b*) from a storage battery on the pontoon; and (*c*) from steam, Diesel or petrol engine-driven generators on the pontoon. Although each method gives economical and reliable service, the limited radius of action of a crane having a flexible cable connection to the shore in many cases outweighs the advantage of low initial cost. To a certain extent this also applies to the storage battery equipment, though a charge of a few hours' duration is generally sufficient for several days' service, and battery makers are prepared to guarantee the performance of their cells. Most electrically-driven floating cranes are provided with an engine-driven generator on the pontoon, and some cranes are equipped with a storage battery as a stand-by.

It is the purpose of this article to describe heavy cranes used by the United States Navy Department. One of these is of the non-revolving bridge-type and the other is of the revolving type. Both are by the Wellman-Seaver-Morgan Co., of Cleveland, Ohio, the bridge-type crane having been in operation since 1912. The revolving crane is now under construction, and is the first large crane of this kind to be built in America.

In an informative article entitled "The Panama Crane Contract," Mr. F. H. Cooke,* a member of the Panama Canal staff, makes a comparison between the various types of floating cranes. Of the bridge-type he states that :—

> This type of crane has the advantage of comparatively low cost, but there are several inherent disadvantages. It is top heavy as to weight and wind-pressure, the movable counter-weight usually provided would probably capsize the crane by its overturning action in its extreme position at one end of the pontoon should the tackle fail at the opposite end of the cantilever, and the size of the load handled by this type of crane is limited by the space between the legs which support the bridge. The greatest disadvantage is the inability to plumb the lift (except as provided by the trolley) without moving the whole crane, which involves the repeated handling of mooring lines. This rigidity is especially objectionable when working about a ship, on account of the interference of the cantilever with the ship's masts and upper works. In narrow waterways . . . the use of this type becomes virtually impracticable, since it can only be operated end-on, with the result that the entire length of the pontoon with the cantilever extension is placed across the channel.

150-ton Floating Bridge Crane.

The 150-ton floating cranes, Fig. 1, for Boston Navy Yard and Pearl Harbour Naval Station consist essentially of a bridge-type superstructure, made up of four trusses mounted on a pontoon. The latter is entirely of steel construction, having a moulded length of 125 ft., a moulded width of 70 ft. and a moulded depth of 14 ft It is divided into 26 water-tight compartments, having collision bulkheads running fore and aft 5 ft. from each side and a water-tight bulkhead extending its entire length, running fore and aft through the centre. Two machinery compartments approximately 43 ft. long by 30 ft. wide, with inner bottoms 4 ft. deep, are formed amidship by transverse bulkheads. At each end of the pontoon there are also four water-tight compartments approximately 15 ft. square, which may be filled and used for counterbalancing the pontoon when the crane is lifting a maximum load at the end of the bridge. The centrifugal pump for filling and emptying these counterbalance compartments is located in one of the machinery compartments. This pump has a 10 in. suction and discharge and is connected to four 8 in. manifold pipes at each end. The pump has a capacity of 2,500 gallons per minute, and is driven by a 25-H.P. motor. The suction and discharge valves for regulating the direction of flow into or out of the counterbalance compartments, are controlled by levers located in the operator's cab.

From the arrangement drawing, Fig. 2, it will be seen that the bridge structure is supported on sheer legs, and has a centre span of 115 ft. It is made up of four trusses arranged

* "Engineering News," May 13, 1915.

so that the auxiliary trolley of 15 tons capacity travels on rails between the two centre trusses. Two 75-ton main trolleys are carried on rails between the centre and outside trusses—one on each side. Each of the two main trolleys carries a 75-ton hook-block on a double four-part hoisting rope of $1\frac{5}{8}$ in. diameter. The ropes are equalised at one end and wound upon drums located in the machinery compartment of the pontoon. The 15-ton auxiliary hook-block is carried on four parts of rope, two of which are wound on a drum in the machinery compartment. The main hook-blocks may be hoisted to 70 ft. above the top of the deck, and may be lowered to 25 ft. below the deck, which gives a total lifting range of 95 ft. for the main lifting mechanisms. The main trolleys have a total travel along the bridge of approximately 251 ft., allowing the hooks to reach about 62 ft. beyond the ends of the pontoon.

Power for operating the crane is obtained from a triple cylinder Diesel engine, direct connected to a 220-volt continuous-current generator rated at 100 kw. Each of the cylinders is 18 in. in diameter, and the engine has a stroke of 24 in. It is rated at 225-H.P. In addition to the Diesel engine there is also installed for emergencies an Edison storage battery, having a capacity of 600 kw. hours. The two 75-ton hook blocks are operated by two separate sets of mechanisms, so arranged that they may be clutched together when using the two trolleys for lifting the maximum load of 150 tons. Each of the 75-ton winding drums is geared up to a 60 H.P. motor, so as to lift its load at the rate of 8 ft. per minute. This mechanism is also equipped with change-speed gears, so that the empty hook block can be hoisted at the rate of 100 ft. per minute. Both of the main trolleys are provided with separate winding drums, each operated by a 37·5-H.P. motor, and are arranged so that they can be clutched together when lifting a maximum load. The trolley mechanism is geared so that the trolleys may be traversed across the bridge at the rate of 50 ft. per minute.

The main-hoist mechanism, main trolley mechanism and magnetic-control boards for the motors are located in one machinery compartment. The other machinery compartment contains the engine-generator set, auxiliary-hoist travel mechanism and the counter balance pump. A 60 H.P. motor, identical with the main-hoist motors, is geared to the auxiliary hoist drum in such a manner that the 15-ton auxiliary load may be hoisted at 35 ft. per minute. This mechanism is also equipped with change-speed gears, so that the empty hook can be hoisted at the rate of 100 ft. per minute. The drum for travelling the auxiliary trolley is geared to a 37·5-B.H.P. motor, so that the trolley may be traversed across the bridge at the rate of 200 ft. per minute.

On the deck of the pontoon there are located four electrically-driven capstans, each operated by 25-H.P. motors controlled by drum-type controllers. All of the motions of the crane are controlled from the operator's cab located on one of the deck houses.

We understand that the cost of the two 150-ton floating bridge cranes at Boston Navy Yard and Pearl Harbour Naval Station amounted to £120,000 in round figures. It is interesting to note that the price quoted by the Deutsche Maschinenfabrik A.G., of Duisburg, Germany, for two cranes of the revolving type was £220,000. The two figures serve to give an approximate idea as to the relative costs of the two types.

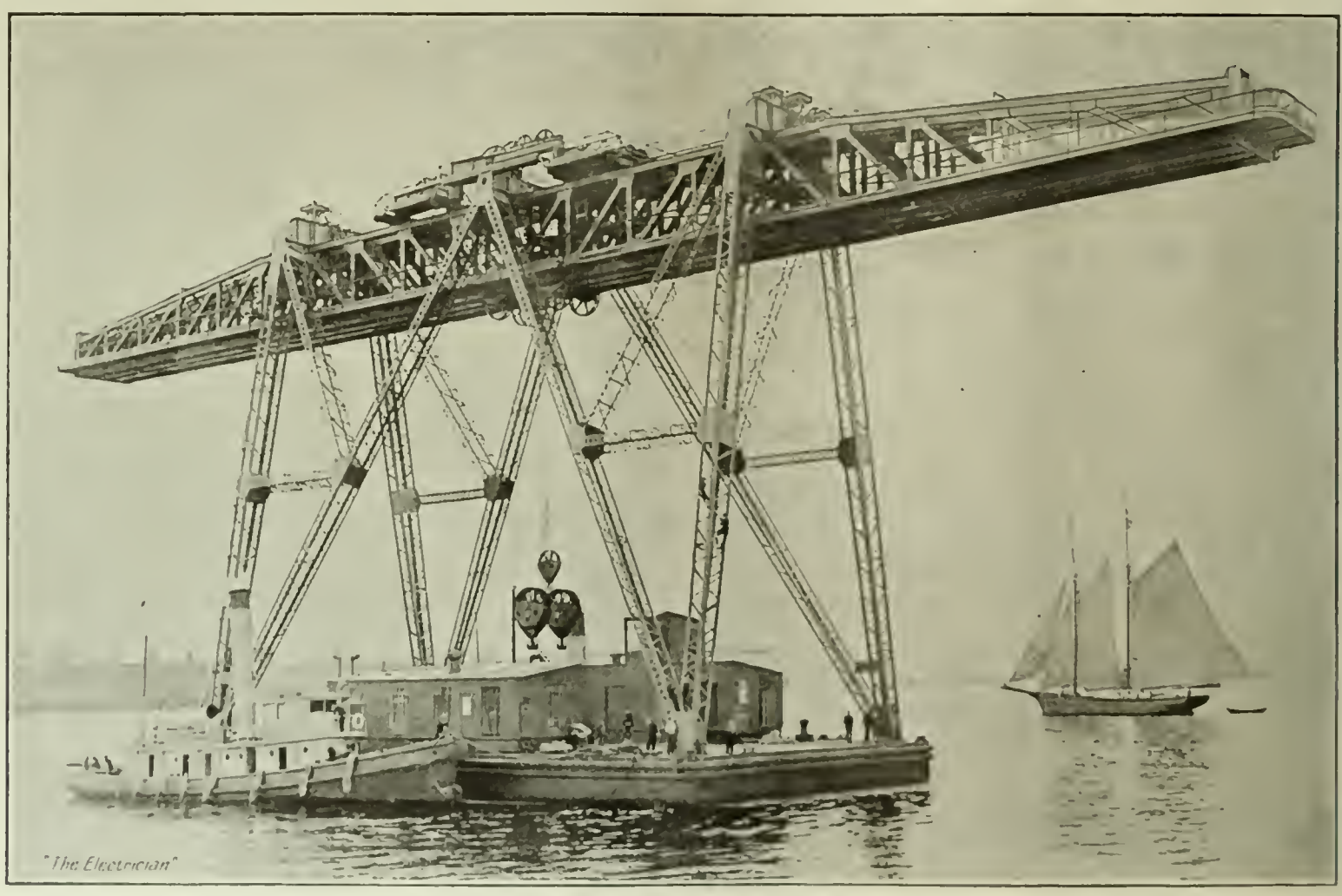


Fig. 1.—150-ton Floating Bridge Crane.

150-ton Floating Revolving Crane.

The floating crane which is being built by the Wellman-Seaver-Morgan Co. for the Norfolk Navy Yard (U.S.A.) is of a different type to the large floating cranes previously built in America, in that it is made to revolve about a central pivot. This crane, Fig. 3, is the first large floating revolving crane of American manufacture.

The crane is electrically operated, power being supplied by a steam engine generator set, which is placed in one of the compartments of the pontoon. The crane consists essentially of a large steel pontoon upon which, equidistant from one end and the two sides is a fixed tower connected rigidly to the pontoon structure. Within this tower revolves a pivot frame, on one side of which the machinery house is suspended. The

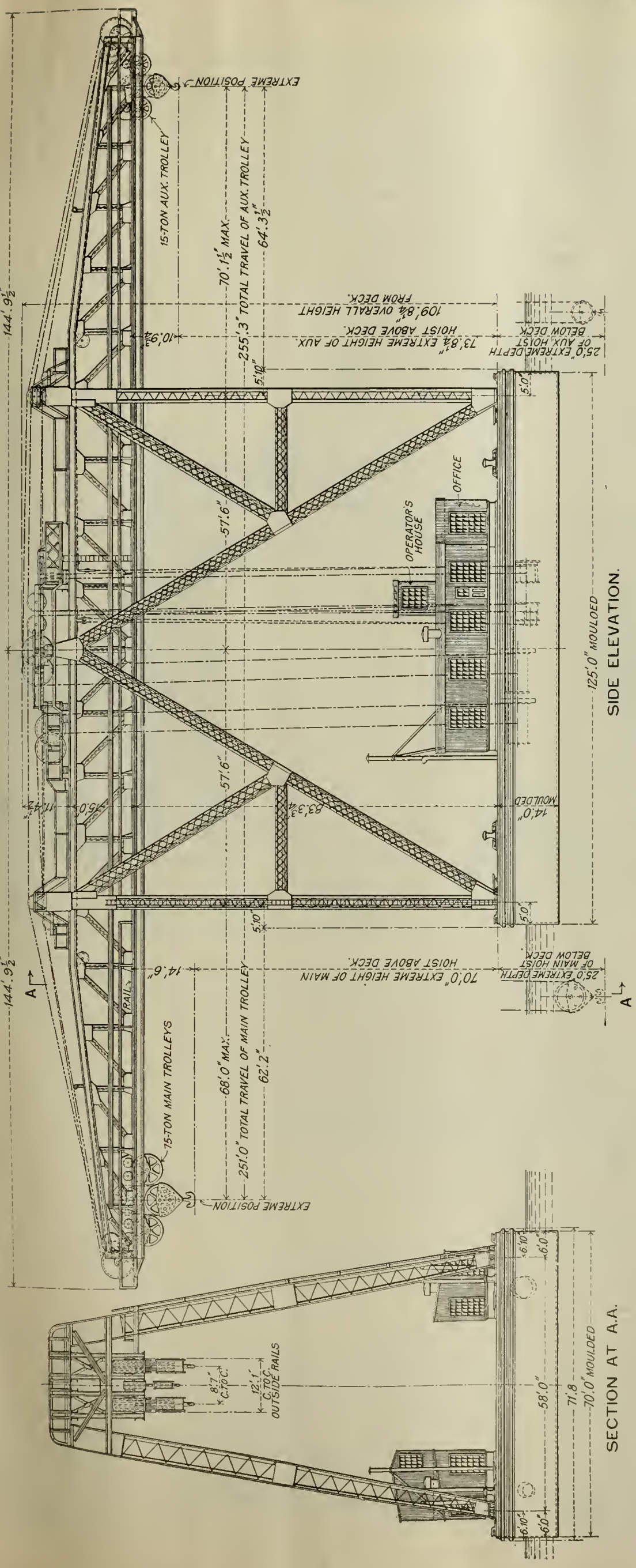


FIG. 2.—ARRANGEMENT OF 150-TON FLOATING BRIDGE CRANE.

"The Electrician"

opposite side of this pivot frame carries the hinge-pins for the jib, which is operated by means of links attached to heavy pins in the back-end of the jib. These links are connected to the cross-head which operates between vertical guides at the rear of the rotating structure. The crane is capable of lifting 150 tons at a minimum reach of 62·5 ft. over the side fenders and approximately the same distance over the end fenders. The maximum lift of 150 tons is accomplished by means of

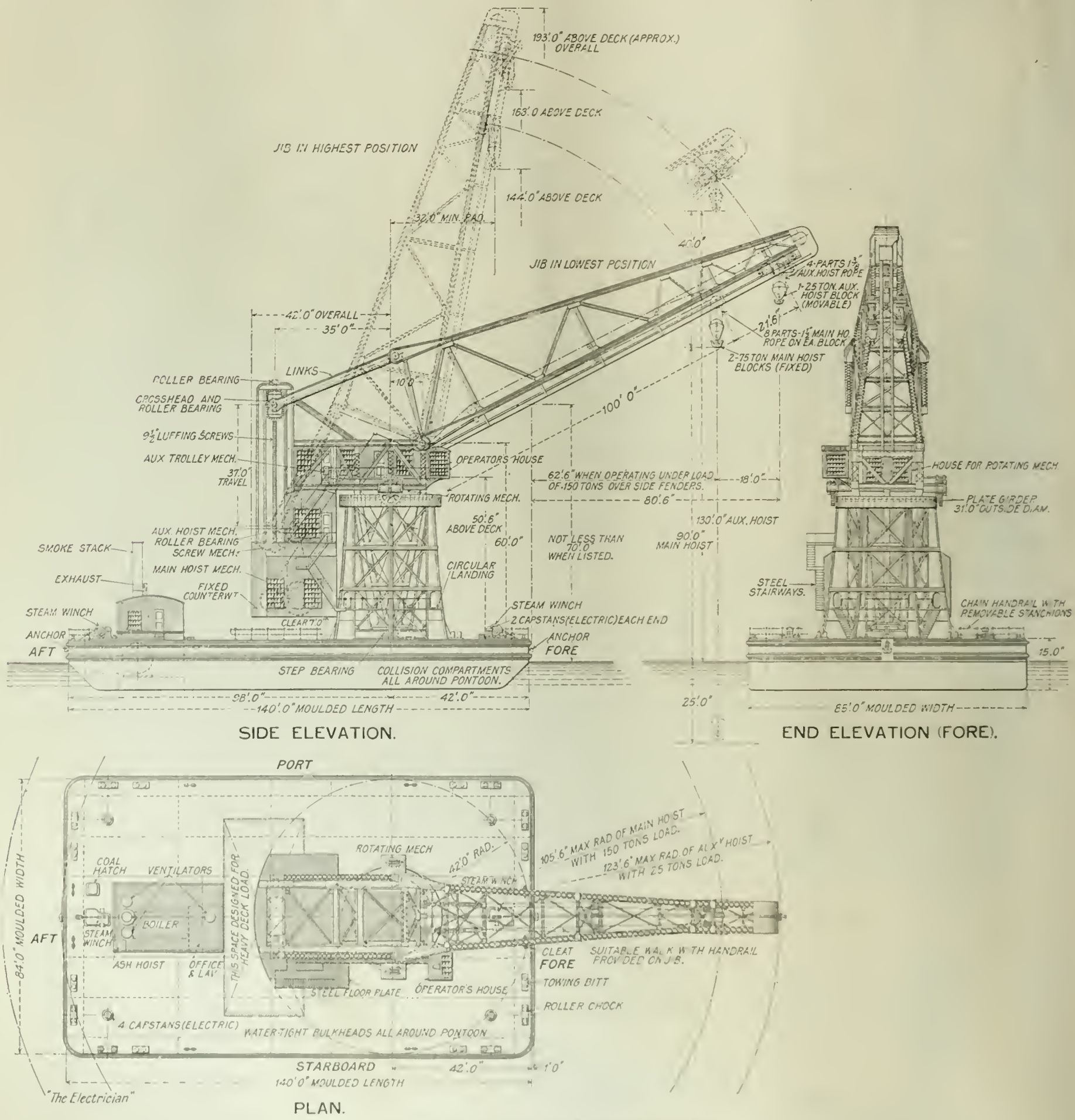


Fig. 3.—150-ton Floating Revolving Crane.

two separate 75-ton hooks suspended by cables from sheaves properly located in the framework of the jib. These hooks are capable of hoisting a load vertically from a point 25 ft. below the surface of the water to 90 ft. above the water, making a total height of lift of 95 ft.

In addition to the two main hooks, an auxiliary hook of 25 tons capacity is suspended from a trolley on the boom in such a position that it is capable of hoisting from a point 25 ft. below the water to 130 ft. above the water at the maximum reach of 62·5 ft. beyond the fenders. This trolley travels on a runway suspended from the underside of the jib, and is capable of travelling the entire length. The arrangement of the mechanism is such that the jib can be luffed under load from the maximum reach to the highest position, giving a minimum reach of approximately 32 ft. The crane is also capable of rotating under full load at maximum reach. All the operating machinery for the different functions of the crane is placed in the machinery house on the rotating structure.

The operator's cab is placed forward of the machinery house, where all of the operations of the crane are in clear view. The pontoon is fitted with four electric capstans and two anchor winches. These anchor winches are placed forward and aft on the pontoon structure. The entire weight of the rotating structure is carried on a step-bearing securely attached

to the pontoon at the centre of the fixed tower. The horizontal load on the pivot frame is taken off close to the deck by means of a circular bearing and at the top of the stationary tower by means of a roller bearing. Rotation of the jib is effected by means of two heavy steel pinions meshing with a bevel gear ring secured to the top of the stationary tower. These pinions are geared to an electric motor located in the rotating structure. The machinery for luffing the jib is located at the rear of the rotating structure, and consists of two motors geared to the luffing screws. These screws are supported on conical roller bearings and pass through the heavy nuts in the luffing crosshead to which the links attached to the jib are connected. The arrangement of the crosshead which operates the jib is such that when the jib is in the extreme outer position the greater part of the load on the jib supporting links is taken as a horizontal load on the vertical crosshead guide, thus minimising the vertical load on the luffing screws.

The machinery for operating the main-hoist blocks is located at the bottom of the rotating framework, and consists of two separate sets of mechanism. Each mechanism consists of a winding drum geared to its motor, and arranged so that the two separate mechanisms can be positively connected for simultaneous operation of the two main hooks when handling the same load. Two ropes lead from each drum over deflecting sheaves in the structure, and the reeving is such that each 75-ton block has eight parts of cable. The main-hoist mechanisms are provided with dynamic braking controllers for manipulating the load. The main-hoist blocks, two in number, are each provided with four cable sheaves 45 in. in diameter, carried in a structural steel frame from which is suspended a 75-ton hook. This hook is mounted on conical roller bearings, and is of the anchor or ram's-horn type. The auxiliary-hoist mechanism is located above the main-hoist mechanism, and consists of a winding drum connected to the hoist motor by means of spur gearing. The ropes from this drum are led over deflecting sheaves in the structure and arranged to form a four-part hoist system for the 25-ton auxiliary block. This block has two sheaves carried in a structural steel frame from the lower side of which is suspended a 25-ton hook. This hook also is provided with a conical roller bearing and is of the anchor type.

An independent set of mechanism in the machinery house is provided for traversing the 25-ton trolley along its runway. This mechanism consists of winding drums upon which the ropes for moving the trolley backwards and forwards along the boom are wound. The ropes leading to the forward end of the trolley are of necessity larger than those leading to the back end on account of the incline of the jib and the necessity of moving the trolley along the jib with the 25-ton load hanging from the hook. The two winding drums are provided with the necessary gearing for connecting them to the travel motor. With this arrangement of mechanism it is possible to traverse the trolley from one end of the jib to the other when the jib is in any position. When the trolley is in the extreme rear position on the jib it is possible to land the material on the deck of the pontoon at a minimum radius of approximately 24 ft.

All of the motors used in connection with the various mechanisms are of one size and are provided with magnet-switch control, the master controllers being located in the operator's cab. Continuous current at a pressure of 250 volts is applied to these motors by means of a steam generating set, which is located in one of the compartments of the pontoon. This set consists of a non-condensing compound engine, direct connected to a continuous-current generator rated at 150 kw.

The boiler plant consists of a 200-H.P. marine-type boiler with feed-water heaters and the usual accessories. It is located in the compartment of the pontoon adjacent to the generator compartment. A deck-house is built to cover the deck openings of the boiler-house and engine-room compartments. One corner of this deck-house is finished off for an office, which is furnished with a steam-heating apparatus.

The pontoon is of steel construction, and has the following moulded dimensions: Width, 85 ft.; length, 140 ft.; depth, 15 ft. Watertight compartments extend entirely around the outside of the pontoon, and in addition to these compartments the pontoon is also provided with the necessary full-depth bulkheads to secure the necessary strength and rigidity.

We record our indebtedness to the makers, Messrs. The Wellman-Seaver-Morgan Co., for kindly placing data at our disposal, and for the drawings and photographs from which the illustrations in the text have been prepared.

NATIONAL PHYSICAL LABORATORY.

(*Continued from p.* 532.)

In what follows we refer to the work that is proposed for the year 1916-17, and we give extracts from the Report of the Director

Owing to the large amount of war work, the programme of work which appears in the Report for last year still stands. In the Physics Department, Electrotechnics Division, it is hoped to make good progress with the research into the temperature of buried cables, undertaken in connection with the Institution of Electrical Engineers. For this a grant has been received by the Institution from the Research Committee of the Privy Council. In the Department of Metallurgy and Metallurgical Chemistry it is hoped, with the assistance of the Privy Council Committee, to commence the systematic study of steels described in last year's report.

The research on optical glass, for which funds have been provided by the Privy Council Research Committee, has important bearing on the war, and will be prosecuted vigorously, but the work already accomplished has shown the need of large extensions both in buildings and apparatus, in order to cope with the problems which present themselves. The Research up to the present has dealt in a large degree with the properties of refractory materials for the pots, the construction of suitable furnaces, and the application of electricity to the industry. It has become clear that such work raises a series of questions relating to the materials required, which need for their solution a well-equipped chemico-technological laboratory.

For many of our refractories, *e.g.*, alundum, carborundum, graphite, zirconia, we are entirely dependent on America; there is also the question of the study of certain of the rare metals and their applicability to industrial purposes, of which the investigation of the aluminium alloys is an example. Work of a similar nature deals with materials, such as tar and bitumen, for the Road Board, dopes and fabrics for the Aeronautical Committee, oils, whether for fuel or for the electrical industry.

For nearly all this work a technological laboratory on a large scale is needed; buildings and plant are necessary, capable of dealing with materials in, say, hundredweight lots, for such purposes as grinding, mixing, burning, extracting, distilling, washing, &c. While it may be difficult under war conditions to make much advance in this direction, it is desirable to prepare, and at any rate to decide whether work of the kind should be undertaken, and if so, to consider ways and means, the organisation of the work, the nature of the buildings and plant, and a number of other details.

The Report of the Director deals, as usual, with the work of the various departments.

PHYSICS DEPARTMENT.—I. ELECTRICITY.

Most of the time of the Department has been spent in work of a confidential nature. The Marine Department of the Board of Trade desired the help of the Laboratory in preparing a specification for liquid compasses for use on lifeboats of merchants ships. Tests were also undertaken on prismatic compasses for the Inspector, R.E. Stores, Woolwich. New apparatus was designed to enable the tests to be made accurately and quickly. It was found possible to test rather more than 1,000 compasses per week. Advice on the manufacture of compasses has been given to a large number of makers, and a Paper dealing with the construction and testing of prismatic and other compasses was read before the Optical Society.

Magnetic Tests.—Chiefly in connection with the testing of magnet-steel, a considerable amount of work was done with a view to obtaining improved methods of testing the magnetic properties of bars, the determination of the remanence and the coercive field being particularly considered. A number of improvements were carried out, most of them involving the use of very thin flat search coils for measuring H (following Madame

Curie, Denso, Gumlich and Rogowski). A flat search coil of this kind placed very close to the surface of the iron bar affords a means of accurately determining the magnetising field to which that portion of the iron is subjected; even though the field is due to several sources such as magnetising solenoids, other magnets, or leakage from free poles of the rod itself. For rectangular bars the coils are wound on thin sheets of insulating material such as glass. In order to determine the H for any particular state of magnetisation without altering it, the coil is arranged in a very narrow frame, so that by pulling a thread it is rotated in its own plane through 180 deg. In conjunction with a ballistic galvanometer or fluxmeter this gives an immediate measurement of the existing H. It is particularly convenient for determining the remanence, which is approximately the value of B when H is reduced to zero. Such a turning coil can be applied even to curved bars, provided that the curvature is not too great. For round rods, tunnel-shaped search coils were constructed. It is difficult to design such tunnel coils so as to obtain good dynamical rigidity and permanence of form. Some of those in use for many months, however, show satisfactory constancy. Curved bars, such as horseshoe permanent magnets, are much more difficult to test than straight rods, as it is not easy to get a sufficient number of turns of winding uniformly into the available space if magnetising fields of 300 to 400 are required. For this purpose a variety of sectioned coils have been constructed Tests of cast steel at high magnetisations (*e.g.*, B=20,000) are of considerable commercial importance. For such tests the simplest method is to place a rod of the material axially in a heavily wound wide solenoid, clamping the rod between the ends of two soft iron rods in line with it and abutting against its ends. The B is determined by a coil of one or two turns round the middle portion of the bar, and the H by one of the search coils as described above. By this method we have recently tested some of the standard rods used for years past in the Ewing Permeability Bridge. These bars had been originally tested in pairs by the Small Yoke Method. The values obtained by the tunnel search coil method are in a very satisfactory agreement with these earlier tests.

Some investigation was made of the use of the Chattock Magnetic Potentiometer and Rogowski's applications of it. The instrument consists of a flexible strip of uniform section, wound uniformly with a large number of turns of insulated wire. It proved to be very convenient for the direct determination of magnetomotive forces, number of turns of coils, and many other tests wanted practically. A fuller description of the magnetic test methods mentioned here has been published. ("Journal" of the Institution of Electrical Engineers, Vol. 54, 1915).*

Further progress has been made with the research on magnet-steel, which is being carried out for the Institution of Electrical Engineers. Small rods of all the samples have been tested for their thermomagnetic properties, and curves have been drawn connecting the magnetic changes with the temperature.

II. Electrotechnics.

Several points, regarding the design and construction of the instruments and apparatus sent in, have had to be raised. This has been particularly the case with large current shunts where, owing to the restricted space for erection, the design of the main current terminals is most important. In one case it was found that, owing to the design of the end connections, differences of 8 per cent. could be obtained, depending on the method of leading in the current. An interesting point in this connection has been the amount of the temperature variation due to Peltier effect. A number of measurements have been made of the amount of the temperature difference, but time has not permitted of an investigation sufficiently complete for publication.

III. Heat.

With a view to the possibility of a more detailed study of the difference between the indications of the Resistance Thermometer as reduced by the method detailed in last year's report, and the scale obtained with the aid of "*verre dur*" thermometers, and also of a study of the individual differences between resistance thermometers of diverse types, some investigations have been made as to the influence of various factors on the behaviour of platinum during its manufacture into wire and during subsequent heat treatment.

Thermal Conductivity of Refractory Materials.—In order to be able to carry out measurements of the insulating properties for heat of bricks of low conductivity, over various ranges up to 450 deg., a special apparatus was constructed, which has proved extremely satisfactory. It has been employed in the study of a number of new commercial materials submitted by a large firm of boiler makers, and these are now being employed for thermal insulation on board ship. The heat transmitted is measured by a flow calorimeter in the usual way, sensitive differential thermocouples being employed for the temperature measurements.

A novel feature of the apparatus is the method of obtaining good thermal contact and uniformity of temperature over the faces of the bricks, which being ordinary commercial samples, are always irregular. This contact difficulty was surmounted by arranging the apparatus so that the hot surface of the slab was immersed in a shallow bath of molten tin electrically heated to a uniform temperature.

An investigation has been carried out on the thermal conductivity of a number of various thicknesses of slag wool, granulated cork, and slab cork. These tests were made with the large hot plate apparatus described in an earlier report. This consists of two steel plates, 3 ft. × 3 ft., bolted together and enclosing a flat resistance coil. The electric energy expended in this coil can be measured accurately, as well as the temperatures attained throughout the material. Considerable attention has been given to the determination of the various corrections necessitated by the fact that the flow lines of heat near the edges of the plate are distorted owing to the boundary effect.

The effect of these investigations has been to render the results obtained with the apparatus of greater accuracy, in so far as the absolute values of the thermal conductivity are concerned; hitherto, comparative data were chiefly desired. The work is still in progress, and it is probable that the firm for whom the present tests are being made will ask for a considerable extension of the range and scope of the experiments.

Heat Transmission through Roofing Materials.—In recent years considerable attention has been paid by manufacturers to the development of a cheap roofing material which would be free from some of the defects inherent in galvanised sheet iron. Some of the substances are composed of cement, to which fibrous material is added to render it less hard and brittle; sheets of any desired form being made up in thicknesses of ¼ in. upwards. Such materials have certain obvious advantages over corrugated iron, and *a priori* it would appear that they would in addition be more efficient than sheet iron in preventing loss of heat from the building through the roof, since the thermal conductivity of cement-like materials is of the order of $\frac{1}{10}$th that of iron.

In order to obtain numerical data as to the amount of radiating surface it would be necessary to install in a very large factory of which the roof was constructed of one of these materials, a sample was sent for test by a firm of consulting engineers. In order to imitate practical conditions as closely as possible, an apparatus was constructed which was a model of a building containing air warmed to a definite temperature. The heating was supplied by large resistance nets, whose actual temperature elevation with the heating current employed was very small. This was in order to ensure that the heat transfer was effected by air currents and not by direct radiation. The walls were of slab cork 2 in. thick, while the roof was composed either of the material under test or of galvanised sheet iron. The interior air of the box was circulated by a small electric fan, whose consumption of energy was added to that expended in the net. Suitably disposed couples gave the temperature of the internal and the external air, the difference being made 30°F. in accordance with the conditions specified.

The results obtained were of a wholly unexpected character. The tests showed that the heat loss per square foot of the composite material was about 20 per cent. greater than that through galvanised iron. The key to the explanation of this apparent anomaly of a badly conducting material transmitting more heat than a good conductor, was supplied by the previous work on the heat loss from surfaces, and it was concluded that the explanation lay in the difference of surface emissivity of the two materials.

The correctness of this view was borne out by further experiments. The top surface of the iron was painted black. It was then found that the heat transmission was increased, and became equal to that of the composite material. In further support of the explanation advanced, it was also found possible to *diminish* the transmission through the roofing material under test by painting the external surface with aluminium paint, when its transmission became practically identical with that found for the sheet iron in the original state. It is interesting to note that by experiment with thermocouples it was ascertained that the gradient through the material, about 2·5°F., was relatively small compared with the difference of 30°F. between the internal and external air. It would be of interest to know whether the efficiency of such protecting materials would not be considerably increased by constructing them in a cellular form with small air spaces between the walls. In countries where extreme climatic changes are encountered these transmission phenomena would be of considerable importance.

Heat Loss from Surfaces.—The work on heat loss from surfaces was continued as occasion permitted during the year. One of the points which received special attention, was the influence of orientation of the emitting surface on the heat loss by convection. The radiation from a plane surface 4 ft. by 3 ft. was investigated in various positions. The effects of radiation and convection were separated by observing the total heat loss and the loss due to radiation; the convection loss being obtained by difference.

To measure in calories per square centimetre the radiation from an ordinary metal surface at a temperature only slightly exceeding that of its surrounding is a difficult matter, owing to the small magnitude of the quantities to be measured. After various preliminary experiments the Melloni form of thermopile was adopted with various modifications, which experience with the instrument showed to be desirable. It was found that this much discredited instrument was most useful for this kind of work when comparatively large emitting surfaces were available.

The sensitivity of a 64-junction thermopile was amply sufficient for the purpose, a black painted surface at 100° C. giving rise to an E.M.F. of about 4,000 microvolts, which was measured with a potentiometer capable of reading to less than 1 microvolt. The details of the instrument employed and the general features of the apparatus will be published later.

The results showed the interesting and important fact that the convection loss was markedly dependent on the orientation of the surface, as might have been anticipated. Polar diagrams of the emission, the convection and the radiation round a horizontal axis, showing distribution and magnitude, were constructed. The application of this work to practical engineering problems is obvious.

(To be concluded.)

* The Electrician, Vol. LXXVI., p. 642.

PROPERTIES OF REACTOR WITH IRON CORE AND AIR-GAP.*

BY S. SANO.

In designing a reactor for purposes of general experiments with alternating currents it is frequently necessary, in order to reduce the weight of copper required, to use an iron core. By providing an air-gap in the iron circuit the reactance can be adjusted to any desired value within comparatively wide limits. In this case the exact calculation of the reactance will be found to be difficult, owing to a number of unknown items entering into the computation, the chief of them being difficulty of determining the exact path of the magnetic flux and its density along the path. In particular cases, however, sufficiently accurate results for practical purposes may be obtained by relatively simple assumptions.

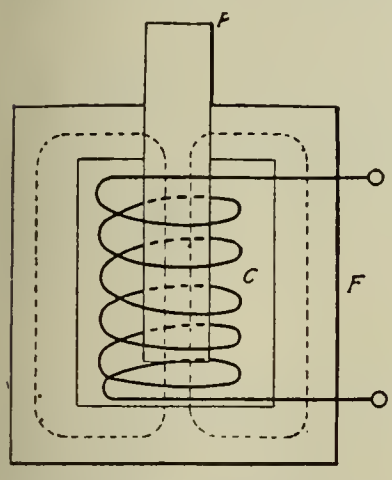


FIG. 1.—GENERAL DESIGN OF REACTOR CONSIDERED.

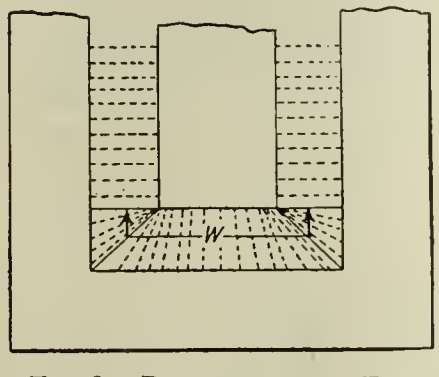


FIG. 2.—DISTRIBUTION OF FLUX BETWEEN PLUNGER AND FRAME.

The author has succeeded in deriving a set of rather simple equations for the calculation of the reactance of one form of construction, the validity of which equations has been repeatedly proved by actual experiments. Fig. 1 shows the general construction of the reactor. C is a coil into which fits a movable plunger, P. F is a framework of sheet iron, which serves to define the path of the magnetic flux and also to reduce the reluctance. The path of the main flux is shown by the dotted lines. Along with this main flux there will also be a leakage flux between the plunger and the framework. The dotted lines in Fig. 2 show this leakage flux.

Derivation of Equations.—The total counter E.M.F. offered by the reactance coil may be considered as made up of two components, the E.M.F. induced by the alternation of main flux and the E.M.F. due

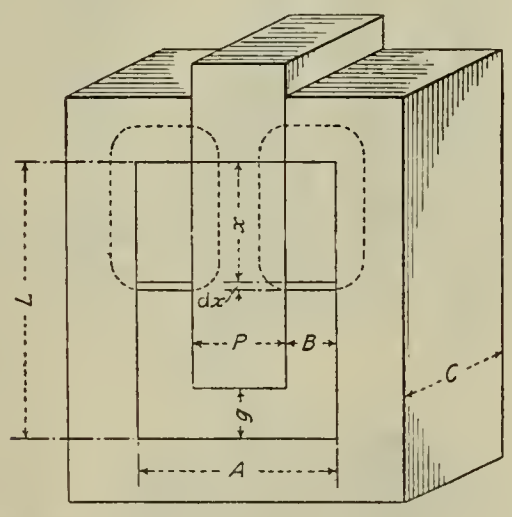


FIG. 3.—CONSTRUCTION REFERRED TO IN THE CALCULATIONS.

to the alternation of the leakage flux. The two E.M.F.s will be in phase with each other, and hence the total counter E.M.F. is the simple arithmetical sum of the two.

Referring to Fig. 3, the leakage flux through the elementary area is proportional to the ampere-turns linking the dotted lines through dx. These ampere-turns are

$$\frac{x}{L}N, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where N is the total turns of the coil. Hence, the leakage flux through Cdx from both sides of the plunger, neglecting the reluctance of the iron frame, is proportional to

$$2\frac{x}{L}N\frac{kC}{B}dx, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where k is a kind of "dispersion coefficient," to take care of the spreading of the section of the flux path at B. The E.M.F. induced by the alternation of this elementary flux will be proportional to

$$\left(2\frac{x}{L}N\frac{kC}{B}dx\right) \propto \left(\frac{x}{L}N\right) = \frac{2kN^2Cx^2}{L^2B}dx. \quad . \quad . \quad . \quad . \quad (3)$$

Accordingly, the total induced E.M.F. due to the leakage of flux is proportional to

$$k\frac{2N^2C}{BL^2}\int_0^{L-g} x^2dx = \frac{2}{3}\cdot\frac{kCN^2}{BL^2}(L-g)^3, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where g is the length of the air-gap between the plunger and the frame.

The main flux at the gap g may be considered to assume the distribution shown in Fig. 2. In this case the main flux is proportional to

$$N\left\{C\left(\frac{A+P}{2}+g\right)k\right\}\frac{1}{g}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Hence the E.M.F. induced by the alternation of this flux is proportional to

$$N^2\frac{1}{g}\left\{C\left(\frac{A+P}{2}+g\right)k\right\}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Thus the total E.M.F. induced in the coil is proportional to the sum of equations (4) and (6), that is, proportional to

$$N^2Ck\left\{\frac{2}{3}\cdot\frac{(L-g)^3}{BL^2}+\left(\frac{A+P}{2}+g\right)\frac{1}{g}\right\} = N^2Ck(K_l+K_m), \quad . \quad . \quad (7)$$

where K_l and K_m stand for the items in the brackets respectively.

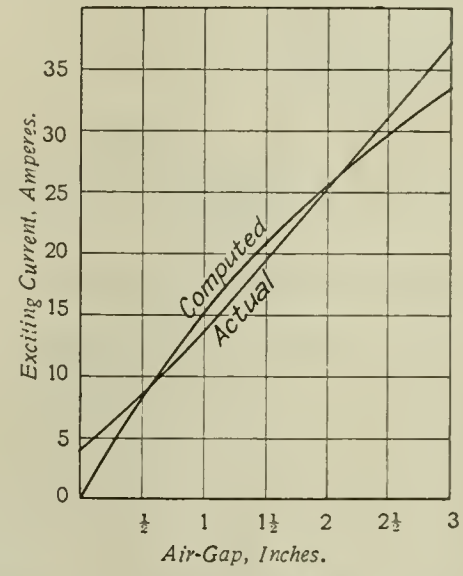


FIG. 4.—COMPUTED EXCITING CURRENTS FOR VARIOUS AIR-GAPS COMPARED WITH ACTUAL VALUES.

The ratio of the E.M.F. due to main flux to the total E.M.F. is thus

$$K_m/(K_l+K_m), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where $K_m = \{(A+P)/2g\}+1$,

and $K_l = 2(L-g)^3/3BL^2$.

After knowing this ratio, the calculation of the exciting current is an easy matter.

As a numerical example, consider a reactor having the following dimensions, the air-gap being adjustable :--

$N=195$. $L=7\frac{5}{8}$ in.

$B=2\frac{3}{16}$ in. $P=2\frac{1}{2}$ in.

$A=6\frac{7}{8}$ in. $C=2\frac{1}{2}$ in.

Impressed voltage=124 volts. Frequency=50 cycles.

The value of k can be determined experimentally, and is usually about 1·15. The value may be computed under certain assumptions, but it seems to the author that the increased complication does not warrant a slightly more exact result.

Take $g=2$ in., then $K_l=1{\cdot}07$; $K_m=3{\cdot}35$,

and therefore $K_m/(K_l+K_m)=0{\cdot}76$.

Hence the voltage available for the main flux is

$$124\times 0{\cdot}76 = 94 \text{ volts.}$$

The area of the main flux path is

$$C\left(\frac{A+P}{2}+g\right)k = 19{\cdot}3 \text{ sq. in.}$$

* From the "Electrical World," slightly abbreviated.

The same value of k is here used as above (*i.e.*, 115). For $N=195$ and frequency=50 cycles, the mean flux-density in the air-gap is

$$B=\frac{94\times10^8}{4{\cdot}44\times19{\cdot}3\times195\times50}=11{,}200 \text{ lines per square inch.}$$

Hence the ampere-turns (effective value) are

$$\frac{11{,}200\times2\times0{\cdot}3132}{1{\cdot}41}=5{,}000,$$

and therefore

$$\text{Exciting current}=5{,}000\div195=25{\cdot}6 \text{ amperes.}$$

In Fig. 4 curves are given showing the exciting current for various air-gaps calculated by the method above described, and also the actual observed value of the exciting current. It will be seen from the figure that the formulæ are fairly accurate at least within and near the limits given by the two intersections of the "computed" and "actual" curves.

Effect of Side Clearance.—Ordinarily the clearance between the plunger and the entrance to the frame can be made sufficiently small so that the effect of this air-gap may safely be neglected. However, when the main air-gap is small the effect will be appreciable. The following method of computing this effect will be found useful for certain cases where accuracy is needed for small values of g.

The total flux passing through the air-gap forming the side clearance is the sum of the leakage flux and the main flux. The former is integral of equation (2); that is

$$\frac{2N}{L}\cdot\frac{kC}{B}\int_0^{L-g}x\,dx=\frac{N}{L}\cdot\frac{kC}{B}(L-g)^2. \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Thus the total flux is, adding equation (5) to the above,

$$NkC\left\{\frac{(L-g)^2}{LB}+\left(\frac{A+P}{2}+g\right)\frac{1}{g}\right\}. \quad . \quad . \quad . \quad . \quad (10)$$

Hence the ratio of total flux to main flux is

$$1+\frac{(L-g)^2}{LB}\cdot\frac{2g}{A+P+2g}. \quad . \quad . \quad . \quad . \quad . \quad (11)$$

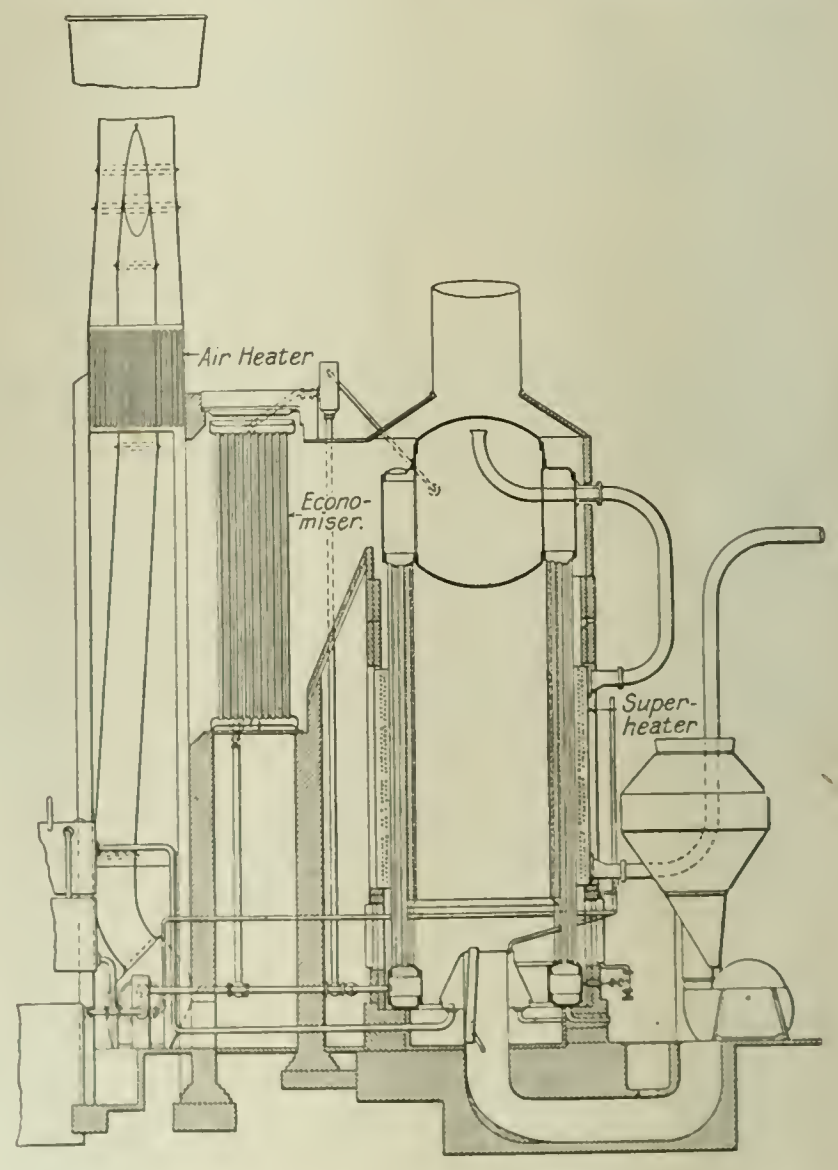
In this way, if the main flux is found, the total flux can be calculated from the dimensions, and the necessary ampere-turns are accordingly computed by the ordinary method.

THE BETTINGTON BOILER.*

This type of boiler, which has been installed at the Johannesburg Municipal Electric Power Station, is essentially a coal-dust fired boiler, and is of relatively new design. The chief pioneering and experimental work was carried out on the Witwatersrand by the late Lieut. Claude Bettington and Mr. Robeson. The particulars of the boiler are as follows: Evaporative capacity, 34,000 lb. per hour; heating surface, 240 tubes, 3¼ in. diameter, 22 ft. long, 4,480 sq. ft.; heating surface of boiler shell, 460 sq. ft.; heating surface of superheater tubes, 1,200 sq. ft.; heating surface, 75 economiser tubes, 3¼ in. diameter, 22 ft. long, 1,400 sq. ft.; heating surface, 188 air-heater tubes, 3¼ in. diameter, 10 ft. 10 in. long, 1,730 sq. ft.

The illustration shows the arrangement of the boiler. It consists briefly of solid drawn steel vertical tubes connected at the top and bottom to mild steel annular headers. The top header is fitted with doors for drawing out the tubes whenever necessary. The steam drum is fitted into the annular space of the top header, large holes being made in the periphery of the steam drum to form one common water and steam space at the top of the boiler. The top and bottom headers, together with the vertical tubes, form a circular structure like a huge cage. The interior part of this structure forms the combustion chamber, where the fuel is burned. The coal is placed in the coal bunker, fed into the coal hopper and falls by gravity on to a worm gear, which forces the coal into a combined pulveriser and blower. This latter arrangement is simply an ordinary centrifugal fan with heavy blade or beater tips, and with a constricted space between the ends of the beaters and the casing. The boiler under review is fitted with two sets of combination blower pulverisers, each directly driven by 100 H.P. motors at approximately 1,400 revs. per min. Each pulveriser is capable of giving the full-rated output of the boiler. In this way the coal is driven outwards by centrifugal force, and is crushed to fine dust and blown into the dust chamber. The heavy particles fall back again into the pulveriser, to be further crushed to fine dust. This is carried upwards to the air and fuel pipe, which terminates in a large tuyere, and the coal dust when ignited burns like a large Bunsen burner. The ignited coal dust forms a mushroom-shaped flame within the closed ring of vertical tubes which form part of the steam-producing plant. The flame strikes the bottom of the steam drum, is deflected downwards, and passes over the interior row of tubes, which are protected from the high temperature of the combustion chamber by specially shaped fire bricks. The hot gases are then deflected upwards and pass over the outer rows of vertical water tubes and the superheater tubes, and finally round the economiser tubes through which the boiler feed passes before it gets to the boiler. There is also another set of tubes through which the gases pass before entering the chimney and passing to the atmosphere. This latter set of tubes forms a separate air heater, and is connected to the pulveriser blower, which draws the air around the hot tubes, thus heating the air before it passes into the boiler and enabling the pulveriser to deal with fairly wet coal. The superheater tubes are connected to the upper part of the steam space of the top header by means of a steel expansion pipe, and the superheated steam is led away to the mains in the usual way. The firing of the boiler when cold is done at the municipal station by inserting a 2 in. gas pipe into a 4 in. air pipe to form a large Bunsen burner, the whole being placed inside the tuyere, and the boiler is started up instantly by simply lighting up the large gas jet.

The Bettington boiler was installed in 1911, and a thermal efficiency of 85 per cent. was guaranteed. The boiler, as depicted in the figure,



had to be somewhat modified. At first it was fitted with a parallel chimney 60 ft. high and 4 ft. 6 in. diameter. It was expected that the pulveriser, which acts as a fan and produces a pressure of 1 in. to 1½ in. in the combustion chamber, would be sufficient to force the hot gases around the boiler tubes, the economiser and air heater tubes and thence up the chimney. In practice, however, the gases were somewhat choked, and cooled to such an extent that additional draught had to be provided to get the full capacity out of the boiler. It was impossible to modify the air pressure at the pulveriser, as it interfered with the combustion of the coal dust. The economiser and air heater were considerably reduced, and a more direct path for the gases to the chimney was provided by raising the air heater about 26 ft. In addition, the boiler was fitted with a Schwabach indirect induced draught plant, and the height of the chimney in the new arrangement is 86 ft., the draught at the bottom of which is about ⅝ in. In this way the rated capacity of the boiler was obtained, but its efficiency was somewhat lowered: the figures below are those obtained from the modified boiler. No doubt in the future design of this boiler its efficiency can be somewhat improved by a proper relation between the pulveriser pressure, the boiler tubes and the magnitude and arrangement of the economiser and air-heater system

* Abstract of a Paper read before the South African Institution of Engineers, from the "Colliery Guardian."

without the necessity of an additional mechanical draught system at the base of the chimney.

After these alterations and certain adjustments at the pulverisers were made, the boiler, whilst not attaining the high efficiency of 85 per cent. as guaranteed, was considered thoroughly reliable for the purposes for which it is used at the municipal power station. Practice shows that the water tubes are practically self-cleaning. The inner row of water tubes do not appear to show any unusual evil effects by being close to the combustion chamber. During a period of four years very few tubes have been replaced. The boiler can be, and is, usually put on the steam mains from cold in about 20 minutes to half an hour from lighting it up by gas. The boiler is usually run to take the evening peak load, but has been run regularly day and night on occasions for a period of over a week, during which time it is necessary to rake out the pebbles of slag every 12 hours, and there was no particular trouble experienced through slag depositing on the brick lining. This boiler has been of great service when part of the other boiler plant has been suddenly put out of action. Its ability to get up steam quickly is regularly taken advantage of, especially during the rainy season, when sudden large increases of load arise in a very short time. As it is fitted with two pulverisers, each of which can give the full-rated output, its overload capacity has ofttimes proved exceptionally useful. Needless to say, the boiler was paid for and taken over, and it forms a valuable portion of the boiler plant, working on conditions of large and sudden power demands.

Results of Tests.

Duration of test, 9·8 hours; gauge pressure, 173·7 lb. per square inch; feed temperature, 65·5°F.; steam temperature, 510·3°F.; water evaporated per hour, 31,561 lb.; coal consumed per hour (no allowance made for carbon value of ashes), 4,477 lb.; lbs. of water evaporated per lb. coal (as fired), 7·050 lb.; gross calorific value of coal as received, 11·50; net calorific value of coal as received, 11·10; heat transmitted to feed by boiler per 1 lb. dry coal, 1,240 British thermal units; evaporative equivalent from and at 212°F. (as fired), 9·049; evaporative equivalent from and at 212°F. (dry), 9·464; efficiency on gross calorific value, 78·6; percentage auxiliary power, 3·8; net efficiency on gross calorific value, 75·6; efficiency on net calorific value, 81·4; net efficiency on net calorific value, 78·3.

NEW GALVANOMETER LAMP AND SCALE.

Two important features characterise a galvanometer lamp and scale which has recently been placed on the market by the Leeds & Northrup Co., of Philadelphia. First it is very easily read, secondly it

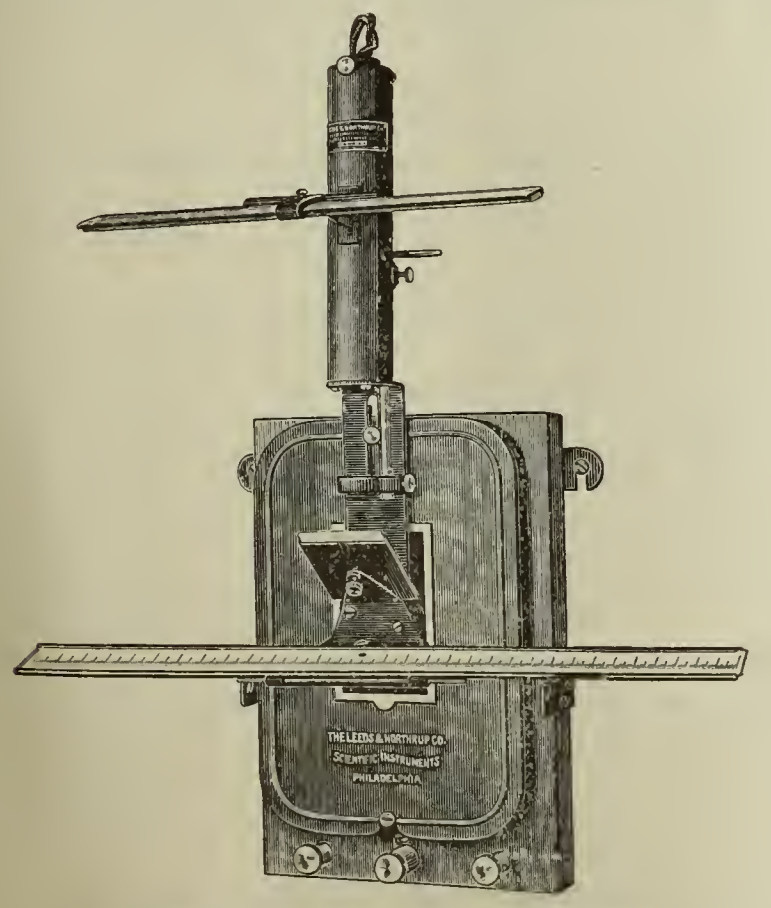


Fig. 1.—Lamp and Scale attached to Galvanometer.

is compact and requires no space on the testing table. The spot is brilliant enough to be seen in broad daylight.

It will be seen from Fig. 1 that the lamp and scale are mounted directly upon the front of the galvanometer, thus economising space. This arrangement obviates the necessity of placing the galvanometer away from the other apparatus used in the test and the necessity of a separate lamp and scale being used. Having a lamp and scale mounted directly upon the galvanometer also makes the adjustment easier, since the operator has the lamp, scale and galvanometer in front of him, and does not have to move from one to the other during the course of adjustment.

The lamp and scale consists of a frame upon which are mounted a low-voltage incandescent lamp, a lens, two mirrors and a cardboard scale. The operation of the instrument will be readily understood from the inspection of Fig. 2. A single straight filament lamp of high intrinsic brilliancy is used. It operates at 4 volts and requires a current of 0·5 ampere, and can be energised either from a storage battery or from an ordinary lighting circuit. Several inches of flexible cord are attached to the lamp socket, and on the end of this there is a double plug connector. Thus, if it is desired to move the lamp and scale when permanent wiring has been installed, this may be done without disturbing the wiring.

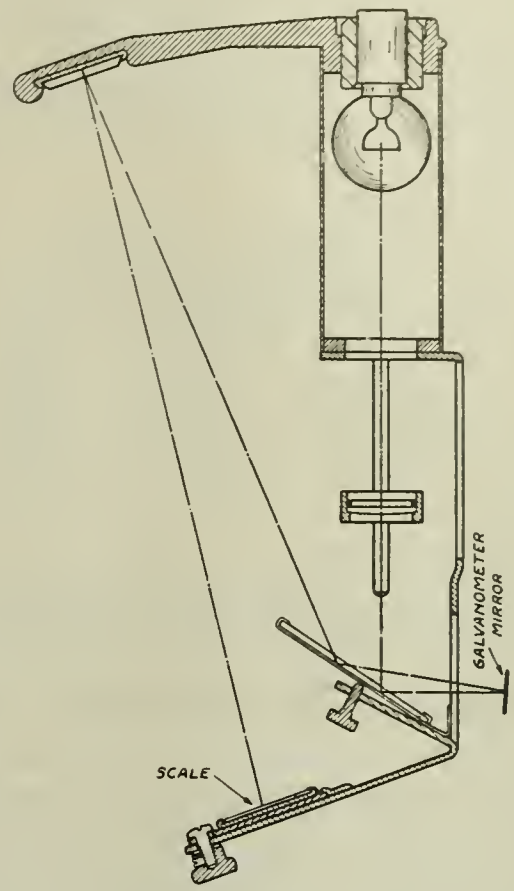


Fig. 2.—Diagrammatic View of Lamp and Scale.

In a pamphlet issued by the makers full instructions are given for setting up.

The "Biggest Things" in Water-Power Development.—At a recent exhibition of water-power apparatus held at the Massachusetts Institute of Technology some interesting data on U.S. water-power were given. The largest high-head development in the United States and Canada is that of the Pacific Power & Light Corpn. at Big Creek, Cal. In the two plants now operated in connection with the 240-mile transmission to Los Angeles, the average head is about 2,000 ft., the larger head being 2,150 ft. The water-wheels are rated at 23,000 H.P. each, and the storage capacity of the main reservoir, Lake Huntington, is 120,000 kw. continuously for eight months. The largest producer of hydroelectric power is the Ontario Power Co., Niagara Falls, Ont., which develops 180,000 H.P. in 14 horizontal units at capacity load fatcor. The Keokuk (Iowa) plant of the Mississippi River Power Co. is the largest low-head development, having a total rating of 150,000 H.P. at 32 ft. The most powerful turbines are machines of 25,000 H.P. rating under 160 ft. head, in the Long Lake development of the Washington Water Power Co., near Spokane. The most powerful vertical turbines are several 20,000 H.P. machines of the Laurentide Co. (Ltd.) installed in a plant on the St. Maurice River in the Province of Quebec. The largest turbines in size are those of the Cedars Rapids Power & Mfg. Co., near Montreal, Quebec. These units have a turbine and generator weight of 850 tons, and a turbine runner diameter of 17 ft. 8 in.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury, court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential circulation all over the World.** *This statement is guaranteed. Advertisement Rates, &c., forwarded on application.*
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.
WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s.
THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.
ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C. Garrard. *Ready in a few days.* 15s. nett, post free 15s. 6d.
THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*
PRIMARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By W R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*
HANDBOOK OF THE ELECTRICAL LABORATORY & TESTING ROOM. Very fully illustrated. By Dr. J. A. Fleming. *Revised Editions.* Vol. I., 12s. 6d. nett. Vol. II., 14s. nett.
SECONDARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.
THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.
INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903), Full Report of Proceedings at, 8s. 6d. ; post free, 8s. 9d. ; abroad, 9s.
INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.
BRAKES FOR TRAMWAY CARS. By H. M. Savers. Price 2s. 6d. nett.
ELECTRICITY IN HORTICULTURE. By Prof. S. Lemström. Illustrated. 3s. 6d. nett.
RADIO-ACTIVITY : AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M A. Price 4s. nett.
MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by G. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.
ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.
A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Geipel and H M. Kilgour. Price 7s. 6d. nett.
THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.
THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.
ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.
THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. G. Bond, M.I.E.E. Price 2s. 6d. nett.
CARBON MAKING FOR ALL ELECTRICAL PURPOSES. By Francis Jehl Price 10s. 6d.
"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Down, Wh.Ex. & M.I.Mech.E. Price 2s. 6d. nett.
THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C E., M.I.M.E., &c. Price 5s. nett.
INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 8d. nett.
INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.

A RELIABLE WORK OF REFERENCE.

THE LOCALIZATION OF FAULTS IN ELECTRIC LIGHT AND POWER MAINS.
By F. C. RAPHAEL.

THIRD EDITION: *Now Ready.* Price **8s. 6d.** nett, post free **9s.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

ANALOGIES AND MODELS.

In trying to account for new phenomena it is customary to make a comparison between such phenomena and some old-established and long-accepted facts. Thus, when the electric circuit is being studied it is helpful to the beginner to put side by side the comparison between the electric current and a stream or current of water in a pipe. Without this analogy the investigation and application of the laws of the electric circuit would be exceedingly difficult, and relatively few people would have the ability to undertake the work.

We are of the opinion that the hydraulic analogy is not carried far enough by teachers of electrical engineering. The fact that materials can be classified under the three headings : Conductors, resistance materials and non-conductors or insulators, is readily grasped by the beginner if he is reminded that a vulcanised-rubber or paper covering is provided round a cable for the same reason that cast-iron is used for forming the boundary wall of a hydraulic main. From experience, and without knowing the reason, he is aware that cast-iron is a water-insulator. He knows that a free-bore pipe is a good conductor of water ; that a pipe more or less choked offers more resistance to the passage of water through it than the free-bore pipe, and that a pipe filled with sand offers enormous resistance to the passage of water.

Valuable as the hydraulic analogy undoubtedly is, it is only one of several which have been found to make a strong appeal to engineers. In some respects teachers of mechanics make the mistake of giving to their students the idea that the theorems which they are studying are peculiar to the subject. This is not the case. Take, for example, the force required to accelerate a heavy body. It is now fairly well known that instead of mechanical force, acceleration and mass, we can substitute electromotive-force, current acceleration and electromagnetic mass. Students who have acquired a certain degree of skill in the solution of examples of the one kind quickly become expert in the solution of examples of the other kind. Problems in mechanical engineering involving complex space-time curves are readily solved by graphical methods from first principles, as also are electrical problems in which the current-time curve is complex.

One of the most fascinating problems in mechanics, namely, the swinging of a pendulum, or the motion of a fluid in a vertical U-tube, if properly understood, can immediately be applied to the parallel problem in electrical engineering, namely, the charge and discharge of a condenser. The grasping of the idea that in one case the discharge is logarithmic, and in another trigonometric is easy, provided that a student has previously made experiments with different liquids in the U-tube. The making of such experiments convinces one that between the two cases there must be a third which, although belonging to neither of the two extremes, marks the transition between them. The problem of the condenser charge and discharge is one of increasing importance not merely on account of its occurrence in a particular branch of electrical activity, but because it is a fundamental property of any electric circuit in which the conditions are varying. The phenomena, which, 60 years ago, needed the master-mind of Kelvin to predict, are now perfectly understood by many elementary students.

Every engineer remembers the difficulties he encountered

before acquiring familiarity with the principles of alternating currents, and we fear that many, even to this day, have the haziest of notions regarding the reasons why inductance and capacity have such a profound effect on an alternating-current circuit. To these we would recommend the careful study of the everyday experiences of life in connection with mechanics, and the construction of models for the purpose of facilitating such study. To this end we give elsewhere a highly instructive article by Prof. W. S. FRANKLIN, on "Some Mechanical Analogies in Electricity and Magnetism." In a footnote the opinion is expressed that the student of physics who is content with a verbal statement is hopeless. With this we are in entire agreement. To the rank and file the only way of acquiring knowledge is to learn by doing, and we hope that the interested reader will make the several simple experiments described by Prof. FRANKLIN.

If mechanical models of the electric circuit were helpful to MAXWELL it may be taken for granted that students generally will find them useful, not in order to make the subject easy by avoiding thought and mathematical analysis, but as a kind of sheet anchor which will prevent them from drifting from the subject. Although it is erroneous to suppose that the properties of alternating currents can be studied without the use of mathematics, it is, nevertheless, highly desirable, if not indispensable, to obtain clear physical conceptions of the phenomena which occur in order properly to understand the true meaning of the mathematical expressions. There are several books in which, while not avoiding the use of mathematics, the foundations of alternate-current theory are based upon simple mechanical analogies, and to these the reader, who has difficulty in understanding the elementary facts of alternating-current engineering, and who is prepared to take mathematics in much the same way as one takes medicine, can turn both with pleasure and profit.

RECENT PATENTS IN RADIOTELEGRAPHY AND RADIOTELEPHONY.

BY W. ECCLES, D.SC.

In the past year or two remarkable progress has been witnessed in radiotelegraphy and radiotelephony, in both generation and detection of electric waves. The outstanding feature in both divisions of the subject has been the elaboration of instruments and methods based on the experimentally discovered properties of thermionic currents in high vacua. For many years the prospective value of ionic currents and cathode streams, in all domains of technology where high-frequency currents are the main subject of manipulation, has been foreseen ; but it is only during the past two or three years, and with unnecessary and surprising dilatoriness, that the knowledge gathered on these subjects in the laboratories devoted to pure science has been carried over into the technical laboratories and successfully transmuted into practical processes of tangible benefit to mankind.

The following selection from recent published patent specifications gives a fair summary of the rise of thermionic currents into practical importance ; processes and apparatus utilising currents in vacuum will be found to form a large proportion of the selection.

I. TRANSMISSION.

F. di G. B. Marzi, in specification No. 12,259/1914, describes a discharge gap for producing electrical oscillations, of which the essential point is that one electrode is kept wet and moving. A way of carrying out the invention is shown in Fig. 1. The rotating disc forms one electrode and is wetted by the jet 3. The electrode 2 is an aluminium rod of circular section almost touching the disc. A felt pad 4 is of help in removing the excess water. When the gap is properly regulated a peculiar crackling arc arises and generates almost continuous trains of oscillations in the usual inductance capacity shunt circuit.

The form of discharge in which the gap is formed between the face of a rotating disc and the end of a blast-carrying tube whose axis is perpendicular to the plane of the disc, is familiar to all and has been used in installations of more than medium power. One of its defects is the rather rapid wearing of the lip of the tube. This is due to the fact that the cooling action of the blast does not extend fully over the lip because a sort of "backwater" forms in the air current. E. Girardeau and J. Bethenod give in specification No. 14,881/1914 means of removing this defect. The disc P (Fig. 2) which faces the end of the tube is now made of only about the same diameter as the

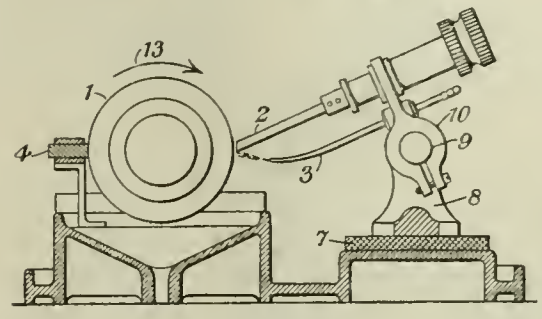


FIG. 1.

tube T^1, and both tube and disc are mounted axially in a larger tube T^2. The blast is now passed along the large tube and no portion of the arc can shelter from the air current. The size of the distance marked x is unimportant, but the diameter d is important. Each of the electrodes may be rotated to make the wear more uniform. Alternatively, as is set forth by the inventors in No. 15,031/1914, the spark may be kept rotating by a magnetic field perpendicular to it. In that case the disc electrode is made the end of a cylindrical magnet energised by a winding on the end remote from the gap. An effective way is to connect the winding in series with the excitation circuit of the alternator and then the magnetic field attains its maximum value at the proper moment. Another method suggested is to produce the magnetic field by a coil traversed by the h.f. current.

The Poulsen arc does not appear so prominently in the recent Patent Office records as might be expected in view of the great modern development of this method of telegraphy. A constructional simplification of the arc generator is, however,

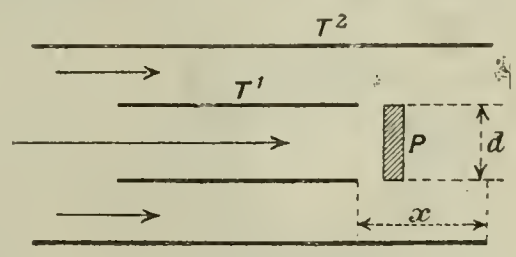


FIG. 2.

protected by J. A. Fleming in specification No. 3,963/1914. In this the carbon electrode is held vertically in heavy mineral oil with about ¾ in. protruding, and a copper vessel is inverted over it to form the anode. When the arc is burning between the carbon and the inside of the copper hat, oil evaporates and supplies the hydrogenous atmosphere. Excessive pressure of the gas is relieved by escape through small holes in the hat. Several hats can be put over carbon cathodes in the same oil tank and adjusted simultaneously by suitable gear. It is stated that four arcs burn well in series on 220-250 volts and eight arcs on 450-500 volts.

R. Arno gives details of a mode of generating practically continuous trains of oscillations in No. 11,928/1914. The apparatus is virtually a combination of a static phase transformer with a static voltage transformer, and is arranged to produce more than 30,000 sparks per second equally spaced in time and of equal damping. It is most easily explained by aid of the

two-phase example shown in Fig. 3, where the magnetic ring carries a continuous winding which is fed with two-phase current at equi-distant places I., I., II., II. In this case the P.D. between the points 4, 4 differs in phase by one-eighth of a period from that between I., I., and the result is a transformation from a two-phase to a 16-phase system. Suppose that the frequency of a polyphase current is n, that the winding is fed with N phases at equi-distant points, and that there are K tappings; then if in each derived circuit there is a spark gap, the total number of sparks will be $2nNK$. In order to make the secondary

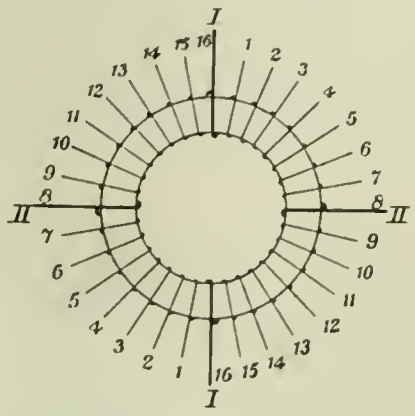


Fig. 3.

voltage high enough for sparking, two obvious alternatives present themselves: First, the input phases may be transformed beforehand, or second, the transformer may be built with two windings, one for the feeding phases the other for the secondary phases, so that the transformer is a voltage as well

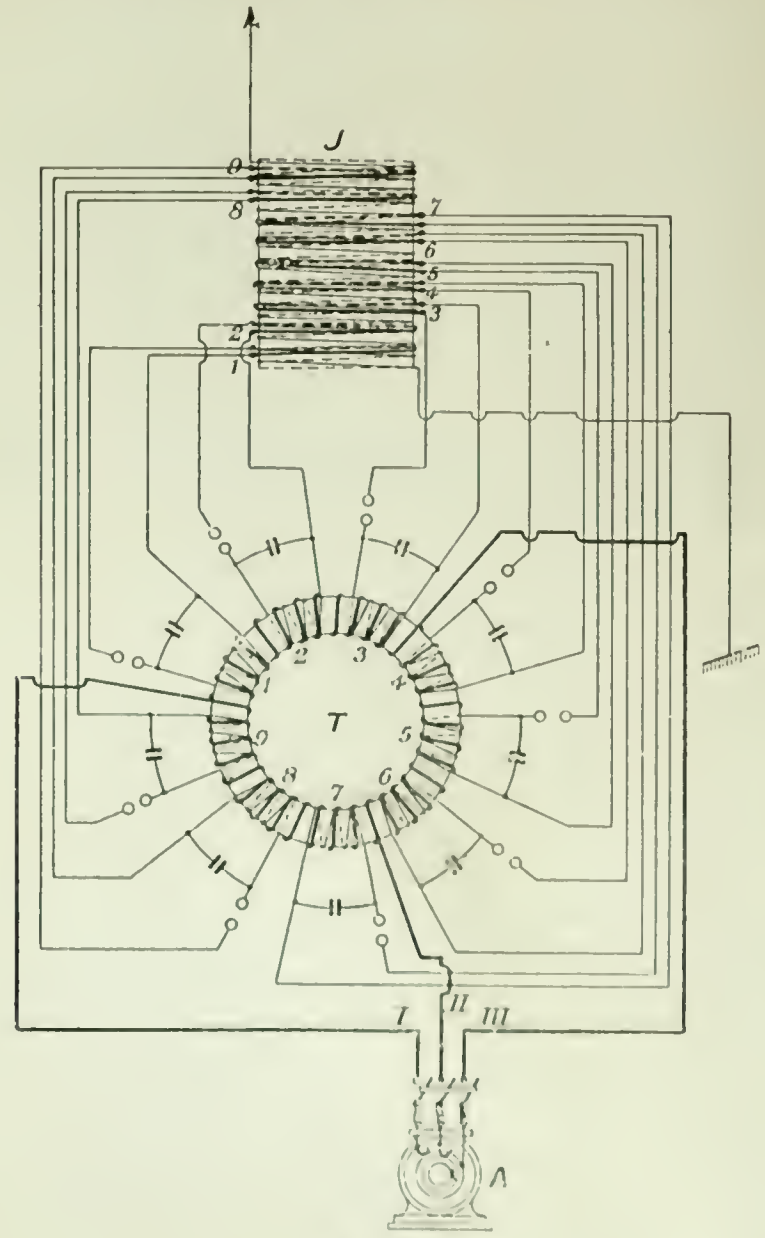


Fig. 4.

as a phase transformer. After remarking that it is best to use an odd number of phases the inventor recommends the system of Fig. 4. The alternator A of 1,000 ~ feeds the primary by means of three connected phases, I., II., III. The nine-phase secondary supplies nine single-phase disconnected high voltage currents to nine corresponding oscillatory circuits connected to one and the same h.f. transformer J.

The vacuum tube with three electrodes has lately become prominent as a generator of oscillations. Arco and Meissner disclose a mode of operation in specification No. 252/1914. An example is shown diagrammatically in Fig. 5, in which an antenna is being excited. The closed oscillation circuit 31, consisting of a capacitance 29, and an inductance 30, is connected on the one hand with the cathode 2 and the control electrode 4 through the circuit 7 by coupling the winding 30 with the winding 8, and on the other hand with the cathode 2

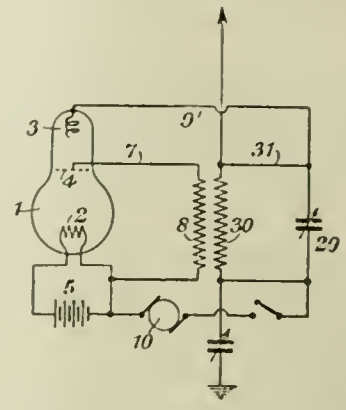


Fig. 5.

and the anode 3 by the circuit 9. If the closed circuit 31 is excited in any way in its own frequency, for example by charging the condenser 29 by the source of energy 10, these oscillations act through the circuit 7 on the control electrode, cause stronger oscillations in the repeat circuit 9 and so further strengthen the original oscillations in the circuit 31. This strengthening process is finally limited by the absorption of energy in the tube. The frequency of the oscillations is determined by the electrical constants of the oscillation circuit 31 and can be adjusted by altering the condenser 29. The power of the oscillations depends on the voltage between the anode 3 and the cathode 2. Since the tube passes current in only one direction, namely towards the cathode, the so-called oscillations in the circuit 9 are really unidirectional pulses of current. Moreover, if the source of E.M.F. be alternating, trains of oscillations are produced only by one-half wave of the E.M.F., and these are separated by blank spaces during the half-wave of opposite sign.

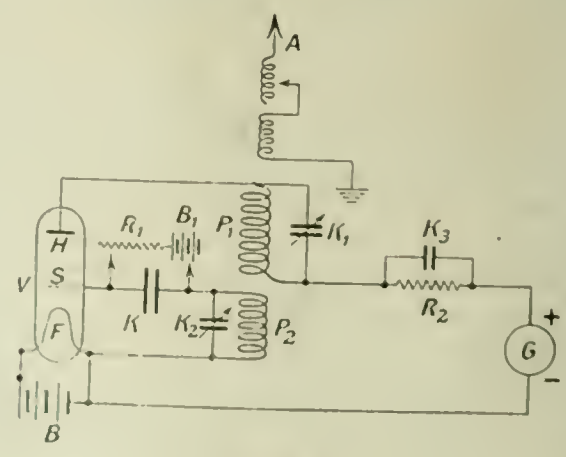


Fig. 6.

The principal application of the generator just described is not to sending of signals or to telephony but to beat reception, which is described below. It is to be remarked that although a cathode covered with oxides gives more copious emission of electrons, yet when a tube is to be used with rather high P.D. for the production of as strong oscillations as possible, the volatilisation of the oxide rapidly reduces the efficiency of the tube.

A somewhat similar arrangement is seen in a patent No. 13,248/1914, granted to Marconi's Wireless Telegraph Company and H. J. Round. A double anode tube is connected so that the control circuit is inductively acted upon by currents in the repeat or magnifying circuit, as in the cases just described. There are, however, in both circuits sources of E.M.F.

with ballast resistance, and these constitute a principal feature. Fig. 6 shows the connections well. In the control circuit S is the screen, F the hot filament, R_1, a ballast resistance, B_1 a source of adjustable E.M.F., and K_2P_2 a capacitance inductance circuit whose natural frequency determines the oscillations generated. The resistance R_1 and the battery B_1 are shunted by a condenser K, the object of this arrangement being to ensure stability of the current and yet to allow the oscillations to pass without loss. The most sensitive adjustment is found by trial variation of R_1 and B_1. In the repeat circuit there is an oscillatory flywheel circuit $K_1 P_1$ tuned to the circuit $K_2 P_2$ and coupled to it, a source of high E.M.F. G, and a steadying resistance R_2 shunted by a condenser K_3. If R_2 be sufficiently reduced an arc starts in the bulb, so R_2 is usually adjusted to about double this critical value.

A number of tubes can be connected to co-operate. The anodes are connected to the high E.M.F. generator through separate adjusting resistances R_2 (each with its condenser K_3); the screens S are connected each through its own R_1 B_1 K to one terminal of the $K_2 P_2$ circuit; and the filaments are heated from the battery B, each having its own separate rheostat, and connected to one end of the $K_2 P_2$ circuit. An application of the above apparatus to telephony is described below.

An improved method of generating sustained electrical oscillations is described by F. K. Vreeland in No. 11,555/1915, who has discovered that the oscillations produced in a mercury arc can be made much more energetic by causing the arc to be concentrated into an intense stream instead of being diffused throughout the tube. This concentration may be accomplished by admitting such gases as hydrogen or nitrogen to the tube in

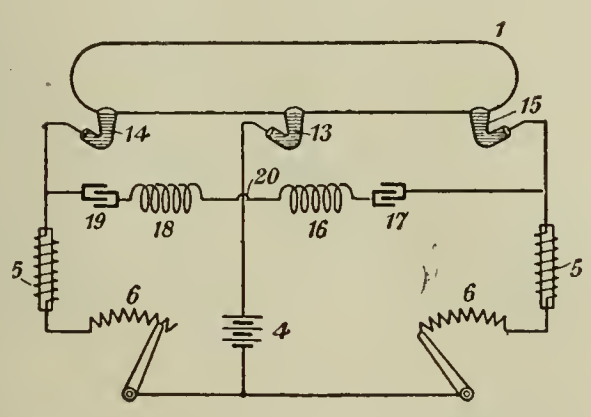


Fig. 7.

proper quantity, and may be assisted if desired by applying an axial magnetic field. The inventor prefers to take a highly-exhausted quartz tube with mercury electrodes, and then, after establishing the arc, to admit a small amount of the gas. The arc concentrates into a bright hot stream, and the terminal voltage is increased. Soon the gas disappears, and the arc becomes diffused again. Another addition of gas is then made with a similar result, and the process is repeated until absorption of gas ceases, and the arc remains concentrated. The intensity and temperature of the arc and the voltage required to maintain it depend upon the pressure of gas in the tube. In general, the arc becomes brighter and hotter and the terminal voltage increases as the gas pressure rises; but the tube will generate oscillations in an oscillatory shunt circuit over a wide range of gas pressures. As an example, the inventor states that tubes with from 5 cm. to 10 cm. between anode and cathode and containing hydrogen at a pressure in the cold tubes of from $\frac{1}{2}$ mm. to 2 mm. of mercury, operate very satisfactorily with an applied terminal voltage of from 75 to 500 volts. As a rule there is a minimum value of the current below which the tube does not operate satisfactorily. A quartz tube having a diameter of 5 cm. and a length of 15 cm., from which the heat is carried off by an air blast or an oil bath, will usually carry a current of from 10 to 15 amperes in a stream 7 cm. long, whose apparent diameter is less than 5 mm. Fig. 7 shows the design recommended by the inventor. Here there is a double arc having a single cathode 13 and two anodes 14, 15. An oscillatory circuit 16, 17, 18, 19 is shunted across the anodes. It is shown in the sketch as containing two inductances and two condensers, so that the central point 20 can, if desired, be connected to the cathode terminal. The two arcs 13, 14 and 13, 15, act on the oscillatory circuit in opposite senses, the current increasing in one when it is decreasing in the other, and these simultaneous actions at opposite ends of the oscillating circuit produce a cumulative effect. The principal advantage of this arrangement over a single arc is that the cathode is eliminated from the oscillating circuit, and, therefore, the surface drop of cathode potential is avoided.

An interesting type of high-frequency alternator is proposed by A. Heyland in specification No. 17,331/1914. The essence of the invention is that the active stator and rotor surfaces are differently subdivided in the direction of their movement, so that when one segment of the rotor iron is bridging the gap between two poles or teeth the next segment is not bridging the next gap, but is facing one of the poles or teeth. Figs. 8 and 9 show two arrangements as examples. In Fig. 8 S is the stator, R the rotor. The poles of the stator are indicated by

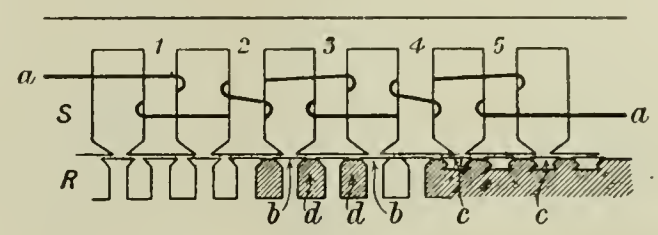


Fig. 8.

numerals 1, 2, 3, 4, ... The winding a a in which the high-frequency current is generated is so connected that a steady current fed into it makes the stator poles on which it is wound alternately N and S. In Fig. 8 the rotor teeth b b have a pitch one half the pole pitch of the stator. Thus the flux leaving pole 3 traverses the tips of the rotor teeth b b and enters poles 2 and 4. In another position half the rotor pitch forward, a rotor slot is opposite a stator slot and, apart from leakage, the only magnetic bridging is the path of much greater reluctance offered by the teeth and body of the rotor. By placing a winding of copper in the rotor slots, as indicated by d d and cross-hatching, the field of the rotor is neutralised by the induced currents. Another arrangement of copper and iron is shown on the right of the figure, where the iron bridge pieces c c are inserted in a conducting body. In this case the counter ampere-turns are produced in the solid metal.

Fig. 9 shows another construction. The stator has alternate teeth of different widths, and the rotor has a slot pitch equal to the larger slot pitch of the stator and double the smaller slot

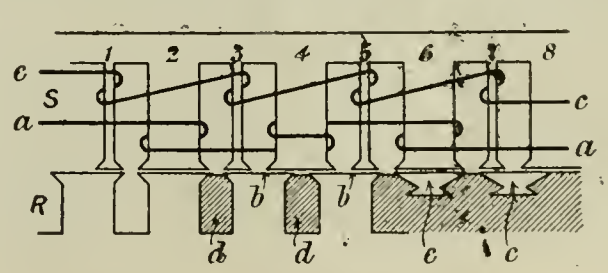


Fig. 9.

pitch. In the position shown the flux circuit of the pole 4 is closed over b b and the poles 3, 5, while the magnetic circuits of poles 2, 6 are longer, being through the rotor body. Conditions are exchanged on moving the rotor forward by half of its pitch. Thus, the flux in pole 2 pulsates in opposite phase to that in pole 4, while the flux in poles 1, 3, 5 does not pulsate. The winding a a on poles 2, 4, 6 is connected as if these poles were of alternate polarity, and therefore the induced E.M.F.s are added. For excitation there is a winding, e e, arranged so that poles 1, 3, 5 become north poles, and 2, 4, 6 south. No E.M.F. is induced in this winding, since the flux pulsations are confined to poles 2, 4, 6. The inventor lays stress on the advantage his design possesses of having closed windings on the rotor; these counter ampere-turns serve to reduce the rotor dispersion and to carry compensation currents corresponding to the load.

(*To be concluded.*)

CORRESPONDENCE.

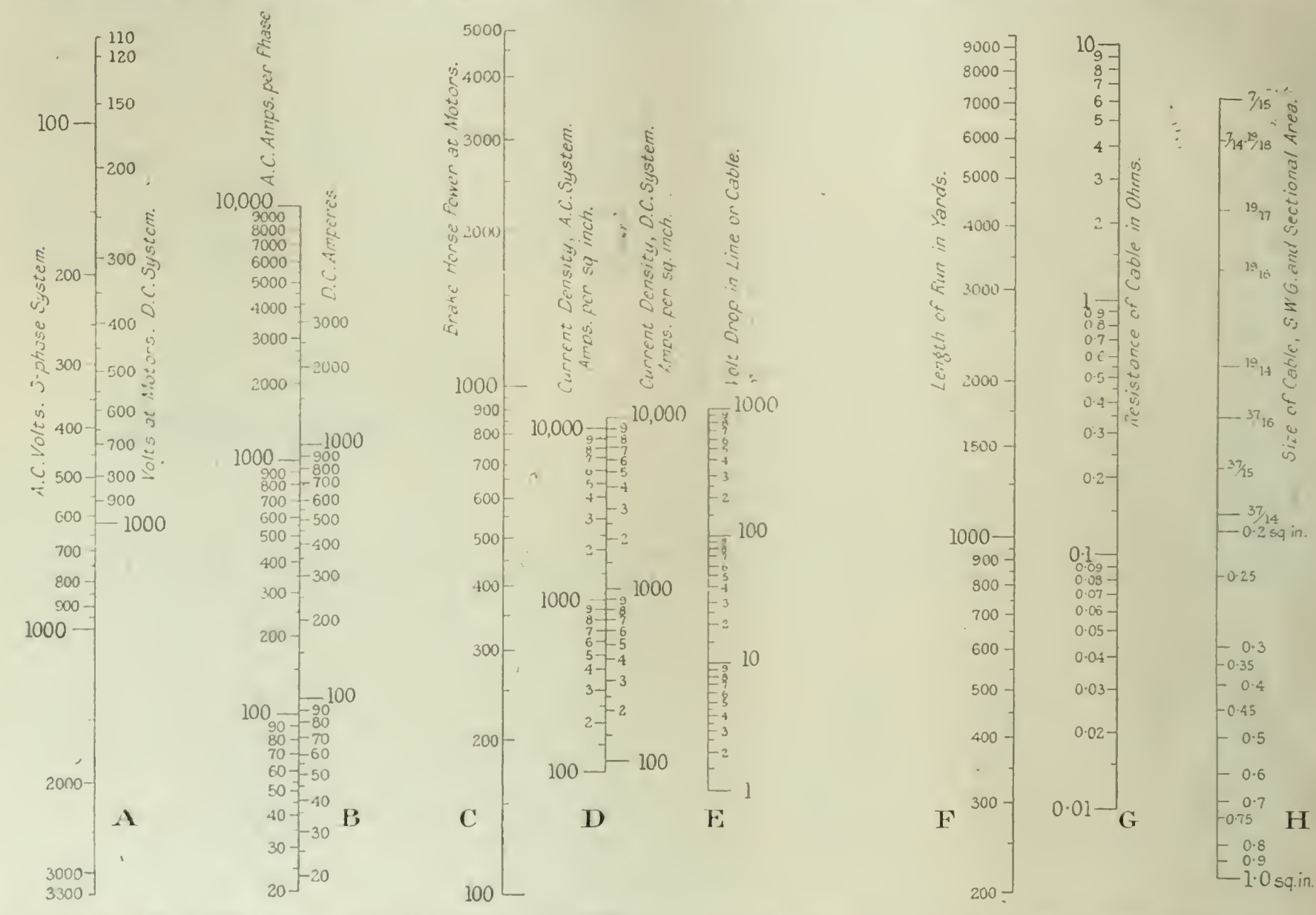
ABACS FOR ELECTRICAL CALCULATIONS.

TO THE EDITORS OF THE ELECTRICIAN.

I have read with interest, in your issue of the 14th inst., the Leading Article and contribution by M. Castex on the use of alignment charts or abacs for electrical problems, and enclose herewith an abac for quickly calculating the correct size of cable to transmit power over comparatively short distances on the two-wire direct-current or three-wire three-phase balanced alternating-current system.

A disadvantage attached to an alignment chart using an unscaled line of pivots is that the point of intersection must be marked in a definite manner for each calculation, and after a series of calculations the pivot line is liable to be so marked as to be almost useless.

In the accompanying example this is avoided by making the support or pivot line represent some useful factor not indicated in the original equation. This is easily done by constructing the chart from first principles thus :—



Scale A represents Voltage at Motors.
" B " Amps. taken by Motors (Effy. 0·83 Power Factor 0·81.)

Scale C represents B.H.P. dev. by Motors.
" D " Current Density in Cable.

Scale E represents Volts Drop in Cable
" F " Length of Run in Yards.

Scale G represents Resistance of 1 cable in ohms.
" H " Size of Cable. S.W.G. and Sectional Area.

I. *To find Current, Given B.H.P. of Motors, and Voltage at Motors.*—Lay a straight-edge to join the Scales A and C at the correct given values.

The intercept on Scale B will give the correct current.

IA. *To find B.H.P. or Voltage, Given Volts and Current, or B.H.P. and Current.*—Proceed on similar lines as for current, reading the result on the scale for the quantity required.

II. *To find Current Density, given Current and Size of Core.*—Lay a straight edge across Scales B and H at the correct given values.

The intercept on Scale D will give the correct C.D.

IIA. *To find Current or Size of Core, given C.D. and Size of Core, or C.D. and Current.*—Proceed as above, using the two given quantities to find the remaining quantities.

III. *To find Resistance of Cable, given Length of Run, and Size of Cable.*—Lay a straight-edge across Scales F and H at the correct given values. The intercept on Scale G will give the correct resistance of 1 core.

IIIA. *To find Length of Run or Size of Cable, given Size of Cable and Total Resistance, or Length of Run and Total Resistance.*—Proceed as above, using the two given quantities to find the remaining quantities.

IV. *To find Volt Drop in Line, given B.H.P. at Motors, Voltage at Motors, Size of Cable and Length of Run.* (1) Find current as indicated in I. (2) Find total resistance as indicated in III. (3) Lay a straight-edge across current and total resistance.

The intercept on Scale E gives the Volt Drop.

EXAMPLE. It is required to transmit 750 H.P. for a distance of 2,000 yds. The voltage at the power station is 2,200 volts three-phase. Find the size of cable to ensure 2,000 volts at motors, and check the current density to make sure the cable is not overloaded.

From Scale B Current = 230 amperes per phase.
" " E Volt Drop = 200 volts.
" " G Resistance = 0·51 ohms.
" " H Size of Cable = 19/14 S.W.G.
" " D Current Density = 2,700 amperes per square inch.

Answer.—A cable chosen from a Volt Drop of 200 volts will be overloaded.

Checking a cable with a current density of 960 amperes per square inch; what will be the drop in the line with 2,000 volts at the motors.

Cable Size = 0·25 sq in. Resistance = 0·2 ohms. Volt drop = 80.

Answer = 80 volts.

INSTRUCTIONS FOR USING CABLE CHART.

The chart submitted represents the equation

$$V = \frac{H \times L}{E \times A} \times K_1 \quad \ldots\ldots\ldots \quad (1)$$

where V = volt drop in cable.
E = voltage at load end of feeder.
H = power delivered to load-end of feeder.
L = length of the conductor.
A = cross-sectional area of the conductor.
K_1 = constant dependent upon units selected for H, L and A.

The value assigned to K_1 is indicated below.

Volts drop (V) = current in amperes (C) × resistance (R) × constant (K_2).

R = total resistance of one core in ohms.

K_2 = two for D.C. system; 1·732 for three-phase system.

This equation is represented by scales E, B and G.

Again,

$$C = \text{current in amperes} = \frac{\text{Brake horse-power} \times 746}{\text{Volts}\,(E) \times \text{Effiy.}\,(\eta) \times \text{P.F.}\,(\cos\varphi) \times K_3}$$

In this equation the

Effy. = 0·83 for both systems.
Cos φ = one for D.C. system; 0·81 for three-phase system.
K_3 = one for D.C. system; 1.732 for three-phase system.

The values chosen for the efficiencies and power factors represent an average motor load.

This equation is represented by scales A, B and C.

Secondly,

$$R=\frac{L}{1{,}000}\times r,$$

where

L=length of run in yards.

r=resistance of one conductor in ohms per 1,000 yds.

$=\frac{0{\cdot}025}{A}$ where A=area of cross-section for copper condr.

This equation is solved by means of scales F, G and H, but scale H is graduated in cross-sectional area of copper conductors instead of ohms per 1,000 yds.

By proceeding through the three sets of scales mentioned above equation (1) is solved, and in addition the working current and conductor resistance are also known. Using the above symbols and units, the value of K_1 for the direct-current system is 0·045 and for the three-phase alternating-current system is 0·028.

An eighth scale, D, is also added, so that the current density can be easily found from the current on scale B and the area on scale H.

Sketty, Glam., July 17. C. Howard.

ENGINEERING EDUCATION AND RESEARCH.

TO THE EDITORS OF THE ELECTRICIAN.

My attention has been drawn to a letter by Mr. A. G. Ellis in your issue of July 14th. Mr. Ellis states that in a report on Engineering Education and Research recently issued by the Council for Organising British Engineering Industry "there is one class of technical man who is not directly catered for." Mr. Ellis goes on to say that on the Continent such positions as he has in mind are filled by men described as "Techniker," who are usually men who have spent two complete years at a technical school—the "Technikum." The technikums of Switzerland and Bavaria correspond closely with the "senior technical school" referred to on page 6 of the Council's report, and shown in the diagram on page 27 of that report as providing a two years' course for young men between the ages of 16 and 18. The importance of the senior technical school is further emphasised in the "Interim Report of the Consultative Committee on Scholarships for Higher Education," recently issued by the Board of Education. But, as your correspondent indicates, and as is emphasised in the report of the Council for Organising British Engineering Industry, as well as in the Government document to which reference has just been made, the senior technical school is not to be confused with a university or college of university rank.

Manchester, July 22. J. C. Maxwell Garnett.
Principal of the School of Technology and Dean of the Faculty of Technology in the University of Manchester.

NEGLECT OF SCIENCE.

TO THE EDITORS OF THE ELECTRICIAN.

At the last meeting of the Committee on the Neglect of Science it was decided to collect well authenticated cases in which the neglect of science by officials, firms or individuals had caused loss or damage to the nation, firms or persons. If you and your readers can assist in this matter it will be much appreciated. Precise information is required as it is desired to quote "chapter and verse" in each case. This naturally makes it difficult to obtain the required information, but it will readily be seen that without such full particulars the examples would be of little value. The Simpson Lever Chain is a case in point.

25, Victoria-street, Alfred S. E. Ackermann,
Westminster, July 20. Hon. Treasurer.

[We would ask our readers who know of such cases to communicate direct with Mr. Ackermann.—Eds. *E.*]

PATENT LAW REFORM.

At the conference of the Society of Chemical Industry, which was held at Edinburgh last week, the principal subject of discussion at one of the sittings was patent law.

Mr. J. W. Gordon, K.C., read the first Paper on "The Overhauling of Our Patent Law." He said that our patent law could be easily reduced to an extremely simple form, in which the patent grant might be expected to produce a maximum of public advantage, by reducing the grant to a qualified monopoly which would in all cases confer upon the patentee the right to grant licences, but only in exceptional cases the right to restrain by an injunction the use of the invention. This reform was urgent, and if carried out it might be accompanied by a repeal of the intricate legislation and vexatious penalties of the last Patent Act. The patentee would then be in the position, that, by promoting the use of his invention he would be turning his patent right to value, whereas he could derive no profit from it by suppressing the use of the invention within the realm.

Mr. W. F. Reid read a Paper on "The Influence of Patent Laws upon Industry." According to the author, the Patent Office was one of the greatest of the many failures of the Board of Trade, and British inventors could have no chance in competition with their foreign rivals until it was completely re-organised. Our present enemies and future trade rivals found a most efficient weapon against us in our own patent law. When peace was declared the old state of affairs would continue if we did not stop it. In his opinion, the whole management of the Patent Office should be re-organised. It should have as its head a man of the highest scientific and technical training, preferably one with some knowledge of English words and their meanings. If he had some experience of British industry so much the better. A mere university training was quite insufficient for the head of an establishment dealing with complicated technical and industrial matters. The inventor should be treated sympathetically and not merely as an individual from whom excessive fees were to be extracted.

Mr. W. P. Thomson, in a Paper on "Some of the Disadvantages of the Present Patent Law," said the main disadvantages were that a vast number of patents suffered an untimely death through the heavy annual taxes which the inventors often found it difficult to pay; the tremendous law costs at present necessary in fighting patent actions; the unsatisfactory way of assessing costs and damages in these actions; the opening left to fraud and useless expense, caused by our system of provisional protection; the uselessness and, indeed, pernicious nature of the compulsory working laws as at present existing; and the shortness of the duration of patents. The tremendous costs of English courts were proverbial, and patent cases were more costly than any, owing to our judges, and very frequently the lawyers also, having very little acquaintance with science. The difference, indeed, between the cost of German patent law and of English was extraordinary. In the German Court of Appeal in patent cases they picked from among their body one lawyer and four scientific men, more or less acquainted with that particular line of science, with power to call in an assessor. Neither side was allowed to call scientific experts qua experts. The result was that law actions there cost much less in shillings than in England they did in pounds, and the decision was much more satisfactory. Great Britain had, with the exception of a few smaller countries, the shortest duration of patents of any country and the tendency in new laws abroad was to extend the time rather than lessen it.

Dr. Ree said that thanks to the quick perception of Mr. Lloyd George, they got compulsory working. Works were started in this country to carry out the provisions of the 1907 Act, and in several cases actual manufacture was commenced. The indigo used in this country up to the time of the outbreak of the war was almost exclusively produced in this country at the works of Meister, Lucius & Bruning, a concern which was to all intents and purposes a German one. That was an illustration of the advantages we had secured, thanks to this compulsory working clause. He thought the community generally and professional men, and also the great body of working men, supported compulsory working as against compulsory licensing, because they realised that it would mean bringing industry to this country. Yet very few of these important German patents were working on a commercial scale in this country. He did not think that this compulsory working that was introduced in the 1907 Act would have met the difficulties of the case, but it was most unfortunate that Lord Parker gave a decision which resulted practically in the annulling of that section of the Act. If they could not have some satisfactory substitute to compulsory working, especially of foreign-owned patents, it would be better for us not to have any chemical patents at all.

Prof. Armstrong said it was well known that German manufacturers had long ceased to bring infringement actions against one another in this country. If that was the case when they had two or three German groups, now when they had only one, there would be absolute unanimity, and the question was now whether there should not be agreement among manufacturers that they were not going to fight with one another but to combine. One direction in which they ought to take some action was in the matter of "blocking" patents, blocking the side tracks leading to a primary invention. That was the most infernal form of interference from which they were suffering. They ought to do justice to the Germans who had taken a high moral view of their obligations under our Act when they set to work to make indigo in this country. Others put up a factory which never was a factory in any sense of the term. They were much more "cutely" advised. They had English agents in their employ who understood the situation much better.

LEGAL INTELLIGENCE.

Metropolitan Railway Co. v. H.M. Postmaster-General.

On Monday the Railway & Canal Commission (Mr. Justice Lush, Mr. A. E. Gathorne-Hardy and Sir James Woodhouse) heard this case which arose out of a difference between the parties with reference to the construction and maintenance of telegraph wires along the railway.

Mr. Harold Murphy appeared for the Postmaster-General; and Mr. F. G. Thomas for the Metropolitan Railway Co.

By an agreement of May 30, 1883, between the Aylesbury & Buckingham Railway Co. and the Postmaster-General the company (*inter alia*) granted to the Postmaster-General, exclusive liberty to construct and maintain telegraph lines along the company's railway, with permission to enter at any time on the company's premises to do anything that might be necessary for that purpose. Clause 8 of the agreement provided that the company should on the request of the Postmaster-General (or of one of the secretaries or assistant secretaries of the Post Office for the time being or of the engineer or other duly authorised officer of the Postmaster-General) convey free of charge over their system of railways all stores intended to be used by or on behalf of the Postmaster-General in the construction, maintenance, or repair of the lines of telegraph of the Postmaster-General, including the wires and instruments provided for the use of the company, and all persons for the time being engaged in the construction, management, maintenance, repair, or inspection of the said lines of telegraph or any of them. The Aylesbury & Buckingham Railway was absorbed by the Metropolitan Company in 1891, and the Metropolitan Company contended that the above clause only conferred a right of free conveyance of men engaged on and stores required for the construction, maintenance and supervision of the telegraphs of the Postmaster-General on the Aylesbury & Buckingham Railway, and on that railway only. The Postmaster-General maintained that the clause was unrestricted and that he was entitled to free conveyance over the railway of all stores for the construction and maintenance of his lines of telegraph wheresoever situated and of all persons engaged in the construction, maintenance and inspection of any of those lines.

Mr. Murphy submitted that as the wording of the clause was general it must have a wider meaning than the words which occurred in other parts of the agreement, which referred always to "the lines of telegraph on the system of railways of the company."

Mr. Thomas argued that the construction contended for was unreasonable. It was never intended that stores and men should be conveyed by the railway without payment to erect or repair a line of telegraph in a different part of the country to which that railway had no access.

Mr. Justice Lush, after stating the facts, said that in his opinion the argument for the Postmaster-General failed. He thought that clause 8 must only mean that if it were necessary to send stores and men over the railway for the purposes of the telegraph lines which were the subject of the agreement, such stores and men should be carried without charge. In construing the clause they must keep in mind the subject-matter of the whole agreement, and that subject-matter was the telegraph lines along that particular railway and nothing else. If it had been intended to give to the Postmaster-General the unrestricted right which was now claimed, clear language would have been employed for the purpose.

The other members of the Court agreed.

Alien Enemy Patents.

In the Patents Court last week Miss E. J. Smith, of Willesden, applied for a licence to use patent 11,639, of 1910, granted to Dr. J. Billiter, of Vienna, for an electrolytic process for obtaining caustic potash. It was stated that the Billiter patent covered a process for electrolysing liquids with cathodes arranged in strips and provided with covers for carrying away gas and permeable to current, the cover enclosing the cathode on all sides like a sack. Modifications provided for membranes completely surrounding the cathodes in the form of tubes so that the cathode product escaped only by diffusion or electro-diffusion; tubes of asbestos fibre and a membrane, permeable to current, stretched over the electrodes by weighting with heavy bodies or rendering the cathodes resilient by springs to prevent the formation of detrimental alterations of shape or detrimental gas spaces.

The applicant explained that she desired to produce caustic potash electrolytically as a stage in the manufacture of potassium permanganate. She expected to manufacture without difficulty, though her work up to the present in this direction had been principally experimental. She did not propose to put caustic potash on the market. She wished to use the Billiter cell simply to manufacture potassium permanganate for which there was a large sale, and the Government, when they ordered it, issued orders for 20 tons at a time. It was used in the trenches and all the military hospitals as a disinfectant, and was (she believed) also used to refine oil for aeroplanes. She purposed starting with a manufacture of half a ton per week, and intended to install a 2 kw. dynamo and a 4 h.p. gas engine.

The Controller inquired as to the royalty.

Applicant answered that the patentee had not afforded her any too precise details in his specification, and she did not think that anything but a small royalty should be paid. There would be a considerable amount of experimenting in several directions by her chemist and herself.

The Controller: Then there are not sufficient instructions? That is very possible. We know these specifications do not usually go beyond a certain limit.

The Applicant: The patentee does not discuss the amount of current nor the relation of output. There is nothing to base royalty upon. I shall have to experiment, though I have a rough idea what to expect.

Sir Cornelius Walton: And what will your electrical apparatus cost?

Miss Smith replied that the dynamo, gas engine and accessories would probably cost £130. The price of potassium permanganate was fluctuating. At the moment on the market it was 8s. a pound, but it might come down to 6½d. as it was before the war.

On behalf of the patentee, Mr. Tennant, chartered patent agent, suggested that the dynamo would not be installed for this purpose only, but for general use in the chemical works.

The Applicant: I am not going to use the dynamo for anything else than to make caustic potash.

The Controller: Then what do you say the royalty should be?

Miss Smith: I will offer 1 per cent. In Germany the material was a by-product of the potash works. They made the permanganate there on the spot. It is as cheap in Germany as salt is in England.

The Controller: We shall report to the Board of Trade favourably to your application and the Board will then communicate with you. The royalty figure may be altered after the war.

"Live Stud" Case at Lincoln.

At Lincoln County Court last week, Judge Sir Sherston Baker and a jury heard an action brought by Mr. Wm. Wright, farmer and contractor, against Lincoln Corporation for £72. 3s., compensation for the loss of a horse, which, plaintiff alleged, had been destroyed owing to the effects of the animal striking a live stud in the G.B. surface contact system.

Mr. C. E. Dyer, for plaintiff, stated that on Feb. 25 plaintiff's horse and cart passed along Bracebridge High-street. The snow had been cleared off the tram track, and the only route was along the tram line. On reaching the tram shed the animal apparently stepped on a live stud and received a violent shock, which threw it down. It was got home but had to be destroyed on March 25. If defendants allowed a stud charged with electricity to be exposed it showed gross neglect, and the least they could do was to take the precaution to keep people away until it was put into proper condition.

Charles Duncombe, the carter, corroborated Mr. Dyer's statements, and said when a man named Fletcher came and touched the horse the electricity ran up his arm. A boy came out of the tram shed with a hammer and knocked at the stud, and told him not to catch it again.

Fletcher stated that when he got hold of the animal's tail he felt an electric shock.

Fredk. Antcliffe spoke as to driving a dray along the same track about 8.30 the same morning. One of the horses fell "as if it was dead," and in trying to raise it he felt the electricity run up his arm.

Dr. Lindley, for defendants, reminded the jury that the tramway system was approved by the Board of Trade, and if any studs went wrong the Corporation was bound to report it to the Board of Trade. Although the trams had been in existence for many years that was practically the only instance where there had been any claim against the Corporation. After the accident Mr. Jeffrey went down from the works and found the current in the stud so slight that he could put his hand on it and keep it there. It was submitted that there had been no negligence on the part of the Corporation and that the death of the horse was due to other causes.

The jury found for plaintiff for £50, for which judgment was given, with costs.

PARLIAMENTARY INTELLIGENCE.

COMPANY WITH ALIEN ENEMY SHAREHOLDERS.

In the House of Commons on Tuesday Mr. Nield asked "whether the business carried on under the name of the Armorduct Mfg. Co. (Ltd.), having works at Birmingham and offices in London, and now under supervision as an enemy firm, is a controlled establishment for the manufacture of munitions; whether the Minister has issued or authorised the issue, of badges to the employés to exempt them from service under the Military Service Acts; whether, in particular, such a badge has been issued to or authorised for one Wilhelm Schmahl, or in his aliases William Ratcliff Small or William Small; and what is the reason for constituting the works of this company and an alien enemy, or a person of alien enemy association, a controlled establishment when there are works wholly English in ownership and management in the neighbourhood who could be so employed but are not."

In a written reply, Dr. Addison stated that the establishment referred to was controlled under the Munitions of War Act. A war service badge had been issued to Mr. Ratcliff Small, among other employés of the company. One of the principal effects of control was to limit the profits which might be retained by the owners of the establishment, and, on the other hand, that the declaring of an establishment controlled did not imply that contracts would necessarily be granted to it.

Mr. Harcourt (Acting President of the Board of Trade) replying to a further question by Mr. Nield, said: The case of the Armorduct Mfg. Co. (Ltd.) has been considered by the Advisory Committee, who recommended that, having regard to the character of the work which is being carried on by the company, it is inexpedient to wind up the business. The right to transfer the shares and debentures held by enemy subjects has been vested in the Public Trustee. Arrangements are being made for the sale of these assets to British purchasers of whom Mr. Small is one. The conditions of sale will be designed to preclude the resumption of German control after the war.

GERMAN INTEREST IN BRITISH COMPANIES.

In the House of Commons on Tuesday Mr. Harcourt stated that steps were being taken to eliminate the German interest in the principal British registered companies which manufacture filament lamps.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	577	**Electric Vehicle Progress Supplement—No. 30.**	
Educational	578	Large Demountable Bodies for Electrics. Illustrated	1*
Imports and Exports of Electrical Manufactures	578	Opportunities in Jamaica for Electrics	3*
Business Notices	578	Driver's Speed Increased by Using Efficient Motor Equipment	3*
Bankruptcies, &c.	578	The "Orwell" Electric Vehicle. Illustrated	4*
Electricity Supply	578	Municipal Electrics: Two Opinions	6*
Traction Notes	579		
Empire Notes	580	Tenders Invited	581
Foreign Notes	580	Tenders Received & Accepted	581
Miscellaneous Notes	580	Municipal Accounts	581
		Companies' Meetings and Reports	582
The Round Table	115	New Companies, &c.	583
Elder's Cable Hangers and Clips	115	City Notes	583
B.T.-H. Hand-Operated Starting Compensators. Illustrated	116	Electrical Companies' Share List	584
The Season's "Quead" Fires. Illustrated	118		
Blue Print Washing, Drying and Ironing Machine	120		

COMMERCIAL TOPICS.

Anglo-Italian Trade Relations. The British Italian Corporation has recently been formed by a syndicate of English and Italian bankers for the purpose of developing and encouraging Anglo-Italian trade relations. The capital is £1,000,000 in £20 shares, and the company will "carry on, assist or participate in financial, commercial, industrial, manufacturing, electrical, railway, mining and other businesses, works and undertakings in the British Empire, Italy and elsewhere; and will undertake any operations commonly carried out by capitalists or merchants, including that of a bank of deposit, agents for the collection, receipt, transmission or payment of money, &c." The first directors are Messrs. Arthur Hill, bank director; Robert H. Benson, merchant banker; J. W. Beaumont Pease, bank director; Sir Henry Babington Smith, K.C.B.; Joseph Burn, actuary; Alberto Pirelli, company director; Ignatius G. Manzi-fe, manager of Credito Italiano; and Riccardo Bianchi, director of public companies.

* * * *

The Australian Trade Outlook. On Thursday last Mr. G. T. Milne, Imperial Trade Commissioner for the Australian Commonwealth, delivered an address on the present position and future outlook of Australian trade at a meeting of business men, convened by the Trade and Industry Committee of the Royal Colonial Institute.

Mr. Milne praised the work of the Trade and Industry Committee and gave advice as to the methods by which trade was to be secured by British manufacturers and traders in Australia. He emphasised the necessity for principals, and not "bag-men," visiting Australia. The home country's trade with the Commonwealth, he said, ought to be considerably increased. There were no currency or language difficulties, and in nearly all cases British goods were given a preference. In regard to imports of metals and machinery manufactures, out of a total of £17,325,592, £17,290,592 was of a class subject to preferential treatment. The Australian people had also departmental preferences, and in dealing with tenders for imported goods gave preferences of varying amount to British goods, in addition to the tariff advantages. The cumulative effect of this on British trade was very great. He thought the Australian tariff would be so re-arranged in future as almost entirely to eliminate German competition.

* * * *

Imperial Trade Policy After the War. The Government have decided to convene at an early date a conference which will be representative of the United Kingdom, the Dominions and India to consider the commercial policy to be adopted after the war.

In the House of Commons on Monday Mr. Asquith stated that in May a telegram was sent by the Government to each of the self-governing Dominions inviting them to attend the conference. The telegram of invitation also stated that: "In view of the past fiscal controversies in this country, we consider it essential as a prior step, in order that the conference may have practical results, to set up a committee here with a view of discovering how far agreement among ourselves may be possible under the changed conditions brought about by the war. But we wish to make it clear that the appointment of this committee, whatever may be its result, will not, as we hope, delay unduly the holding of the larger conference or interfere in any way with the free and unprejudiced discussion of the problems with the oversea representatives. I trust that this method of procedure will commend itself to your Ministers."

Mr. Asquith further announced that the Dominion Governments concurred in the procedure, and a committee had accordingly been appointed.

* * * *

War Material Order. In virtue of regulation 30A of the Defence of the Realm (Consolidation) Regulations, 1914 [which makes it an offence to deal in war material without a permit from the Admiralty or the Army Council or the Ministry of Munitions], the Minister of Munitions has made an order that the war material to which the regulation applies shall include:—

Aluminium and alloys of aluminium, unwrought and partly wrought, including ingots, notched bars, slabs, billets, bars, rods, tubes, wire, strand, cable, plates, sheets, circles, strip. Granulated aluminium, aluminium powder, "bronze," "flake" and "flitter."

The Order of Dec. 7, 1915, relating to all kinds of aluminium and alumina, is cancelled. Applications for a permit in connection with the above Order should be addressed to the Director of Materials, Ministry of Munitions, Armament-buildings, Whitehall-place, S.W.

* * * *

Excess Profits Duty. The Inland Revenue Department gives notice that it is incumbent upon every person chargeable with excess profits duty in respect of the excess over the pre-war standard of profits of the profits arising from any trade or business to which the duty applies in any accounting period ended after Aug. 4, 1914, and before Aug. 1, 1917, to give notice to the Commissioners of Inland Revenue or the Surveyor of Taxes for the district in which the person so chargeable resides, or carries on business, within two months after the termination of any accounting period in respect of which he is chargeable, or if the accounting period terminated before July 19, 1916 (the date of the passing of the Finance Act, 1916) within one month of the passing of the Act.

* * * *

Municipal "Electrics" to the Fore. During the past month the subject of the commercial battery vehicle has been given special publicity, and to a considerable extent in the lay press. This arises in great measure out of the annual conference of the Institute of Cleansing Superintendents recently held at Cardiff, and also the rapidly rising price and growing restrictions upon the use of petrol. From the reports of the meeting of the cleansing men at Cardiff we gather that "electrics" were the centre of attraction of the conference itself, and the subject of much private discussion on the part of the members at those unofficial gatherings in the hotels, which, as a rule, are more valuable and informative than the formal Papers and discussions. Mr. J. Terry, the Cleansing Superintendent of Nottingham, read an instructive Paper on the results obtained by electric vehicles in the removal of house refuse. He was able to speak from an extended experience acquired in his own city with these vehicles, and he also quoted figures which we have already published, and which were put on record by Mr. Priestley, the Cleansing Superintendent at Sheffield, and Mr. Jackson, the Cleansing Superintendent at Birmingham. The interest aroused confirms our opinion, so often expressed, that the commercial battery vehicle needed but to receive a fair trial under operating conditions in the class of service for which it is designed, to at once prove its suitability, economy, efficiency, and reliability, in comparison with all other forms of road traction. Cleansing Superintendents, Borough Surveyors, and men of this class are, as a rule, only convinced after trials of any contrivance under the operating conditions with which they are daily familiar. Attempts were made some years ago to bring to their notice the merits of the "electric," but these could only be accompanied by paper figures, which, as it happened, were unconvincing. Now there is every indication that there will be a boom in the commercial "electric." At any rate, we are convinced that it will never look back so far as the municipal field is concerned, and we have always argued that the

advertisement which it will secure in this province will be sufficiently valuable to awaken public interest and to produce in the right class of power vehicle users the desire to put such machines into service. It will be interesting to note to what extent the suppliers of these vehicles arrange to meet the increasing demand. If the degree of enthusiasm shown at Cardiff is displayed in other branches of municipal work, and extends to some of the more important fields of transport service, there will be some difficulty in keeping up the supply of vehicles. Perhaps when that state of affairs arrives we shall witness the establishment of factories in this country for the production of these machines on an extensive scale.

EDUCATIONAL.

City and Guilds Technical College, Finsbury.—The training at this College is adapted to the needs of various students, including pupils above 15 from secondary schools, who desire a practical and scientific training bearing upon their future industry or profession, and young men who, having previously served a pupilage or apprenticeship in works, desire a more systematic training in engineering and applied chemistry. The College has well-equipped laboratories and workshops for practical work. The entrance examination will be held on Sept. 19. The programme of the College has just been issued, and gives full particulars of the courses of instruction, fees, time-tables, &c. Further particulars may be obtained from the Registrar of the College, Leonard-street, Finsbury, London, E.C.

Armstrong College (University of Durham) Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

University of London.—An anonymous donor has given a sum sufficient to produce £200 a year, which is to be devoted to experimental scientific research at King's College by members of the staff and post-graduate students of the college.

University of Bristol. The following students have passed the final examination for the degree of B.Sc. in engineering :—

Wm. Reg. Holland (with first-class honours in electrical engineering), John A. Derry, Frederick H. R. Kemshead, Donald Geo. Smith, Gordon A. Stephens, Ambale Viswanath and Robt. V. E. Wong.

Institute of Chemistry. The results of the July examinations have now been published :—

Five candidates passed the intermediate examination—viz., A. C. Francis, Miss P. L. Garbutt, A. J. Hall, B.Sc., H. J. Hegan, B.Sc., and J. Sandilands. Nine candidates passed the final (A.I.C.) examination—viz., in Mineral Chemistry : E. C. Macintyre, B.Sc., and A. Stewart, B.Sc. ; in Organic Chemistry : P. J. Brannigan, M.Sc., T. Hopkins, B.Sc., D. Madden, A.R.C.S.I., James Ogilvie, B.Sc., and E. E. Wells, B.Sc. ; in Chemistry (and Microscopy) of Food and Drugs, Fertilisers and Feeding Stuffs, Soils and Water : H. E. Cox, B.Sc., and T. L. McEwan, B.Sc. One candidate examined for the fellowship also took the chemistry of food and drugs, &c., and passed : J. Wood, M.A., B.Sc.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From July 15, 1916, *to* July 21, 1916.

IMPORTS.

Gothenburg.—*Sweden :* Elec. machinery, 180 ...

Liverpool.—*U.S.A.* : Elec. lamps, £143; telegraph material, £105; carbon candles, £32, unenumerated, £19,121. 208 ... *Holland* Elec. lamps, £5,357; elec. glow lamps, 74 pkgs. ; unenumerated, £360. *Japan* Unenumerated, £145. *France* Elec. lamps, £228; carbon candles, £191; unenumerated, £67. *Switzerland* Unenumerated £4,316. *Denmark :* Unenumerated £... *Spain* Elec. cables, 46 ...

Southampton. *France* Elec. cable, 16 ... elec. lamps, £4...

EXPORTS.

To Australasia.—*Auckland* Elec. lamps, 240 ... unenumerated, £4. *Melbourne :* Wire and cable, £388; elec. machinery, £2,774; unenumerated, £498. *Sydney :* Elec. machinery, £144; wire and cable, £... unenumerated, £725. *Rangoon* Elec. machinery, £59; wire and cable, £23; unenumerated, £1,... *Christchurch* Wire and cable, £58. *Lyttelton :* Elec. machinery, £3... wire and cable, £1,24..., unenumerated, £225. *Dunedin* Unenumerated, £30. *Hobart* Elec. machinery, £... unenumerated, £5. *Brisbane* Unenumerated, £... Unenumerated, £45. *Ballarat :* Unenumerated, £67. *Perth* Unenumerated, £3.

Africa. *Durban :* Elec. machinery, £79... wire and cable, £417; unenumerated, £860. *Cape Town* Elec. machinery, £16... unenumerated, £40. *Port Elizabeth :* Wire and cable, £1... unenumerated, £3... *East London* Elec. machinery, £48; unenumerated, £49. *Mauritius* Telegraph material, £27; unenumerated, £220. *Beira :* Wire and cable, £2...

Bermuda.—Unenumerated, £67.

Egypt. *Port Sudan :* Unenumerated, £80. *Suez* Unenumerated, £49.

India, Ceylon, Indo-China and Straits Settlements. *Bombay* Elec. machinery, £258; elec. glow lamps, 2,300 n.o. ... wire and cable, £23; unenumerated, £1,10... *Penang :* Wire and cable, £203; unenumerated, £6... *Singapore* Wire and cable, £173; unenumerated, £38. *Calcutta* Elec. machinery, £16; unenumerated, £1,42...

Madras : Wire and cable, £27. *Colombo :* Unenumerated, £17. *Port Swettenham :* Unenumerated, £190. *Surabaya :* Elec. machinery, £349; unenumerated, £158.

Burma.—*Rangoon :* Elec. lamps, 595 n.o.; wire and cable, £49; unenumerated, £20.

China.—*Shanghai :* Elec. machinery, £120; unenumerated, £151. *Hong Kong :* Wire and cable, £208. *Hankow :* Unenumerated, £370.

U.S.A.—*New York :* Unenumerated, £121.

Canada.—*Montreal :* Elec. glow lamps, £225; elec. machinery, £121; unenumerated, £170. *Toronto :* Elec. machinery, £28.

South and Central America. *Buenos Ayres :* Elec. machinery, £441; wire and cable, £432; unenumerated, £1,809. *Punta Arenas :* Wire and cable, £20. *Rio de Janeiro :* Unenumerated, £84. *Santos :* Unenumerated, £29. *Valparaiso :* Wire and cable, £12; unenumerated, £81. *Monte Video :* Unenumerated, £23.

West Indies.—*Trinidad :* Elec. machinery, £33; unenumerated, £80. *Demerara :* Unenumerated, £222.

East India Islands. *Padang :* Unenumerated, £18.

Java.—*Samarang :* Unenumerated, £126.

Holland.—*Amsterdam :* Wire and cable, £1,307; unenumerated, £94. *Rotterdam :* Unenumerated, £92.

France. *Dieppe :* Elec. machinery, £392; unenumerated, £311. *Paris :* Elec. machinery, £83; wire and cable, £63; unenumerated, £197. *Bordeaux :* Elec. machinery, £138; unenumerated, £291. *Boulogne :* Elec. machinery, £244; unenumerated, £50. *Havre :* Wire and cable, £60; unenumerated, £17.

Gibraltar.—Telegraph material, £88; unenumerated, £48.

Malta. Unenumerated, £17.

Russia.—*Vladivostok :* Unenumerated, £187.

Denmark. *Copenhagen :* Wire and cable, £105; unenumerated, £71.

Spain. *La Union :* Unenumerated, £22. *Malaga :* Unenumerated, £20. *Bilbao :* Elec. machinery, £20.

Greece. *Syra :* Telegraph material, £23.

Portugal. *Lisbon :* Elec. machinery, £76; unenumerated, £532.

Italy. *Genoa :* Elec. machinery, £32; wire and cable, £383; telegraph material, £3,178; unenumerated, £645.

FOREIGN GOODS (duty paid and free).

Melbourne : Unenumerated, £229. *Cape Town :* Unenumerated, £143. *Valparaiso :* Elec. lamps, £200; elec. machinery, £647; unenumerated, £95. *Bordeaux :* Unenumerated, £648. *Boulogne :* Unenumerated, £110. *Perth :* Unenumerated, £14. *Nagasaki :* Elec. machinery, £94. *Coronel :* Unenumerated, £140. *Durban :* Unenumerated, £200. *Port Elizabeth :* Unenumerated, £328. *Oporto :* Unenumerated, £15. *Shanghai :* Lamps, 1,464 n.o. ; unenumerated, £16. *Talcahuano :* Elec. lamps, £240. *Montreal :* Unenumerated, £2,816. *Calcutta :* Unenumerated, £100. *Christ Church :* Unenumerated, £36. *East London :* Unenumerated, £180. *Madras :* Unenumerated, £17.

IN TRANSIT.

Melbourne : Elec. lamps, £878.

Note.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

Thermit Ltd., 675 Commercial-road, E., informs us that it has received an official notification from the Public Trustee to the effect that he has entered into an agreement to sell the whole of the enemy shareholding in the company to the Birmingham Metal & Munitions Co. The company will, therefore, continue to trade in exactly the same way as hitherto.

Fredk. A. Dennison and Wm. Sillem, electrical engineers, 116, Great Portland-street, London, W., have dissolved partnership.

BANKRUPTCIES, &c.

Fredk. Brown, electrician, 8, Stafford-street, Llanelly (formerly a partner in the firm of Hugh Bros. & Brown), has been adjudicated bankrupt. The first meeting of creditors will take place on Aug. 1 at 4, Queen-street, Carmarthen, and the public examination on the same date at the Guildhall, Carmarthen.

A first and final dividend of 2s. 2¾d. is payable at the O.R.'s, 14, Bedford-row, London, W.C., to creditors of Geo. Edwd. Bonner, electrical agent, 105, Fox-lane, Palmer's Green, Middlesex.

ELECTRICITY SUPPLY.

EXTENSIONS.

Bradford.—The L.G. Board recently intimated that they could not at present accede to the application of the City Council to borrow money for extensions of plant at the electricity works, but the Board were willing, however, that extensions of mains should proceed as at present without the submission of a special resolution in each case.

The Electricity Committee have invited the three city Members of Parliament and the Member for Shipley to meet them in order to consider the position with a view to an interview being sought with the Minister of the Government Department most interested in the subject of extensions.

Derby.—The Corporation have applied for sanction to borrow £9,000 for extensions of mains and for electric motors.

Edinburgh. The Electric Lighting Committee has decided to spend £1,300 upon additional plant for McDonald-road station.

Luton.—The Council has been recommended to apply to the L.G. Board for sanction to borrow £900, being balance of amount ex-

pended for plant for the electricity undertaking, in excess of the sums previously sanctioned for that purpose.

The number of units generated during the four weeks ended July 6 last shows an increase of 27 per cent. over the corresponding period last year. The total consumers are 1,932, the lighting connections representing 73,217 8 c.p. lamps, and there are also 1,152 motors of 6,834 H.P. and heating devices of 1,645¾ kw.

Poplar (London).—The Borough Council is to apply to the L.C.C. for sanction to a loan of £4,512 in respect of capital expenditure for mains extensions and in respect of the amount spent in anticipation of loans at Mach 31 last.

The load has developed to such an extent in the central area of the borough owing to many new connections for power that all feeders in this area are fully loaded, and in some cases overloaded. Important applications have now been received that cannot be considered unless immediate steps are taken to increase the capacity of the feeders and also to extend the existing distributing network. The total expenditure for this work is estimated by the engineer (Mr. J. Horace Bowden) at £4,531 ; but in order to reduce this sum the reclaiming, at a cost of £406, of the remainder of the original Old Ford feeder (which became dormant when the northern sub-station took over the supply to the northern area) is suggested for use in the present scheme. This will ultimately effect a saving of £1,814.

The Electricity Committee proposes to purchase a site in the neighbourhood of High-street for a new sub-station.

The Committee is advised by Mr. Bowden that plant extensions will be necessary to meet demands of the winter load in 1917-8.

Walthamstow.—The L.G. Board has sanctioned the borrowing of £2,635, the estimated cost of supplying electric control switches, &c., for the street lamps.

GENERAL.

Belturbet (Ireland).—The Urban Council are in negotiation with the owner of the local electric supply works for the purchase of the undertaking. A meeting of ratepayers is being held to consider the matter.

Hackney (London).—The Electricity Committee has under consideration a communication from the secretary of the Gas Light & Coke Co. as to the scale of charges for the supply of electricity in the borough, and particularly to that part of it which provides for a reduced charge for energy supplied for lighting to consumers who also use energy for power.

The company stated that it had taken counsel's opinion on the matter, and was advised that the reduced charge constituted "undue preference." It was, therefore, a breach of secs. 19 and 20 of the Electric Lighting Act, 1882, and consequently illegal. The company contended that it was considerably affected by that system of charge, and requested that an undertaking should be given to discontinue it.

The committee states that it has also obtained opinion of counsel, who has advised that there was no "undue preference," and an intimation to this effect has been forwarded to the company. Subsequently the company's solicitors wrote to the effect that unless the Council desisted from making the charges complained of, their clients would have no alternative but to commence proceedings. Thereupon, the committee, whilst maintaining the position of the Council, intimated that the present was not an opportune time for litigation upon a subject which had remained unchallenged and undisturbed for so long, in view of the prevailing conditions and the fact that apparently the staffs of the company and of the Council's electricity department are working at high pressure, and suggested that the matter should remain in abeyance until after the conclusion of the war, but that if proceedings were now commenced, the committee would immediately apply, under the circumstances, for a "stay."

In reply, the company's solicitors intimated that they were only prepared to delay proceedings upon an undertaking from the Council not to offer during the continuance of the war to further consumers, the scale of charges to which objection was taken. In view of the strength of the Council's position, the committee does not see its way to recommend that any such undertaking as that required by the gas company should be given, and has recommended that in the event of legal proceedings being taken by the company they be authorised to defend the action on behalf of the Council.

Hamilton.—The Corporation has asked Edmundson's Electricity Corpn. to forego its proposal to increase the charge for electrical energy in the town by 20 per cent., but the Council think a 15 per cent. increase would be justified.

The company state that coal, oils, wages, rates and taxes for the March quarter increased £311, while the increase of 10 per cent. only produced £206. 10s. The burgh chamberlain has been instructed to take advantage of the company's permission to examine its books.

Increased Charges for Current.—The charges for current are being increased by the following authorities :—

Llandudno Council has decided to increase the flat rate from 4½d. to 6d. per unit, the differential rate from 7d. and 2d. to 7d. and 3d., and the power rate from 2d. to 3d.

Londonderry Corporation has increased its charges by 15 per cent. to all consumers

Southampton Electricity Committee has resolved to charge 10 per cent. extra after Michaelmas to all consumers, making in all 20 per cent.

Marylebone (London).—The Electric Supply Committee reports a serious breakdown on the 14th inst. on the trunk feeder in Aybrook-street and Blandford-street, lasting for close on five hours.

The Committee states that the damage was so great that the origin of the fault could not be discovered, but moisture probably caused the trouble. Had the feeder protection device contemplated just prior to the war, and abandoned owing to the difficulty of raising the necessary money, been installed, a fault of that kind would of course, have been very improbable. It is quite impossible to re-arrange the cables, owing to lack of space, but the congestion can be relieved if a number of the cables are turned into the sub-station through the old Metropolitan Electric Supply tunnel that ran into Blandford-street, and the general manager (Mr. A. H. Seabrook) recommended that the above alternative route should be used for a number of the feeders. The risk being so great the Committee has authorised this work being carried out at an estimated cost of £1,100.

South London Linking-up Scheme.—At the meeting of Southwark Borough Council on Wednesday the Electric Light Committee submitted a report on the invitation of Bermondsey Electric Light Committee to discuss terms for giving a bulk supply of electric current.

At a conference between the parties, Southwark intimated it was not prepared to enter into competition with a private company for such a supply, but preferred that the Bermondsey authority should co-operate with Southwark purely as a mutual arrangement in the interests of their respective ratepayers. On this understanding, Southwark would be prepared to name a price and discuss the basis of a scheme for giving effect thereto. The chairman of the Bermondsey Committee thereupon explained that they had already received tnders from certain private lighting companies, and though they were desirous of coming to an arrangement with Southwark, yet they were not prepared to forego the right of comparing the private companies' prices with that of Southwark, and they declined to negotiate on those lines. It was also stated that Bermondsey did not intend to enter into a longer contract than for a three years' supply, but it was necessary to obtain a bulk supply for the coming winter. It being practically impossible, having regard to the labour market and other war conditions, to comply with this suggestion, Bermondsey were informed that it was not possible to give a bulk supply at such an early date, whereupon the chairman of the Bermondsey Committee stated that it would be necessary for them to accept one of the companies' tenders, and asked that, in that event, the two engineers might be instructed to confer together with a view to a joint agreement being entered into between Southwark and Bermondsey as to linking up the two undertakings. Having regard to the circumstances, it was felt by the Southwark deputation that there was no alternative but to drop the question of the proposed bulk supply, but the Clerk has been instructed to the Board of Trade a copy of the whole of the reports and correspondence relating to the negotiations.

Walton-on-Thames.—At last week's meeting of the Urban Council the Clerk reported having received letters urging the Council to secure the best terms possible from the Electric Supply Co., who proposed to raise the prices of current. He said the Board of Trade had been unable to make any order which would benefit consumers. It was decided to write to the Board of Trade on the matter.

Willesden.—The Electricity Committee, reporting on the suggestion of the Board of Trade re linking-up of electricity undertakings, is of opinion that the matter is one which should be dealt with by the power company rather than by the Council.

The electrical engineer (Mr. A. W. Blake) is, however, to report as to whether a saving can be effected in the running costs of the undertaking by a re-arrangement of the staff. Mr. Blake reports that the Summer Time Act will have the effect of causing an estimated loss of profit to the undertaking of £31 a week. Having regard to the fact that the work of substituting flame arc lamps for those of the open type has for some time been entirely suspended by reason of the lighting restrictions, the Council has been recommended to suspend the operation of the resolution agreed to in May, 1913, allocating £500 a year for carrying out the work.

To meet the increased demand for current at Cricklewood, the Council is recommended to apply for sanction to borrow £828 for extending the h.t. main in Dollis Hill-lane and for an additional transformer.

TRACTION NOTES.

Cardiff.—*Women Tramway Employees.*—At a recent meeting of the Tramways Committee, Mr. A. Ellis (electrical engineer and manager) said the Tramway and Vehicle Workers' Association had made a complaint to the Chief Industrial Commissioner as to their employing women as drivers.

The association had expressed their opinion that it was not safe. The women, Mr. Ellis said, were driving as well as the men, and better than most of them. There were 128 women drivers in Glasgow, and there was no question of applying to Sir George Askwith. At Cardiff they had

about eight, and they would have to have more. The object of the Committee had been to release every available man. It was only there that protests were made. They did not get it in the other towns. It was resolved that the chairman of the Committee and Mr. Ellis should see Sir George Askwith on the matter.

Mr. ELLIS said he had received a suggestion that seats be provided for the women conductors, but they had complaints that conductors did not look out for the passengers. Five minutes' rest was allowed at each end of the journey. No action was taken.

East Ham.—The Corporation has under consideration letters from the Leyton and West Ham authorities as to the abolition of all halfpenny fares, and the revision of the existing fares and stages.

Edinburgh.—The lease of the Edinburgh & District Tramways Co. will expire on June 30, 1919, and the Corporation have appointed the Burgh Engineer and Mr. J. B. Hamilton, Leeds, and Mr. Brodie, Liverpool, to report on the methods of traction which should be adopted for the tramways after the expiration of the company's lease, keeping in view probable future extensions, with full information as to the probable costs of installation and working.

They were asked to consider whether it was practicable to arrange for a system of traction other than the cable being installed so as to be operated immediately on the expiry of the present lease. In an interim report they have replied in the affirmative. Their view is that it is possible to arrange for an electric system without interfering with the cable cars up to the expiry of the lease. The Town Council accordingly may proceed with their arrangements for the new system independently of the tramway company. They do not favour the adoption of a new system of traction for some of the routes of the city, retaining the cable for other routes. It would be possible for the electric system to be operated in such a way that there would be no overhead wires in the central parts of the city, but it could not be put into operation immediately on the expiry of the lease. The tunnelling for an underground conduit system would require considerable preparation, and would involve interference with the running of the cable cars up to June 30, 1919. What is suggested as a possibility is that the overhead system might be introduced all over, so that there would be no delay in securing a sufficient service, the formation of underground electrical sections being proceeded with later, if desired. Alternative systems dealt with in the report include self-propelled tramcars and various types of 'buses. A full report will be presented in September. The Tramway Committee has decided to submit the interim report to the Town Council without comment.

Neath.—The Town Council have decided to take over the tramway from Skewen to Briton Ferry from the Provincial Gas Traction Co. The transfer will not take place until after the war, when the line will be converted to electric traction.

EMPIRE NOTES.

Australasia. The first electric tramway to connect Melbourne city with a series of its suburbs, viz., that from Prince's Bridge via Swan street, Richmond, and Hawthorn to Burwood, has been completed. The line is controlled by the Hawthorn Tramways Trust, and the engineer and general manager of the service is Mr. F. A. McCarty, of Melbourne.

Mr. J. P. C. Bradfield, chief engineer for Railway Construction in New South Wales, in a report on the proposed Sydney underground electric railway, states that if the maximum traffic efficiency is to be maintained and air in the subway kept as pure and cool as possible, accommodation of only one class should be provided, and no special provision should be made for smokers on any trains. It is estimated that the loss of revenue consequent upon the abolition of first-class fares will be more than compensated for by saving expense in working.

The Premier of Victoria, Sir Alex. Peacock, recently stated that difficulty has arisen with the contractors in England regarding the fulfilment of the railway electrification contracts. Negotiations have been proceeding for the transfer of certain contracts. The Railways Commissioners were sending Mr. Jones to England to confer with the Agent-General, Mr. Merz and all concerned, and decide the course of action to be followed. Mr. Jones sailed on June 8.

The estimates submitted by the Commonwealth Treasurer to the House of Representatives include £117,500 for telegraph and telephone lines, instruments, &c. £24,000 for telephone exchange equipments and £4,000 for heating and ventilating telephone exchanges, and £14,000 for materials and equipment (motor vehicles, engines, tools, &c.), for the Flying School. £132,000 for machinery, machine shops, &c., for Cockatoo Island, and £300,000 for construction of conduits and laying wires underground.

Canada. Extensions are being made to the Canadian Niagara Power Co.'s plant at Niagara Falls. Three new units of 12,500 H.P. are being erected in the south section of the plant, and when these are in operation the total output of Canadian Niagara power will be approximately 112,500 H.P.

FOREIGN NOTES.

Colombia.—H.M. Minister at Bogotá states that the provincial towns in Colombia are gradually being supplied with electricity supply works, and cheap electric lighting fittings are required in many districts. House building is proceeding on a considerable scale at Bogotá and at Medellin.

Japan.—The British Consul-General at Yokohama says an efficient electric train service was established in 1915 between Tokio and Yokohama, in addition to the ordinary train service.

A Tokio journal states that zinc mining in Japan has suddenly sprung into a state of briskness in harmony with the swift development of the zinc refining industry, and the output of zinc ore will greatly increase at no distant date. A mine in the Miyagi Prefecture, which in 1915 produced some 4,000 tons of ore, is expected to more than double its output in 1916. Attention has been paid to a mine in the Hokkaido, which had been neglected. It is hoped that this mine will yield 3,200 tons of ore in 1916 and 5,000 in 1917. Mining for zinc has commenced at a mine formerly worked for copper in the Gumma Prefecture. In 1917 the monthly output is expected to reach 2,500 or 3,000 tons. The ore, however, contains only 12 or 13 per cent. of zinc.

Prior to the war, a zinc mine in Hida Province had an output of 20,000 tons a year. Efforts have been made to increase production, and the output will be increased by 30 per cent. during 1916. The annual output of another mine, in the Nagasaki Prefecture, was not more than 3,000 tons before the war. At present it produces 500 tons a month. The total annual production of zinc ore in Japan before the war only amounted to 40,000 tons, but this year the production will be over 60,000 tons.

MISCELLANEOUS NOTES.

Enemy Firms Wound-up.—The Board of Trade has ordered the winding-up of 259 businesses controlled by alien enemies.

The latest list includes the Roumanian Oil Trading Co. (Ltd.), 6, Lloyd's-avenue, London, E.C., shipping agents of a Roumanian company (Controller: R. Stephens, 31, Lombard-street, E.C.); Balcke & Co. (Ltd.), Broadway-court, Broadway, London, S.W., water-cooling engineers (Controller: J. W. Barratt, 19A, Coleman-street, E.C.)

For British Hulm Metallic Packing Co. (Ltd.), which appeared in a previous list, *read* British Huhn Metallic Packing Co. (Ltd.).

Exports to China.—The "London Gazette" of July 25 contains a further list of persons and firms in China to whom goods may be consigned from the United Kingdom. These include the Westinghouse Electric Export Co. (Shanghai).

London Electricians' Wages.—The electricians in the London district have been awarded an advance of ½d. per hour by the Committee on Production. The Committee have also awarded assistants and labourers in the industry pro rata increases.

Mine Electricians.—At the Miners' Federation Conference recently, a resolution was carried urging that Regulation 131 of the Home Office Regulations under the Coal Mines Act be so amended as to make it illegal for a person in charge of an electric coal-cutter, whose wages depend upon the amount of mineral gotten, to be appointed as the responsible person to supervise, examine or adjust the electrical apparatus.

Mr. S. ROBERTS, who moved the resolution, said there was a case in Yorkshire where to overhaul the electrical machinery they coupled up to a steam engine, and for 20 minutes the fan was stopped, there was no ventilation, and an explosion occurred. Prof. O'Shea found that during those 20 minutes there would be an accumulation of gas on the face of 37 per cent., and it was also found that there was a sparking from the electric coal-cutter. The man who was working the coal-cutter was employed at piece rates, and had five men working for him, and he was not entitled to compensation for stoppages of less than two hours.

Trading With the Enemy.—The "London Gazette" of July 18 contains further lists of firms, and persons with whom trading by firms and persons in the United Kingdom is prohibited.

These include the following: *Brazil.*—Sociedad Tubos-Mannesmann (Rio de Janeiro). *Chile.*—Siemens Schuckert, Ltd. (Valparaiso and Santiago). *Netherlands.*—Nederlandsche Maatschappy N.V. (Rotterdam). Nederlandsche Hunstelefoon Maatschappy (Rotterdam, Amsterdam and The Hague). *Netherlands East Indies.*—Technisch Bureau Altmann (Bandoeng). *U.S.A.*—Electro Bleaching Gas Co. (Niagara Falls and New York), Goldschmidt Chemical Co. (New York), Goldschmidt Detinning Co. (New York), Goldschmidt Thermit Co. (New York), National Zinc Corpn. (New York), Orenstein & Koppel (Pennsylvania).

Corrections are published to the entries in previous lists of the following firms: *Argentina and Uruguay.*—Allgemeine Electricitäts Gesellschaft Sudamericana (Buenos Ayres and all branches in Argentina and Uruguay) Cassmi & Co. (Buenos Ayres), Gasmotorenfabrik Deutz (Buenos Ayres). *Norway.*—A. E. G. (Christiania, Stavanger and Trondhjeim). *Portugal.*—A. E. G. (Thomson-Houston Iberia) (Oporto and Lisbon). *Sweden.*—A. E. G. (Stockholm).

TENDERS INVITED.

Telegraph and Telephone Material.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. Aug. 8 for the supply and delivery in Melbourne, Sydney, Brisbane, Adelaide, Perth and Hobart of Standard Battery Material, including Pots, Porous Jars, Zinc, Carbon Rods, Chemicals, &c., for the AUSTRALIAN COMMONWEALTH, Postmaster-General's department. (Schedule 1,327.) Specifications, &c., from the Deputy Postmaster-General.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

Tenders are invited up to July 31 for the supply and erection at G.P.O., Brisbane, of Power Board and Accumulators (Stores' Schedule 381). Specifications and tender forms from Commonwealth Offices, 72, Victoria-street, Westminster, London, S.W.

Tenders are invited up to Aug. 16 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

Turbo-Alternator, Condenser, &c.

The Town Clerk, INVERCARGILL (N.Z.) will receive tenders until 4 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 40). Specification, &c., from the Town Clerk.

Electric Crane and Air Compressor, Crane Motors, &c.

The NEW SOUTH WALES GOVERNMENT RAILWAYS & TRAMWAYS DEPARTMENT require tenders by noon Sept. 20 for the supply and erection of an Electric Overhead Travelling 50-ton Crane (specification 474); and by noon Oct. 11 for a motor-driven Air Compressor (specification 480) for Zarra-street power house. Specifications, &c., from the Electrical Engineer, 61, Hunter-street, Sydney.

The VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

Street Lighting.

CASTLEBAR Urban Council require tenders by 2 p.m. Aug. 5 for Electric, Gas or other lighting from Sept. 15 to April 1 next.

TENDERS RECEIVED AND ACCEPTED.

HAMMERSMITH (LONDON).—The Electricity Committee recommends the Borough Council to enter into a contract with the British Electric Transformer Co. for a 12 months' supply of transformers. It is proposed to purchase five 200 kw. transformers now at £840.

SOUTHAMPTON.—The Education Committee has accepted the tender of H. C. Taplin (at £250. 13s. 6d.) for wiring the Eastern District School. Another tender was at £371. 15s. 3d.

WESTMINSTER.—The Guardians have accepted the tender of Matthew Hall & Co. (at £45) for inspecting and maintaining the lifts at the infirmary for 12 months.

BUENOS AYRES.—The Buenos Ayres Western Railway Co. has placed an order with the Leeds Forge Co. for under-frames and bogies for motor coaches and bogies for trailer coaches. These materials are for rolling-stock now being built in this country in connection with the electrification of a portion of the company's system. The value of the order amounts to about £70,000.

Tyre Inflators.—The Metropolitan Asylums Board proposes to install power-driven tyre inflators at four ambulance stations. The electric motor will be supplied by the Crypto Electrical Co.

Government Contracts.—The following tenders were accepted by the British Government Departments during July:—

War Office.—F. R. Butt & Co., X-ray apparatus; W. T. Henley's Telegraph Works Co., Midland Electric Wire Co., Ward & Goldstone and Western Electric Co., electric cables and wires; Siemens Bros. & Co., electric cells; General Electric Co., electric generators and motors; C. Collins (Ltd.), Efandem Co. and J. & R. Oldfield, electric lamps; Automatic Telephone Mfg. Co., telephone switchboards; Edmundsons' Electricity Corp., electric light installation at Rendcombe; H. J. Cash & Co., electric lighting at Wye.

Post Office.—Gell Telegraphic Appliances Synd., telegraph apparatus: British L. M. Ericsson Mfg. Co., Peel Conner Telephone Works and Western Electric Co., telephone apparatus; Siemens Bros. & Co., iron arms; Telegraph Construction & Maintenance Co., telegraph cable; British Insulated & Helsby Cables, W. T. Glover & Co., Union Cable Co., and Western Electric Co., telephone cable; London Electric Wire Co. &Sm iths and Phœnix Telephone & Electric Works, telephone cords; North British Rubber Co., telephone mouthpieces; British Insulated & Helsby Cables, cable plugs; Siemens Bros. & Co., bronze wire; Dorman, Long & Co. (Ltd.), Johnson & Nephew, Rylands Bros. and Whitecross Co., g.i. wire; Eyre Smelting Co. and Siemens Bros. & Co., battery zincs.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Carlisle.—The accounts of the municipal electricity department for the year ended March 31 show gross capital expenditure £129,638 (increase £3,464), and £76,073 is outstanding.

Revenue was £25,109 (compared with £21,404 in previous year), and total costs, including special charges but not capital charges, were £15,384 (£13,063), leaving gross profit £9,725 (£8,341). Interest required £3,388 (£2,963) and instalment of capital £6,163 (£5,301), leaving net profit £174 (£76). Average revenue per unit was 1·51d. (1·48d.), works costs were 0·53d. (0·59d.), and total costs, including 0·55d. (0·55d.) for interest and sinking fund, were 1·5d. (1·47d.). Units generated were 5,200,843 (4,282,873) and sold 3,973,039 (3,470,492). Maximum load was 2,210 kw. (2,108 kw.), and load factor 20·5 (19·6) per cent.

Mr. F. W. Purse (city electrical engineer) says in his report the average price of coal was 38 per cent. over that paid in previous year. The increase in net profit was obtained without any general increase in the charges for current. But for the power load (which amounted to 3½ million, compared with ½ million for lighting, in round figures) the charges for lighting would have had to be increased at least 25 per cent. The revenue per horse-power demanded was about 50 per cent. more in the case of power than in the case of lighting supplies, although the average charges for lighting and power respectively are about 3¾d. and 1d. The 154 power consumers provide a revenue of £16,000, while it takes 711 lighting consumers to produce £8,000, with greater capital cost of services, meter reading, &c.

In moving the adoption of the report and accounts at the last meeting of the Council, the Mayor said the result of the year's working reflected the greatest credit on the engineer and his staff. He had particulars before him of over 150 towns throughout the kingdom showing that for the past year they were uniformly unprofitable. He called attention to the benefit the Carlisle undertaking was deriving from the last extension of the plant. The output increased over half a million units, while the coal consumption was 100 tons less.

Hammersmith.—The accounts of the electricity undertaking for the year ended March 31 have been prepared.

Having regard to the greatly increased cost of fuel and to decreased revenue from public lighting consequent upon the restrictions imposed, the Electricity Committee thinks that the net profit on the year of approximately £600, may be considered very gratifying, especially as no increase had been made in the charge to general consumers.

The Committee is in communication with Battersea and Fulham Borough Councils with the objects, if possible, of agreeing to the conditions upon which the three Councils should carry out the linking-up scheme approved in June, 1915, so far as it relates to the Hammersmith and Fulham stations. The Committee is also in communication with the Treasury, the Board of Trade and the L.C.C. regarding the sanction for the necessary expenditure.

Hull.—The electricity accounts for the year to March 31 show gross capital expenditure £549,099 (increase £9,236), of which £212,61. has been repaid or placed in sinking fund.

Revenue was £89,208 and working expenses and special charges amounted to £48,905, leaving gross profit £40,303, or £42,030 before deducting special charges (works protection and war allowances). Interest required £15,049, loan instalments £18,900, and income tax £2,105, the net profit carried to reserve being £4,247. Works cost per unit was 0·64d. (against 0·66d. in previous year), total working cost 0·79d. (0·81d.) and capital charges were 0·55d. (0·61d.). Units generated were 19,952,605 (17,729,060) and sold 14,795,426 (12,969,776). Maximum supply demanded was 7,810 kw. (6,700 kw.).

Mr. J. F. Magoris (acting city electrical engineer) says, in his report, lighting restrictions caused a decrease of £5,060 in receipts for lighting, in spite of an increase of 307 in the number of lighting consumers, but income from power supply increased by £9,517. The connections to the mains are equal to 28,790 kw.

Mr. Magoris also informs us that the effect of the lighting restrictions was to reduce the revenue from lighting per average kilowatt connected from £5·13 to £3·79. The gross profit represents 7·85 per cent. on the average capital employed, or 14·7 per cent. on the outstanding loan debt of £285,858. From time to time the committee have contributed large sums towards the cost of capital work (amounting to nearly £50,000) from reserve, which latter now stands at £20,500, or slightly over 7 per cent. on the outstanding loan debt.

Middleton.—The electricity department's accounts for the year ended March 31 show a net deficit of £1,066.

Income was £8,593, in addition to £1,748 paid to Manchester Corporation for current. Generation costs were £5,011, distribution £655, and the remainder of the costs, other than capital charges, amounted to £1,277. Interest and sinking fund required £3,315.

Oldham.—The electricity departments accounts for the year ended March 25 show total capital expenditure £383,813 (increase £26,815), of which £236,749 is outstanding.

Revenue was £63,920 (against £52,293 in previous year), and total costs were £37,222 (£27,006), gross profit being £26,698 (£25,287). Sinking fund required £10,465 (£9,337), interest £10,902 (£11,366), and expenditure on meters £224 (£1,034), and net profit was £5,107 (£3,550). Average price obtained was 1·44d. (1·51d.). Total revenue costs were 0·852d. (0·812d.). Units generated were 13,288,641 (9,874,187) and sold 10,487,235 (7,985,859). Maximum load was 5,360 kw. (4,591 kw.) and load factor 22·27 (19·85) per cent.

The report of the joint engineers and managers (Mr. F. L. Ogden and Mr. W. Chamberlain) states that there have been installed and put into commission during the year a 3,000 kw. British Westinghouse turbo-alternator; three 25,000 lb. Babcock & Wilcox water-tube boilers, with chain grate stokers, Green's economisers and induced draught plant; two water-cooling towers; a new battery house, battery booster and switchgear; one 250,000 gallons per hour motor-driven centrifugal pump; and two boiler feed pumps. Tenders have been accepted for two Babcock & Wilcox 22,000 lb. water-tube boilers with chain-grate stokers, foundations and pipework, Green's economisers and induced draught plant; one 1,250 kw. British Westinghouse rotary converter, transformer and switchgear; and one 250,000 gallon motor-driven centrifugal cooling tower pump. Contracts have been arranged for the supply of energy to several cotton mills for driving purposes, and energy is being supplied to a number of engineering works

Stoke-on-Trent.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £344,086 (increase £7,382), of which £141,463 is outstanding.

Revenue was £60,970 (compared with £51,305 in previous year). Total costs were £34,111 (£30,010) Interest required £10,543 (£10,080), repayments £12,698 (£11,144), new meters £987 (£1,076) and other items of a capital nature £74 (£29), leaving a surplus of £1,183 (£71), to which are added £278 (£789) for steam sold and £1,097 (£1,618) for street lamp repairs. Total receipts were 1·873d. (1·700d.) per unit sold, and total costs were 1·067d. (0·969d.), or 1·827d. (1·700d.), including capital charges, new meters, &c.

Mr. C. H. Yeaman (chief electrical engineer) says in his report units sold were 7,673,381 (7,432,910). The increased surplus included £1,111 resulting from the extra revenue of £6,885 Cost of coal and destructor steam rose from £10,799 to £14,582 net

COMPANIES' MEETINGS AND REPORTS.

Electric & General Investment Co. (Ltd.)

The twenty-seventh ordinary general meeting was held on Tuesday, Mr. J. B. Braithwaite in the chair.

The SECRETARY (Mr. S. R. Shaw) having read the notice convening the meeting and the certificate of the auditor,

The CHAIRMAN said: Gentlemen, with regard to our balance-sheet, the year, as you know, has been one of war, and, owing to Treasury restrictions, practically all financial business such as that which we engage in has been at a standstill, and we have had to live on our dividends and trustees' fees. We have, however, materially improved the Company's position during the year. The two items of liabilities—sundry creditors and open accounts and loans from bankers and others—which in the last balance-sheet stood at £120,400, this year stand at £101,700, so there is an improvement in those items of £18,700. That, of course, materially strengthens our position. With regard to our earnings, we have received, as you see, £7,336. 10s. 11d., and had a carry forward of £5,222. 5s. 7d., making our total receipts £12,558. 16s. 6d. On the other hand, our general charges, including directors' and auditors' fees, are about the same as they were last year—£1,473. 12s. 11d.; interest on debenture stock is slightly less, and the balance carried to the balance-sheet is £10,194. 10s. 1d., instead of £5,222. 5s. 7d. We have, therefore, improved our carry forward by nearly £5,000, which, of course, belongs to our preference shareholders, and we shall distribute it to them when financial conditions are more favourable than they are at present. The only other remark I think I need make is as to our investments. Our valuation of them at the end of the year showed an improvement on that of last year of £15,000, so that, again, is in the right direction. Putting the £18,700 reduction of our liabilities and the increase in the valuation of our investments together there is an improvement of over £30,000 in the position of the Company, which I think is satisfactory under the circumstances. I am a preference shareholder, and I sympathise with my brother shareholders that we do not feel it wise to make a distribution, but the amount is carried forward and is theirs, and I am sure we shall all agree that it is better to strengthen our financial position in times like the present. I propose the adoption of the report and accounts.

Mr. EMILE GARCKE seconded the motion, which was carried unanimously.

Mr. J. Cecil Bull was then unanimously re-elected a director, and Mr. H. Leigh Williams, F.C.A., was re-appointed auditor, a vote of thanks to the chairman, the directors and staff terminating the proceedings.

COUNTY OF DORSET ELECTRIC SUPPLY CO. (LTD.)—The report of the directors for 1915 states that the capital expended in the associated companies to date is £34,450. 11s. 4d. Revenue receipts, exclusive of the Lyme Regis dividend, were £2,460. 14s. 1d., against £1,062. 5s. 1d. last year. Gross profit (including dividend for the Lyme Regis Co.) is £1,271. 7s. 8d. Against this must be placed interest on temporary loans £845. 19s. 9d., leaving a profit of £425. 7s. 11d., against a deficit of £160. 3s. 10d. in 1914. The subsidiary companies, viz., the Lyme Regis Electric Light and Power Co., Ltd., Blandford Forum and District Electric Supply Co., Ltd., and Swanage Electricity Supply Co., Ltd., have each shown satisfactory progress. The Lyme Regis Co., in spite of lighting restrictions, shows a profit equivalent to a dividend of 8 per cent. The number of consumers in Dorchester on Dec. 31 was 112, in Blandford 64, in Lyme Regis 133, and in Swanage 86. The company's progress has been steady and satisfactory, especially when the adverse conditions due to the war are taken into consideration.

CREDENDA CONDUITS CO. (LTD.)—The profit for the year ended April 30 last, after providing for repairs, depreciations, directors' fees and reserve for income tax and excess profits, amounts to £6,093, which, with £862 brought forward, gives an available balance of £6,955. The directors have written off the goodwill account £2,000, and they recommend payment of a dividend at the rate of 8 per cent. per annum (tax free) on the ordinary shares, and to carry forward £955.

CROMPTON & CO. (LTD.) At the annual general meeting on Monday the chairman (Mr. Carleton E. Tufnell), in moving the adoption of the report and accounts, said that the trading for the year ended March 31 last had been profitable The year had been one of difficulty in many directions, but they had managed to do a larger turnover. The gross profit increased from £57,900 to £63,100, and, after meeting various charges, the disposable balance was £37,950, against £28,648. It was proposed to put £6,700 to general reserve, and the board suggested a larger sum as a special depreciation fund They also proposed to write off the balance of preliminary expenses (£1,000). The directors recommended the payment of the full dividend of 7 per cent. on the preference shares, but they felt compelled to again appeal to the patience of the ordinary shareholders. When he had the pleasure of addressing them last year he referred to the need of husbanding their resources, and they had now to bear war taxation on a scale which was altogether unforeseen 12 months ago The amount carried forward was £10,479 (against £7,501), but it was subject to excess profit duty and assessment under the Ministry of Munitions Act for the year under review, and also the previous year. Their works were declared a "controlled establishment" in August of last year. During the year they had delivered a very large amount of war material [illegible] electrical machinery, projectors, &c., for the Admiralty, the War Office and for our Allies, as well as equipment for Government and other munition works, and the orders in hand for

these various classes of work at the end of the year showed a considerable increase over the figure at which they stood 12 months previously. With regard to the future, he said that they had plenty of work in hand to keep them busy for many months to come. Some people anticipated considerable activity for a period after the war ended, but the board were taking steps to meet a possible set-back in the demand. He hoped the results of what they were doing would enable them to obtain business in other directions, as and when they required it, to compensate for any falling off in their ordinary trade, and that matter of the future was receiving their most careful attention.

The motion having been seconded, was carried unanimously.

EDMUNDSONS' ELECTRICITY CORPN. (LTD.)—At the annual general meeting of this company last week the chairman, Mr. P. D. Tuckett, in moving the adoption of the report and accounts, said there was a shrinkage of profit which interrupted the record of steady progress which they were making year by year prior to the war. Almost all the undertakings with which they were connected had been adversely affected, their profits showing in the aggregate a reduction of over £12,000. Not only had their lighting revenue been shrinking but the cost had increased. Coal accounted for a difference of £13,000, and they had lost 364 men who had gone to the front, many of them highly-trained men whom they could not afford to lose. The Isle of Wight was chiefly responsible for the reduction in dividend and interest. At Lymington the lighting revenue had dropped 15 per cent., at Ilfracombe 16 per cent., at Ramsgate 23 per cent., and at Cromer 29 per cent., following on a drop of 10 per cent. the previous year. Melton Mowbray's hunting season and Newmarket's racing and training activities had suffered owing to the war, and dividends there had been affected, while at Bromley and at Surbiton lighting consumption had decreased. Save at Melton Mowbray and Newmarket, the cost of coal had been substantially higher. At Scarborough the resident population of the town was reduced and the town had been deprived of nearly 500,000 of its summer visitors. The tramway revenue had shrunk by 58 per cent., and the undertaking presented a difficult problem, as it was obvious it could not be run indefinitely at a loss. On the other hand, the Lancashire Power Co. had increased its profits, though the stage at which they could be divided prudently had not yet been reached, while a satisfactory development was the taking over from the Council of the Surbiton undertaking. Generally, they were by no means sanguine of their ability to avoid further shrinkage in profits, but their position was wholly due to war conditions, and should rapidly improve as the country resumed its normal way of life.

The report and accounts were adopted.

SOUTHERN BRAZIL ELECTRIC CO. (LTD.)—An ordinary general meeting of this company was held last week. Mr. E. H. Tootal (chairman), in submitting the report and accounts (abstracted in our issue of 14th inst.), said little more than six months had elapsed since their last general meeting, so that it was not possible to make any comparison with the figures given in the previous report, which covered a year. Steady progress was being made, and there was every reason to look for a satisfactory increase of revenue all round, but the present stage was largely one of development and extension. The first section of the Piracicaba tramway line was opened for traffic in four months from the grant of the municipal concession. This line had been received with favour by the people in the district, and it was expected that it would soon show a material development of passenger and goods traffic. Work was progressing well with the electrification of the Campinas Steam Railway, though here some delay has occurred through unfavourable weather and the difficulty at times of obtaining the requisite material. The financial difficulties in Brazil had been appreciably mitigated, though much remained to be done before they are finally surmounted. The Federal Government was making strenuous efforts towards that end, and it was hoped that the Brazilian exchange would at length show a more marked improvement. In their principal field of action, the State of Sao Paulo, prospects were very encouraging.

YORKSHIRE ELECTRIC POWER CO.—The report of the directors of this company for the half-year ended June 30 states that the company has continued to make satisfactory progress. There has been an increase in revenue from sale of electricity, and notwithstanding the very high costs of coal and labour the net profits, after payment of bank and other interest, have also increased. The net profits for the half-yearly period ended June 30 were £13,549. 11s. 6d. in 1916, £9,873. 8s. 9d. in 1915 and £10,414. 5s. in 1914. Dividend for the half-year on the 6 per cent. cumulative preference shares will absorb £4,786. 15s. 5d. In view of the financial conditions arising out of the war and the heavy commitments which the company has had to incur due to the demands for munitions, the directors have deferred the consideration of a dividend on the ordinary shares until the end of the year. An important extension of the Thornhill power station is being made in consequence of the demands upon the company for additional supply, and as a first instalment a turbo-alternator of a capacity of 6,000 kw. will shortly be erected.

COMPANIES TO BE STRUCK OFF THE REGISTER.—The following are to be struck off the Register of Joint Stock Companies unless cause to the contrary is shown before Oct. 14. : Aladdin Lamp Synd., Electric Ozone Synd., International Asbestos Co., Lancashire & Yorkshire General Omnibus Co. and County Borough Tramways, Wireless Electric Light Co.

The following will be struck off unless cause to the contrary is shown before Oct. 21: Anglo-German Wireless Synd., Bridlington Electrical Engineering Co., British Metallurgical Co., Houchen Electro-Plating Co., Improved Railway Signals, Power Transmission Synd., United Electric Light & Power Co.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

ARTHUR ELLIS & CO. (LTD.) (144,348).—Reg. July 14, capital £2,000 in £1 shares (1,000 preferred), to carry on the business of general, mechanical and electrical engineers, makers of electric lamps and apparatus, electricians, &c. Preferred shares entitled to cumulative preferential dividend of 8 per cent. per annum and to a further 40 per cent. of any surplus profits available for dividend after providing for 8 per cent. on ordinary shares. Private company. First directors are A. T. Ellis and W. L. Heald. Reg. office : 201, Caxton House, Westminster, S.W.

BIRMINGHAM ELECTRICAL ACCESSORIES MFG. CO. (LTD.) (144,386). Reg. July 19, capital £1,000 in £1 shares, to carry on the business of manufacturers of and dealers in electrical fittings and accessories, electrical and mechanical engineers, &c. Private company. First directors are G. Garratt, C. E. Garratt, E. A. Welch and Alice Welch. Secretary : Amy M. Garratt. Reg. office : Whitmore-street, Hockley, Birmingham.

BRITISH ELECTRIC TRADING CO. (LTD.) (9,641).—Reg. in Edinburgh July 17, capital £2,000 in £1 shares, to carry on the business of manufacturers of and dealers in all apparatus and articles connected with electricity. Private company.

BRITISH ITALIAN CORPN. (LTD.) (144,404).—Reg. July 20, capital £1,000,000 in 50,000 shares of £20 each, to carry on, subsidise, assist or participate in financial, commercial, industrial, manufacturing, electrical railway, navigation, land development, mining and other businesses, works, contracts, undertakings and operations of all kinds in the British Empire, Italy and elsewhere, to undertake any operations commonly carried out by financiers, company promoters, bankers, underwriters, concessionaires, contractors for public and other works, capitalists or merchants, to establish and carry on the business of a bank of deposit, to act as agents for the collection, receipt, transmission or payment of money, &c. First directors are Arthur Hill, Robert H. Benson, J. W. Beaumont Pease, bank director; Sir Hy. Babington Smith, K.C.B., Joseph Burn, actuary ; Alberto Pirelli, company director ; Ignatius G. Manzi-fe, manager of Credito Italiano ; and Riccardo Bianchi, director of public companies.

HIGGINS & GRIFFITHS (LTD.) (144,330).—Reg. July 12, capital £10,000 in £1 shares, to take over the business of electrical and general engineers, carried on by A. Higgins and S. Griffiths. Private company. First directors are A. Higgins and S. Griffiths (both permanent, subject to holding 3,000 shares each). Reg. office : 21, Orchard-street, Portman-square, W.

JULIEN & GREBERT ENGINEERING CO. (LTD.) (144,318).—Reg. July 11, capital £600 in £1 shares, to carry on the business of consulting, civil, mechanical, electrical, constructional, chemical, marine, ventilating, heating, refrigerating, motor and inspecting engineers, &c. Private company. Reg. office : 47, Victoria-street, London, S.W.

KILMALLOCH ELECTRIC LIGHT & POWER CO. (LTD.) (4,364)—Reg. in Dublin on July 10, capital £2,700 in £1 shares, to carry on the business indicated by the title. Private company. Secretary : D. Cussen. Reg. office : Kilmalloch, co. Limerick.

MORTGAGES AND CHARGES.

EDISON ACCUMULATORS (LTD.)—Debenture, charged on the company's undertaking and property, present and future, including uncalled capital, dated July 4, 1916, to secure all moneys due or to become due from company to London County & Westminster Bank, not exceeding £15,000 in addition to a previous amount for not more than £5,000.

M. HOWLETT & CO. (LTD.)—Mortgage, dated May 30, 1916, as collateral security to debentures dated Nov. 12, 1915, securing £10,000 charged on land and premises in Hockley Hill, Birmingham. Holders : A. Rose and W. Bellamy.

LAMPLOUGH & SON (LTD.)—Mortgage dated June 23, 1916, created by the receiver and manager to secure not more than £2,500, charged on the company's undertaking and property, present and future, including uncalled capital. Holders : Messrs. Hoare.

CITY NOTES.

MEMORANDA (July 26).—**Bank rate 6 per cent. (since July 13, 1916). Consols 59⅝. Consols Pay Day, Aug. 2. Stocks and Shares Ticket Days, Aug. 15 and 30. Pay Days, Aug. 16 and 31. Price of silver, 30⅛d.**

BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)—An interim dividend on the ordinary shares at the rate of 5 per cent. per annum (less tax) is announced.

CENTRAL LONDON RAILWAY CO.—Interim dividends for the first half of the present year on the undivided ordinary stock at the rate of 3½ per cent. per annum (compared with 3 per cent. a year ago) and on the preferred ordinary stock at the rate of 4 per cent. per annum have been declared.

CHATHAM & DISTRICT LIGHT RAILWAY CO.—An interim dividend at the rate of 3 per cent. (less tax) on the ordinary share capital for the half-year to June 30 has been declared.

CITY & SOUTH LONDON RAILWAY CO.—An interim dividend for the first half of 1916 on the ordinary stock at the rate of 1½ per cent. per annum has been declared.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares at the rate of 5 per cent. per annum (less tax) for the half-year ended June 30.

LANARKSHIRE TRAMWAYS CO.—An interim dividend at the rate of 6½ per cent. per annum (less tax) has been declared for the half-year ended June 30.

LONDON ELECTRIC RAILWAY CO.—An interim dividend for the first half of 1916 on the ordinary shares at the rate of 1½ per cent. per annum has been declared.

MATHER & PLATT (LTD.)—A dividend of 5 per cent. actual (compared with 3 per cent. actual last year) has been declared on the ordinary shares for the past half-year.

METROPOLITAN DISTRICT RAILWAY CO.—An interim dividend for the first half of 1916 has been declared on the second preference stock at the rate of 3 per cent. per annum (the same rate as that for the first half of last year).

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO. (LTD.)—It has been decided to postpone payment of the preference dividend until about the end of September.

UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)—Interest on the 6 per cent. cumulative debenture stock will be paid on Sept. 1 (less tax), and coupon No. 17 off 6 per cent. income bonds will be paid (tax free) on the same date.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date July 25, the following as the present basis prices of

New Metals.	per lb.
Solid Drawn Brass Tubes	14½d.
Solid Drawn Copper Tubes	17½d.
Brazed Copper Tubes	17½d.
Brazed Brass Tubes	16½d.
Brass Wire	14½d.
Copper Wire	18d.
Rolled Brass	14½d.
Brass Sheets	15½d.

	per ton.
Copper Sheets	£146 0 0
Spelter	£59 0 0
English Lead	£28 15 0
Antimony	Nominal.

Old Metals.	per ton.
Clean Copper Scrap	£35 0 0
Clean Brass Scrap	£58 0 0
Braziery Copper Scrap	£75 0 0
Old Lead	£23 0 0
Old Zinc	£39 0 0
Hollow Pewter	£115 0 0
Black Pewter	£75 0 0
Gun Metal	£72 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date July 25, the following approximate prices of Scrap Metals:—

	per ton.
Aluminium Cuttings	£110 0 0
Clean Mixed Brass	£59 0 0
Clean Copper	£84 0 0
Braziery Copper	£72 0 0
Gun Metal	£72 0 0
Old Lead	£3. 10s. under English lead price.
Old Zinc	£45 0 0
Hollow Pewter	£120 0 0
Shaped Black Pewter	£85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £97; Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, July 25. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., July 25.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	9⅞	6 10 2	Mar, Sept
10	4½%	Do. 4½% Cum. Pref.	8⅞	5 11 8	Feb, Aug
10	6%	Do. 6% Cum. 2nd Pref.	10⅛	5 19 3	Feb Aug
5	10%	Brompton & Kensington Ord.	6⅞	7 12 5	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St	80	5 0 0	..
St.	4%	Charing Cross West End & City Debs.	82†	4 17 7	Jan, July
5	2/3	Do. 4½% Pref.	3⅜	6 4 2	..
5	5%	Do. Ord.	3¼	6 13 4	Aug, Feb
5	4½%	Do. City Pref.	2⅛	7 13 2	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3½	6 8 0	Mar, Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan, July
10	8%	City of London Elec. Lt. Ord.	12⅜	6 3 8	Feb, Aug
10	6/0	Do. 6% Pref.	10½	5 14 3	Mar, July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun, Dec
St.	4½%	Do. 4½% Debs.	90	5 2 6	Jun, Dec
10	7%	County of London Ord.	10⅛	6 8 9	Mar, Sept
10	6%	Do. 6% Pref.	10⅛	5 14 1	Feb, Aug
St.	4½%	Do. 1st Deb.	87½	5 4 2	Jan, July
St.	4½%	Do. 2nd Deb.	83½	5 7 4	My, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	75½	5 18 10	July
5	7%	Kensington and Knightsbridge Ord.	5⅛	6 13 4	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6/-	London Elec. Supp. 6% Pref.	4⅛	6 17 2	..
St.	4%	Do. 4% Mort. Debs.	82	4 17 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅛	6 6 4	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn., 1st Mort. Deb. St	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Dbs	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db St.	99	5 8 8	Mar, Sept
1	6%	North Metropolitan E. P. Supp. 6% Pref	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord	2½	7 0 8	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., July 25.	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	6⅞	6 9 4	Feb, Aug
5	7%	Do. do. Pref.	5⅛	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs.	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	73½	6 2 5	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations.	1⅛	6 8 0	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6½	5 12 0	Mar, Sept
5	4½%	Do. 4½% Cum. Pref.	4⅞	5 10 9	Jan, July
		Electric Railways & Tramways.			
St.	5%	British Elec. Traction 5% Debs.	85	5 17 4	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	80½	7 9 1	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	74	5 8 1	..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	..
St.	4½%	Do. 4½% Pref.	81†	5 11 1	Jan, July
St.	4%	Do. 4% Deb. St.	76†	5 5 3	Jan, July
St.	4%	City & S. London Deb.	71½	5 7 0	May, Nov
St.	5%	Do. Pref. 1895	70½	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2½	5 0 0	Jan, July
St.	4%	Do. 4% Pref.	69½	5 15 5	Mar, Sept
St	4%	Do. 4% Debs.	75½	5 6 0	Jan, July
St	1%	Metropolitan Ry. Con. Ord.	26⅛	3 16 7	Feb, Aug
St.	3½%	Do. 3½% Pref.	65½	5 5 10	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	60	5 16 8	Feb, Aug
St	3½%	Do. 3½% A Debs.	69	5 1 5	Jan, July
St	3½%	Do. 3½% Debs.	63½	5 1 10	Jan, July
St	..	Metropolitan Dist. Ry. Ord.	19	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	76	5 5 3	May, Nov
St.	4½%	Do. 4½% First Pref.	72½	6 4 2	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 7	Jan, July
St.	4%	Do. 4% Debs.	77	5 3 11	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	73	5 2 7	Jan, July
St.	4%	Do. 4% Guar. Stock	70	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2⅜	5 2 2	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	3 1 11	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅞	5 6 8	Mar
100	5%	Do. Prior Lien Debs.	93	5 8 8	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12⅞	7 4 7	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅞	5 15 8	Jan, July
1	6%	British L.M.Ericsson Mfg. Cm. 6% Pref	⅞	6 8 0	Mar, Sep
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅞	5 17 1	April
100	6%	Do. 6% Prior Lien Debs.	101½	5 18 3	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	65½	6 2 2	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅞	8 5 10	Jan, July
5	5%	Do. 5% Pref.	4⅛	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	Jun, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅞	7 7 8	Sept
5	..	Elison & Swan U.Elec.Lt.A. £3 pd.	½	..	Feb, Aug
St.	4%	Do. 4% Deb.	60¼	6 12 3	Jun, Dec
1	7½%	Elec. Construction Ord.	⅞	9 4 7	May
1	7%	Do. 7% Cum. Pref.	⅝	7 4 6	Jan, July
St.	4%	Do. 4% Debs.	78†	5 11 6	Jan, July
10	10%	General Electric Ord.	13½	7 8 2	July
10	6%	Do. 6% Pref.	10	6 0 0	Jun, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	15⅛	6 5 6	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4⅛	5 9 1	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G. P. &c., Ord.	12⅛	8 3 3	Feb, Aug
10	5%	Do. Pref.	8	6 3 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39½†	6 1 11	Mar, July
100	4%	Do. 4% Debs.	95⅛	4 4 1	Jan, July
1	7½%	Vickers Ord.	1⅛	4 1 4	May, Aug
1	6d.	Do. 5% Pref.	⅜	5 3 3	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 4	Jun, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 2	Jun, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	41	10 1 2	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	103†	5 16 6	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	22⅜	6 18 7	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	70½	5 13 6	Ja.Ap.Jly.O
10	5%	Cuba Submarine Ord.	8½	5 17 8	May, Nov
10	10%	Do. 10% Pref.	13½	7 5 5	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅞†	6 9 4	Ja,Ap,Jly,O
St.	8%	Eastern Tel. Co. Ord.	148½†	5 8 5	Ja My, Jly,O
St.	3½%	Do. 3½% Pref.	67†	5 4 6	Ja,My, Jly,O
St.	4%	Do. 4% Debs.	78½	6 7 10	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78⅛	5 2 3	Feb, Aug
10	8%	Do. Ord.	14½†	5 11 5	Ja, Ao, Jly,O
10	22%	Gt. Northern Tel. Co. With Coup 11	37½	5 16 7	Ja. My, Jly
25	13%	Indo-European	48⅜	6 19 6	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3⅛†	3 1 6	April
1	7%	Do. 7% Pref.	2⅜	2 12 8	July
10	1%	West India & Panama Ord.	1⅛	9 4 8	May, Nov
10	6%	Do. 1st Pref.	7⅛	7 12 5	May, Nov
10	8%	Western Telegh. Co.	14½	5 7 4	Mr, Jly, O, Dec
St.	4%	Do. 4% Deb. St.	77½	5 3 3	Jun, Dec
..	4½%	Western Union 50 yr. Bds.	99½	4 10 10	May, Nov.
		Telephones.			
1	7½d.	Monte Video Telephn. Ord	⅝	7 13 7	Nov.
1	10%	Oriental Telephone Ord.	2	5 0 0	Apl, Oct
St.	4%	Do. Db. St.	79½	5 0 11	Jan, July
St.	4½%	Telephn. Co. of Egypt Do. St	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅜	5 18 0	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅛	5 6 8	Jan, July
St.	4½%	Do. Deb. Stk.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12⅛†	4 13 8	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10⅛†	5 19 4	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	83½	5 19 9	Ja, Apl, Jly,O
..	4%	Do. $100 Pref.	70	5 14 3	Ja,Ap, Jly,O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	5⅛	5 18 6	Mar, Sept
St.	5%	Do. 5% Debs.	94⅛	5 5 10	Jun, Dec
10	6/-	Bombay E. S. & T. 6% Pref.	10⅛	5 14 3	..
St.	4½%	Do. 4½% Debs.	83	5 8 5	Jan. July
5	9%	Calcutta E. S. Corp. Ord	6⅛	7 0 6	May, Nov
5	5%	Do. 5% Pref.	4⅛	5 11 1	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,994. [No. 18. Vol. LXXVII.] **FRIDAY, AUGUST 4, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 585
Arrangements for the Week.. 587
Tests on Oil Switches. By Bruno Bauer. Illustrated. 588
Calculation of Flywheel Motor-Generator Sets. Illus..... 591
National Physical Laboratory. *Concluded* 593
Recent Patents in Radiotelegraphy and Radiotelephony. By W. Eccles, D.Sc. Illustrated.—*Concluded*.... 595
German Bounty-Fed Steel. By Sir Robert Hadfield, F.R.S. 600
The Wile Electric Furnace. Illustrated 601
BOUNTIES AND DUMPING 602
REVIEWS..... 603
The Universe and the Atom [Erwin].
REVIEWS—*Continued.*
A Meteorological Treatise on the Circulation and Radiation in the Atmospheres of the Earth and of the Sun [Bigelow].
Totally-Enclosed Brake Solenoids. Illustrated 604
CORRESPONDENCE..... 605
Electric Discharges in Sub-Stations.
An Absolute Thermopile. By W. W. Coblentz and W. B. Emerson. Illustrated 606
LEGAL INTELLIGENCE 608
PARLIAMENTARY INTELLIGENCE 609
Educational 609
The "Electrician" Commercial and Industrial Section .. 611–618

NOTES.

Copyright in Examination Papers.

THE action brought by the University of London Press (Ltd.) and Others against the University Tutorial Press (Ltd.) to restrain the latter from publishing or selling the examination Papers for the matriculation examination of London University, strikes us as being somewhat frivolous. Although we do not question the soundness of the judgment, we are of the opinion that it is in the best interests of the University to allow of reproduction of the questions by well-established firms, together with answers thereto, and criticism thereon, by competent persons. Pushed to a logical conclusion, it would appear to be illegal for writers of text books to make use of such questions, and for teachers to produce mimeograph copies of University questions for the use of their students. The owners of the copyright may win actions in the Law Courts, but we argue that the withholding of permission enabling others to give wide publicity to the questions will, in the long run, be detrimental to the University. It may very well be that valid copyright can be obtained for a set of questions in elementary arithmetic, but it was not till we heard of the recent action that we imagined anyone in the twentieth century would set the whole of the machinery of the law in motion in order to uphold the copyright of any elementary examination questions on any subject under the sun. Were it our business to set examination questions, and were we in a position so to do more as the result of the efforts of countless workers in the same subjects than to our own efforts, as must be the case in practically every examination that is held, we would see to it that encouragement was given to others to use such questions. We hold a brief for neither party in the recent action, but we venture to think that the matter is one which could have been readily adjusted by the parties themselves.

Validity of Contracts Under War Conditions.

IN the action of the Metropolitan Water Board *v.* Dick, Kerr & Co., the important point has been raised whether a contract is terminated when the Ministry of Munitions suspends it temporarily by enforcing restrictions. In the present instance the defendants had a large contract for the construction of reservoirs and other works, but at the beginning of the present year the Minister of Munitions gave notice that they were not to employ any more workmen for the time being, as such men were wanted elsewhere. Moreover, certain machinery and material were requisitioned and sent to various parts of the country, and for this the defendants received the sum of £40,000. As the result of the action, judgment was given to the effect that the contract was not abrogated. It appears to us that this is a reasonable view to take, though, on the other hand, it seems to us that the original contract price cannot now hold good. There must be many instances of the same kind, and if the action of the Minister of Munitions led to the termination of such contracts a good deal of confusion would result. Nevertheless, it cannot be supposed that contractors are liable in such cases to carry out the work specified at the original prices, as the holding up of a contract in the middle of the work necessarily entails a loss which may be very considerable for the contractor. It appears to us that a Court of Arbitration will be necessary to decide what is reasonable in the form of extra payment on account of suspension of work on contracts through the action of the Government.

The Future of Wireless Telephony.

IT is well that the investor should be on his guard against the unsoundness of the extravagant claims made for wireless telephony by non-technical people in the non-technical press. To his cost, he knows the value of the wild claims made for wireless telegraphy, and, vast as the development of the latter has been in certain directions, it should be remembered that the position of wired telegraphy has, if anything, been strengthened by the advent of "wireless." In a recent address before the Franklin Institute, Dr. J. J. CARTY, the chief engineer of the American Telephone & Telegraph Co., summed up the position in the following terms: "As a result of exhaustive researches . . ., it has been ascertained that the function of wireless telephony is not to do away with the use of wires, but rather to be employed in situations where wires are not available or practicable, such as between ship and ship, and ship and shore, and across large bodies of water. . . . In the case of the wireless telegraph, the number of messages which may be sent simultaneously is much restricted. In the case of the wireless telephone, owing to the thousands of separate wave-lengths required for the transmission of speech, the number of telephone conversations which may be carried on at the same time is still further restricted, and is so small that all who can employ wires will find it necessary to do so, leaving the ether available for those who have no other

means of communication. This quality of the ether which thus restricts its use is really a characteristic of the greatest value to mankind, for it forms a universal party line, so to speak, connecting together all creation, so that anybody, anywhere, who connects with it in the proper manner may be heard by everyone else so connected."

Demountable Bodies for Electric Vehicles.—With reference to the description of these bodies in "Electric Vehicle Progress" in our last issue, we are informed that similar bodies have been in use by Messrs. Ransomes, Sims & Jefferies, of Ipswich, for some years past in connection with their steam wagons. In this case the lifting arrangements are worked from the engine of the steam wagon.

Electricity Supply.—A conference has taken place between the Electricity Supply Committee of the Institution of Electrical Engineers and the Joint Committee of the Incorporated Municipal Electrical Association and the Incorporated Association of Electric Power Companies in regard to co-operation between the Committees. These Committees are constituted as follows :—

I.E.E. Committee.

R. A. Chattock (Chairman).
C. P. Sparks (President, I.E.E.).
C. H. Merz.
S. L. Pearce.
G. W. Partridge.
T. Roles.
W. B. Woodhouse.

Joint Committee of the I.M.E.A. and I.A.E.P.C.

I.M.E.A.	I.A.E.P.C.
J. H. Bowden.	W. A. Chamen (Chairman).
R. A. Chattock.	J. S. Highfield.
W. W. Lackie.	C. H. Merz.
S. L. Pearce.	D. A. Starr.
H. Faraday Proctor (Ex Officio).	A. de Turckheim (Ex Officio).
T. Roles.	W. B. Woodhouse.

In order to avoid overlapping and to ensure co-operation and co-ordination, two members common to both Committees have been delegated as intermediaries, so that the two Committees will be in continuous touch with each other's work. It has been agreed that the I.E.E. Committee will devote its attention to the question of electricity supply from the point of view of the requirements of the country as a whole, and will deal with the engineering aspect of the matter, while the Joint Committee will go into more immediate questions of organisation and linking-up of existing undertakings, &c. It will be seen from the above that the work of both Committees is of national importance.

Speeding-Up in Factories.—We recently referred to a Bill introduced in the United States House of Representatives to render illegal the timing of workmen by means of a stop watch, thus preventing the spread of what is called the "efficiency" system. A correspondent in New York informs us that organised labour in America is now generally opposed to such timing because it has been resorted to in many large private establishments for speeding up, *i.e.*, to learn the maximum speed of the most efficient workman and thus to set approximately that speed as the standard for all piece work payment, the result being that wages instead of being raised for efficiency and improvement from the average standard are in effect on the average reduced, and speeding up, which is already high in America, is yet further intensified. It may be said, therefore, that in private industries there are two sides to this question on its merits, but in Government works there is no question on the merits. Wages in such works are exceptionally high, the hours are exceptionally short and the efficiency is relatively low. The officials only wish to get the work carried out in a reasonable number of days with a reasonable number of hands, and for that purpose seek to increase efficiency in every reasonable way, but for the double reason that there are a relatively high proportion of employés in Government service who cannot stand any fair test of efficiency and that the working people directly interested conceive it to be to their interest to prolong jobs as much as possible and to secure jobs for as many as possible by each doing as little as possible, all methods of increasing efficiency are opposed. Owing to the tendencies and standard of the present Congress such provisions as are provided by the present Bill stand a good chance of receiving favourable consideration. The Bill has been reported upon favourably by the Committee on Labour of the House of Representatives, but it is very doubtful whether the Bill will be passed by the Senate and approved by the President. In any case the Bill can only apply to Government works and cannot interfere with private enterprise. A similar Bill relating solely to employés in the Postal Service is also pending.

Board of Trade Regulations for Non-Statutory Electricity Undertakings—During the week a revised set of the regulations prescribed by the Board of Trade under Sec. 4 of the Electric Lighting Act, 1888, was issued. We set out in full the modified regulations :—

10. (*a*) The owner on receipt of these Regulations shall forthwith serve upon the Postmaster-General a statement containing full particulars of every electric line used for the supply of energy, together with a plan showing the mode and position in which such electric line is laid.

16. Where alternating current at a pressure exceeding 125 volts between any two conductors is used, the middle point of the winding of the transformer on the consumer's side in the case of single-phase supply, or the neutral point in the case of two or three-phase supply shall be connected with earth.

17. Where a medium pressure continuous-current supply, or where alternating-current supply at a pressure exceeding 125 volts between any conductor and earth is used, one conductor consisting of one or two continuous earthed neutral wires shall be carried from pole to pole. The other conductor or conductors shall be arranged in such a manner that in the event of breakage of one of them, it must make contact with the earthed conductor or with wires connected thereto.

Connection of Alternating-current Circuits with Earth.

26. Alternating-current circuits shall be connected with earth in accordance with the following conditions :—

I.—GENERAL.

(*a*) The connection with earth shall be made only where energy is delivered to each circuit, that is to say, at a generating station, sub-station or transformer, and shall be made at a neutral point in the circuit, and in such a manner as will ensure at all times an immediate and safe discharge of energy.

(*b*) The connection with earth shall be efficiently maintained, except when it is interrupted by means of a switch or link for the purpose of periodical tests for ascertaining whether any current is passing by means of the connection with earth.

(*c*) The insulation of the mains shall be efficiently maintained at all other parts.

(*d*) Tests shall be periodically made to ascertain whether any current is passing by means of the connection with earth, and if at any time the current so passing exceeds one-thousandth part of the maximum supply current of the circuit, steps shall be immediately taken to improve the insulation.

Connection of Concentric Mains with Earth.

27. Concentric mains used either for continuous or for alternating current shall be connected with earth by means of the external conductor in accordance with the following conditions :—

(*a*) The connection with earth shall be made by means of the external conductor.

(*b*) The connection with earth shall be made only at the point or points where energy is given to each distinct circuit, namely, at a generating station, sub-station, or transformer.

(*c*) The insulation of the external conductor shall be efficiently maintained at all other parts.

(*d*) The external conductor shall form a complete metal sheathing round the inner conductor.

(*e*) The connection with earth shall be efficiently maintained except when it is interrupted by means of a switch or link for the purpose of periodical tests for ascertaining whether any current is passing by means of the connection with earth.

(*f*) Tests shall be periodically made to ascertain whether any current is passing by means of the connection with earth, and if at any time the current passing by means of the connection with earth exceeds one-thousandth part of the maximum supply current of the circuit, steps shall be immediately taken to improve the insulation.

OBITUARY.

KILLED IN ACTION.—We regret to announce the following deaths in action or of wounds :—

Company Sergeant-Major E. C. Laughton, who was recently killed in action, was for nine years associated with the lamp fittings department of Siemens Bros. Dynamo Works. He joined the Forces in September, 1914, and sailed for France in May 1915. Commencing as an ordinary private, he gained promotion to corporal before leaving for France, and gained the remaining steps in promotion while on foreign service. A portrait of Company Sergeant-Major Laughton appears in our Round Table columns.

Lieut. H. D. Allen (West Yorks. Regt.), was formerly a civil engineering student at King's College, London. He returned home from the Malay States at Christmas, 1914, to join the Army.

Capt. John Chapman (Manchester Regt.), killed in action, was engaged at the Partington Steelworks, near Manchester, at the time the war commenced. He took his B.Sc. (Honours) in civil engineering at University College, London.

Second-Lieut. W. B. Lycett (Northampton Regt.), killed in action on July 24, was educated at Wolverley and at Dover Technical School, and was an engineer at the Tilling-Stevens Works, Maidstone.

Second-Lieut. C. E. Pringle (North Lancs. Regt.) was formerly district factory inspector at Manchester and Hull.

Sergt. E. Shorrocks (R.F.), aged 41, who has been killed in action, was an M.Sc. of Manchester University, and science master at Queen's College, Taunton, and subsequently at Taunton Grammar School.

Second-Lieut. L. L. Vigers (R.E.), aged 25, who was killed in action on July 1, was a student of the Institution of Civil Engineers. After training at the City and Guilds Engineering College, he was articled to Messrs. Mott & Hay, engineers, Westminster.

PERSONAL.

Lieut. C. A. Boraston received the Military Cross from the hands of H.M. the King at Buckingham Palace on July 28th. Lieut. Boraston is one of the members of the teaching staff of the department of electrical engineering and applied physics of the Northampton Polytechnic Institute. He joined the Engineer Company of the Officers' Training Corps of the University of London in 1911, and when war broke out held the rank of cadet corporal. In September, 1914, he obtained a commission as second lieutenant in the R.E., and was attached to the Lowland Divisional Engineers (T.F.). He was sent out to Gallipoli in May, 1915, his Division remaining at Hellas until August 20th. Under constant shell and rifle fire day and night, the Division lost officers very rapidly, and when a month or two later the Division was ordered to Suvla Bay Lieut. Boraston found himself the only surviving commissioned officer. Shortly afterwards he lost his one remaining sergeant, and was himself buried and seriously injured by the explosion in which his sergeant was killed. The struggle that followed was so great that when, a month later, some officers were able to come to Lieut. Boraston's relief he found himself played out, and, to use his own words, "a welcome shrapnel bullet enabled me to exchange the discomforts of field service for the idle luxury of a hospital ship." Lieut. Boraston expects shortly to be well enough to resume active service.

Sapper E. Jackson, of Lytham, has been awarded a commission. He is attached to the 12th Field Company Royal Engineers, and last year he won the D.C.M. Lieut. Jackson was an electrical engineering student in the Preston tramways department prior to the war.

It is announced that Mr. W. T. Hatch is retiring from the position of engineer-in-chief to the Metropolitan Asylums Board.

War Casualties.—The following casualties are announced :—

Capt. C. E. Hoffmeister (S. Wales Borderers), formerly science master of Middleton School, Bognor, is reported wounded.

Lieut. John Wilson (Manchester Regt.), reported wounded, was an electrical engineer at the British Thomson-Houston Works, Rugby, before the war.

Lieut. H. L. Hull (Canadian F. A.), who was reported missing on June 2 and believed to have been killed on that day, was an engineering graduate of the McGill University, Montreal.

Col. W. F. M. Newall, who is wounded and in a London hospital, practised as a civil engineer before the war.

APPOINTMENTS VACANT AND FILLED.

An electrician is required for the Gold Coast Government Waterworks. Salary £300, rising to £350, per annum, with free quarters. Applications to the Crown Agents for the Colonies, 4, Millbank, London, S.W. *See an advertisement.*

Mr. D. T. Miles has been appointed mains superintendent at Bath.

INSTITUTIONS AND SOCIETIES.

Engineering Standards Committee.—At a special meeting of the Main Committee (Sir John Wolfe Barry, K.C.B., chairman), held on July 27th last, Mr. Charles le Maistre, A.M.Inst.C.E., M.Inst.E.E., who has been in charge of the work of the electrical section since 1903, was appointed Secretary to the Committee in succession to the late Leslie S. Robertson, M.Inst.C.E., who was lost with Lord Kitchener in the disaster to H.M.S. "Hampshire" whilst on an important Government mission.

Municipal Tramways Association.—The annual conference of the Municipal Tramways Association will be held in London on September 21st and 22nd.

The Electric Vehicle Committee.—Considerable progress has been made during the past two years by the Electric Vehicle Committee of the Incorporated Municipal Electrical Association, in the matter of organising facilities for road transport by means of electric-battery vehicles. The constitution of the Committee is on a broad basis. It includes representatives of the parent Association, the Commercial Motor Users' Association, the Royal Automobile Club, the Society of Motor Manufacturers and Traders, the Provincial Electric Supply Companies, the Electrical Contractors' Association, the British Electrical and Allied Manufacturers' Association, the Incorporated Association of Electric Power Companies, the Institution of Municipal and County Engineers, and of the Tramways and Light Railways' Association. The Chairman of the Committee is Mr. R. H. Chattock, City Electrical Engineer of Birmingham. The hon. secretary is Mr. F. Ayton, Chief Engineer and Manager of the Ipswich Corporation Electric Supply and Tramways Departments. The electric vehicle has its own special field in goods-delivery work in urban and suburban areas, and the excellent results that have, so far, resulted from its use by some of the largest and most up-to-date business firms would seem to indicate quite a considerable field for its extended employment in the future, not only for the delivery of merchandise but also for passenger-carrying work in and about towns and cities. The economy in operating cost and the simplicity of the mechanism are, of course, the main features of this class of vehicle. While these advantages were manifest in the period before the war, the present scarcity of horses, the high price of fodder and the rising cost of petrol, very greatly enhance the merit of economy possessed by "the electric."

Diesel Engine Users' Association.—At the July meeting of the Association, after further new members had been elected, questions in connection with the use of tar oils as fuel in Diesel engines were further discussed.

Mr. Napier Prentice (Felixstowe) gave his experience in regard to the use of tar oil which he had obtained from a local distiller. He had found difficulty in obtaining quotations and in getting the work in hand of altering a Diesel engine so as to adapt it specially for the use of tar oil in the manner which had been successfully employed on the Continent, and he therefore decided to try the effect of using tar oil in one engine without any alteration. At about half-load he found this was not successful, as misfiring and a smoky exhaust occurred. He was advised to work with a sharp edge on the flame plate, and with this alteration and a slightly different quality of tar oil he obtained satisfactory results, so long as the engine was not run below about three quarters of full load. The blast pressure at all running loads was maintained at five atmospheres below the normal pressure used when running with petroleum fuel oil, and the cooling water outlet was restricted so as to maintain a temperature of 125°F., as against 110°F., which had been maintained when using the other class of fuel oil.

Mr. F. Banks Warner gave some information as to the general position in regard to the question of obtaining suitable supplies of tar oils, including delivery on site. At the present time the high railway rates for this class of business were a serious handicap to its development in certain parts of the country where local supplies were not available.

Mr. P. H. Smith read a Paper on "Crankshaft Breakages in Diesel Engines." He attributed practically all cases of shaft fractures to a lack of alignment of the main bearings, due to wear, or to negligence during erection, or to defective foundations. He stated his views as to the best method of re-bedding a crankshaft, and of securing perfect alignment, and as to the best proportions in the design of crankshafts for Diesel engines.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for August.

Headquarters and Range.—The headquarters will be closed during August, except on Tuesday evenings. The range will be open on Thursday evenings only. On these evenings the Sergeant-Major will take charge and be responsible for the maintenance of order and discipline. Recruits are urged to take advantage of this arrangement for drill and shooting.

Instruction Classes.—Instruction classes at Regency-street will be held as usual for Platoons Nos. 9 and 10.

Camp.—The camp at Otford will be available until Aug. 31. Members wishing to attend should enter their names at headquarters on the sheet provided for the purpose. The cost will be about 3s. per day. Members should provide themselves with two blankets, knife, fork spoon, plate, mug and a spare pair of boots.

Entrenching.—As many members as possible should endeavour to attend the Sunday entrenching parades, in order that the work to be done may be completed as expeditiously as possible. Parade in uniform as usual at Victoria Station (S.E. & C. Railway) Booking Office, 8.45 a.m. Members are reminded that this work is of national importance, and therefore all who are able to put in Saturdays or occasional week days are urged to do so. They are reminded that they can obtain railway vouchers from the booking clerk by showing their cap badges.

TESTS ON OIL-SWITCHES.*

BY BRUNO BAUER.

The previous reports of the Commission were principally concerned with the determination of the energy developed in the switch when it is operated under given load conditions. The present report has the object of elucidating the conditions that must be fulfilled for the switch-energy to be a minimum. It has already been shown that the switch-energy depends mainly on the magnitude and power-factor of the load and that for a given load the switch-energy increases with increasing angle of lag of the load current, reaching very high values at a phase angle of 90 deg. In further explanation of this fact it is necessary to note that in the expression for the switch-energy $A=CI_0Et_r$,† I_0E is the product of the current and the *open-circuit voltage*, and does not denote the load volt-amperes I_0V, in which expression V is the *terminal voltage*. The reason for writing E instead of V in the expression for the switch-energy is given by the consideration that the alternating-current arc formed at the switch contacts breaks after each half-period, and its re-establishment takes place at the open-circuit voltage, which quantity, therefore, governs the magnitude of the "interrupted load" I_0E, which must be distinguished from the "switched load" I_0V. For a similar reason the phase angle of the load must be taken as the angle between I_0 and E when determining the duration of the arc t_r. It thus appears that this phase angle is in general not zero on non-inductive load, and that the condition of the "purely ohmic" circuit is only obtained if the load is so small in comparison with the capacity of the generating plant that the internal phase angle of the latter is negligibly small. When opening on a short-circuit the great switch-energy developed results from the large value assumed by the quantity I_0E, although the quantity I_0V has a zero value.

This fact is illustrated in Fig. 1, which shows the relation between the "switched load" ($P=I_0V\cos\varphi_n$) and the corresponding values of the "interrupted load" (I_0E) for two values of the external power-factor at a constant open-circuit voltage of 6,000 volts. The maximum switch-energy obtained for short-circuit on the generator used has the value $E^2/x_a=626$ k.v.a., the reactance of the machine being given by $x_a=57{\cdot}4$ ohm.

The important influence of the power-factor of the load suggests that the switch-energy may be decreased by reducing the reactance in circuit as far as possible, or by introducing a resistance into the circuit during the operation of switching. Both these methods are fully considered below, and for the moment it is necessary to point out that the apparent conflict between the first method and the common American practice of using current-limiting reactances will be explained.

The switch-energy is also dependent on the values of the quantities C and t_r and theory and experiment show that C lies within close limits, but increases somewhat in value as t_r increases. The variation of C, which takes place between the limits 0·01 and 0·08, is related to the power-factor of the load, and the value appears to be little affected by the current and voltage. If C is plotted as a function of the phase-displacement, the curve starts at about 0·01 for $\tan\varphi=0$, and rises asymptotically to the value of 0·08 for the large angles of lag that occur at short-circuit. The curves of Fig. 2 are drawn with the aid of the relation just described. In the last report * it has already been shown that the duration of the arc depends on the phase lag of the current according to the relation

$$t_{r,L}=t_r(1+k_1\tan\varphi+k_2\tan^2\varphi+\ldots), \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which t_r is the value of t_r in the case of the "purely ohmic" circuit, and $t_{r,L}$ is the value of t_r when the circuit contains inductance. The expression in brackets has not yet been determined experimentally,

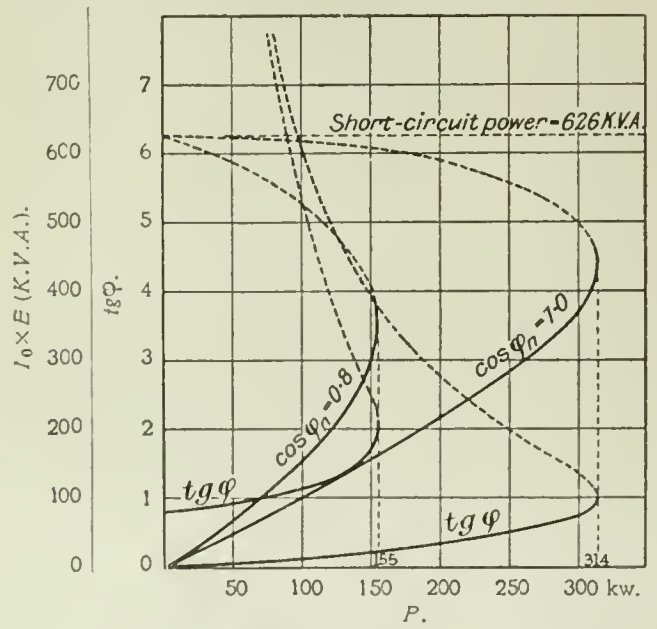


Fig. 1.—"Interrupted Load" and Phase Lag.

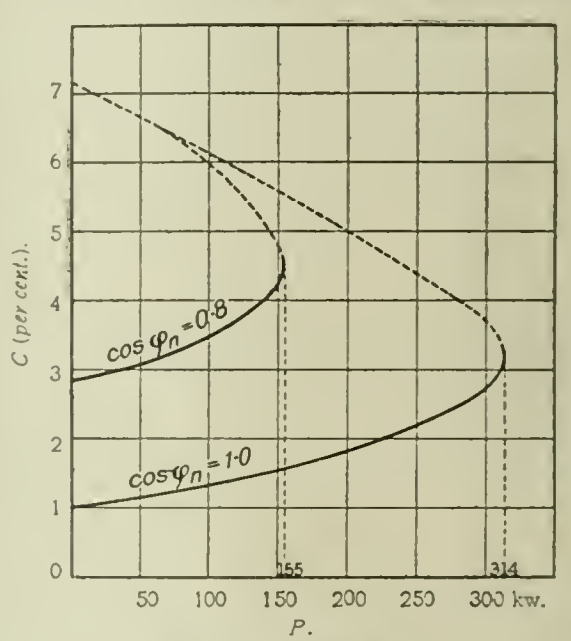


Fig. 2.—Constant C.

but Fig. 3, obtained for non-inductive load with a variable current limiting reactance in circuit, shows that the duration of the arc is closely related to the quantity $\tan\varphi$. The following table compares values of t_r and $t_{r,L}$ obtained by switching different loads off a single 1,000 kw. generator and the whole Beznau-Löntsch station.

The table shows that when switching off 400 k.v.a. from the single generator the duration of the arc is 7·4 times as great as when switching the same load off the combined station. A reference to Fig. 3 shows that on short-circuit of the single generator, for which condition the calculated "interrupted load" is 480 k.v.a., the duration of the arc would be still further increased. Very long arcs will be drawn at the switch, and if the speed of the switch is 55 cm. a second, the longest arc corresponding to the figures in the table would be 6·5 cm.

Figs. 4 and 5 are drawn to show the dependence of the duration of arc and switch-energy on the magnitude of the "switched load"

* Being an abstract of the Third Report of the Commission on High-tension Apparatus and Fire Protection, appointed by the Schweizer Elektrotechn. Verein und Verband Schweizer Elektrizitätswerke. The report appears in the "Bulletin" (No. 4 of 1916) of the Schweizer Elektrotechn. Verein, known also as the Association Suisse des Electriciens. For previous reports, *see* The Electrician, March 3, 1916, and April 7, 1916.

† *See* The Electrician, Vol. LXXVI., p. 768, March 3, 1916.

* The Electrician, March 3, 1916, p. 768, equation (6).

Non-inductive Load, 6,000 Volts.

Interrupted load in K.V.A.	Single machine with series reactance. Tan φ. Measured.	t_r in seconds. Calculated.	C in per cent. Measured.	Switch-energy in K.W. sec. Calculated.	Beznau Löntsch Station ($\tan\varphi=0$ approx.). t_r in seconds. Measured.	$(1+k_1\tan\varphi+\ldots)=t_{r,L}/t_r$. Calculated.	C in per cent. Measured.	Switch-energy in K.W. sec. Calculated.
100	0·46	0·032	1·9	0·061	0·013	2·37		0·015
150	0·70	0·034	2·6	0·135	0·014	2·47		0·023
200	0·97	0·035	3·2	0·228	0·014	2·49		0·031
250	1·30	0·037	3·7	0·347	0·014	2·51	1·1	0·041
300	2·15	0·043	4·5	0·580	0·015	2·77	Constant	0·051
350	5·30	0·057	6·0	1·20	0·016	3·59		0·061
400	19·0	0·119	6·5	3·10	0·016	7·40		0·071

for the same single machine without series reactance. The parts of the curves drawn in full lines correspond to the normal range of loads, whereas the dotted portions refer to exceptional loads reaching into the short-circuit region.

The conditions under which oil-switches are expected to operate may be classified under three groups.

I. The switch has to break a definite useful load in kilowatts. The switch-energy depends greatly on the power-factor of the load, and from Fig. 5 it will be seen that for $P=155$ kw. the switch-energy at $\cos\varphi_n=0{\cdot}8$ is about nine times as great as for $\cos\varphi_n=1$. Thus, the magnitude of the "switched load" is no measure of the loading of the switch.

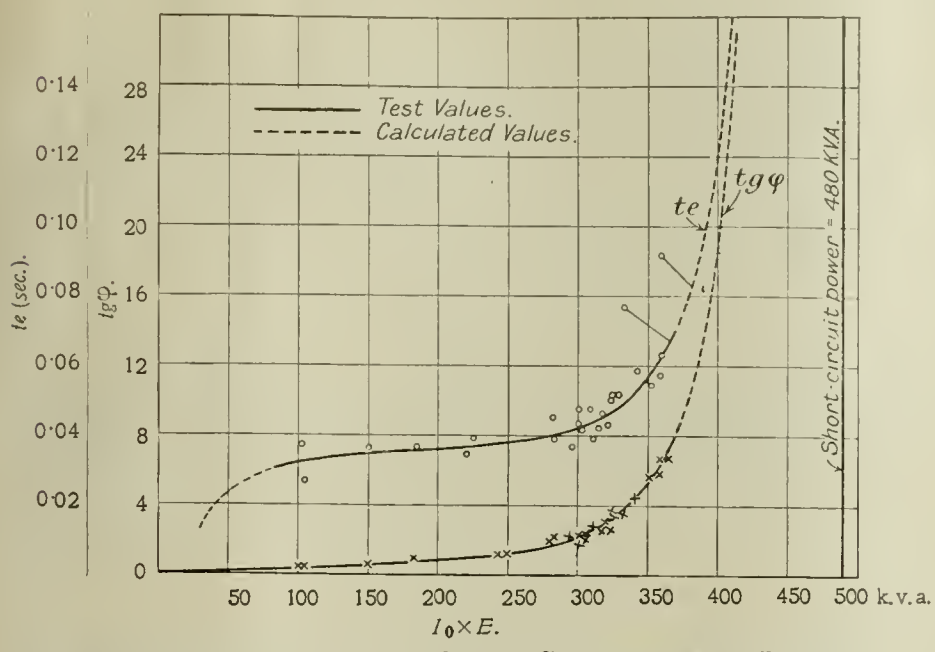


Fig. 3.—Switching Tests on a Single Generator with Protective Reactance. 6,000-volt on Open Circuit. Non-inductive Load.

II. More frequently the switch is set to operate at a definite current. This is equivalent to breaking circuit at a given value of the "interrupted load" I_0E. Reference to Fig. 1 shows that for $I_0E=510$ k.v.a., or a maximum current of 85 amperes, we obtain a load of 295 kw. at $\cos\varphi_n=1$, and that at $\cos\varphi_n=0{\cdot}8$ the load is decreased to 110 kw. This corresponds to a switch-energy of 0·84 kw. second at non-inductive load and of 1·65 kw. second at the inductive load. Thus, the magnitude of the "interrupted load" is no definite criterion of the loading of the switch, the loading being doubled in the example quoted for a variation of the power-factor from 1 to 0·8. Even if the power-factor of the load is constant the switch-energy A depends greatly on the internal phase displacement in the generators, as will be seen from the table. To show this more clearly, Fig. 6 has been drawn for non-inductive load at 6,000 volts

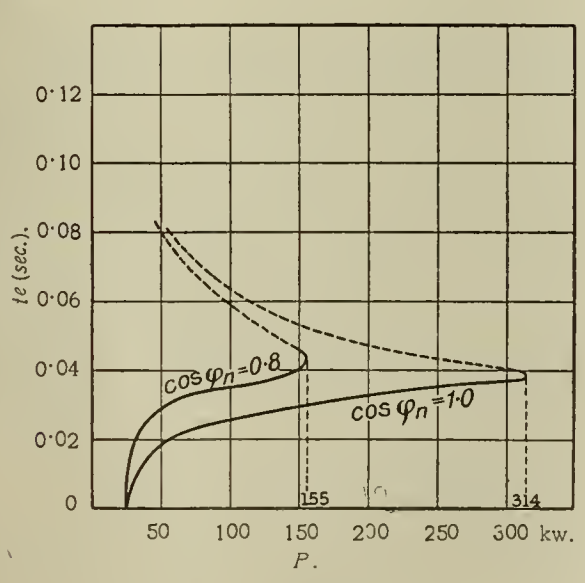


Fig. 4.—Duration of Arc.

thrown off (*a*) the single machine with series reactance, giving a total reactance of 75 ohms, (*b*) the single machine without series reactance, giving a total reactance of 57·4 ohms, (*c*) the whole Beznau-Löntsch station, without series reactance giving a total reactance of less than 3 ohms. It may be seen from the curves that for switching off at a given limiting current no advantage to the switch is gained by the use of current-limiting reactances.

III. The switch has to open on a short-circuit. In this case the provision of a series reactance is a safeguard only in limiting the transient maximum value of the current, but does not relieve the switch, as it will generally not operate until several half periods have elapsed after the passage of the maximum current rush. It is not necessary or desirable that the switch should open during the large initial current rush, and we may, therefore, assume that the conditions will be such that the switch has to deal only with the normal permanent short-circuit current. A series reactance has the beneficial effect of reducing the value of this short-circuit current, and the harmful effect of increasing the duration of the arc.

The power-factor and magnitude of the load to be controlled may be improved by the use of two-step switches that insert resistance on the first step before breaking circuit on the second step,* but the limitations of this method will be seen below in the discussion of the proportions in which the total switch-energy is divided between the two steps of the switching operation. The main results of the investigations that follow may now be stated.

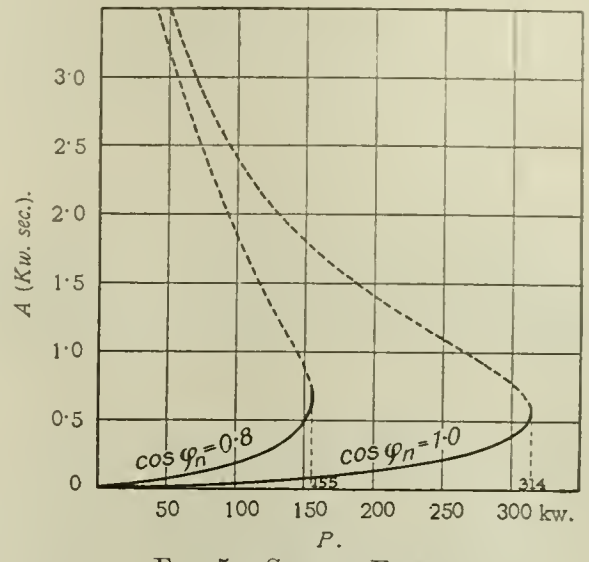


Fig. 5.—Switch Energy.
$A=I_0 . E . C . t_e.$

The oil-switch suffers the maximum loading if it has to interrupt in one step the greatest short-circuit load that can take place at the point where it is installed.

The provision of a preliminary step on which a reactance is inserted into the circuit does not ensure a diminution of the switch-energy. It is only possible to be certain that the switch-energy will be diminished by this device if very large reactances are used, and in this event the protection given is afforded only to the second step of the switch, the first step having to break almost the full short-circuit load. If, however, reactance is included permanently in the circuit, a resistance inserted on the first step will certainly afford a protection and the switch-energy will be a minimum if the resistance is chosen so as to be equal to the reactance of the path traversed by the short-circuit. The "interrupted load" will then be divided

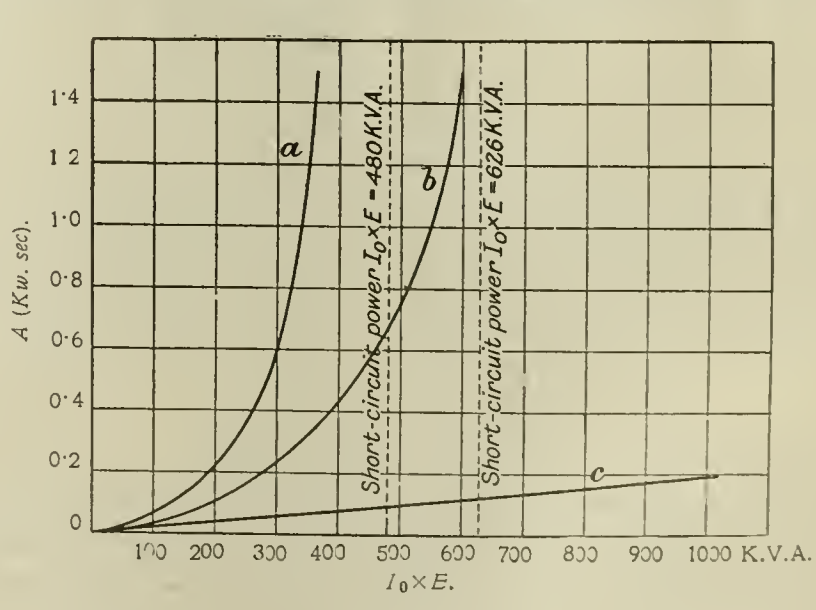


Fig. 6.

nearly equally between the two steps of the switch and the power-factor will be raised, on both steps, to a value that precludes the formation of dangerous arcs. If the oil-switch breaks a circuit in which the reactance is appreciably smaller than the resistance inserted by the switch, the major portion of the load will be thrown on to the first step and *vice-versa*.

The Two-step Oil-switch with Non-inductive Protective Resistance.—We will assume that the resistance r_z is inserted on the first step, and

* *See* Fig. 3, p. 9, The Electrician, April 17, 1916.

the current flowing is I_0, and that after the insertion of r_z the current takes a new value I' and the voltage across r_z is E'. The first step of the switch has, therefore, to interrupt a load of I_0E'. If the second step in the switching occurs after the arc is extinguished between the contacts of the first step, the load remaining to be interrupted is $I'E$, where E is the open-circuit voltage of the generator.

If r and x are the total resistance and reactance in the circuit to be broken, it is easily shown that

$$I_0E'=E^2r_z/\sqrt{[x^2+r^2][x^2+(r+r_z)^2]}, \quad . \quad . \quad . \quad . \quad (2)$$

and

$$I'E=E^2/\sqrt{x^2+(r+r_z)^2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The maximum short-circuit load is given by putting $r=0$ in these equations.

We thus find that

$$\text{the "interrupted load" on the first step}=I_0E'=\frac{E^2}{x}\cdot\frac{r_z}{\sqrt{x^2+r_z^2}}, \quad . \quad (4)$$

$$\text{the "interrupted load" on the second step}=I'E=\frac{E^2}{x}\cdot\frac{x}{\sqrt{x^2+r_z^2}}, \quad . \quad (5)$$

and

$$I_0E'+I'E=\frac{E^2}{x}\cdot\frac{x+r_z}{\sqrt{x^2+r_z^2}}. \quad . \quad . \quad . \quad . \quad . \quad (6)$$

As E^2/x is the maximum short-circuit load to be dealt with, it appears from equation (6) that for finite values of r_z the total "interrupted load" is greater than the maximum short-circuit load. It follows from the above relations that the maximum value of the sum $I_0E'+I'E$ is obtained when $r_z=x$, and that in this case $I_0E'=I'E=E^2/(\sqrt{2}x)$.

If, for instance, the switch has to open on a short-circuit of a large 6,000-volt station of combined reactance 2 ohms, we have $E^2/x=18{,}000$ k.v.a., and if $r_z=x=2$, the switch energy is 12,750 k.v.a. on each step; if $r_z=10$ the energy is divided so that 17,600 k.v.a. and 3,500 k.v.a. fall respectively on to the first and second contacts. An increase of resistance does not greatly affect the division of these loads, so it appears that with resistances of the order of 100 ohms, as are commonly used with oil-switches, practically the whole of the work is done on the first step of the switch, which is often not constructed to withstand the formation of an arc.

In order to calculate the switch-energy on the two steps of the switch it is necessary to know the phase angles between the currents and open-circuit voltages. For the first step we are concerned with the angle φ_1 between I_0 and E' after the conditions have become stationary, and for the second step with the angle φ_2 between I' and E. If we denote the angle between I_0 and E by the symbol φ_0 we have:—

$$\tan\varphi_0=\frac{x}{r};\ \tan\varphi_2=\frac{x}{r+r_z};\ \tan\varphi_1=\frac{\tan\varphi_0-\tan\varphi_2}{1+\tan\varphi_0\tan\varphi_2}.$$

From these equations it follows that:—

$$\cot\varphi_1=\cot\varphi_0+\frac{r^2-x^2}{xr_z}, \quad . \quad . \quad . \quad . \quad . \quad (7)$$

and

$$\cot\varphi_2=\cot\varphi_0+\frac{r_z}{x}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Regarding φ_0, r and x as given and noting that the additive fractions in the equations (7) and (8) are positive for all values of r_z, it follows that the phase-angles on both steps are diminished for all values of the protective resistance. With increasing values of the resistance φ_1 tends to approach the value φ_0 and φ_2 always has values less than φ_0. For the case of short-circuit ($\varphi_0=90$ deg.) we obtain

$$\tan\varphi_1=\frac{r_z}{x}, \text{ and } \tan\varphi_2=\frac{x}{r_z}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

If $r_z=x$, the angles φ_1 and φ_2 become equal.

In the above it has been tacitly assumed that the angles φ_1 and φ_2 and the voltages E' and E assume their stationary values immediately after the rupture of the arc. This is true for the first step, but requires correction for the second step. Suppose, for instance, that the generator is short-circuited. The current I_0 will lag nearly 90 deg. behind the open-circuit voltage, and when the first contact is opened it will at first be bridged by an arc carrying the current I_0. This arc will be extinguished near the time when the current passes through its zero value, at which time the voltage E' has its maximum value. Thus, the magnitude of the current I' is given by the condition that the short-circuited leads are switched on through the resistance r_z at the moment when the open-circuit voltage has its maximum value. The establishment of the current I' will take an appreciable time, and, as far as the phase angle φ_1 is concerned, we may say that it starts from an initial zero value and increases to its final value $\tan^{-1}(r_z/x)$ with a speed that increases with the rate of establishment of the stationary conditions in the circuit. In using this value of φ_1 in the further calculations we are allowing for the most unfavourable case that is possible.

We are now in a position to calculate the switch-energy on the two steps from the formula—

$$A_t=A_1+A_2=I_0E'C_1t^r{}_1(1+k_1\tan\varphi_1+\ldots) + I'EC_2t_{r2}(1+k_1\tan\varphi_2+\ldots) \quad . \quad (10)$$

The result of this calculation is shown in Fig. 7 for a complete short-circuit of the Beznau-Löntsch generating station, the combined reactance being 2 ohms. For very small resistances excessive switch-energy is developed on the second step; a marked minimum of the total switch-energy appears at $r_z=1{\cdot}85$ ohms, and at $r_z=2{\cdot}2$ ohms the energy is the same on both steps; when $r_z>10$ the second step is practically inoperative.

The minimum switch-energy is seen to be developed in the neighbourhood of the value $r_z=x$, and a calculation shows that this is not an accidental result of the particular conditions chosen, but that for any short-circuit the minimum value will be obtained if the protective resistance is taken equal to the total reactance in the circuit.

The Two-step Oil-switch With Protective Reactance.—If a reactance x_z is inserted on the first step we have

$$I_0E'=\frac{E^2}{x}\cdot\frac{x_z}{x_z+x} \text{ and } I'E=\frac{E^2}{x}\cdot\frac{x}{x_z+x}. \quad . \quad . \quad . \quad (11)$$

The sum of these quantities is E^2/x, and the total "interrupted load" is therefore always smaller than in the case of the use of a protective resistance (*see* equation 6). This advantage is discounted if we consider the values of φ_1 and φ_2 as given by the relations—

$$\tan\varphi_1=\tan\varphi_0+\frac{x^2+r^2}{r\,.\,x_z}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

and

$$\tan\varphi_2=\tan\varphi_0\frac{+x_z}{r}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

These equations show that the reactance x_z always increases the angles of lag φ_1 and φ_2, and that for $\varphi_0=90$ deg. both $\tan\varphi_1$ and $\tan\varphi_2$ become infinite for all values of x_z. Notwithstanding this harmful effect the switch-energy will be diminished if the reactance is chosen large enough to reduce the short-circuit current to a sufficiently low value, but it appears that for such large reactances the division of the load between the two steps will become unsatisfactory, the first step having to deal with practically the whole of the load. The conditions are clearly shown in the following table drawn up for short-circuit of the generating station that has been referred to above. For this station we have $E=6{,}000$, $x=2$ giving a maximum short-circuit load of $E^2/x=18{,}000$ k.v.a. The resistance in the circuit has been taken as 0·1 ohm.

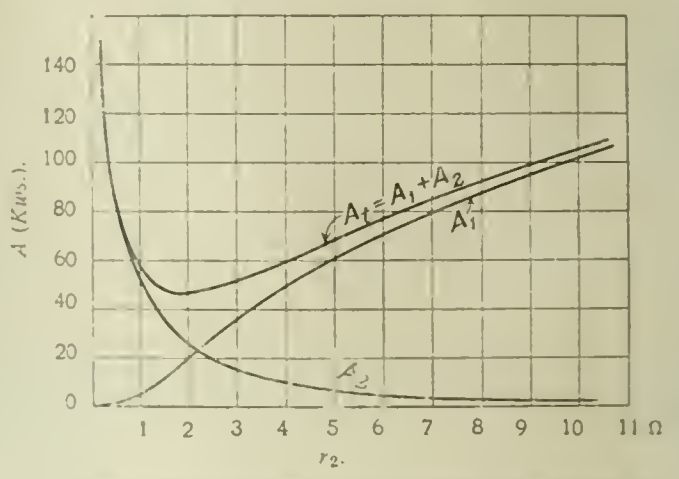


Fig. 7.—Switch with Protective Resistance.
Short-circuit with $E=6000$ v., open circuit voltage $x=2$.

It will be seen that for $x_z=x=2$ the loads on the two steps are equal, but the value 10 for $\tan\varphi_1$ and $\tan\varphi_2$ is far too high to promise

r_z or x_z in ohm	With protective resistance r_z. "Interrupted load." First step, K.v.a.	Second step, K.v.a.	$\tan\varphi_1$	$\tan\varphi_2$	With protective reactance x_z. "Interrupted load." First step, K.v.a.	Second step, K.v.a.	$\tan\varphi_1$	$\tan\varphi_2$
0	0	18,000	0	20·0	0	18,000	∞	20
1	8,100	16,100	0·5	2·0	6,000	12,000	60	30
2	12,750	12,750	1·0	1·0	9,000	9,000	40	40
3	15,000	10,000	1·5	0·65	10,800	7,200	33·3	50
5	16,750	6,700	2·5	0·4	12,850	5,150	28	70
7	17,400	5,000	3·5	0·3	14,000	4,000	25·7	90
10	17,600	3,500	5	0·2	15,000	3,000	24	120
20	17,900	10,700	10	0·1	16,360	1,640	22	220

a satisfactory protective effect of the reactance. The load per step has been halved, but there is no less danger of the production of a destructive arc at 9,000 k.v.a. with tan $\varphi=40$ than at 18,000 k.v.a. with tan $\varphi=20$. The resistance of 2 ohms is more satisfactory, the loads being broken at 12,750 k.v.a. with tan $\varphi=1$. Increase of the reactance above 2 ohms does not relieve the first step appreciably, which has to interrupt a load of about 15,000 k.v.a. at nearly 90 deg. phase-lag. It thus appears that no certain protection is afforded by the insertion of reactance by the first step of an oil-switch.

If reactive coils are inserted permanently into the circuit for any object the resistance on the first step of the oil-switch should be adjusted so as to be equal to the total reactance in the circuit, if the switch-energy is to be a minimum. The minimum values will decrease as the values of r_z and x increase together. It is, however, not possible to be sure that the reactance will be equal to the resistance for all the short-circuits that may have to be cleared by the switch. It is, therefore, of interest to examine the behaviour of a switch protected by a definite resistance r_z when operating on a short-circuit of variable reactance.

The equations 4, 5 and 9 show that the load interrupted on both steps decrease with increasing reactance, and that the rate of decrease is greater for the first step than for the second step. At the same time tan φ_1 decreases while tan φ_2 increases linearly with x. The "interrupted load" preponderates on the first step when $x<r_z$, and on the second step when $x>r_z$. Using the equation (10) we gather that for low values of x the switch-energy is mainly thrown on to the first step, but that for large values of x the energy on the first step sinks to negligible values, and the total switch-energy is practically developed on the second step.

It thus appears that the resistance r_z should in any particular case be so chosen that it is equal to the smallest value of the reactance that can possibly be included in a short-circuit. If this is done the

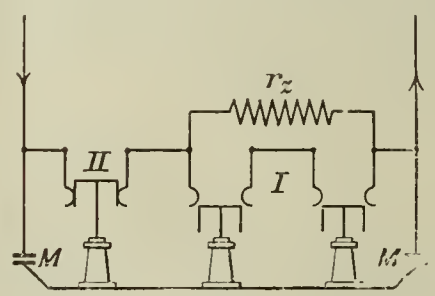


Fig. 8.

switch energy will be a minimum and will be equally divided between the two steps on the switch, and for any short-circuit of greater reactance the loading of the switch will be decreased, although it will no longer be divided equally between the two steps. On account of the inclusion of the feeders switches at the end of long feeders will require greater resistances than the switches installed in the generating station.

It is common practice to provide a resistance, r_2, of as much as several hundred ohms to diminish the current-rush on switching in a large transformer or for a similar purpose. If such values of the resistance are employed the effect of a short-circuit on the low-tension side of the transformer will be to throw the whole load on to the first step of the switch. In such cases the arrangement shown in Fig. 8 may be adopted. The main contacts M are used only for current-carrying purposes, and are opened before the contacts I and II open in succession. The heavy load on the contacts I is divided between four breaks in series.

The most perfect method of switching off large loads would appear to be by successive insertion of resistance-steps by a number of switches in series with one another.

CALCULATION OF FLYWHEEL MOTOR-GENERATOR SETS.*

A number of interesting Papers on the large electric winder, recently installed by the North Butte Mining Co., of Montana, have been read before several of the engineering institutions in America. One of these, by Mr. W. Sykes, describing the electric equipment, was given in abstract in The Electrician, Vol. LXXV., p. 955. A further description by Mr. F. Moeller in a Paper read before the American Institute of Mining Engineers contained a note on the preliminary calculation of flywheel motor-generator sets, by Mr. C. D. Gilpin. The conditions to be met in this installation were as follows:—

Weight of rock to be raised per trip, 7 gross tons ...	15,680 lb.
Weight of skip ...	8,000 lb.
Weight of cage ...	1,800 lb.
Maximum depth of hoisting ...	4,000 lb.
Diameter of rope ...	1⅝ in.
Total weight suspended on one rope from drum ...	42,000 lb.
Normal hoisting speed per minute ...	2,760 ft.
Maximum hoisting speed, per minute ...	3,000 ft.

Desired capacity: 200 tons per hour from 4,000 ft. depth.

The hoist consists of two 12-ft. drums fitted with a clutch, post-brake and band-brake. The drums are mounted on a shaft supported in three bearings, this shaft having a flanged coupling to connect to the motor. The clutches and post-brakes are operated by oil cylinders, the pressure being supplied by an accumulator and an electrically-operated pump. The band-brakes are operated by hand wheels.

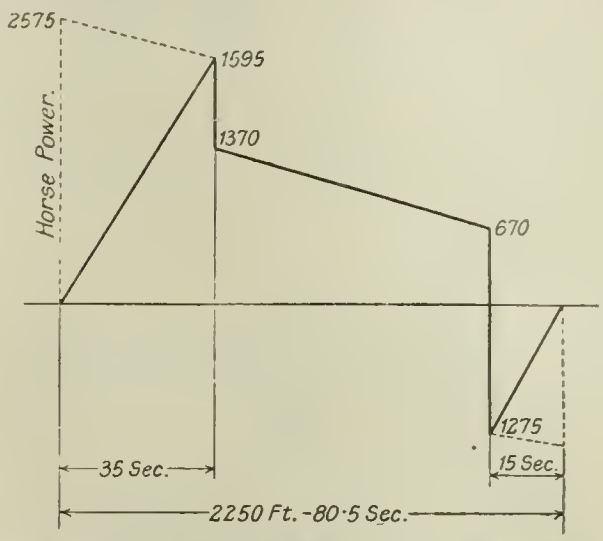


Fig. 1.—Power Curve at 10 per cent. below Normal Speed.

The drums are 12 ft. in diameter by 9 ft. 4 in. face, grooved to hold 5,000 ft. of 1⅝ in. rope in two layers. The clutches are designed to take a load of 50,000 lb. on a 12 ft. diameter, with a factor-of-safety on all parts of not less than eight. The clutches are of the flat friction type, consisting of two heavily-ribbed annular rings, faced with wood, supported on a six-armed spider keyed to the shaft. These rings clamp a flat steel plate bolted to the drums, and are moved by six sets of toggle arms connected to a sliding sleeve and rock shaft operated by an oil cylinder.

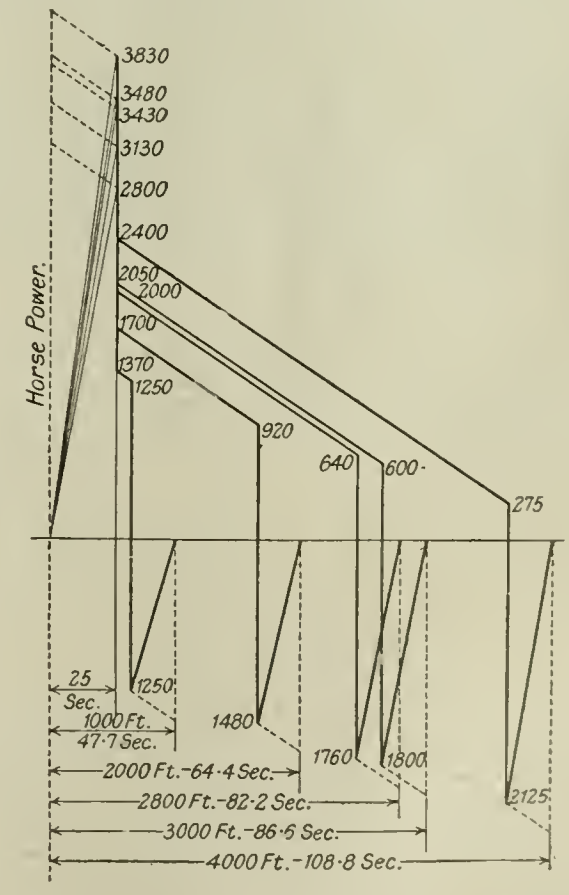


Fig. 2.—Calculated Hoisting Speed and Power Curves.

The post-brakes are made of plates and angles in the form of a box girder. They are of the parallel type applied by weights and released by oil cylinders. The combined weight of drum shaft with two drums and two clutches is 300,000 lb.; the radius of gyration is 4·86 ft.

The electrical equipment consists of a 1,850 h.p., 71 revs. per min.,

* Abstract of a Paper read before the American Institute of Mining Engineers.

550 volt, direct-current, direct-connected hoist motor, directly connected electrically to a generator of equivalent capacity, which is driven by a 1,400 H.P., 505 revs. per min., alternating-current motor. A 100,000 lb. flywheel is mounted between the motor and the generator of the motor-generator set. Both the hoist motor and the generator are designed to carry high overloads. The field current of the generator is not regulated directly, but by means of magnetic switches operated by the master controller.

Fig. 1 is a power curve taken when the operator was hoisting at a speed about 10 per cent. below normal from a depth of approximately 2,250 ft. Fig. 2 shows a series of calculated curves. As a matter of interest, the values from the 1,000 ft. level curve and 3,000 ft. level curve have been applied to equation (4) in the note appended to the Paper, with the result that a flywheel sufficient to smooth out all the peaks is indicated, based on assumed values for demand and meter charges. Calculations made from these curves indicate for the 1,000 ft. level that a 90,000 lb. wheel will be required, while for the 3,000 ft. level a 111,000 lb. wheel will be necessary, a minimum time of 15 seconds being allowed for loading in each case. In these calculations the slip was taken at 20 per cent.

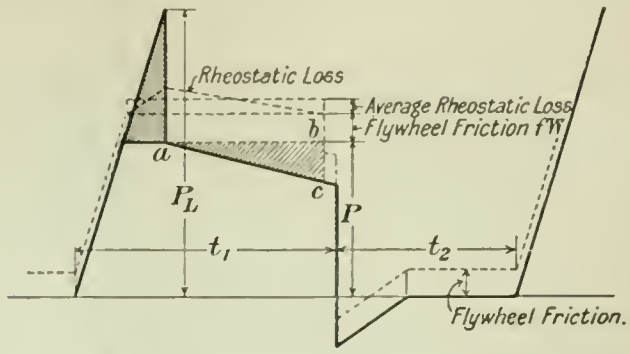


Fig. 3.—Power Curve for Flywheel Calculations.

Finally, there are many instances in which a short inspection of the load cycle and the power contract will make it certain that a flywheel system is necessary. Just how much of the peak it is desirable to cut off is not so easily determined. The following method of calculation may, perhaps, be of interest.

A curve should be plotted, similar to the one shown in solid lines on Fig. 3, this curve to represent the power at the flywheel shaft. The peak cost per horse-power per trip (C_1) should next be determined by dividing the peak charge per horse-power per month by the probable number of trips per month, allowing for the losses in the alternating-current motor. The current charge (C_2) per horse-power-second should be figured. It is obvious that the acceleration peak of the curve will be comparatively easy to do away with, and this point should be first considered. Assuming a constant maximum slip, s, for the flywheel (expressed as a decimal fraction of normal speed), and calling the weight of the flywheel, W, energy from wheel (in horse-power-seconds) equals

$$\frac{Wv^2(2s-s^2)}{2g\times 550},$$

where v is the equivalent linear velocity of the flywheel in feet per second ($v = 2\pi$ revolutions per second $\times$ radius of gyration of wheel).

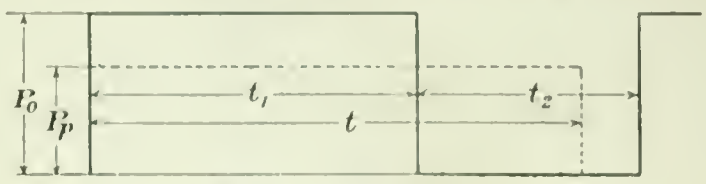


Fig. 4.—Load Curve.

This expression may be more conveniently written, nW; and to obliterate the acceleration peak it is only necessary to equate this value to the energy in the acceleration peak above the gravity load.

Referring to Fig. 3, re acceleration would be represented by the area, a, b, c. The actual peak at the wheel is P plus the wheel friction and the rheostatic losses, and the power curve has assumed an approximately rectangular shape. It would not, therefore, be far out of the way in figuring the desirability of a further increase in the flywheel, to assume that the load curve is a rectangle as shown in Fig. 4, in which t_1 is the time of hoisting up to retardation, P_o the average power at the wheel required by the hoist during this period, and t_2 the time of retardation plus the time of rest. P_p is the power delivered at the wheel shaft by the alternating-current motor, the difference between P_o and P_p being supplied by the wheel. The energy $P_o t_1$ then equals $P_p t$. The negative power has been disregarded, as it does not ordinarily enter largely into the final result.

Let f equal friction horse-power per pound of flywheel, and T = total time wheel runs per trip. Since approximately all the power passes through the motor generator set while the latter is accelerating or retarding, the average rheostatic loss in power equals

$$\frac{s}{2}(P_p+fW).$$

The peak load, therefore, equals

$$P_p+fW+\frac{s}{2}P_p+\frac{s}{2}fW=\left(1+\frac{s}{2}\right)(P_p+fW).$$

$P_p = P_o$—the power supplied by the wheel $= P_o - \frac{nW}{t_1}$.

Substituting, peak load equals

$$\left(1+\frac{s}{2}\right)\left(P_o-\frac{nW}{t_1}+fW\right).$$

Let the peak load cost of power per trip $= F_1$.

$$F_1 = C_1\left(1+\frac{s}{2}\right)\left(P_o-\frac{nW}{t_1}+fW\right)$$

The rate of change of peak cost with regard to wheel weight is the first derivative of F_1, or $dF_1\ dW$.

$$\frac{dF_1}{dW}=C_1\left(1+\frac{s}{2}\right)\left(f-\frac{n}{t_1}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

With ordinary values for n, t_1, and f, this rate of change will be negative, showing a decrease in peak cost for an increase in wheel weight.

The energy consumption at the flywheel shaft is the sum of three quantities: the energy demanded by the hoist, the energy consumed by the flywheel, and the energy lost in the slip regulator rheostat. The first of these quantities is represented by $P_o t_1$, and the second by TfW, it being remembered that T is the total running time of the wheel per trip of the hoist.

The third quantity (E_3) is equal to the energy lost when introducing resistance plus the energy lost while resistance is being cut out; it may be expressed as follows:—

$$E_3=\frac{s}{2}(P_p+fW)t_1+\frac{s}{2}(P_p+fW)(t-t_1)=\frac{s}{2}(P_p t+tfW)=\frac{s}{2}(P_o t_1+tfW).$$

The quantity t is a variable dependent on W, and may be expressed in terms of the latter; but for approximate calculations of this kind, it is much simpler to equate t to T, which is its limit. The error so introduced, as will be shown hereafter, will be small, when determining the rate of change of energy cost.

The total energy, E, may therefore be approximated as follows:—

$$E=P_o t_1+TfW+\frac{s}{2}(P_o t_1+TfW).$$

Let the meter-cost per trip be F_2. Then

$$F_2=C_2\left\{P_o t_1+TfW+\frac{s}{2}(P_o t_1+TfW)\right\}.$$

The rate of change of meter cost $= dF_2\ dW$,

$$\frac{dF_2}{dW}=C_2\left(Tf+\frac{s}{2}TF\right)=C_2\left(1+\frac{s}{2}\right)Tf. \quad . \quad . \quad . \quad . \quad (2)$$

(It will easily be seen that if t equals 0 instead of T, the term $s\ 2$ will be eliminated: with 15 per cent. slip, $s\ 2 = 0{\cdot}075$. The error is, therefore, usually much less than $7\frac{1}{2}$ per cent.).

$dF_2\ dW$ is a positive expression, and shows F_2 increasing with the weight of the wheel. If the derivative of F_1 is negative, and is greater numerically that the derivative of F_2, the power cost per trip will decrease continuously as the wheel weight is increased, until the peaks are entirely smoothed out. If the derivative of F_2 is the greater, any increase in the wheel weight will increase the cost of power. This relation may be expressed as a ratio of the two derivatives

$$dF_1\ dW \div dF_2\ dW = dF_1\ dF_2 = \frac{C_1\left(1+\frac{s}{2}\right)\left(f-\frac{n}{t_1}\right)}{C_2 Tf\left(1+\frac{s}{2}\right)} = \frac{C_1\left(f-\frac{n}{t_1}\right)}{C_2 Tf} \quad . \quad . \quad (3)$$

If e_1 equals the average efficiency of the alternating-current motor; R_1 the peak charge per horse-power per month; R_2 the meter charge per horse-power hour; D the working hours per month; and Z the average trips per working hour, then

$$C_1=\frac{R_1}{DZe_1};\ C_2=\frac{R_2}{3{,}600e_1};\ T=\frac{3{,}600}{Z};$$

and

$$\frac{C_1}{C_2T}=\frac{R_1 3{,}600e_1 Z}{DZe_1R_2\times 3{,}600}=\frac{R_1}{DR_2}.$$

Substituting in (3),

$$\frac{dF_1}{dF_2}=\frac{R_1}{R_2Df}\left(f-\frac{n}{t_1}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

If the numerical value of dF_1/dF_2 exceeds unity and is negative, all the peaks should be removed; otherwise additional flywheel weight will only increase the cost of power.

It may be objected that a flywheel merely large enough to obliterate the acceleration peak will not in every case produce an approximately rectangular-shaped power curve. This objection is met by an inspection of the typical load cycles shown in Fig. 5. In both cases h will be the average power for the time t_1+t_2. Let W_1 be the wheel required to reduce the triangular load to h, and W_2 be a similar wheel for the rectangular load. Without going into the mathematics on this point, the relation of the wheel weights is as follows :—

$$\frac{W_1}{W_2}=\frac{(t_1+2t_2)^2}{4t_2t_1+t_2)}.$$

When t_2 is very large as compared to t_1, W_2 will be as large as W_1; and since the reduction in peak for the rectangular curve is much less than for the other, if it is advantageous to reduce the rectangular peak it will be still more so to smooth out the triangular curve. The other extreme is represented by the value of t_1, which is large compared to t_2; in actual practice this ratio will hardly exceed 10 to 1 in cases where a flywheel is applicable. W_1/W_2 then becomes equal to $1{\cdot}44t_1^2/0{\cdot}44t_1^2$, and $W_1=3{\cdot}3W_2$.

The rectangular curve will show a reduction in peak of less than one-tenth, while the triangular curve will be reduced approximately one-half. Since the losses are roughly proportional to the wheel weights the triangular load will show a ratio of saving over that of the rectangular load in the neighbourhood of 5 to 3·3. It would appear, therefore, that the rectangular form of curve, for any ordinary conditions, is the limit of the other forms. Therefore, it may be assumed that if any hoisting cycle shows by means of equation (4) that its input should be made constant, a saving in power bills will

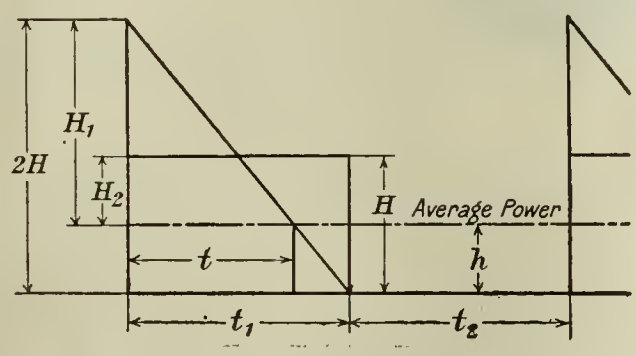


Fig. 5.—Typical Load Cycles.

result by so doing. The converse is not necessarily true, *i.e.*, a curve of markedly triangular form, which by the use of equation (4) shows a value of somewhat less than unity for dF_1/dF_2, should be further investigated by means of one or two trial wheel weights.

Referring again to the formula for dF_1/dF_2, approximate value may be placed on all the constants. The expression R_1/R_2 would probably lie between the ratios 50/1 and 400/1 with various power constants; D (working hours per month) should approximate 600; f may be estimated roughly as 0·001 for ordinary speeds of flywheel (1 H.P. per 1,000 lb. of wheel). Quantity n may be taken as 0·4, and the value of 0·15 for s would not be far off.

Substituting the greatest ratio of R_1/R_2 and the other values as stated,

$$\frac{dF_1}{dF_2}=\frac{400}{600\times0{\cdot}001}\left(0{\cdot}001-\frac{0{\cdot}4}{t_1}\right)=666{\cdot}7\left(0{\cdot}001-\frac{0{\cdot}4}{t_1}\right)=0{\cdot}6667-\frac{266{\cdot}7}{t_1}.$$

Equating dF_1/dF_2 to -1, which is the ratio at which it will cease to be profitable to add a flywheel, t_1 will equal 160 seconds.

Substituting the minimum ratio of R_1 and R_2 (50/1), t_1 becomes 31 seconds. Therefore, when the time of hoisting, less the time of retardation, is less than 31 seconds, and the working hours per month are about 600, it is extremely likely that a sufficient flywheel should be supplied to make the power input constant; if it is more than 160 seconds no flywheel should be added over that necessary to remove the acceleration peak. If 20 per cent. slip were assumed instead of 15 per cent., n would have a value of about 0·5, and the preceding time values would be increased about 25 per cent.

No attempt has been made to discuss the question as to the propriety of treating the slip, s, as a constant, but the writer believes that for most cases this value should be as great as the design of the motor-generator set will allow. Values of n can readily be worked out for various speeds of the flywheel.

NATIONAL PHYSICAL LABORATORY.

(*Concluded from page* 566.)

Optical Pyrometers.—During the latter part of the year considerable time was spent on the study of the methods of calibration and the sources of error of optical pyrometers of the polarising type. The necessity for this work arose in connection with the new type of optical pyrometer, which the Cambridge Scientific Instrument Company has placed on the market. A considerable number of these instruments have passed through the Laboratory. Since, under war conditions, numbers of these pyrometers were urgently required for munition work, the Laboratory undertook to supply the data necessary for calculation of the temperature scale, determining for each instrument the position of the fiducial point most suitable for obtaining the scale desired. The pyrometers, which were of various ranges, were received in the first instance provided with an angular scale only. While it is possible to calculate the temperature scale of such an instrument from observations at two temperatures on a black body, it has not been deemed advisable to rely on that procedure, and on each scale a considerable number of standardising points, distributed throughout the range, were taken by observations on a black body furnace. The relation connecting log tan φ and $1/T$ was deduced from these, whence a table giving the corresponding values of the angle reading and the temperature was calculated for every 50°C. Many of the instruments were provided with more than one range, the usual method of a neutral tinted absorption glass being used to obtain lower intensities at the higher temperatures. It was found that, while most of the instruments conformed closely to the simple theoretical law which postulates that log tan φ plotted against $1/T$ should give a straight line, with others, on the contrary, no simple relation could be assumed. Two causes for this phenomenon were found to be operative. It was observed in some instruments, and in particular those intended for work at the lowest temperatures down to 700°C., that, in the early pattern, there was a slight scattering of the light in the interior. Means for preventing this and for obviating other minor constructional difficulties were discovered.

In order to check the satisfactory behaviour of each instrument, and in particular to ascertain whether satisfactory matching of the two halves of the field could be attained at the higher ranges, each instrument was directly tested not only on the black body furnace, whose maximum temperature could not exceed 1,450°C., but at some appropriate higher point. For the attainment and control of such temperatures the carbon tube type of furnace was chosen. A new pattern of small furnace, having its details very conveniently arranged, was designed and constructed for the Laboratory by Mr. C. G. Eden, and this has been in constant use for about five months at temperatures ranging to over 2,000°C., without even the necessity having arisen of replacing the original tube. The details of the furnace are illustrated in the photographs (Figs. 1 and 2), which show, respectively, the general construction and, in larger scale, the water-cooled clamps carrying the current to the tube. The working of the furnace requires only about 1½ kw. at the highest temperatures.

British-made Porcelain for Pyrometer Tubes.—The manufacture of porcelain tubes for pyrometer sheaths has been a highly specialised trade, which before the war was largely in the hands of foreign manufacturers. The demand for this class of goods has grown enormously in recent years, and has become abnormally large, owing to the war. It became imperative, therefore, to obtain ware of an appropriate quality in this country. Such porcelain must possess special properties and comply with requirements totally different from those demanded of an ordinary glazed ware. One of the special tests carried out in the Division was an investigation for a large user of such tubes into the suitability of some samples of hard paste porcelain, made by a well-known British firm, with a view to ascertaining how far they complied with the exacting requirements demanded by the conditions of pyrometry at high temperature.

The chief requirements are: (1) Ability to stand high temperature without deformation; (2) ability to stand sudden changes of temperature, especially such as occur when the tube is plunged into hot molten metal; (3) impermeability to gases.

The first and second requirements are governed chiefly by the nature of the body material of the tube, its coefficient of expansion, its thickness and the method of closing the lower end. The third is determined mainly by the nature and degree of permanence of the glaze. A fundamental point is that no furnace gases should diffuse through the walls of the tube at high temperature and injure the platinum or platinum alloy of the couple or resistance pyrometer in the interior. One of the simplest ways of determining the permeability of the tube would be to exhaust the interior, and to measure and analyse the gases which might permeate. Such a test, however, would probably give erroneous results by subjecting the tube to stresses greater than those occurring in practice. A satisfactory and expeditious method was found in the use of very simple apparatus. The tube to be tested, closed at the lower end in the usual manner by a hemispherical cap, was placed in a suitable electric furnace, and heated to the desired temperature. Through the furnace a current of any gas chosen could be passed during the tests. Hydrogen was employed in most cases, on account of its rapid diffusivity. The upper end of the porcelain tube was closed by a metal cap, cemented on, through which a small bore porcelain tube was fitted. By this tube a current of pure carbon dioxide was led into the interior. Any hydrogen or other gas from the furnace diffusing through to the interior of the porcelain tube under test was swept on by the carbon dioxide stream, and collected and measured in a vessel, similar to a nitrometer, containing potash solution. At any moment blank tests could be made of the amount of the impurity in the original carbon dioxide, and the whole apparatus lent itself very well to indicating sharply the point when the glaze ceased to be

impermeable and the general effect of temperature on the properties of the porcelain.

In these experiments varieties of porcelain tubes known by previous experience to be satisfactory as pyrometer sheaths, as well as others of a less refractory character, were compared as regards permeability with the samples under test. Although the specimens submitted were only regarded by the makers as early attempts, their behaviour was very encouraging. Further experiments at the works are in progress, with a view to the improvement of the product in certain details.

Tungsten Arc Apparatus.—The recently described small tungsten arc lamp of Messrs. Gimingham and Mullard, made by the Edison-Swan Company, showed the possibility of applying some such method of

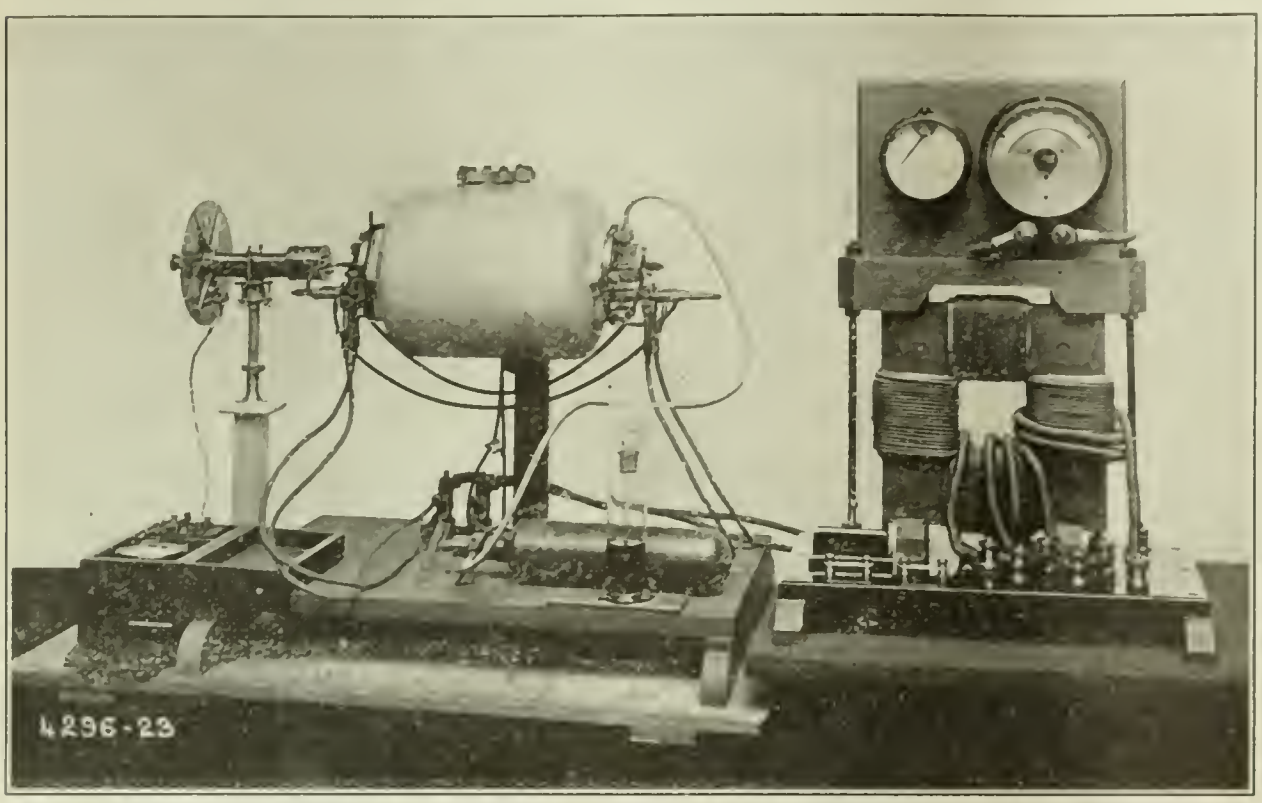


Fig. 1.—Laboratory Electric Furnace.

obtaining conveniently in the laboratory a source of considerable dimensions at the highest temperatures. Experimental lamps of larger size than the commercial patterns were placed at our disposal by the makers. The hot electrode, instead of being a small sphere, was a flat circular disc of about 8 mm. diameter. This proved to be an extremely useful source of radiation for optical pyrometer work, and an apparatus has been constructed for use with the new method, which promises to give very satisfactory results with great economy of time as compared with the use of furnaces.

Beyond routine tests the following special work may be mentioned :—

1. The ruling of a Ré can plate for star photography. The sources of supply of these plates in both France and Germany being cut off by the war, the Laboratory was approached with a view to assisting in the matter, and a ruling was made on the Blythswood machine. For this it was necessary to modify the machine in such a way as to lengthen the ruling stroke, and a grant towards the cost of this, and of the necessary experiments in connection with the work, was made by the Government Grant Committee.

Considerable difficulty was found in obtaining, first, a satisfactory silver deposit free from pinholes, and, secondly, a tool which would rule on the film lines of suitable and uniform width, with clean edges. In the ruling as ultimately made it was found necessary to accept a width of line rather greater than was desired, and the accuracy of the spacing was found on measurement to be considerably less than had been anticipated. This may probably be attributed to slight variability in the thickness of the lines (affecting one edge of a line more than the other) and to the fact that it was necessary to rule each line separately by hand, instead of allowing the machine to operate automatically. Further plates were to have been ruled, but this again was stopped by the urgent work for the Ministry of Munitions referred to above.

2. An investigation, made at the instance of the Engineering Standards Committee, into the sizes of commercial sparking plugs and tapped holes for motor engines. Difficulty having been experienced in securing interchangeability between sparking plugs and engines of English, Continental and American makes, it was desired to ascertain whether the standard recently laid down by the E.S.C. really represented current practice. For this purpose a number of sparking plugs were obtained commercially, and tried, together with a screw plug gauge representing the E.S.C. standard, into a number of engines on the premises of various firms who were visited. The analysis of the results is not yet completed.

V. Optics.

The department gave assistance to the Admiralty in the preparation of a book of instructions on the correct use of telescopic sights and other instruments for gunlayers. Special tests have been made for the Admiralty on new designs of sextants made to laboratory specifications.

The division calculated, at the request of the Director-General of Munitions Supplies, the curves to be used in making cemented telescope objectives with standard glasses, manufactured by Messrs. Chance Bros. These are published in pamphlet form. Additions have since been made for special glasses. Further tables showing the results of tracing rays trigonometrically through the various objectives, which number between 200 and 300, and others giving means of interpolating when the glasses to be employed differ somewhat from the standard glasses for which the first tables give the curves, will shortly be published.

An investigation has been made of the way in which the kinds of glass to be employed should vary when an objective is not to be corrected for an object at infinity, assuming that very good correction is required. The results of this investigation have been presented to the Physical Society.

VI. Radium and X-ray Work.

The comparison of radium preparations with the British radium standard has been continued throughout the year. The apparatus has been maintained in good order, and the work has proceeded in a satisfactory manner.

The question of the adequate protection of X-ray workers has been considered in detail by the Council of the Röntgen Society during the past year. It was felt that very considerable help would be afforded in this connection, if means were available for users and makers of X-ray apparatus to obtain the absorption-coefficients of the materials used for protective purposes, under conditions of use. The Laboratory was accordingly invited to undertake such work, and arrangements have now been made to do so. An installation has been purchased, which should enable this and other branches of X-ray work to be dealt with efficiently. The apparatus has, for the present time, been accommodated in the room employed for the radium tests; this must, however, be regarded as a

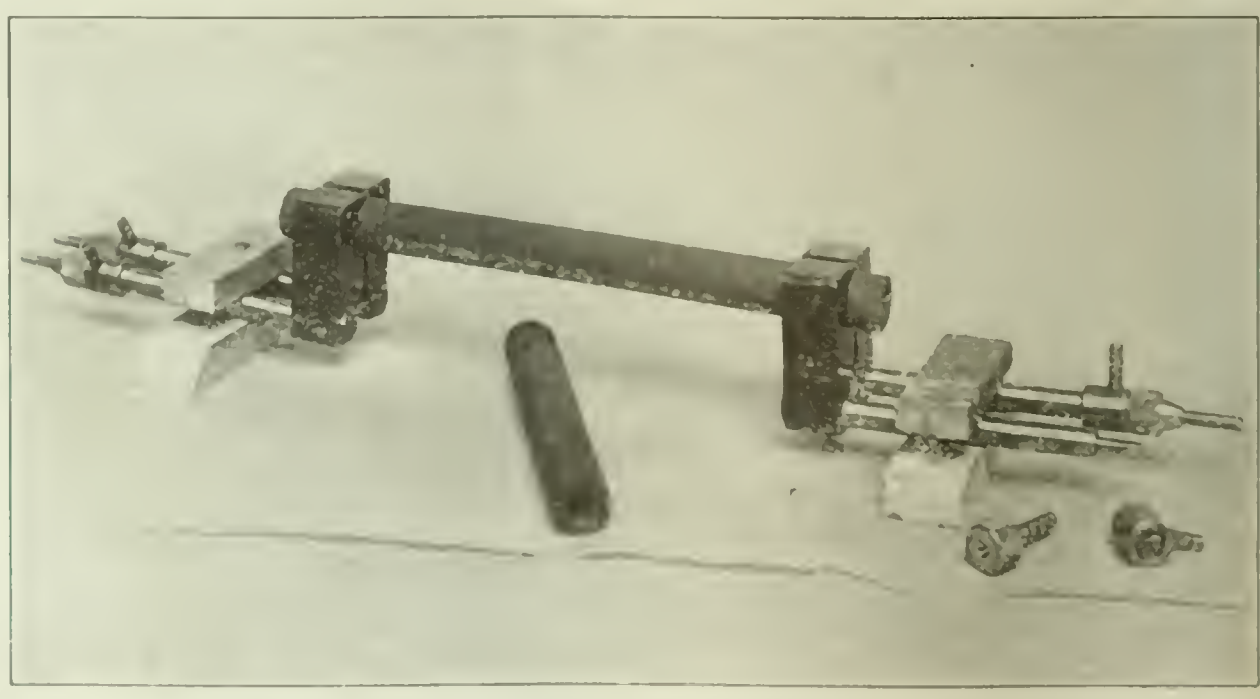


Fig. 2.—Water Cooled Electrodes and Resistance Tube.

temporary expedient, until other and more adequate space can be allotted to the work.

The equipment with which a start is to be made consists of a 16 in. coil, with a mercury jet interrupter, and a selection of X-ray tubes. These include, in addition to the ordinary types, a Coolidge tube with accessory apparatus, and a Shook hydrogen tube. This latter, the latest type of X ray tube, was presented to the Laboratory by Dr. Kaye.

It is greatly regretted that Dr. Kaye is at present unable, by reason of his absence on military duties, to take active part in the formation of this new section. The remaining equipment includes the necessary measuring apparatus and protected tube-holders. A control switchboard for regulating the output of the coil was designed and constructed at the Laboratory.

ENGINEERING DEPARTMENT.

A new fatigue testing machine for testing the endurance of specimens under combined bending and twisting has been constructed, and a considerable number of tests have been carried out on specimens prepared from the special mild steel supplied by the British Association Committee on Complex Stress, and from a sample of harder steel in the possession of the Laboratory.

The three testing machines referred to in last year's report for making impact tests on geometrically similar specimens have been completed, and a considerable number of tests on the two samples of steel obtained from the Engineering Standards Committee for the purpose have been made. In the design of the machines, the geometrical form of the striker and knife edges recommended by M. Charpy, have been adopted, so that the complete system of specimen, striker and knife edges is geometrically similar in each machine.

Work has also been carried out on the hardness and wear of materials, resistance of railway couplings to tensile impact, resistance of wood to reversals of stress, and resistance of tension members of a structure to lateral vibrations. There were a number of investigations in aeronautics.

Steam Joint Packings.—Most of the packings used for steam jointings have been in the past made abroad, and, in consequence of the difficulty of obtaining supplies, several British firms have been endeavouring to make in this country packings of equally good quality. The chief difficulty has been to obtain packings which can be used for joints in superheated steam pipes. Several samples have been tested in the apparatus for testing the blowing-out pressure of joints. The makers have been so far successful in producing joint rings varying from $\frac{1}{32}$ in. to $\frac{1}{8}$ in. in thickness which will stand a pressure of 250 lb. per square inch at a temperature of 1,000°F. to 1,100°F., without any signs of breaking down. The apparatus used for these tests was described in the annual report for 1912.

RECENT PATENTS IN RADIOTELEGRAPHY AND RADIOTELEPHONY.

BY W. ECCLES, D.SC.

(*Concluded from page* 573.)

II. RECEPTION.

The patents dealing with detectors relate almost entirely to the vacuum tube type. In some the currents are carried to perhaps a large extent by charged ions of molecular order of magnitude ; in others the currents are carried by electrons or negative corpuscles. Both kinds are used as relays as well as for detecting oscillations—in fact, there is often difficulty in deciding whether a tube is being used as an amplifier or as a detector in a particular set of connections. Nearly all the tubes mentioned below have three electrodes, of which one, the cathode, is kept at a high temperature, so that there is continuous evolution of electrons by the process called thermionic emission. The main anode, which in the earlier form of tube was a metal plate, is connected with the circuit in which the amplified current is to flow, and in consequence this circuit may be called the plate circuit or the repeat circuit. The repeat circuit is closed through the tube by its other terminal being connected to the glowing cathode. The third electrode is sometimes spoken of as the auxiliary anode, but in some modes of using the tubes it is kept at negative potential on the whole, and therefore this name is not always appropriate. Since this electrode appeared as a grid of wires or a perforated plate in the early forms of apparatus it is often called the grid ; but it may also be called the control electrode, for the reason that minute variations of its potential relative to the cathode, affect and control the relatively large currents flowing to the main anode, though the current flowing from the grid is inappreciable. The control electrode and the cathode are generally connected between two points of the high-frequency receiving circuit between which a large voltage arises during the reception of signals.

The properties of these tubes, so far as they find employment in wireless telegraphy, may here be briefly mentioned. Though there are many obscurities, it is clear that much must depend on the amount of residual gas left in the so-called vacuum tube. In an ordinary tube with a fairly high vacuum a current of about 10 microamperes may be passed from a hot cathode to an anode under a voltage of about 30 volts, with only negligible ionisation of the residual gas. At a higher voltage the velocity acquired by the electrons in the larger electric field may reach a value sufficient to enable an electron to split a gas molecule with which it collides into a negative electron and a positively charged ion of molecular size. Such "ionisation by collision" is the cause of the blue glow that marks the track of the cathode rays in a Crookes tube. These new ions take part in carrying the current immediately they are formed. With higher voltages and more complete ionisation the cathode becomes the target of a bombardment by positive molecular ions, which heat it and rapidly disintegrate it. Moreover, the bombardment releases occluded gas from the electrodes, which tends to spoil the vacuum. If, however, the original vacuum is extremely good and the electrodes are initially free from occluded gas, there is no ionisation by collision, no disintegration of the cathode, and greater permanence of the vacuum.

The precise modes of operation of the tubes in all the circumstances in which they are now employed are not yet fully understood. According to Langmuir, the space charge between cathode and anode—a sort of cloud of electrons—once it is set up limits the current flowing through the tube. Now the grid or control electrode is so placed in these devices that its electric field may have as great an effect as possible on that of the space charge. If the grid be made negative, the escape of electrons from the cathode is made still more difficult ; if the grid be made positive, the escape of electrons s facilitated, because the field of the space charge is cancelled to a greater or less extent. If the current between the cathode and the repeat electrode is mainly carried by electrons, it is evident that pulses of current will be created in response to variations of the control electrode potential. When, on the other hand, residual gas is present, the high external voltage always applied in the repeat circuit promotes ionisation by collision, which may be expected to assist the magnifying process. This explanation of the action of the control electrode is, however, only a partial one. It neglects the fact that slow-moving electrons may be liberated from the anode and collected by the cathode—a circumstance that may become of paramount importance in some designs of tube.

The General Electric Company of America communicate in No. 15,788/1914, a description of the main constructional features of the nearly gasless three-electrode tubes which have been developed chiefly by Irving Langmuir. These tubes, in their various forms, are employed for detecting and amplifying high-frequency or low-frequency current, for generating oscillations, and for rectifying current of high voltage and any frequency. The principal distinction between most of the tubes here described and the older double-anode tubes lies in the extremely high vacuum—only a few hundredths of a micron of mercury—which is an essential feature. In such a tube the current is conveyed almost wholly by electrons, for there is insufficient gas present to afford an appreciable number of positive ions by the process of ionisation by collision. Thus the blue glow seen in a cathode ray tube and the glass fluorescence are absent at even very high voltages. Moreover, there is no bombardment of the cathode by heavy positive ions, and therefore the disintegration of the cathode is almost negligible. The operation of the tube is also more regular and reproducible than in the tubes containing gas.

The chief aim in the evacuating process is, as in the preparation of the Coolidge X-ray tubes, the expulsion of occluded gas from the electrodes. During the evacuation the glass is heated as much as possible without softening, and the most approved methods of incandescent lamp exhaustion are adopted. Then, while the tube is still hot, a Gaede molecular pump is employed to remove the residual vapour and gases ; or chemical evacuating means such as the electrical vaporisation of calcium or magnesium may be employed. Either before or during evacuation the anode is heated, especially when the electrodes are to be run at an elevated temperature during the normal operation of the finished tube, in which case their

temperature is carried to brilliant incandescence during evacuation. When the exhaustion has reached an advanced stage a suitable voltage is applied between two of the electrodes so as to bombard the metals by electrons. Care must be taken not to produce the blue glow, or sputtering and disintegration of the cathode will result. Meanwhile the pump is constantly operated, the voltage is gradually increased, and so on, step by step, till a higher voltage is reached than that for which the apparatus is designed. If the tube is intended for heavy currents the bombardment should be vigorous enough to heat the electrode. Metals so treated may be exposed to the atmosphere at ordinary pressure without re-absorbing gas, and may, therefore, be removed to other tubes.

Figs. 10 and 11 represent a tube designed to operate as an

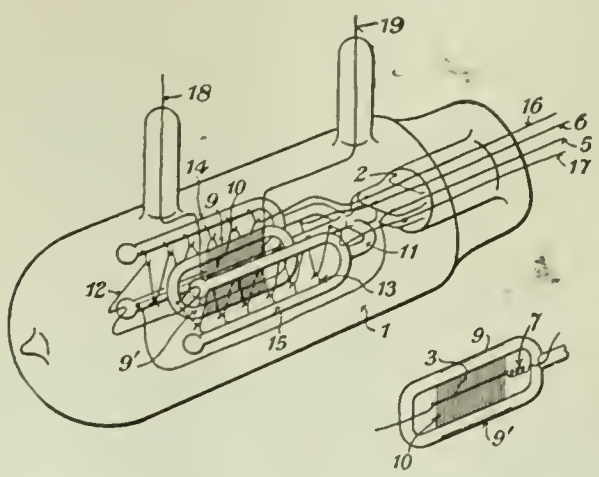


Fig. 10. Fig. 11.

amplifier. There is a hot cathode, seen plainly in Fig. 11, held taut by a spring, 7, which takes up sag on heating; a control electrode 10 in the shape of a grid of fine wire wound on the glass or quartz frame 9, 9', that carries the cathode; and there is an anode, 12, forming a zig-zag running over hooks. Both the anode and the grid are tantalum or similar refractory metal. The anode has two leads 16, 17, and the grid has the leads, 18, 19, so that they can be heated electrically during the evacuation; but only one lead in each case is necessary for the work of the tube. Many other details of construction are given in the specification.

For use as a detector, a tube should contain a trace of gas of rather definite amount. With the correct pressure of vapour or gas in the tube the variation of current in the repeat circuit follows the variation of potential imposed on the control electrode very much as in the case of the pure electron discharge: but at a certain voltage between the control electrode and the cathode, and within a small range, there exists a condition of lability such that when high-frequency oscillations are impressed on the control electrode there follows a sudden decrease of current in the repeat circuit. It is stated that the cause of this phenomenon "is decidedly obscure, but the existence of the phenomenon is very real." The result is that a very sensitive detector is obtained. To ensure exactly the necessary gas pressure, there is placed in the bulb, before sealing off, a small amount of vaporisable material—for example, an amalgam, or sulphur, or phosphorous pentoxide. Mercury itself gives too high a vapour pressure. When an amalgam is used, the metal to be amalgamated—for example, silver—is placed in the envelope before evacuation, and some mercury in a side tube. After exhaustion the mercury vapour is allowed to diffuse through the tube. At room temperature one or two days are required for the amalgamation. The excess vapour is condensed in the side tube by a freezing mixture and the tube sealed off. It is stated that the device so prepared will give at ordinary room temperature a substantially pure electron discharge between anode and cathode without gaseous ionisation, even when the impressed voltage is raised to 400 volts.

The constructional details of thermionic amplifiers are the main consideration of specification No. 1,694/1915, by the Western Electric Co., and the type known as the Audion is specially dealt with. The principal feature of the mode of construction described is the placing very close together of the control electrode and the hot cathode, actual electrical contact being, of course, avoided. The nearer these two electrodes are to each other the more effective, it is stated, is the amplifying action of the device. In practice it has been found that a thin coating of such a substance as nickelous oxide may be relied upon to separate the two electrodes. Another important feature is the proper placing of the main anode with respect to the other two electrodes, due regard being paid to the use to which the particular instrument is to be put. One broad rule in this connection is that the further the anode is from the cathode and control electrode, these two being supposed close together, the greater is the voltage required in the repeat circuit. This is to be explained by the well-known fact that in such an arrangement as that of the Audion the chief effect of the control electrode is electrostatic. Stress is laid, throughout the specification, on the fact that the control electrode should have a large surface area.

An idea of the way in which the above conditions are fulfilled may be gained from Figs. 12, 13, 14 and 15. In Figs. 12 and 13, where Fig. 13 is a plan, the control electrode consists of a wire, 1*b*, shaped like an inverted V, and on it is wound the filament 2*b*, which supplies the electron discharge when heated. The repeat electrodes are the plates 3*b*. It will be seen that the "grid" of the Audion is represented here by a V-shaped wire, which does not intervene between the cathode and the main

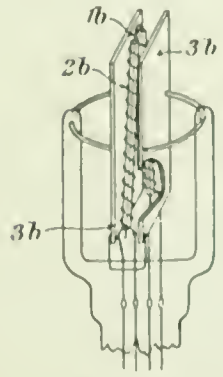


Fig. 12.

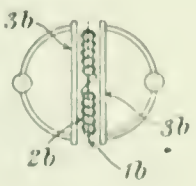


Fig. 13.

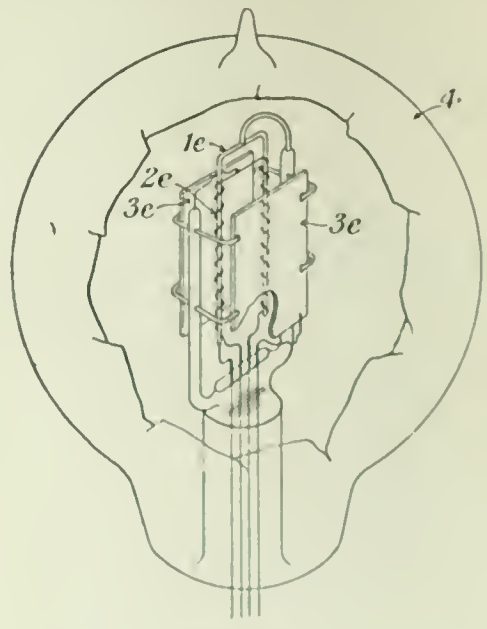


Fig. 14.

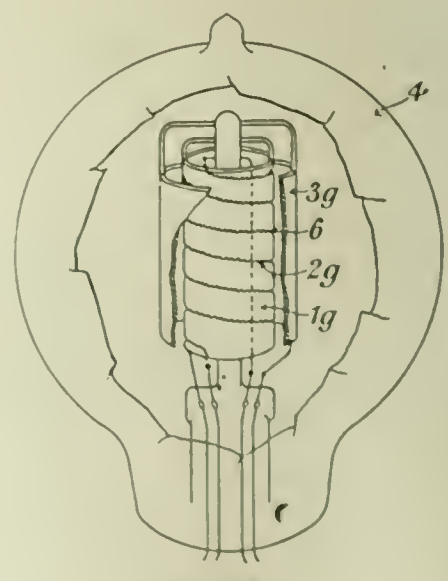


Fig. 15.

anode. In Fig. 14, again, the control electrode, which may consist of any number of arms or branches, is over-wound by the cathode, the insulation between these two electrodes being usually nickelous oxide, as stated before. By placing the anode plate 3*c* near the other electrodes a low voltage high current amplifier is obtained. Fig. 15 shows a different type. The control electrode 1*g* is a shell with a helical groove, in which the filamentary cathode 2*g* is wound. The repeat electrode 3*g* is a large concentric spherical shell. Finally, Fig. 16 shows an elaboration of this last type intended

for use with large currents. The new feature is a tube down the middle of the vacuum tube, and passing through both cylindrical electrodes. Down this channel cooling liquid can be passed, or the whole tube can be put in a tank of liquid. Efficient cooling allows of the tube being worked energetically.

In specification No. 13,636, 1913, Marconi's Wireless Telegraph Co. and W. C. S. Franklin show a method of reception of signals in which a three-electrode tube amplifies the high-frequency oscillation received on an antenna, whether damped or undamped. The circuits are seen in Fig. 17, where the vacuum tube v has the usual hot cathode k, control electrode a, and repeat anode a'. The circuit clm is tuned to the antenna, and is arranged so that the oscillatory voltage at the terminals of condenser c acts, after addition of a steady voltage from battery p, on the control screen a. The figure shows coils m and n coupled, but even without this coupling the pulses of current in the magnifying circuit on the right of the tube set

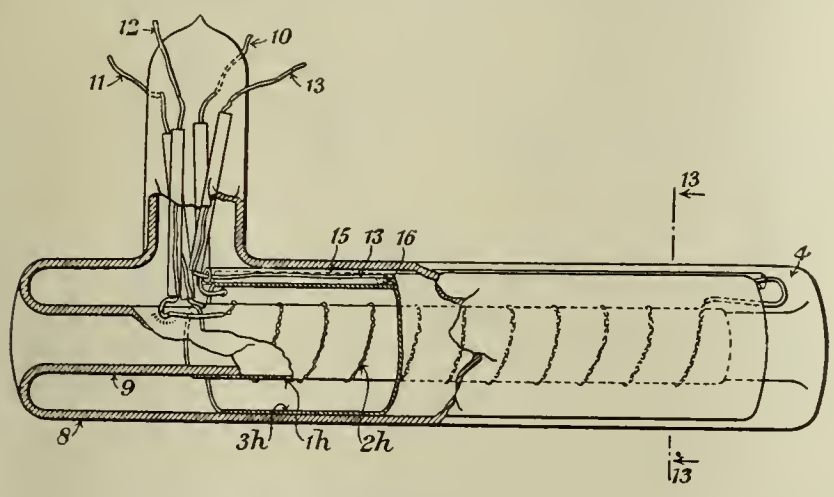


Fig. 16.

the tuned circuit fno into oscillation with augmented vigour when the voltage of the battery s is fairly large, say about 200 volts. When the coupling $m\ n$ is made appreciable the retroaction of the repeat circuit on the control circuit builds up still greater magnification. If the coupling were made close enough the tube would generate oscillations continuously; but if it be made just less than this critical value the circuit behaves as if the effective damping of the whole system has been made very small. In consequence, when the antenna is set into oscillation by external agency, the disturbance subsides relatively slowly, and during this prolonged period D.C. energy is drawn from the cells s and passes as A.C. energy to the detector. The detector q, potential divider p', and telephone t are connected in the customary way for the indication of oscillations in the circuit fno.

Arco and Meissner, in No. 252/1914, give a method of amplifying received signals, which shows resemblances to the last described. In Fig. 18 are seen the connections for amplifying

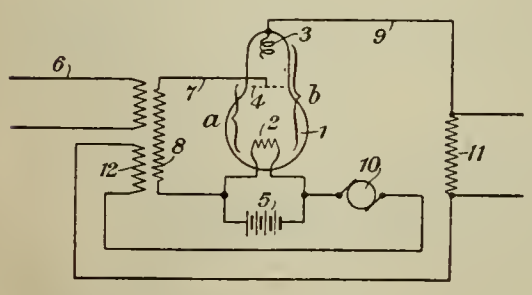


Fig. 18.

any variable current running in circuit 6. There are the usual hot cathode 2, control electrode 4, and main anode 3. The circuit 9 contains a source 10 of high E.M.F., so that current flows from 3 to 2 inside the bulb. The essential feature of the invention is that the amplifying circuit 9 is caused to react on the control circuit 7, and this increases the amplitude of the disturbance in 7. The increase exerts in turn magnified effects on circuit 9, and thus a reinforcing process is set going which is only limited by the properties of the tube and by the amount of energy that can be drawn from 11. These circuits and this process are seen applied to the reception of signals in Fig. 19. The circuit 15, with detector 19, block condenser 20 and telephone 21, constitute an ordinary receiving set. When a wave-train arrives transformer 8 applies an E.M.F. to the path 4-2 in the amplifying tube; the magnified disturbance acts through transformer 12 and augments the oscillation in circuit 15; and thus an amplified oscillation is quickly built up at the expense of the generator 10, and only dies away when the wave-train ceases.

Much the same sequence of events takes place in the scheme of Fig. 20, where, instead of employing a separate detector such as 19 of Fig. 9, the tube is made to function as both detector and amplifier. The rectifying action of these tubes arises because, as in the Fleming valve, the cathode 2 emits negative corpuscles almost entirely, and the current in the repeat circuit therefore consists of unidirectional pulses when alternating E.M.F. is applied in the control circuit 7. The

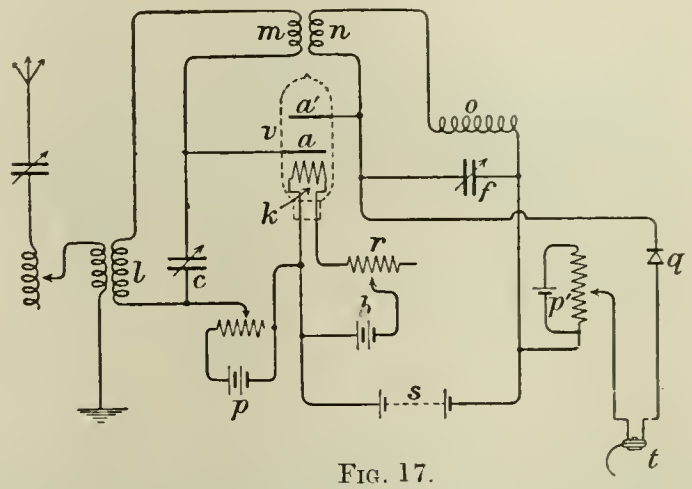


Fig. 17.

scheme of Fig. 20 operates thus: A train of oscillations received on the antenna affects, via transformer 14-8, the control electrode 4, with the result that pulses of current pass from 3 to 2 across the bulb. These pulses react by means of transformer 12 on the control circuit 7, and tend to augment the oscillation there. In this way the pulsating current in 9 is worked up to a maximum, and the train of oscillations becomes translated into the passage of a jet of current in one direction through the primary 26 of the telephone transformer. The variable condenser 28 is not used for tuning to the waves received but for the double purpose of passing the high-frequency pulses by the transformer 26-27 and of regulating the rate of handing of energy to the telephone.

Arco and Meissner, in specification No. 252/1914, apply the vacuum tube oscillation generator described above to the method of reception in which the oscillations excited in the antenna by the incoming waves are caused to beat with slightly mistuned locally generated oscillations. In Fig. 21 the

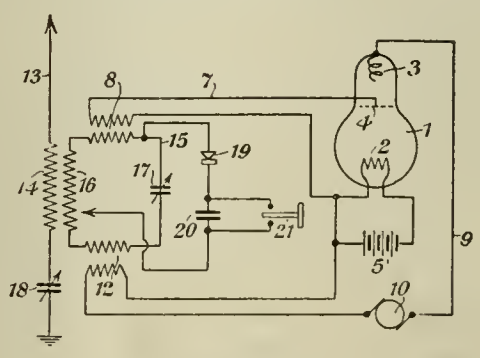


Fig. 19.

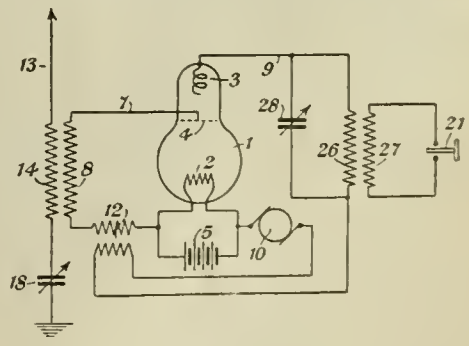


Fig. 20.

retroactive circuits are connected to the vacuum tube 1 seen at the right-hand side; and circuit 31 is slightly out of tune with the signal waves. These waves excite the antenna 13, and this acts, through the filtering circuit 37, upon a circuit containing a detector 19 and telephone 21. This last circuit is coupled to the local generating circuit by the coil 43 of the non-oscillatory circuit 41. Thus beats arise in the detector-telephone circuit. If the beats are slow enough they give rise to a musical tone of frequency equal to the difference between that of the incoming waves and that of the local oscillations.

The inventors state that the arrangement possesses high selectivity and also great freedom from strays.

In Fig. 22, from the same specification, is shown a highly magnifying arrangement for use with damped or undamped oscillations. The retroactive circuits shown in Figs. 18 and 21 are again employed. The antenna 13 is coupled by windings 14, 40 with the oscillatory circuit 31, which is slightly out of tune with the antenna. The forced oscillations in circuit 31 act by means of windings 30, 8 on the control electrode 4, and the magnified result in the repeat circuit 9 further enhances the current in 31. The tube thus acts as a relay. But if the coupling between windings 30 and 8 is made sufficiently close the tube acts at the same time as a retroactive generator, and free oscillations arise in circuit 31. Therefore, beats are produced, and a pulsating current of much lower frequency than the other frequencies may be made to flow in circuit 9. Now the telephone receiver 21 is coupled to the circuit 9 by the

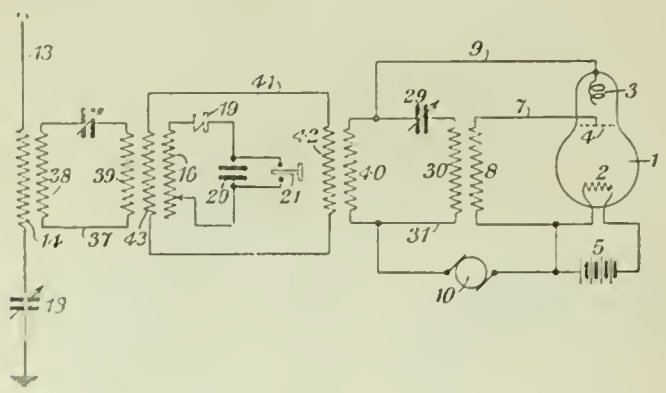


Fig. 21.

transformer 26, 27, and, further, the inductance coil 26 is short-circuited by the condenser 28. The low frequency oscillatory system thus formed is easily started into vibration, and the vibration is sustained at a certain intensity by the tube and the retroactive circuits; and thus a musical note is permanently produced in the telephone. This note may or may not have the same frequency as the pulsating current mentioned ten lines above; but this matter is easily arranged by adjustment of condenser 29. If these two low frequencies differ slightly the permanent sound will vary considerably when signal waves arrive. The specification states that the contrast between the permanent sound and the sound as changed by the arrival of waves can be heightened by arranging the sending station to emit one wave-length for a mark and another for a pause. The rather complicated processes just

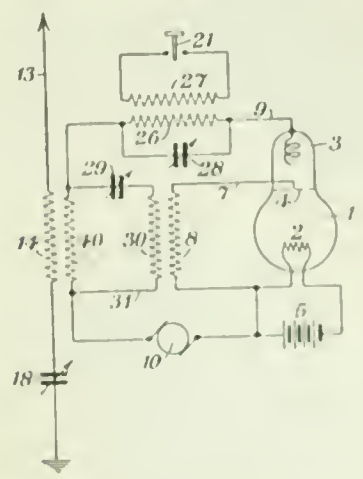


Fig. 22.

described comprise, it will be seen, (1) amplification of the received oscillations at radio frequency, (2) generation of local radio oscillations, (3) interference of the radio oscillations and amplification of the resulting audio current, (4) generation of an audio current in the telephone circuits, (5) interference between these last two; and all with one vacuum tube.

A noteworthy design for beat reception of continuous-wave signals is given by E. H. Armstrong in No. 24,231/1914, and is reproduced in Fig. 23. Here the usual resonant receiving circuit L, C, S, where S is the secondary of the coupling transformer, is connected to the control side of the vacuum tube through condensers C', C^3. The repeat circuit L', C^5, C^4 is also

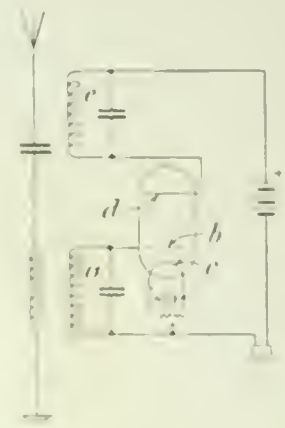


Fig. 24.

connected to the tube, and is coupled to the control circuit by condenser C^2 and inductance R. In this particular sketch the inductance of the telephone receivers is used for coupling. The condenser C^5 is varied till the oscillations generated by retroaction between the circuits has a frequency slightly different from that of the resonant circuit, and beats of audible frequency can thus be produced. These low-frequency vibratory currents are amplified in their turn by the tube and its circuits, and, therefore, become evident as loud signals.

For beat reception of sustained waves the Marconi Company and H. J. Round give in No. 28,413/1913 the methods sketched in Figs. 24, 25, 26. In Fig. 24 the circuit *a* is tuned to the antenna and to the signals, and by connection with the control electrode *b* produces forced oscillations in circuit *e* on the magnifying side of the tube. At the same time oscillations of the frequency natural to circuit *e* are generated by retroaction through the coupling between *e* and *a*, the energy being supplied from the

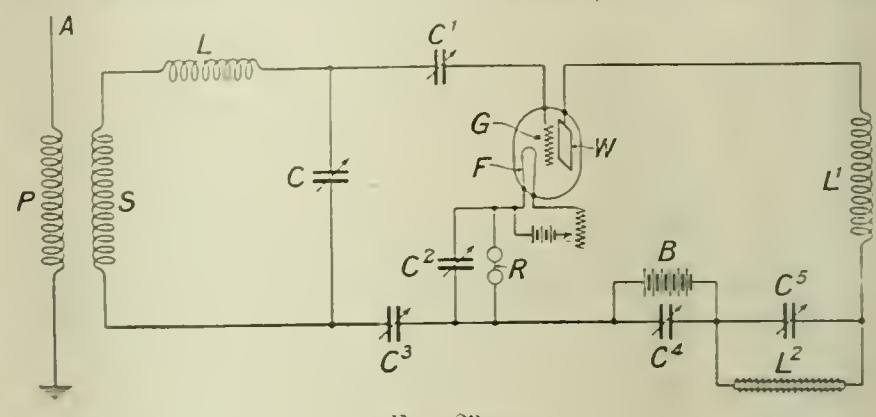


Fig. 23.

battery in series with the telephone. At both frequencies, it would appear that the accidental capacitance of the telephone leads is trusted to pass the high-frequency pulses that keep *e* in vibration. Since the frequencies of the two currents in *e* are different, beats are produced; and then the rectifying action of the tube causes unidirectional pulses of the beat frequency to be delivered to the telephone. If the beat frequency is low enough the pulsating current through the telephone receiver is audible. By varying the coupling between *a* and *e* the effective inductance and the co-operation of the circuits is varied, and the pitch and intensity of the beat note adjusted.

Fig. 25 shows a similar arrangement, except that the filament and grid are connected directly to the aerial instead of to an oscillatory circuit coupled indirectly, and, besides, the

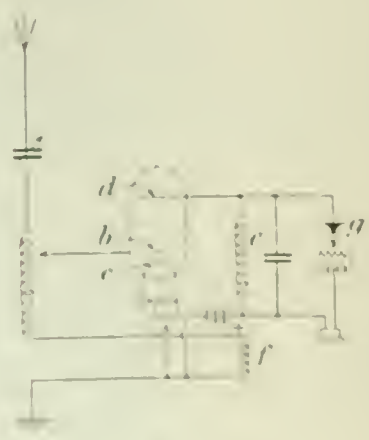


Fig. 25.

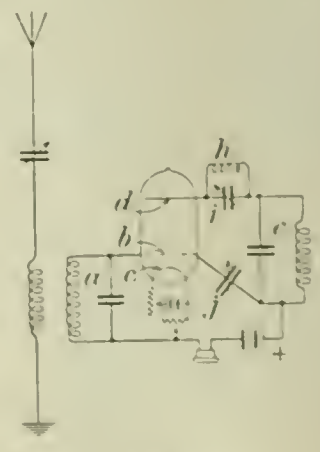


Fig. 26.

inductance of the circuit *e* is linked inductively with the coil *f* in the aerial to obtain the necessary retroaction. A rectifying detector, *g*, is required in the telephone branch. In Fig. 26 a choke coil *h* shunted by a variable condenser, *i*, is inserted in series with the third electrode, and in this case magnetic coupling between circuits *a* and *e* is not necessary. The condenser *j* is sometimes desirable, it is stated, in order to "negative the effect of the capacity *i* between *a* and *b*." It is mentioned that in vacuum tubes of this type the glass becomes electrified through exposure to the cathode stream, which introduces effects similar to polarisation. To obviate this, both control and repeat electrodes are made in the form of

closed cylinders completely surrounding the filament. The capacitance between the cylinder may be sufficient to bring about the linkage between control and repeat circuit necessary for the generation of oscillations, thus allowing the magnetic coupling to be dispensed with.

A telephone relay or magnifier of the dynamo-electric type appears in specification No. 8,903/1915, the inventors being V. Tedeschi and A. G. Rossi, of Turin. The fundamental principle of the invention may be understood from the diagram of Fig. 27. Here R is a copper disc capable of rapid rotation. A, B are fixed coils connected as shown and placed in series with a circuit, I, carrying the alternating current to

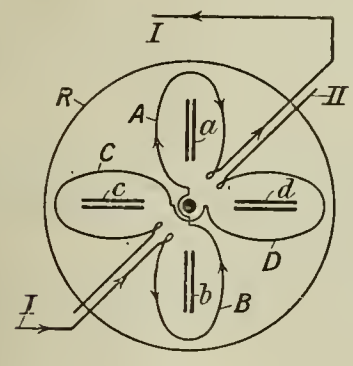


Fig. 27.

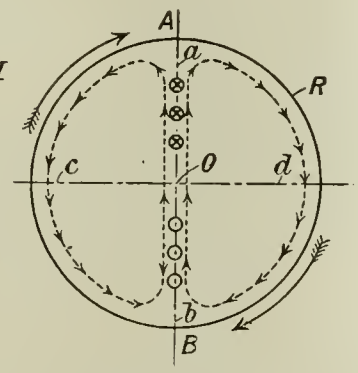


Fig. 28.

be magnified. Coils C, D are fixed coils connected similarly in circuit II., and placed relatively to coils A, B, so that the pairs possess no mutual inductance. The iron cores *a*, *b*, *c*, *d* of the coils are perpendicular to the disc. When the copper disc is stationary the alternating current in circuit I. produces no effect in II., for the eddy currents generated in the copper by coils A, B, are centred under the cores *a*, *b*, but when the disc is rotated an alternating E.M.F. is generated in II. by the system of eddy currents indicated diagrammatically in Fig. 28, which are centred under coils C, D. These latter eddy currents



Fig. 29.

are generated by the copper cutting the magnetic flux induced on the line A*a*, *b*B of Fig. 28 by small circles, of which those with crosses represent downward flux and the blank circles represent upward flux. The intensity of the motional currents is proportional to the speed of rotation, and, therefore, so is the E.M.F. in circuit II. on open circuit; at constant speeds the E.M.F. is also proportional to the currents in I. The magnified current that flows in circuit II. draws its increase of energy from the mechanical work done in rotating the disc. The

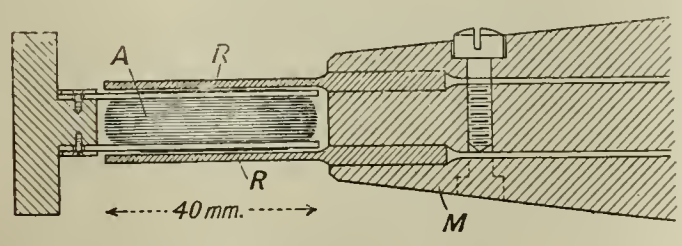


Fig. 30.

above figures are merely diagrammatic; the specification describes a multiple apparatus in which the rotor has nine parallel copper discs, diameter 110 mm., thickness 1·5 mm., secured at equal distances of 13 mm. on the same shaft, which a direct-current motor drives by friction gearing up to 8,000 revs. per min. Between the nine rotor discs eight groups of windings are held, each containing a pair of primary and a pair of secondary coils.

The number of pairs of coils may be increased from the two pairs seen in Fig. 27 up to a large even number, and the copper disc may be replaced by an annulus. This is indicated in Fig. 29, where the coils, cores and eddy currents are represented as in Figs. 27 and 28. In such a relay it is advantageous to have a copper annulus at each face of the windings, and this is shown in the sectional view of Fig. 30, where A is a coil, either primary or secondary, R indicates the copper annuli and M a non-magnetic rotating member. An obvious modification of the last form is made by using one rotating conductor with a coil on each side of it.

Wireless Telephony.

In specification 13,248/1914, Marconi's Wireless Telegraph Co. (Ltd.) and H. J. Round disclose suitable connections for effecting telephony by aid of oscillations generated by vacuum tubes. These are shown in Fig. 31. The microphone M is in

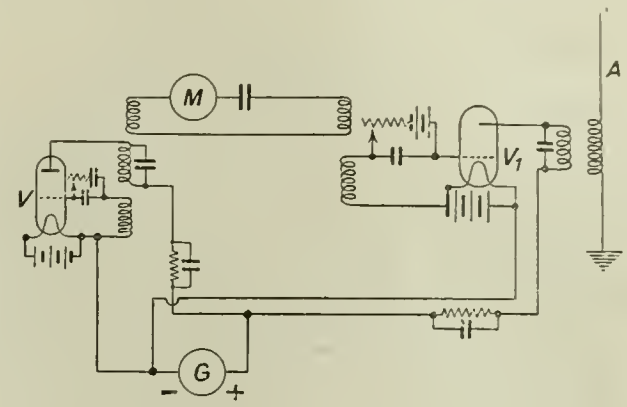


Fig. 31.

an intermediate oscillatory circuit, which is excited by a generating tube, V, operating in the manner described previously. The intermediate circuit is also coupled inductively with a three-electrode tube of large dimensions arranged for amplifying the oscillations in the microphone circuit. By adjusting the steady potential acting at the control electrode of the second tube, it is possible to arrange that uniform oscillations applied to it have no effect in the anode circuit, and then only the microphonic variations are magnified. If this be done, it is said that the second tube may be made the same size as the first. Alternatively, the microphone circuit may be arranged between the two coupled inductances belonging to the generating circuits of tube V and the second tube omitted.

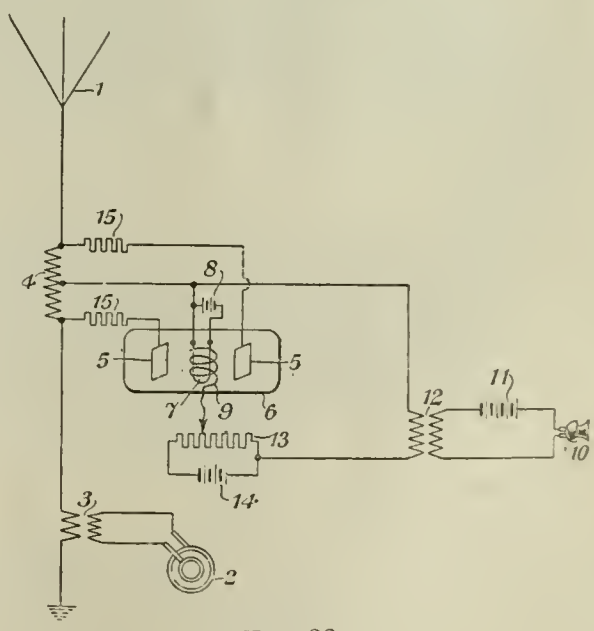


Fig. 32.

In specification No. 21,388/1914, an application of the pliotron to wireless telephony is communicated by the General Electric Co. of America. A mode of carrying out the invention is seen in Fig. 32. The electron discharge tube 6 has a hot-filament cathode 7, heated by a battery 8, a control grid 9, and two anodes 5. The control circuit includes the secondary of a transformer 12, whose primary is supplied with the sound-varied current. The repeat circuit includes a large part 4 of the antenna inductance, so that when the antenna is excited

by the high-frequency generator 2, via transformer 3, a large alternating P.D. exists between the ends of coil 4. On account of the unilateral conductivity of these tubes, this special scheme of connections is advantageous. The middle of coil 4 is connected to the cathode 7, and thus the alternating P.D. in 4 tends to cause current to flow from alternate anodes to the cathode. In the figure resistances 15 are included in the repeat circuit, and a potential divider 13 in the control circuit. The action of the apparatus is as follows : The microphone currents impose variations on the electric field which is maintained near the cathode by the potential divider, and the flow of current varies in the repeat circuits in accord and in augmented degree ; the antenna coil 4 thus finds itself in shunt with a variable resistance, and thus the radiated energy of the wave-length normal to the aerial varies in accordance with the original microphone currents.

GERMAN BOUNTY-FED STEEL.

NOTES PREPARED BY SIR ROBERT HADFIELD, F.R.S.

The importance of the following statements is emphasised by the fact that they were written in *June, 1911*—that is, three years before the war—and are based on remarks by a naturalised German who held an official and diplomatic position on behalf of Germany in this country. In other words, there were those in this country who knew and understood the subtle lines upon which the German export trade to Great Britain was conducted, and who, although not English born, were prepared to show this country what the now (1916) enemy was then doing.

The manufacturers connected with the various branches of the German steel trade are combined to form a syndicate, and about 93 per cent. of German steel manufacturers are members of it. The whole organisation of the industry, including selling and fixing of prices in the home and foreign markets, is regulated and directed by the syndicate. There is also an understanding between the German syndicates and similar combinations in Belgium.

The influence of these combinations, as far as England is concerned, is as follows :—

In order to increase the German export trade to this country, the steel syndicate undersell the British steel maker by invoicing steel billets to English buyers at below the market price. To enable them to do this the syndicate pays to the exporter a sum of money for each ton exported varying from 12s. to 20s. a ton, *according to the state of trade.*

To illustrate this, steel billets are sold, say, for £4. 10s. a ton, and are invoiced at this price to the English consumer, while the cheapest market price here for English steels is 10s. to 15s. per ton higher. In this trade a profit of from 5s. to 10s. per ton is considered a good profit. In order, therefore, to compete with the German invoice price the English manufacturer would have to work for nothing, or more probably at a considerable loss. But the German exporter, receiving bounty of from 12s. to 20s. a ton repaid by the syndicate, in addition to his invoice price, is able to thrive on this kind of trading, while the British steel manufacturer is rendered helpless.

It pays the German to do this, because by doing so he is able, even when trade is bad, to keep his furnaces fully going and his workpeople and machinery fully employed. His costs also per ton of output are reduced to the lowest point. The English manufacturer, on the other hand, must let the orders pass, while his works costs rapidly increase and his workmen walk the streets.

It comes especially hard, of course, in times of bad trade. It also tends seriously to discourage the outlay of capital in many important branches of the British steel trade.

To the extent that British trade is injured by these methods the British nation is that much the poorer, and the bounty received by the German steel maker is practically being paid by the British steel maker, whose resources are crippled, and by the British workman, who is thrown out of employment. The contention of this memorandum is that this is not Free Trade, but a gross and disastrous abuse of Free Trade.

It is not desired to limit freedom of trade, but the objection is to the unfair method of selling below cost by the aid of bounty. If the surplus steel sent to this country were only the exceptional result of bad trade and low prices the matter would not be serious, but it appears to be part of the fixed policy of the syndicate to produce for export on these terms so as to increase and maintain their hold upon the British steel market.

The effect on the English steel trade must necessarily be a serious one, as illustrated by the growth of the German steel trade, which shows an increase of 1,500,000 tons during the last 12 months as compared with the British increase, which amounts to probably less than one-quarter of this amount. Formerly we made considerably more steel than Germany. Last year our output was something over 5,000,000 tons, while the output in Germany was over 11,000,000 tons.

There are, of course, certain consumers who, for their own purposes, support the present system of bounty-fed German steel, but it must be remembered that this system is endangering the position of the British steel industry, and is every year bringing about more and more a condition of dependence upon bounty-fed foreign steel, a condition which is reached as soon as the British manufacturer ceases to be able to supply all the requirements of the home market. It is believed that a state of absolute independence in the matter of steel production is essential to the well-being of this country, and that no greater disaster could befall us than that we should be at the mercy of the German steel syndicate for the supply of steel required to maintain our staple industries.

There is a further danger ahead. A movement is on foot in Germany to form syndicates in other important trades—for instance, the textile trade—and a probability, therefore, that the introduction of bounty-fed goods will start in other directions.

It now remains to inquire what ways and means can be found to prevent a continuation of the above unsatisfactory method of trading.

It is suggested that the foreign exporter should be compelled to invoice his steel to the English consumer at the full price realised. Already this country is bound by law to give, for statistical purposes at the shipping port, the full value on the invoice of the goods exported, and failure to do this means being threatened with penalty. It is thought possible, therefore, to require of importers of steel to this country the same conditions. In other countries, where duties on valuation exist, bounty-fed goods are excluded from importation, or otherwise valuation is fixed by the authorities. Cannot, therefore, the very reasonable condition be imposed that goods entering this country shall be invoiced at their true and proper value ?

Free Traders desire no duties of any kind, neither duties for us nor duties against us, neither duties positive nor duties negative, and in this case the duties negative, in the form of bounties, are even more objectionable than the duties positive.

It is felt confident that the British steel maker is able to hold his own against all comers when the conditions of competition are fair, but it is impossible for him to do so in competition with bounty-fed goods, and it has, therefore, become urgent that some serious step should be taken to prevent the present system of invoicing.

There is much more that could be said in explanation of this point that cannot well be said in writing, but it is hoped to have the honour of a personal interview in order that further views may be explained on this matter of the under-priced invoicing of imported goods.*

(*The following remarks were prepared at a later period—namely, June, 1914.*)

Some little time ago attention was called to the system prevailing in the German iron and coal industries of giving export bounties. From a reliable source the Board of Trade "Journal" has now received information summarising the bonuses granted by various syndicates during the last year. From this it appears that:—

1. The Rhenish-Westphalian Coal Synd. *granted a bonus* (bounty) in July of 1.50 marks per metric ton *on fuel* obtained from the syndicate for which proof was produced that it had been used in the manufacture of iron for export. In October this bonus was raised to 2.50 marks for blast furnace coke and coke coal. During November-December the export bonus was reduced again to 1.50 marks, and at the same time the sale prices for the first half of 1914 were reduced.

2. The Pig-Iron Synd. granted an export bonus of 4.75 marks per metric ton in July on pig iron bought from the syndicate for the manufacture of goods subsequently exported : this rate included the 1.50 marks granted by the coal syndicate. In October the bonus was raised to 6.25 marks, to include the increased rate granted by the coal syndicate, and in January last was reduced to 4.75 marks again in view of the fact that the coal syndicate had reduced its bonus.

3. With regard to the steel works syndicate, an increase in the amount of the existing export bonus has been refused in March, but it was granted upon the export of half-finished goods as from June 1st. The increase amounted to 5 marks per metric ton, thus bringing the total amount of export bonus granted by the syndicate to 15 *marks* per metric ton.

---

*The above memorandum was drawn up for submission to His Majesty's Government, but as strong hints were given that it was useless to bring up the matter this went no further.

4. The rolled wire syndicate increased its bonus in July by 5 marks per metric ton, so that the export bounties amounted to 11.50 marks per ton of raw material used in the case of iron wire and wire goods, and 16.50 marks in the case of wire tacks.

Metric ton	2,204 lb.
Mark	11·8d.

Another point may be added for consideration. By law we are bound to give at every shipping port the exact full value of our shipments, for statistical purposes presumably. The Germans give as the value of their shipments the invoice value, which is not the proper value, for in the case of this bounty-fed steel it is about 18 to 20 per cent. more. Is it not possible for the Crown solicitors to find such instances and insist upon proper declarations ? What do the Americans do in respect to bounty-fed goods ? *They accept no invoice values*, but assess the value of Custom House purposes themselves and *some bounty-fed goods are not allowed at all to be imported.*

It can only be repeated what has been stated above. If our Free Trade system is in danger, it is brought on by this miserable subsidising business. It is astonishing to read in the paper published recently by the Board of Trade (1914) what are the figures.

THE WILE ELECTRIC FURNACE.*

A new type of arc electric furnace has recently been introduced. The three-phase type of construction has been adopted, because electric supply systems generally are three phase. The only other prominent arc furnaces using this current are the Stassano and the Héroult. The Stassano has three horizontal electrodes, but is limited to a capacity of 5 tons ; the Héroult has three electrodes inserted through the roof with no bottom electrode ; while the Wile furnace has two electrodes at the top and one electrode at the bottom.

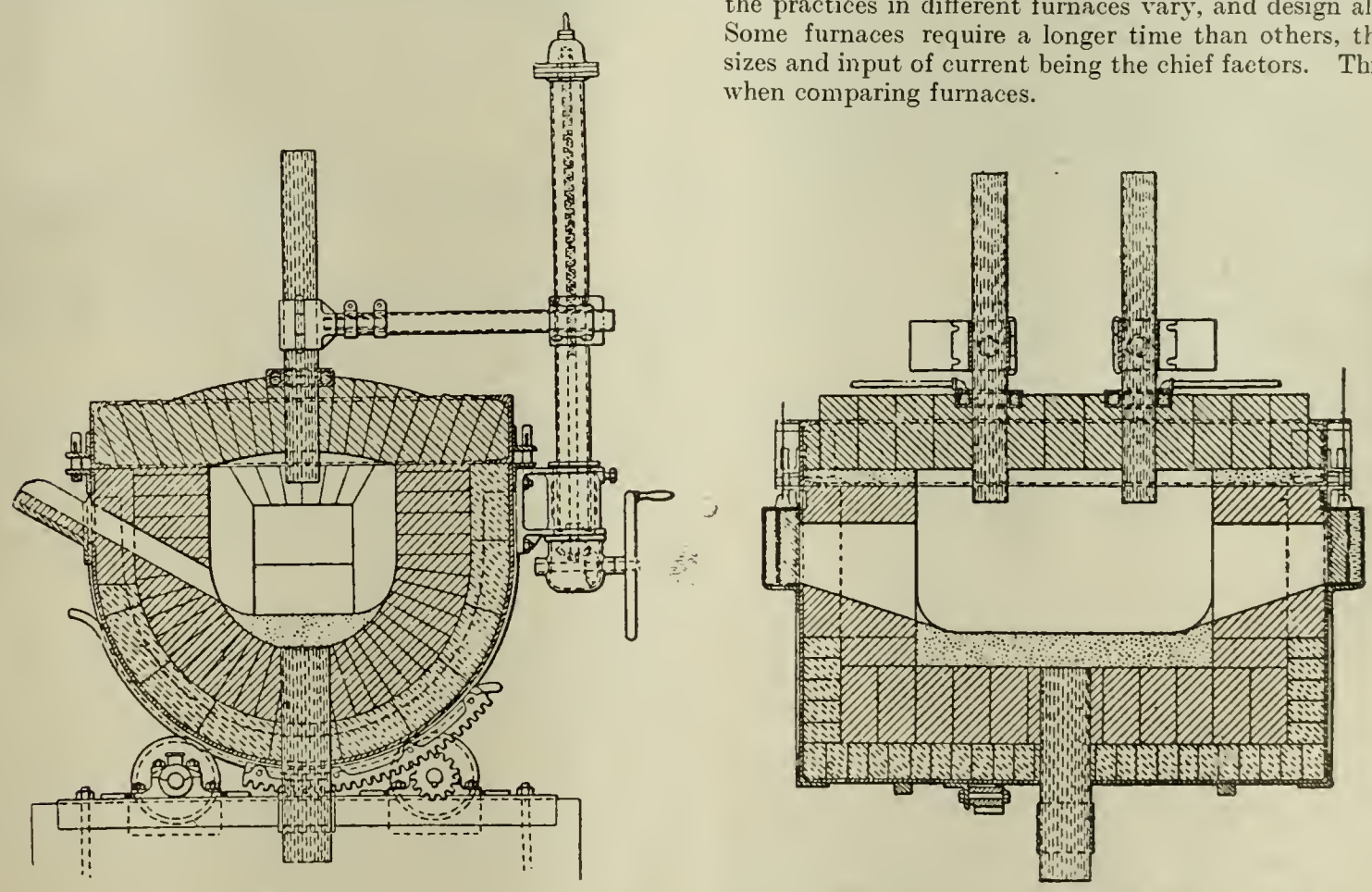
It is claimed that this latter connection has a number of advantages. In all steel-refining one of the most essential points is to eliminate gases in order to make sound castings or ingots. In the furnace with the three top electrodes, or those entirely above the charge, it is necessary to superheat the steel or cause it to boil to free it of gases. This temperature is much higher than the pouring temperature, hence it is necessary to cool the steel before pouring. This causes undue wear upon the furnace linings. This is not the case in the three-phase furnace with the bottom electrodes, as the circulation of the steel is plainly visible and the superheating is unnecessary.

Again, it is often imperative that the furnace be started on cold stock. In loading the furnace the heavier pieces are placed on the bottom, and the lighter and smaller pieces are placed on top, so that the top presents a fairly smooth appearance, without ragged projections to cause unnecessary fluctuation in the line.

In starting a furnace with three top and no bottom electrodes it is necessary to burn a hole through the pile of steel clear to the bottom in order to form pools of metal to do away with violent fluctuations. These occur also in the furnace with the two top electrodes and one bottom electrode, but to a smaller extent, owing partly to the absence of one top electrode, but more particularly because of the melting of the steel on the bottom at the same time it is melting at the top, in that manner forming the pool more quickly and with fewer surges. In the Wile furnace the bottom electrode is made of graphite, but it stops short of the metal bath, the actual furnace bottom being made of a conducting compound of magnesite and tar, which causes no more trouble in operating than does the bottom in any furnace.

It is preferable, of course, to use molten materials. A large number of furnaces are thus operated, but it is often expedient to use cold stock where there is no open-hearth plant to furnish steel in the molten state. It is not prohibitive to melt it cold, but the demand on the source of power is greater and the installation more elaborate, owing to the greater amount of current needed if the same tonnage is required that is obtained from the furnace refining molten stock. It is not claimed that the current consumption in the Wile furnace is any less than in the furnace with three top or horizontal electrodes, as this factor depends largely upon furnace design and insulation ; but it does enable the furnace to be worked with fewer abnormal variations of the load, and it can be more easily regulated by hand where there are only two electrodes to manipulate, though automatic regulators are supplied to this furnace where desired, as they usually are. It uses less current than a single or two-phase furnace in instances where these take the supply from a three-phase system, when the heat insulation of the furnace is not the sole factor, but the losses in transforming enter as well.

Violent fluctuations of the load occur only when melting cold stock. All furnaces are uniformly quiet when running on molten material, and the number of furnaces refining molten steel is probably in excess of those starting with cold stock. The time consumed in refining the molten steel depends upon the impurities to be removed, though this is also true when cold material is used ; but in this latter case the practices in different furnaces vary, and design also enters here. Some furnaces require a longer time than others, the variation of sizes and input of current being the chief factors. This is important when comparing furnaces.



Sections of the Wile Electric Furnace, showing Positions of Electrodes and Tilting Mechanism.

Most readers are familiar with the possibilities of steel refining, but a few figures are offered to show the current consumption in a Wile furnace of 2 tons capacity, starting with cold scrap having the following fairly uniform analysis :—

	Cold scrap. per cent.		Finished product. per cent.
Sulphur	0·061	.....	0·018
Phosphorus	0·04	.....	0·024
Silicon	0·09	.....	0·110
Carbon	0·28	.....	0·12
Manganese	0·31	.....	0·31
Time of melting and refining	4 hrs. 20 min.		
Kilowatt-hours per ton	868		
Electrode consumption per ton	2s.		

These figures are given, not to prove superior practice, but as an idea of one operation. They will vary for different requirements, and will give a fair average in this one installation.

* Abstracted from the " Iron Age."

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence. Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential circulation all over the World.** *This statement is guaranteed. Advertisement Rates, &c., forwarded on application.*
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d.; Canada and India, 2s.; Australasia and South Africa, 3s.; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.
WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preparation.*
THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.
THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*
PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*
THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.
ELECTRICITY METERS: THEIR CONSTRUCTION AND MANAGEMENT. By C. H. W. Gerhardt. Profusely illustrated. Price 9s. nett. [Price 10s. 6d.
MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.,
SIGNALLING ACROSS SPACE WITHOUT WIRES: THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.
BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By C. M. Baines. Price 7s. 6d. nett.
THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. 2s. 6d nett, post free 2s. 9d.
THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone. 9s. nett, post free 9s. 4d.
STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett
ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S. Heather, M.I.E.E. 9s. nett.
AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.
THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.
WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.
ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.
LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.
ELECTRIC BLASTING APPARATUS AND EXPLOSIVES: With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.
THE SHOT-FIRER'S GUIDE: A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.
THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.
THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*
LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.
ELEMENTARY THEORY OF ALTERNATE-CURRENT WORKING. By Capt. C. L. Hall, R.E. 3s. 6d. nett.

Ready Next Week.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s.** nett, post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s.; post free, 2s. 4d.

BOUNTIES AND DUMPING.

We have often heard vague statements in regard to dumping, the nature of the statements generally depending upon the political views held by the speaker. Thus dumping is sometimes said to be the cause of all our periods of depression; equally, the evil is often said to be non-existent. If by dumping is meant the selling of an article so as to give no profit to the seller, this may perhaps be rare, and it may be difficult to give specific instances; but if we class with dumping the export of goods at prices which are made artificially low by means of bounties, then it becomes possible to produce some evidence of the practice.

In this connection we are glad to give publicity to certain statements which have been prepared by Sir ROBERT HADFIELD, F.R.S., partly because they come from a reliable source and partly because they deal to a large extent with the steel industry, in which Sir ROBERT holds a prominent position. Surprise is sometimes expressed at the rapid growth of German-made steel during the last few years, as compared with British-made steel. We think that this may be explained to some extent by the practice adopted in Germany of giving bounties. It appears that the German steel manufacturers are mostly combined in a syndicate, which not only fixes prices in their home market, but takes steps to encourage export. In order to increase the export trade, the syndicate pays to the exporter a sum varying from 12s. to 20s. per ton exported, according to the state of trade, so that steel billets can be invoiced to English buyers at prices below the market price. Thus these steel billets may be sold at £4. 10s. per ton, and are invoiced at this price to the English consumer, while the cheapest market price for English steels is 10s. to 15s. a ton higher. Since the ordinary profit is 5s. to 10s. per ton, the English manufacturer would have to forego his profit, or even to sell at a loss, in order to compete with the German steel so sold. We refer, of course, to pre-war conditions.

If this practice is adopted in the selling of steel there is no reason why it should not be extended to other products, and from the notes which we give elsewhere it will be seen that the practice has been so extended to some extent. For example, bonuses have been granted on fuel in Germany when proof was given that the fuel has been used in the manufacture of iron for export.

At first sight it may seem that the German trader is doing something which is very beneficial to us, and of no use to themselves. This, however, is scarcely to be expected. The effect is to hamper the British steel producer and to enable the German producer to keep his furnaces going to the fullest possible extent. The Free Trader will reply that this does not matter, and that if the Germans are good enough to send us over steel for nothing we ought to be grateful. But in looking at the matter from this point of view some inquiry should be made as to the motive underlying the transaction. The German trader is not likely to consider the good of the British nation, or of the British producer, but will merely consider his own advantage. Suppose we take the extreme case that the British producer finds it no longer worth while to continue in business. Is it then to be supposed that when British steel ceased to be produced the price of German steel would continue at, say, 10s. below the British market price, or even at a figure as low as the British market price then ruling? We think we may, without hesitation, say that the German producer

would not be so philanthropic as to maintain a low price if he could equally well obtain a price that was higher.

The motive of the German producer is simply to damage British trade as far as possible to the advantage of his own. Although it may be a temporary advantage to the British buyer to be able to purchase steel at a price of 10s. per ton less than the British market prices, the advantage in the long run cannot be to this country.

Unfortunately, questions of this kind are always tainted with politics, and it is interesting to notice the consequence of this—that the notes to which we have referred, although they were prepared in 1911 with a view to submitting them to the Government, were not pressed home, as strong hints were given that it was useless to bring up the matter.

Free Trade on a true Free Trade basis is one thing, but Free Trade on an artificial basis is quite another. Although Sir ROBERT HADFIELD is himself a Free Trader he feels strongly that this country should not permit what is equivalent to a negative tariff, and it is suggested that we should follow the lead of some other countries in matters of this kind. In America, for example, no invoice values are accepted for bounty-fed goods, and some bounty-fed goods are not allowed to be imported under any conditions. Considering that the Council of the Institution of Electrical Engineers is now favouring Protection as against Free Trade, we think it would be well if they would give attention to this question of bounties. Wholesale protection may be regarded by many people as a disastrous course to adopt, but the most pronounced Free Trader will surely see that it is not in the best interests of the manufacturers of this country to permit Free Trade on a purely artificial basis.

REVIEWS.

Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

A Meteorological Treatise on the Circulation and Radiation in the Atmospheres of the Earth and of the Sun. By F. H. BIGELOW, M.A., L.H.D. (London: Chapman & Hall.) Pp. xi.+431. 21s. net.

The author considers that the usual treatment of the fundamental gas equations in text-books on meteorology is incomplete and inexact, on account of the fact that adiabatic conditions are assumed, which do not actually obtain in the atmospheres of the earth and of the sun. As an example, he mentions that in an adiabatic system there would be no circulation and no radiation. The facts of observation, however, imply that both, occur and the author whilst Professor of Meteorology in the United States Weather Bureau (1891-1910), and later in the Argentine Meteorological Office, extended the thermodynamic adiabatic equations so as to adapt them to the actual conditions prevailing in the atmosphere.

This new method of treatment implies that the characteristic gas constant $R[=pv/T]$ and also the specific heat of air C_p depend on the height of the layer of gas considered above the sea level.

The book is entirely of a mathematical character, the subject being dealt with under the following heads: Meteorological constants and elementary formulæ; thermodynamic meteorology; thermodynamics of the atmosphere; examples of the construction of vortices in the earth's atmosphere; radiation, ionisation and magnetic vectors in the earth's atmosphere; terrestrial and solar relations; extension of the thermodynamic computations to the top of the atmosphere; and it contains the solution of a number of problems which have hitherto been intractable along the old lines of procedure, such as *e.g.*, the diurnal convection, and semi-diurnal barometric waves, with the radiation; the thermodynamics of the general circulation; and electric and magnetic problems connected with the atmosphere. There are 98 tables of constants and summaries of results, and 78 diagrams and graphs assist in explaining the text, while a comprehensive index (9 pages) materially adds to the value of the book. B. W. C.

The Universe and the Atom. By M. ERWIN. (London: Constable & Co.) Pp. iv.+314. 8s. 6d. net.

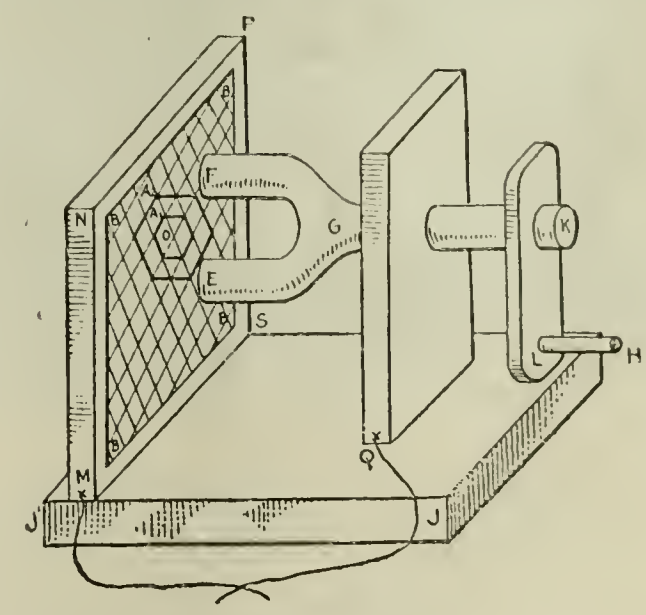
Those of our readers who are tired of the war and everything connected therewith, provided they be of a studious turn of mind and possessed of some knowledge of natural philosophy, are advised to read Mr. Erwin's book.

By so doing, both high and low will conclude that theirs is but a minor part in the order of things. It is well that man should come to such a conclusion, for, as the author reminds us, "Arrhenius, in his 'Worlds in the Making,' has pointed out that, however long the time, the final catastrophe must come to every sun, when it will collide with some other sun, and by that collision the energy represented by the rectilinear velocity of the masses bowling through space will be converted into vibratory motion of the atoms of which they are composed, and those atoms will be scattered through millions of miles of space as a great nebula."

One of the most striking passages in the book is the concluding paragraph which reads as follows: "We must therefore conceive that in the universe, matter is being created by radiations from other matter all the time; that there is going on all the time the gathering up of this new-born matter by gravitation into clusters and suns; that in time these suns go to a kinetic death, and finally the matter of which they are composed is converted again into ether substance. Thus we have an endless cycle of births, lives, deaths and resurrections in the material universe."

Practical readers will be interested in the author's description of the operation of a simple magneto-electrical machine, which is "an apparatus for turning mechanical energy into an electric current," in the chapter on "The Birth of the Electron or Corpuscle."

"Let MNPS, Fig. 48, be an iron plate or armature mounted on an insulated platform or table JJ. EGF is a bar of magnetic iron bent in



the shape of a horseshoe, the bend of the horseshoe being fastened to the axle GK, which is mounted perpendicular to the iron plate. To the end of the axle is fastened an insulated crank, KL-H. When the crank is turned the ends of the horseshoe are revolved in front of the iron plate or armature as it is called. The surfaces of the two ends of the magnet are made smooth and true so that when the magnet is mounted in the frame the ends come very near but not quite to touching the iron plate. The support Q is a conductor connected with the axle. M and Q have wires attached so that when desired they may be joined to form a circuit. At first we will consider them as disconnected.

"Now, as is well known, when a magnet is so mounted, by induction it immediately magnetises the iron plate or armature or sets up induction currents in the surface of the plate, and this induced magnetism reacts back and makes the magnetism in the poles E and F still stronger. The poles E and F being positive and negative, there are corresponding negative and positive poles created in the surface of the plate.

"It is fully established that the whole space between the poles of the magnet and plate becomes filled with lines of force or 'flows' of energy passing from pole to pole, and there is created in the space between the poles of the magnet a field of high magnetic pressure.

"If now the wires are joined to make the circuit, and the crank is rapidly turned, a current of electricity is sent through the wire, and the

intensity of the current, and therefore its capacity to do work, is in proportion to the speed with which the crank is turned. In turning the crank it is found that 'something' opposes a powerful resistance, and this resistance increases with the speed. If the iron plate or armature is removed, the resistance disappears. The electrical current produced in such a machine constructed with a little more of detail than we have found it necessary to describe, can be made to light a burner, run a small sewing machine or do other work, and yet when the turning of the crank is stopped nothing apparently has been consumed or used up except the energy represented by the turning of the crank."

In such terms does the Author refer to one of the greatest discoveries of the age and his description would have been even happier had it been more accurate. Pressure on our space prevents us dealing with the book at greater length.

TOTALLY-ENCLOSED BRAKE SOLENOIDS.

Particulars of the new range of series and shunt-wound brake-releasing electromagnets, made by Mr. G. Ellison, of Birmingham, have recently been issued. The magnets described are suitable for operating the mechanical brakes in cranes, hoists and winches, and for any purpose requiring a definite pull through a limited stroke. The salient features of the design are set out below, and extracts are taken from the sections of the list devoted to rating, cycle curves and specifications.



Fig. 1.—Range of Totally-enclosed Brake Solenoids.

The frame consists of two massive iron castings, bolted together at an accurately machined joint to form an outer yoke, which encloses the coil. A suitably-tapered mild-steel fixed core of circular section is secured to the top frame casting, and the moving core, or plunger, of mild steel tapered to suit the fixed core besides forming the core of the solenoid, also acts as a piston to give an adequate dash-pot effect. A groove in the movable core serves to retain the lubricant, and to accommodate a steel packing ring where the maximum dash-pot effect is required.

A brass tube expanded into two cast-iron cheeks forms the coil spool, which is stove enamelled to prevent the formation of oxide, and its injurious reaction on the windings. Liberal oiled-cloth insulation applied to the spool precludes any possibility of breakdown due to the high inductive pressure rises which occur when the circuit is interrupted. Unprotected wound spools insulated in this manner have been subjected to tests of the utmost severity, and shunt-wound magnets have been excited with more than twice the normal pressure, and the circuit opened and closed as rapidly as possible for extended periods without signs of trouble. The shunt coils are wound for any line pressure up to 650 volts, the winding being of enamelled wire with oiled-paper insulation so applied between layers that moisture cannot penetrate further than the top layer.

To one side of the magnet frame is bolted a substantial box-shaped casting, which totally encloses the terminals. These consist of heavy brass blocks bolted to micanited rods. Shell clamps are mounted on the blocks to take the small cables required for shunt magnets, and heavy sockets of the Admiralty pattern are used for series magnets.

A small adjustable valve fitted to the top cheek of the coil bobbin permits the free exit of air from the space between the cores as the plunger rises, but prevents its entrance. The partial vacuum formed as the plunger falls retards the movement and prevents sudden application of the brake.

Characteristics of Series and Shunt Windings.—Series windings are arranged to take the full-load current of the motor for a specified time without overheating. The weight they will lift varies with the current, and therefore with the load on the motor, and this load may be so low that the magnet fails to pull, or having pulled it fails to complete the stroke. This happens frequently when the motor is on the lifting motion of a crane which has efficient gearing, with low inertia, and will occur no matter what amount of current is passed on the first notch of the controller.

In such cases it is usual to specify that the magnet shall pull with a certain percentage of the full-load current, while being capable of carrying full-load current without overheating. If this percentage is low, the magnet becomes extremely costly and large, and on top load it pulls the brake off very abruptly. If it is not low, the magnet will not pull off or remain off when the motor is lowering a load a little less than the friction of the crane, or is lifting the empty hook. In such cases it is easy to specify that the magnet shall pull with a moderate percentage of full-load. Actually the series-wound magnet is rarely required to carry full-load current, because the maximum load to be handled is generally well within the rated capacity of the motor, and advantage may be taken of this to use a magnet of smaller size with normal heating at usual loads.

A shunt winding is inherently safer than a series winding, because the current decreases as the magnet heats, and the maximum temperature rise is far lower than for a series winding of the same rating.

Ratings.—The ratings that have been adopted are 15-minute, 30-minute, 60-minute and continuous, and represent the time the magnet may be kept in circuit to arrive at 100°F. temperature-rise.

It is very little use telling a user that a piece of apparatus will heat to a given temperature in a given time unless this information is accompanied by a statement defining the equivalent time in service and time out of service required to maintain the temperature-rise. This is one of the principal difficulties in rating electrical machinery, and it has been solved for the magnets made by Mr. Ellison by the preparation of cycle curves embodied in the list and described below.

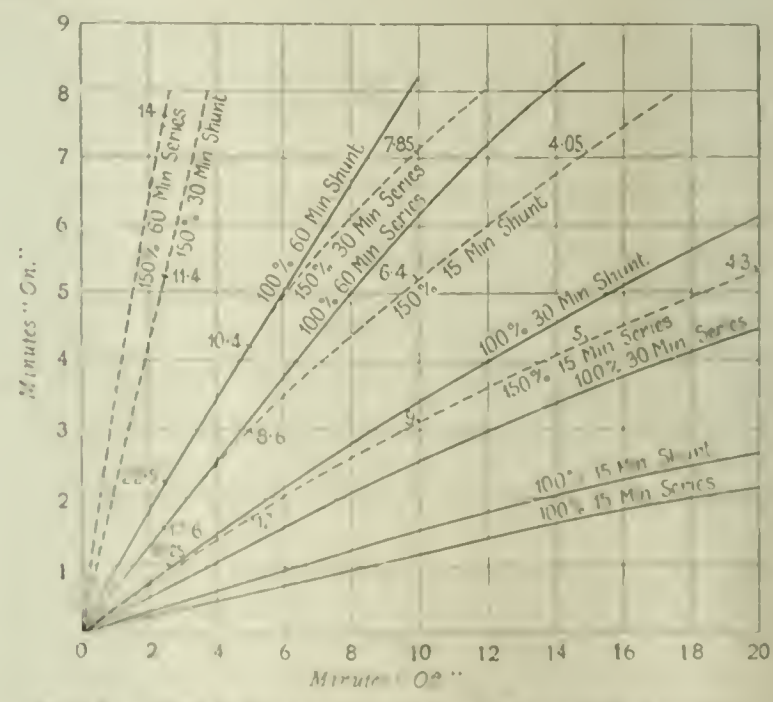


Fig. 2.—Cycle Curves of Brake Magnet Solenoid.

Cycle Curves.—The curves given in the accompanying illustration show precisely the minutes "on" and minutes "off" to maintain the temperature rise for each rating for each magnet under series and shunt conditions. They also show the equivalent cycle required to maintain 50 per cent. excess temperature, and the figures on the latter curves show the number of times the excess cycle must be repeated to raise the temperature from the normal to 50 per cent. excess, in this case from 100 F. rise to 150 F. rise.

Their utility is obvious; they tell the user what rating to adopt to suit his conditions; they tell him how much he can increase his requirements on emergency, and they tell him how often he can meet that emergency consecutively to arrive at the increased temperature.

Increasing the time a magnet is in use is much the same thing as increasing the watts at the old time, so these curves also show to what extent a series magnet may be overloaded with safety as regards current, although they are drawn to show how it can be overrun as regards time. For example, the curve for No. 3 series magnet 30-minute rating gives 1 minute "on," 4 minutes "off," 100 per cent. heating; and 3·4 minutes "on," 4 minutes "off," 150 per cent. heating, with 100 per cent. current. Therefore a magnet ordered for $100\sqrt{(1/3{\cdot}4)}=54{\cdot}4$ per cent. of full-load current will heat 100 per cent. with this current, and 150 per cent. with full-load current in a cycle of 1 minute "on," 4 minutes "off," and if specified to pull with 40 per cent. current it will really pull with $54{\cdot}4\times0{\cdot}40=21{\cdot}76$ per cent. of the true full-load current of the motor.

It should be remembered that the magnet must be rated for the time the motor is in service, and in this respect the magnet rating differs from the resistance or controller rating, which is based on the time the motor is accelerating or running at reduced speed.

Magnet Fitted with Switch.—The duty obtainable from the magnet decreases very rapidly on the longer ratings, and becomes less than half on continuous rating. This state of affairs may be remedied by using a double winding and a switch arranged so that one winding is in circuit momentarily and lifts the load while the other is in circuit continuously and retains the load. Pulls up to two or three times the normal for 15-minute rating are obtainable by this method on a continuously-rated solenoid. The method is of special interest in connection with shunt magnets, but it may also be applied to series magnets, and it has a special application to hoisting motors fitted with rheostatic braking controllers.

Typical Specifications.—The service must be clearly and accurately stated, and the following information must be given: The pull in pounds; stroke in inches; brake horse-power of motor and rating; pressure of supply for shunt coils; maximum current to be carried; minimum lifting current and minimum current to hold the load for series magnets.

A typical specification for a series magnet would be as follows: The magnet is for use on a hoisting motor, and is to pull 50 lb including the plunger, 4 in. stroke. The motor takes 100 amperes on full load, but the general load to be handled is 65 amperes, and the controller passes 40 per cent. current on the first notch. There is no automatic brake and the maximum current when hoisting the empty hook is 25 amperes; on lowering full load it may be nearly zero, but the magnet has to release when the speed is 2½ times normal full-load speed, to prevent the motor racing, and the current corresponding to this speed is 15 amperes.

The heating with 65 amperes on a cycle of 30 seconds "on" and 68 seconds "off" repeated continuously must not exceed 100°F., and the heating on full load on the same cycle repeated six times after the magnet has attained 100°F. rise must not exceed 150°F.

The dash-pot effect must be sufficient to cause the plunger to perform its outward stroke in two seconds.

A similar specification for a shunt magnet is: The magnet is to pull 50 lb. including the plunger at 4 in. stroke. The pressure of supply is 440 volts, but it may vary from 420 volts to 450 volts. The normal duty is a cycle of 30 seconds "on," 68 seconds "off" continuously, and on this cycle the temperature-rise must not exceed 100°F., but on emergency the duty may be increased to 45 seconds "on" and 68 seconds "off," and on this cycle the temperature-rise must not be sufficient to injure the insulating materials used.

The magnet must pull the specified load after the temperature has arrived at a steady state on the more severe cycle at the highest pressure.

A discharge resistance, ventilated pattern, must be supplied to limit the momentary pressure rise at break to 500 volts, and its temperature-rise must not exceed 200°F. on a cycle of 30 seconds "on," 68 seconds "off," or 350°F. on a cycle of 45 seconds "on," 68 seconds "off." The insulation of the magnet must be sufficient to stand the maximum pressure rise when not shunted by the resistance and when the circuit is broken on a double-pole quick-break knife switch.

As regards pull, stroke and exciting voltage, the magnets listed cover most of the cases likely to occur, and full particulars and dimensions of each magnet in the range are given. Notes on the several methods of mounting the magnets bring to a conclusion a list which is more a work of reference than a mere catalogue, and which will be found invaluable by users of such magnets.

CORRESPONDENCE.

ELECTRIC DISCHARGES IN SUB-STATIONS.

TO THE EDITORS OF THE ELECTRICIAN.

I enclose a photograph taken at the Dudley sub-station of the Shropshire, Worcestershire & Staffordshire Electric Power Co. So far there is no explanation of the appearance of electric flashes to the right of the photograph. The negative could not have been previously exposed, as a new film pack was opened and three exposures were made *before* this one and one exposure



was made *after*. The time of exposure was one second. The discharge in the exact centre of the photograph is over a lighting wire which was discovered afterwards to be alive, and the large discharge beneath is just over an iron plate.

The girl is operating one of the oil switches.

Birmingham, July 26. SWITCHBOARD.

Colliery Electrification; Existing Plant Problems. Writing in the "Iron and Coal Trades Review" on the production and economical use of power, Mr. G. Stanley Cooper utters a word of warning against a too optimistic view of electrification. He says: "Too frequently we find that when manufacturers are advocating the installation of new and up-to-date plant they entirely omit to take the existing plant into consideration. At many collieries it would be impossible to make the wholesale change to electrical working which electrical engineers frequently advise. Existing winding engines represent in most cases a considerable capital outlay, and the change could only be made at great loss and expense. With new collieries, of course, the position is somewhat different, and no such restrictions apply."

AN ABSOLUTE THERMOPILE.*

BY W. W. COBLENTZ AND W. B. EMERSON.

Summary.—The results of investigations of a bismuth-silver thermopile suitably arranged to measure radiant energy absolutely are given. The incident radiation fell on a blackened metal strip instead of directly on the thermopile. This metal strip acts as a receiver for radiant energy, also as a source of radiation by electrically heating it, and finally as a standard source of radiation for testing the sensitivity of the radiometer. Results of experiments on 13 different receivers are referred to in the Paper.

The Radiometer.

The radiometric receiver shown in Fig. 1 is a simple device, consisting of a thin strip of metal blackened to absorb radiation. Behind this metal strip, at a distance of 2 mm. to 3 mm. is placed a thermopile of bismuth-silver having a continuous receiving surface of tin. The thermopile is connected with a d'Arsonval galvanometer, which serves to indicate the rising temperature of the metal strip. This strip of metal serves three purposes: (*a*) As a receiver for radiant energy, (*b*) as a source of radiation, and (*c*) as a standard of radiation

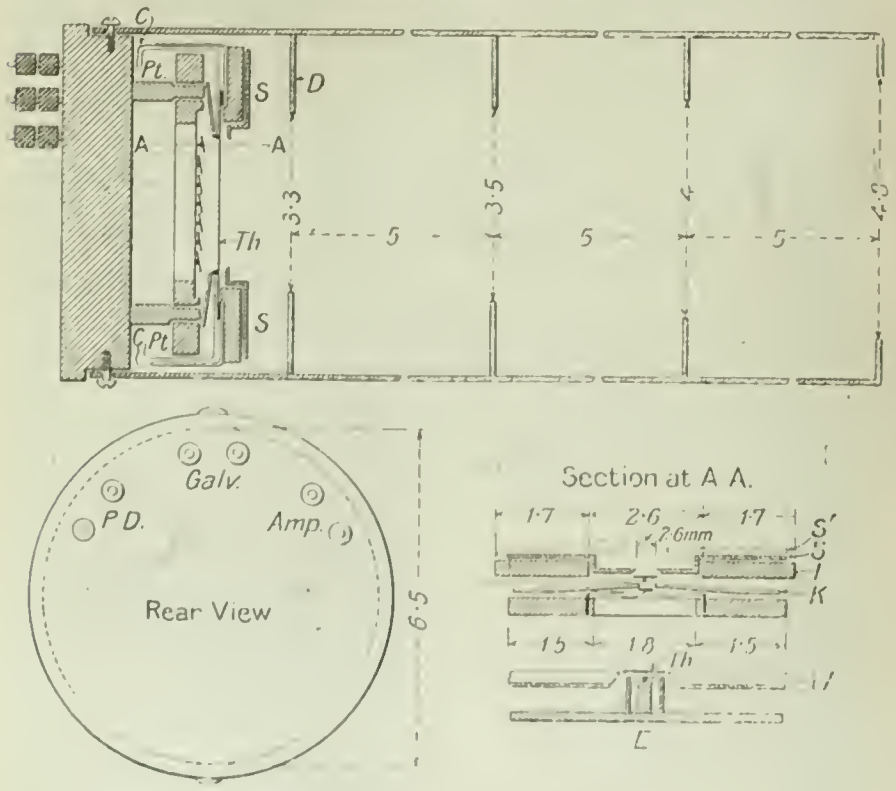


Fig. 1.—The Radiometer.

to test the galvanometer by heating the strip electrically. By using a thermopile separated from the receiver it is possible to use various receivers, and the apparatus was designed so that the receivers could be mounted over the thermopile, as shown in Fig. 2.

It will be seen on referring to Fig. 2 that each receiver is a complete unit, consisting of an insulated base of slate (*B*) 3 mm. in thickness, to which are attached the copper electrodes *EE* 0·05 mm. in thickness, the receiver *R*, potential terminals *PP*, the knife-edge slots *SS* at the front, and the strips of copper *CC* at the back, which are used for the purpose of preventing radiations not intercepted by the receiver from falling upon the thermopile. The platinum used for receivers was "platinum silver," the metal used for bolometers. This material is cut into strips by means of a special cutting device, and soldered to the electrodes, which were then covered with Chatterton compound in order to protect them from the nitric acid which was used for removing the silver from the platinum. The platinum strip is then cleaned electrolytically by dipping it in hydrochloric acid, and finally the strip was coated electrolytically with platinum black. The opening in front of the platinum receiver is defined by means of knife-edge strips of metal along the sides and across the ends. The latter were placed directly over the potential terminals. When it was found impossible to detect the difference in the radiation constant as measured with and without the slits (which were made of thin copper) across the ends, they were discarded, and the entire length of the receiver was exposed to radiation. The knife-edge slits in use are of two kinds—brass ones 0·5 mm. in thickness and aluminium ones 1·95 mm. in thickness. They were both bright for a distance of about 1 cm. along the knife edge on the side exposed to the radiator. Owing to the uncertainty of the exact area exposed, when a hemispherical mirror is placed in front of the receiver, as in previous work, this is not done. The receiver of the thermopile had an area of 1·8 mm. to 19 mm. The thermopile is

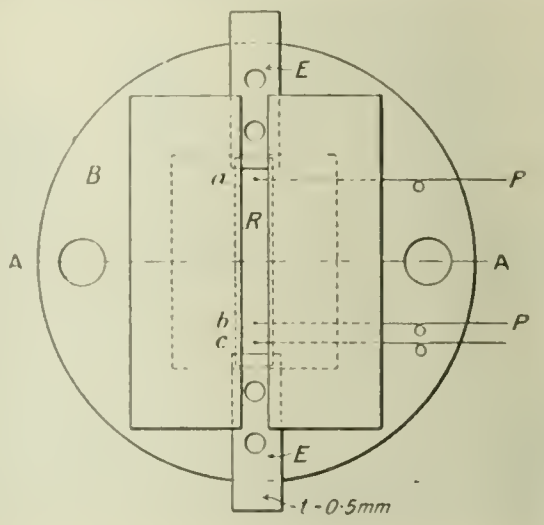


Fig. 2.—Construction of the Receiver.

coefficient of resistance of platinum which is positive when unblackened becomes negative after it is coated with platinum black. This is illustrated in the Paper.

Thermopile and Galvanometer.

The thermopile, with its auxiliary receiver, requires from 12 to 15 seconds to produce a maximum galvanometer deflection. This long period requires uniform conditions in order to obtain accurate results. No observations were made on very windy days when the thermopile was affected by air currents. The d'Arsonval galvanometer is used as a check on the observations made with an ironclad Thomson galvanometer of 5·3 ohms, which is operated on a single swing of 1·5 to 2 seconds, an external resistance of 60 to 120 ohms being kept constantly in the circuit. The galvanometer deflections are then from 150 mm. to 200 mm. The galvanometer is completely shielded magnetically, and any unsteadiness is due to air currents acting on the thermopile.

Water cooled Shutter and Diaphragm.

As shown in Fig. 3, this consists of a tank 25 cm. in diameter and 1·5 cm. in thickness, which faces the radiator and the tank *B*, 20 cm. in diameter and 3 cm. in thickness, which faces the radiometer. The water cooled shutter shown in the figure consists of a thin metal box 3·5 by 3·5 by 0·8 cm., and operated in vertical ways between these two shields. A thermometer, *T*, having its bulb in the water flowing from the shutter is used to measure the temperature *T* used in the equation below. The side of the shutter facing the radiometer was smoked in a sperm candle, and in connection with the conical-shaped opening in the water-cooled diaphragm *B* it forms a miniature black body, the temperature of which remains constant throughout the series of measurements. The temperature of the water varied, sometimes being as low as 10° C. in the winter and over 15° C. during the investigation. The temperature of the shutter

* Based on Scientific Paper No. 261 of the Bureau of Standards.

is easily kept constant to within 0·5°C. The opening of the diaphragm *B*, which must be accurately known, is defined by a series of small perforated discs of brass 8 mm. in diameter and 1·5 mm. in thickness, which are mounted in a recess provided for the purpose. These brass discs had accurately cut knife-edge holes having various diameters. This enables one easily to change the size of the opening which admits radiation upon receiver, and thus study the effect upon the radiation constant. The size of the water-cooled diaphragm has no appreciable effect upon the radiation constant, as was shown by subsidiary experiments given in the Paper.

The Radiator.—This so-called black body is one (painted Marquardt porcelain) used in a previous investigation, and the temperature measurements were made with thermo-couples, the radiator being operated at a high temperature (1,000°C.) to produce sufficient energy for measurement without affecting the calibration of the thermo-couple. At this temperature the radiator is easily kept constant to 0·1°C., and it is painted with a mixture of cobalt and chromium oxides. A similar series of measurements were carried out on a white porcelain radiator, which gave a value of the radiation constant about 1 per cent. less than that obtained with the painted tube. The whole apparatus is shown in Figs. 4 and 5 below.

A section of the apparatus is shown in Fig. 4 and the general arrangement in Fig. 5. To keep the apparatus in alignment the

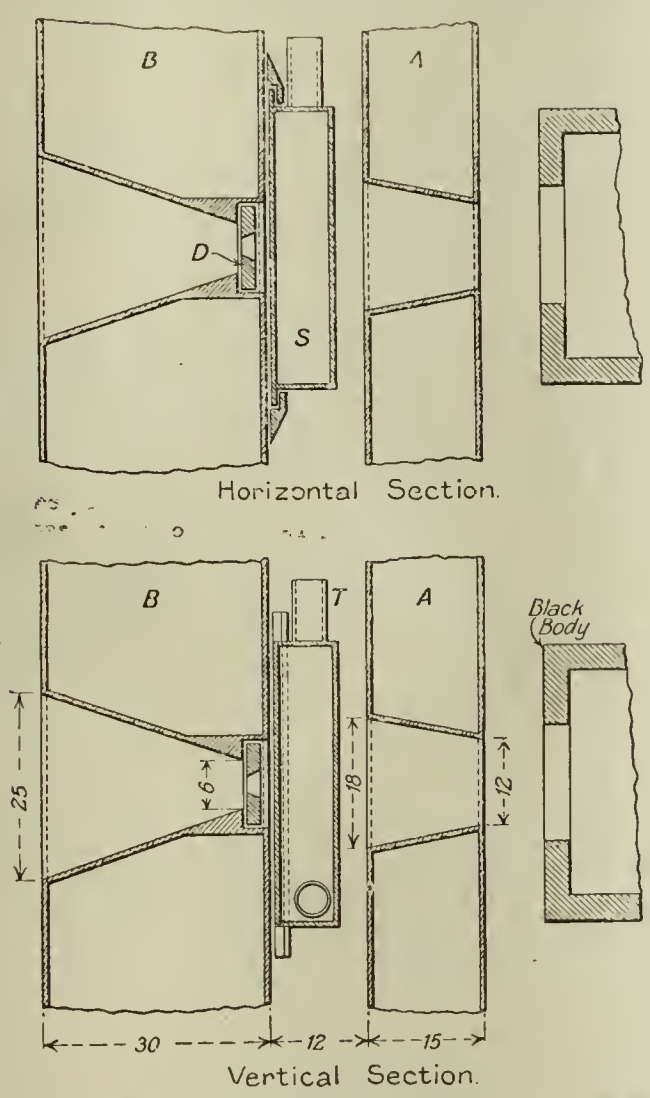


Fig. 3.—Water-Cooled Shutter and Diaphragms.

optical path is operated by means of a series of telescoping brass tubes, *DE*, shown in the figures. For this apparatus the collar *C* is permanently attached to the water-cooled diaphragm *B*, over which one end of the brass tube *E* was slipped, making a tight-fitting junction. This tube had diaphragms in order to prevent further reflections. The inside surface was smoked in an acetylene flame. A small aluminium box containing phosphorescent oxide was placed inside the collar to absorb any moisture, and the whole was kept quite airtight, the outer brass tube *D* having a guard ring permitting telescoping the radiometer tube shown in Fig. 1 into the brass tube *E* without injuring the lampblack surface of the latter. The wide ring *R*, which was permanently attached to the radiometer tube, ensured accurate alignment by always bringing it in contact with the ring on the tube *D*. The length of the receivers and the areas of the opening of the water-cooled diaphragm were such that when the distance between the receiver and the diaphragm was less than 30 cm. there was a possibility that radiations coming from the edges of the opening in the first diaphragm within the radiator might fall upon the receiver. The whole interior, however, for a distance of 8·10 cm. from the radiator wall is uniformly heated, and no marked difference is found in the values of the radiation constant as determined at very short distances from the water-cooled diaphragm.

Method of Operation.

This is very simple. The receiver is exposed to a series of radiation. A so-called black body is heated to a definite temperature, and its rising temperature is noted by reading the deflection produced by the galvanometer. The galvanometer sensitivity having been determined, an electric current of sufficient strength is passed through this strip to heat it, and this causes a deflection of the same magnitude as that obtained when the strip was exposed to radiation. The energy expended in heating the receiver is determined by measuring the drop in potential between two terminals, which define

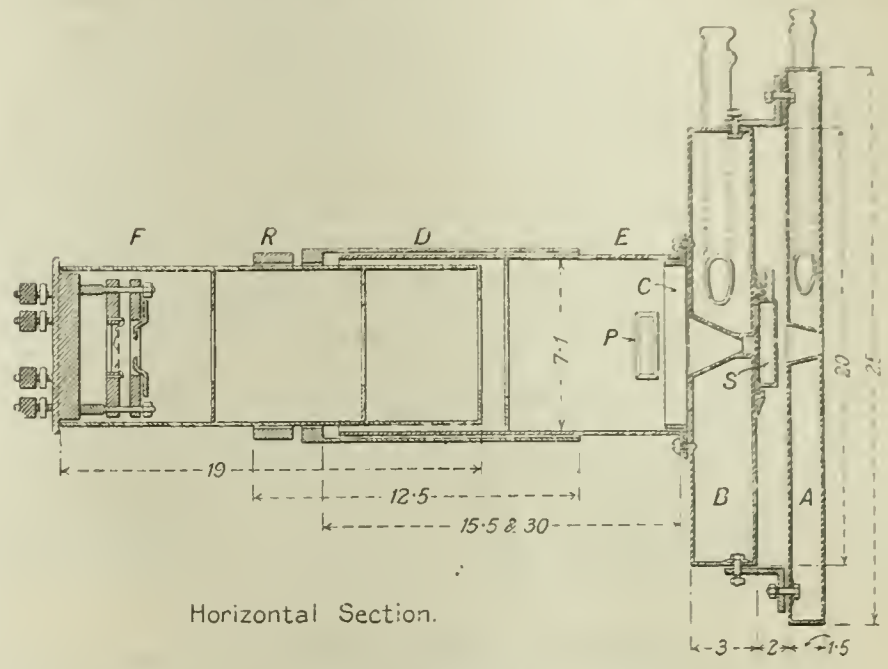


Fig. 4.—Assembled Apparatus.

the length of strip exposed to radiation and the electric current through the strip. Current is determined by measuring the drop of potential across a standard resistance of 1 ohm, shown as *O*, Fig. 5. These E.M.F.s were measured by means of a potentiometer having shunts in suitable ratios. The exact amount of energy necessary to cause the same deflection as that produced by the absorbed radiant energy is obtained by multiplying the observed energy input by the ratio of the galvanometer deflection. This gives the "constant" of each receiver. To reduce all the measurements to a common basis, and at the same time obtain a value of the

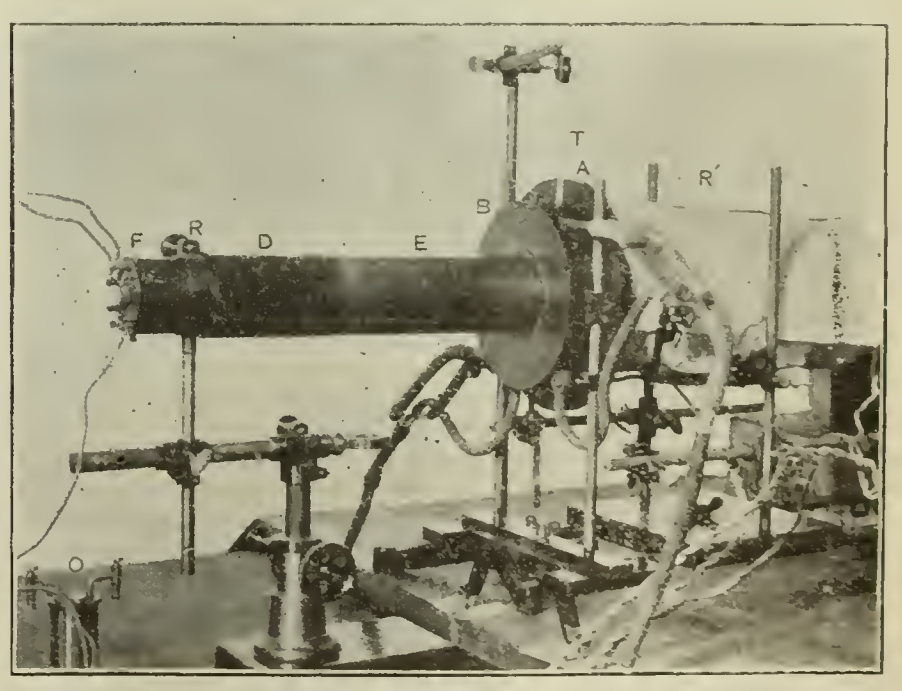


Fig. 5.—Photograph of the Assembled Apparatus used in Evaluating Radiant Energy in Absolute Measure.

coefficient or so-called Stefan-Boltzmann constant of total radiation, the data is reduced. If A_1 is the area of the water-cooled diaphragm, A_2 the area of the receiver which is exposed to the radiation coming from A_1, D the distance between these two services, T_1 the absolute temperature of the shutter, T_2 the absolute temperature of the radiator, the electrical energy per second equal to EI, then we have

$$EI = \frac{\sigma}{\pi}(T_2^4 - T_1^4).A_1.A_2/D^2,$$

where σ is the coefficient of total radiation, E the voltage, and I the

current. This expression generally requires correction, the short correction factor being

$$A_1A_2/D^2[1-a^2+b^2/4D^2].$$

In any case, this second correcting term is quite negligible in the present investigation, since it usually amounts to less than two parts in 1,000.

In carrying out the experiment on 13 different receivers various corrections had to be kept in view. Some of these are as follows: Incorrect readings of the galvanometer deflections, incorrect measurements of current, variations in reflecting powers of the absorbing surfaces, the effect of the potential terminals, errors in the width of receiver exposed to radiation, extraneous radiation affecting the receiver, errors in measurements between distance of the water-cooled diaphragm and the receiver, and absorption of radiation of water vapour. With a receiver having a length of 3·095 mm., width of strip 2·545 and width of slip 2·150 the value of $\sigma \times 10^{12}$ was 5·60, the receiver being re-painted and smoked and the slips being of aluminium. Thirteen different sets of experiments are given, the value of the radiation constant differing from the main value of each set by about 1·5 to 2 per cent. The difference appears to be independent of the length and width of the receiver, and of the kind of slits used, and the departure of individual determinations from the mean value appears to be of the order of 1 per cent.

As the instrument appears to be applicable for precise measurements, the whole outfit has been placed in an evacuated enclosure, and radiation measurements will be made at fixed temperatures as defined by the melting points of such metals as gold, silver and platinum. In this way it is hoped to eliminate the effect of atmospheric absorption and otherwise improve the reliability of the measurements.

LEGAL INTELLIGENCE.

Assessment of Electricity Works.

At the County of London Quarter Sessions last week, the Brompton & Kensington Electricity Supply Co. (Ltd.) appealed against the assessment of their works and mains at £22,800 gross and £12,000 rateable by the Kensington Borough Council. The hearing took three days.

Mr. A. Macmorran, K.C., and Mr. E. M. Konstam appeared for appellants; and Mr. W. Ryde, K.C., and Mr. Cecil Whiteley for respondents.

On behalf of appellants evidence was given by Mr. H. M. Carpenter (of Messrs. Humphreys-Davies & Co.), Mr. G. W. Spencer Hawes (Messrs. May & Hawes), Mr. E. T. Ruthven Murray, Mr. R. S. Downe (general manager and engineer of the company) and Mr. J. T. Owens (the secretary). On behalf of the Council, Mr. W. Harold Eve (Messrs. William Eve & Sons) submitted a valuation, on which he found a rateable value of £16,330.

The valuation put before the court by Mr. Carpenter was as follows: Gross receipts £56,465, working expenditure £26,028, leaving £30,437. The tenant's share of the profits was £8,355, and gross value plus rates £22,082. Statutable deductions were £10,200, and the rateable value plus rates was £11,882. Rates at 7s. 3d. in the £ came to £3,161, leaving rateable value of the entire undertaking £8 721.

The valuation of Mr. Spencer Hawes was on much the same lines and produced a similar result. The evidence of Mr. Ruthven-Murray was chiefly upon the proper allowance from the gross value in respect of the statutable deductions for repairs, renewals and insurance, and he confirmed the evidence given by Mr. Carpenter and Mr. Hawes that a sum of about £10,200 to £10,500 should be allowed.

Evidence was given for the Kensington Assessment Committee by Mr. W. Harold Eve, who produced a valuation showing a rateable value for the undertaking of £16,330, or £4,330 more than the sum which was appealed against. He was supported by Sir John Snell, who contended that the plant at the company's generating station at West Brompton could be replaced at more's less than the original cost, and that the annual provision for a renewal fund should be estimated upon the present-day replacement cost rather than the original cost. In the course of cross-examination by Mr. Macmorran, Sir John contended that he had done the right thing in basing his tables for renewals on a figure of £68,000, although the prime cost was £103,000. He also expressed the opinion that there would be a considerable drop in prices after the war. He happened to be connected with a large number of important contracts, and he had it from most eminent manufacturers in this country that there would be a very considerable drop, especially in metals. He also anticipated a drop in wages, as the war bonus would have gone. Sir John admitted that in a certain calculation in which he had taken the 3½ per cent. table it was customary until a few years ago to take the 2½ or 3 per cent. The price of money had increased in the meantime, and it was now customary to take 3½ per cent. But on that particular point the difference between the 3 and 3½ per cent. table would be very small—about £80, certainly under £100. That day he should take it certainly at 4½ per cent.

Mr. Ryde, K.C., then addressed the Court, and submitted that the assessment was amply justified. As regarded Sir John Snell's tables for renewals, counsel argued that the position depended, not on prime cost, but the cost of producing an efficient substitute.

Mr. Macmorran, K.C. (for the company), said that whereas the gross receipts of the company were substantially the same, the expenditure had increased, and that made a difference of £3,876 in 1915. That loss accrued to the company, despite that increased charges were operating for nine months of the year. He submitted that the assessment which it was sought to impose on the appellants was excessive, and not in accordance with the true principles of assessment. He urged that it should be remembered that in the case of electricity companies there were serious possibilities of litigation from time to time. Mr. Eve's gross value worked out at £22,995, which was £195 more than the Assessment Committee's valuation. As regarded Sir John Snell's figure of £68,000, instead of the prime cost, counsel contended that they could not ignore conditions as they existed.

The Deputy-Chairman, in announcing the decision of the Court, said he had gone into all the figures connected with the case with considerable care. The decision he had come to was that the gross value should be reduced to £19,778 and the rateable to £11,378, and as that was a substantial reduction—a very considerable reduction—and as the appellants could not get it reduced without coming there, respondents should pay half the appellants' costs.

University of London Press and others v. University Tutorial Press.

Last week Mr. Justice Peterson gave judgment in this action, which raised a point as to copyright in examination questions. Plaintiffs claimed an injunction to restrain defendants from continuing to publish or sell or offer for sale the examination papers for the matriculation examination held in January, 1916, and from publishing or selling or offering for sale the examination papers for the matriculation examination to be held in June and September, 1916, or otherwise producing or reproducing them or any substantial part or parts thereof, and from otherwise infringing plaintiff company's copyright in such examination papers.

In 1915 the Senate of the University of London made it a condition of the appointment of every examiner that any copyright possessed by him in examination papers prepared by him for the University should be vested in the University. Examiners (including plaintiffs, Prof. Lodge and Mr. Jackson) were appointed in 1915 for the three ensuing examinations in September, 1915, and January and June, 1916. On July 26, 1915, the University entered into an agreement with plaintiff company by which they agreed to assign, as from Aug. 31, 1915, their copyright and rights of publication in examination papers for six years from the date of publication. On January 13, 1916, there was an assignment by the University to the plaintiff company of their copyright in accordance with the agreement, particulars of which were contained in a schedule. The schedule contained among other things the matriculation examination papers for January, 1916. Plaintiff company published in January, 1916, the examination papers for the examination of that month. In the same month defendants published their publication, and in it they included 16 of the matriculation papers for January, 1916. These papers were not copied from plaintiff company's publication, but were taken from copies of the examination papers supplied by students. Among the 16 papers taken were three papers set by Prof. Lodge and Mr. Jackson, one in arithmetic and algebra, another in geometry, and a third in mathematics more advanced. In addition to those papers the defendants in the same book published the answers to the questions in some of the papers, including the arithmetic and algebra papers and the geometry papers, but they did not publish any answers to the questions in more advanced mathematics. In February last plaintiff company commenced proceedings, but objection was made that plaintiff company was not entitled to sue, and in the course of the proceedings Prof. Lodge and Mr. Jackson were joined as co-plaintiffs.

For plaintiffs it was contended that the examiners were under contract of service with the University, and that therefore the copyright in the papers set by them was in the University, and that under the assignment it passed to the plaintiff company.

For defendants it was maintained that there was no copyright in those papers, but that if there were it was not in the plaintiff company, as the examiners were not under contract of service.

Mr. Justice Peterson, in delivering a written judgment, said that papers set by examiners were, in his opinion, literary works within the meaning of the Copyright Act. Assuming they were literary work, the question then was whether they were original. The word original did not in that connection mean that the work must be the expression of original or inventive thought. Copyright Acts were not concerned with the originality of ideas, but with the expression of thought, and, in the case of literary work, with the expression of thought in print or writing. In the present case it was not suggested that any of the papers were copied. Prof. Lodge and Mr. Jackson proved that they had thought of the questions which they set, and that they made notes or memoranda for future questions, and drew on those notes for the questions set. In his Lordship's judgment the papers by Prof. Lodge and Mr. Jackson were original literary works, and a proper subject for copyright under the Act of 1911.

The next question was, in whom did the copyright in the papers vest when they had been prepared? The author was the first owner of the copyright, subject only to the exceptions contained in the Act. Sub-sec. 1 (*b*) of sec. 5 provided that where the author was in the employment of some other person under a contract of service or apprenticeship and the work was made in the course of his employment by that person the

person by whom the author was employed should, in the absence of any agreement to the contrary, be the first owner of the copyright. The examiners were, no doubt, employed by the University of London, and the papers were prepared by them in the course of their employment. But in order that sec. 5 (1) (*b*) should be applicable, the examiners must have been under a contract of service. The examiner was employed to prepare the papers on the subject in respect of which he was elected or appointed examiner. He had to set papers, and his duty also comprised the perusal of the students' answers, and the consideration of the marks to be awarded for the answers. For that he was to be paid a lump sum. He was, however, to prepare his questions at his convenience so long as they were ready by the time appointed for the examination, and it was left to his skill and judgment to decide what questions should be asked, having regard to the syllabus, the book work, and the standard to be expected at the matriculation examination. Prof. Lodge and Mr. Jackson were regularly employed on other educational establishments, and were not part of the staff of the London University, and it was not suggested that the other examiners were on the staff of the University. It was impossible to say that the examiners in such circumstances could be appropriately described as the servants of the University, or that they prepared these papers under a contract of service. The examiner was the first owner of the copyright, and he had not assigned it in writing signed by himself or his agent. The copyright therefore remained in the examiners, subject to the obligation under the contract of employment to assign it to the University or as it might direct. The University assigned its rights to plaintiff company, which was not equitably entitled to the copyright. In order to sue for infringement of the copyright plaintiff company had either to obtain a proper assignment of the copyright or join the examiners, who were the legal owners as parties. Plaintiffs had joined Prof. Lodge and Mr. Jackson as co-plaintiffs. They could, therefore, sue for infringement of the copyright in the papers prepared by Prof. Lodge and Mr. Jackson, but in the absence of the other examiners the action failed in respect of the copyright in the papers which were composed by them. Defendants must pay the costs, except so far as they were increased by the claim in respect of the papers set by the examiners other than Prof. Lodge and Mr. Jackson.

Metropolitan Water Board v. Dick, Kerr & Co.

On Monday Mr. Justice Bray was asked for a declaration that a contract made between plaintiffs and defendants for the construction of new reservoirs near Staines was still in existence, and had not been determined by certain action of the Minister of Munitions in the temporary stoppage of works and the diversion of labour to Government work during the period of the war. Plaintiffs also asked for a declaration that the Board were entitled to the plant, tools and materials on the works, and to the proceeds of the sale of the plant.

Mr. Holman Gregory, K.C., and Mr. Goodland appeared for plaintiffs; and Mr. A. A. Hudson, K.C., and Mr. D. Hogg for defendants.

It appeared that in July, 1914, Messrs. Dick, Kerr & Co. entered into a contract for the construction of two new reservoirs and contingent works in the riverside parishes of Littleton, Laleham, Shepperton and Sunbury for £673,811. On Feb. 21, 1916, the Minister of Munitions gave notice to defendants that they were not to employ any more workmen for the time being, as they were wanted elsewhere. Certain machinery and material were also requisitioned and sent to various parts of the country, for which £40,000 was received. Clause 10 of the contract provided that the plant, tools and materials provided by the contractor on the site of the works should become the property of the Board until the completion of the contract. Counsel pointed out that several other large works which the Board had in hand, and which had been stopped under similar circumstances would be governed by the decision in the present application.

For the defence it was contended that the notice from the Minister of Munitions requiring defendants to cease work on their contract, made further work impossible, and both parties were excused from the continuance of the contract. Defendants also denied that the material and plant were the property of the Board.

His Lordship decided that the contract was not abrogated, that under clause 10 all the plant which came upon the site became the limited property of the Board, and that defendants were not bound to repay the money already received from the Ministry of Munitions. He granted an injunction against Messrs. Dick, Kerr & Co. removing any machinery or receiving the proceeds of the sale of any machinery removed, or which might hereafter be removed, except so far as they were acting under the order of the Ministry of Munitions.

The costs would follow the event.

Commercial Cable Co. v. Government of Newfoundland.

On July 31 the Judicial Committee of the Privy Council gave judgment in the appeal of the Commercial Cable Co. from a judgment by the majority of the judges of the Supreme Court of the Colony of Newfoundland, holding that the company were entitled to recover nothing against the Governor of Newfoundland in Council.

Sir Robert Finlay, K.C., and the Hon. M. M. Macnaghten appeared for appellant company; Mr. Gordon Hewart, K.C., and Mr. Barrington Ward for respondent.

Viscount HALDANE, in giving judgment, said what had to be determined was whether the appellants, who were an American company incorporated in the State of New York, were entitled to receive two sums of $12,000 and $10,916, alleged to be due under an agreement of the Great Seal of Newfoundland, dated Feb. 18, 1909, to which the parties were the appellants and the Governor of Newfoundland in Council. Prior to 1905 the company owned and worked five submarine cables laid between Waterville (in Ireland) and Canso (in Nova Scotia). None of those cables touched Newfoundland, but by a contract of Aug. 26, 1905, made between the same parties and subsequently ratified by a Newfoundland Statute, the Government agreed to grant to the company, on certain conditions, the right to land any of its through cable at Newfoundland. In September, 1905, a cable from Port aux Basques, on the south coast of Newfoundland, constructed by the plaintiff company for the defendant, was completed and opened for business. That cable was the property of and was worked by the Newfoundland Government. A contract of Feb. 18, 1909, provided for the cutting of one of the trans-Atlantic submarine cables and the joining up with it of a cable so as to establish communication between Newfoundland and New York. The contract was to have been for 25 years and $4,000 annually was to be paid the company. The laying of the cable was completed, and the import duties claimed had in fact been paid by the company, amounting to $10,916, and the goods whereon they were paid were such as were contemplated by the agreement, but no part of the annual payment or subsidy of $4,000 had been paid for any year. The company's application for a grant of Crown lands was also refused, and they thereupon lodged a petition of right. The order appealed from held that the contract was not binding, and, therefore, the claim of the company was dismissed. His Lordship said that the Committee were of opinion that the order was right. The agreement in question had not been approved by a resolution of the House of Assembly, and the position of a governor of the colony was not that of a Viceroy in the sense that he was the person to whom the full prerogative power of the Crown had been delegated. No damages could be recoverd for breach of an implied term to make a grant of public money unless the discretion of the Legislature to make the grant had been exercised in some sufficient fashion. The appeal, therefore, failed.

Re Madras Electric Supply Corpn. (Ltd.)

Last week, Mr. Justice Astbury confirmed a reduction of the capital by writing off £2 per share from the ordinary shares. The preference shareholders, Mr. Whinney stated, were to give up last year's dividend and were to take it in fully-paid shares. In an affidavit the chairman said the installation in Madras became very defective. New plant had been erected. The plant was now in full working order, and last year they made a substantial profit. The company wished to write off the balance of loss.

PARLIAMENTARY INTELLIGENCE.

INTERCONNECTION OF ELECTRIC SUPPLY UNDERTAKINGS.

In the House of Commons last week Mr. T. M. HEALY asked whether a circular had been issued by the Board of Trade Department urging an arrangement to merge electrical supplies with a view to saving coal: had he considered that new cables and other expense might be necessary to enable such plans to be carried out, involving capital expenditure? And would enabling legislation be introduced to render possible the desirable economies which the Board of Trade wished to effect in cases where statutory authority would be required?

In reply, Mr. HARCOURT said the answer to the first two portions of the question was in the affirmative. In issuing the circular the Board of Trade had not in mind any large schemes of inter-connection involving heavy capital expenditure and a large use of material, but rather contemplated arrangements between undertakings whose areas of supply adjoin or nearly so. He did not think that legislation for that purpose was requisite; but should the necessity for it appear to arise he should be prepared to give the matter full consideration.

Royal Assent.—On July 19 the Royal Assent to the following Acts of Parliament was read: Electric Lighting Order Confirmation Act, Metropolitan Electric Tramways Act, London County Council (Money) Act.

EDUCATIONAL.

Armstrong College (University of Durham) Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

University of Edinburgh.—The next session of the engineering department commences on Oct. 10th. The preliminary or entrance examination is held in September. Complete courses of instruction in civil, mechanical and electrical engineering are provided; they qualify for the degree of B.Sc. in engineering and extend over a period of three years. Particulars of entrance examinations,

scholarships, &c., may be obtained from the Matriculation Offices, the University of Edinburgh.

University of Birmingham.—At this University there are courses in mechanical, civil and electrical engineering. The full courses extend over four years, and students who enter after matriculation and pass the examinations at the end of each year will be entitled to the degree of Bachelor of Science in Engineering. The next session commences on Tuesday, Oct. 3. Syllabus, with particulars of courses, fees, &c., can be obtained from the Secretary.

University of Manchester.—In the physics department the lecture and laboratory courses prepare for both the ordinary and honours degrees of the university. Particulars can be obtained on application to the Registrar, and Prof. Sir E. Rutherford will meet intending students on Thursday, Oct. 5.

City and Guilds Technical College, Finsbury.—The training at this College is adapted to the needs of various students, including pupils above 15 from secondary schools, who desire a practical and scientific training bearing upon their future industry or profession, and young men who, having previously served a pupilage or apprenticeship in works, desire a more systematic training in engineering and applied chemistry. The College has well-equipped laboratories and workshops for practical work. The entrance examination will be held on Sept. 19. The programme of the College has just been issued, and gives full particulars of the courses of instruction, fees, time-tables, &c. Further particulars may be obtained from the Registrar of the College, Leonard-street, Finsbury, London, E.C.

Northampton Polytechnic, London.—In the day engineering college full-day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by Messrs. Mewburn, Ellis & Pryor, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 Specifications.

7,979 Berry & Markham. Protected or armour-clad electric switches.

8,712 British Insulated & Helsby Cables & Harrison. Telegraph systems and apparatus therefor.

The distributors are driven isochronously or synchronously by impulses sent to line at one station, the impulses being sent during the signalling intervals, each impulse forming one of the impulses used in the code of signalling impulses, the said impulses driving the distributor at the other end of the line.

9,282 Langdon-Davies, Soames & Naamlooze Vennootschap de Nederlandsche Thermo-Telephoon Maatschappij. Means for driving dynamo-electric machines.

9,345 Relay Automatic Telephone Co. & Bygrave. Electrical selectors or impulse responders. (Cognate Application, 17,956/15.)

9,527 Shortt. Electric clocks.

9,557 British Thomson-Houston Co. (General Electric Co.) Method of and apparatus for casting squirrel cages in the magnetic cores of induction motors.

9,684 Bronsted & Hellesens Enke & V. Ludvigsen (firm of). Galvanic battery cell of the mercuric oxide type.

A galvanic battery cell of the type in which the anode is of zinc, the electrolyte is alkaline, and the depolarizer consists of a mixture of mercuric oxide with an indifferent conductor such as graphite, in which an electrolyte is employed of highly concentrated alkali lye containing at least six or seven equivalents of hydroxide per litre.

9,836 British Thomson-Houston Co. (General Electric Co.) Electric motor-control systems.

10,330 Harlow. Protective reactance coils.

A reactance coil is provided with two magnetically linked co-axial windings, one being connected in series with the feeder or other electric circuit, and the other being short-circuited, and provision is made for relative motion taking place between the two windings. By this arrangement when an excessive current passes through the circuit the mutual repulsion of the windings causes them to separate by which means the choking effect of the coil is increased, and the heavy current flow reduced.

12,991 Mackay. Electric-arc lamps. (12/9/14.)

13,733 Joly. Sparking plugs.

15,460 General Accessories Co. (Rosenthall & Seymour). Electric adapters.

15,539 Automatic Telephone Manufacturing Co., Savin & Smith. Alarm fuses for telephone, telegraph and like systems.

15,681 Railing & Garrard. Operating rotary converts and other alternating-current machinery. (Addition to 10,841/13.)

15,863 Dr.-Ing. Schneider & Co., Elektrizitats-Ges. Electric pocket lamps. (3/12/14.)

15,922 Begg. Combination electric turn switch and wall plug.

16,349 Bennett. Electric incandescent lamp holders.

1916 Specifications.

1,248 Igranic Electric Co. (Cutler-Hammer Manufacturing Co.) Means for controlling electric motor circuits. (26/1/16, 100,703.)

1,390 Graham & Rickets. Apparatus for the observation of azimuth angles and the simultaneous electrical transmission of the value of such angles to remote indicators. (28/1/16, 100,704.)

4,688 Kettering & Chryst. Electrical systems for engines. (16/7/14) (Divided application on 7,758/15, 100,228.)

5,085 Miller & Collard. Magneto-electric machines. (6/4/16, 100,713.)

6,042 Baumann. Dry battery. (4/2/16. Addition to 100,086. (100,714.)

APPLICATIONS FOR PATENTS

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked • are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

June 27, 1916.

9,055 Steinberg. Electric furnace for steel melting.

9,062 McLachlan. Shade-holders for gas or electric light fittings.

9,050 Watkins. Sparking-plugs.

June 28, 1916.

9,079 McGregor. Sparking plugs for internal-combustion engines.

9,099 Igranic Electric Co. (Cutler-Hammer Mfg. Co.) Controlling electric motors.

9,105 Simpson. Electric spark-gap. (20/3/15, U.S.)

9,112 Westinghouse Machine Co. Power-developing apparatus. (30/6/15, U.S.)

June 29, 1916.

9,127 Dodd & Horstmann Gear Co. Automatic trolley alarm for electric tramcars.

9,137 Johnson. Sparking plugs for internal-combustion engines.

9,139, 9,140 Barraclough. Switch-operating mechanism for electric transformer starters, &c.

9,152 Herwin. Portable apparatus for producing and transmitting waves in wireless telegraphy.

9,165 Marconi's Wireless Telegraph Co. & Wright. Means for controlling speed of electric motor.

9,171, 9,172 Thomas & Thomas Transmission (Ltd.). Differential gearing for electro-mechanical variable-speed mechanism.

9,179 Merriman. Telephone systems.

9,180 Vernier. Joints for electrical conductors.

9,185 Treherne. Electrical switches.

9,193 Mellersh-Jackson. (Western Union Telegraph Co.) Telegraph apparatus.

June 30, 1916.

9,206 Ball & Parsons. Electric clocks.

9,212 Cowper-Coles. Process for refining zinc.

9,232 Marden. Dynamo-electric machinery.

9,246 Marconi's Wireless Telegraph Co. Measuring instruments, extensometers, ammeters, &c.

9,249 Igranic Electric Co. (Cutler-Hammer Mfg. Co.) Controlling electric motors.

9,263 Vickers (Ltd.) & Halstead. Electric regulators or rheostats.

July 3, 1916.

9,277 Firth & Rhodes. Driving and controlling dynamo-electric generators.

9,279 Pellowe, Trickett & Electromotors (Ltd.). Field-regulating rheostats, motor-starters, &c.

9,310 Hall. Combined pocket and suspension electric lamp.

9,318 Linneker. Miners' safety lamps.

9,332 Steward. Magnetic compass.

9,335 Murgatroyd. Continuous-current dynamo-electric machines.

9,336 Dale. Electrical replacement indicators.

9,339 Hatton. Double-deck tramcars, motor-omnibuses, &c.

9,349 De Forest. Automatic switching devices for telephone systems. (7/7/15, U.S.)

July 4, 1916.

9,370 St. Helens Cable & Rubber Co. & White. Electric lamp, &c., guards.

9,371 St. Helens Cable & Rubber Co. & White. Devices for gripping or securing electric cables, &c.

9,408 Manley. Electric handlamps.

July 5, 1916.

9,447 W. Chadburn & W. R. Chadburn. Ships' telegraphic apparatus.

July 6, 1916.

9,539 Marconi's Wireless Telegraph Co. & Shoenberg. Measurement of frequency of electrical currents.

9,541 British Westinghouse Electric & Mfg. Co. Electric rotary converters. (6/7/15, U.S.)

July 7, 1916.

9,589 Inrig. Firing ordnance by electricity.

9,607 Dehn. (Martens.) Code telegraphy.

9,608 Deutsche Gasglühlicht Akt.-Ges. (Auergес.) Evacuating bulbs of electric incandescent lamps, &c. (27/8/15, Germany.)

9,609 Deutsche Gasglühlicht Akt.-Ges. (Auergес.) Electric incandescent lamps and production of same. (27/9/15, Germany.)

July 8, 1916.

9,635 MacCallum. Producing electricity.

9,642, 9,643 Train. Signalling apparatus for mines.

9,646 Anderson & Ellison. Electric switches.

9,647 Anderson & Ellison. Electric contacts.

9,649 Constantinesco & Haddon. Transmission of energy by wave motion.

9,655 Bell, Davey & Sterling Telephone & Electric Co. Electric signalling systems.

9,660 Taylor. Lightning conductors.

9,667 Martin. Motor ploughs, cultivating implements, cable laying machines, &c.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from The Electrician Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Emission of Electricity from Hot Bodies." By O. W. Richardson, F.R.S. (London: Longmans, Green & Co.) Pp. vii.+304. 9s. net.

"The Electrical Contractor: Principles of Cost-keeping and Estimating, Wiring and Illumination Calculations and Other Technical Problems of the Business." By Louis W. Moxley, jun. (London: Hill Publishing Co.) Pp. vii.+86. 6s. 3d. net. 1st edition.

"Trade as a Science." By E. J. P. Brien. (London: Jarrold & Sons.) Pp. 184. 2s. 6d. net.

"Air Supply to Boiler-rooms of Modern Ships of War." By R. W. Allen, M.Inst.C.E., M.I.N.A. Pp. 57.

"Test Questions in Junior Algebra." Edited by F. Rosenberg, M.A., B.Sc. (London: University Tutorial Press.) Pp. 113. 1s. 3d.; 1s. without answers.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	611
Imports and Exports of Electrical Manufactures	612
Business Notices	612
Liquidations	612
Electricity Supply	612
Lighting and Power Notes	613
Traction Notes	613
Empire Notes	614
Foreign Notes	614
Miscellaneous Notes	614
The Round Table	121
Electric Supply at Holmfirth	122
"Sun" Fans and Portable Tools. Illustrated	124
Peculiar Behaviour of a Three-Phase Motor	126
Electric Lighting Sets with Overhead Valves	126
New Pumping Plant at Exeter	126
"Evolution in Ventilation Hygienics"	128
"The New Maid"	128
Tenders Invited	615
Tenders Received & Accepted	615
Municipal Accounts	616
Companies' Meetings and Reports	617
New Companies, &c.	617
City Notes	617
Electrical Companies' Share List	618

COMMERCIAL TOPICS.

Controlled Establishments. It is announced that further orders have been made under the Munitions of War Act, 1916, under which 124 additional establishments have been declared controlled establishments. The total number of controlled establishments under the Act is now 4,052.

* * * *

Claims on Alien Enemy Property. It is announced that the Public Trustee is preparing a statement showing the amount of claims made by British creditors against the property of enemies which has been vested in him, but it will take some time to complete this statement. The claims already paid by him amount to £149,838. 11s. 4d.

* * * *

A Government Subsidy for Foreign Trading. In our last issue we referred to the formation of the British Italian Corpn. (Ltd.) for the purpose of promoting commercial intercourse between this country and Italy, &c. In the House of Commons this week Mr. McKenna (Chancellor of the Exchequer) made the interesting announcement that the British Government had agreed to contribute to the company by way of subsidy during each of the first 10 years after its incorporation an annual sum of £50,000, or the equivalent of 5 per cent. upon its paid-up capital, if less than £1,000,000. The decision of the Government would seem to show that greater attention is to be paid to the foreign trade and commerce of the country in future, and from that point of view we welcome the new departure.

In consideration of the subsidy Mr. McKenna said the company had agreed to pay to the Government amounts equal to any dividend above a cumulative dividend of 5 per cent. per annum until by such means the Government had been repaid (without interest) the amount so received by the company by way of subsidy. He proposed to ask Parliament to give authority for the subsidy in the next Government War Obligations Bill. A company under the style of the Compagnia Italo-Britannica would forthwith be formed under Italian law with a capital of 10,000,000 lire (£400,000), one-half of which was to be taken by the British-Italian Corpn., and the other half by the Credito-Italiano and their friends. The two companies would work in close collaboration. The primary object of the two companies was the development of the economic relations between the British Empire and Italy, and the promotion of undertakings in the commercial and industrial field in Italy. They would carry on the banking and financial operations which did not necessarily fall within the strict definition of banking as understood in this country.

* * * *

Alien Enemy Companies. A report of the work of the Advisory Committee appointed by the Board of Trade under the Trading with the Enemy Amendment Act, 1916, has been issued.

Under the Act the Board of Trade were directed to order the discontinuance or winding-up of businesses owned or controlled wholly or mainly by enemy subjects, unless in any case for special reasons it appeared to them inexpedient to do so. Under the earlier Acts the Board had no power to make winding-up orders, but were authorised in certain specified circumstances to appoint inspectors and supervisors of businesses with a view to the detection or prevention of offences against the Trading with the Enemy Acts and Proclamations. Special investigation of each of the cases was necessary in order to determine whether they came within the scope of sec. 1 of the Act, and whether any special reasons existed rendering its enforcement inexpedient.

The Committee was appointed on Feb. 9, 1916, and consisted of Mr Ernest Moon, K.C., C.B. (chairman), the Hon. J. D. Fitzgerald, K.C., Mr. Gershom Stewart, M.P. and Sir Geo. Croydon Marks, M.P. The last named was succeeded by Sir Edwin Cornwall, M.P., on the Feb. 22, who was in turn succeeded by Mr. Arthur Acland Allen, M.P., on June 1. It is the practice of the Committee, in addition to considering the reports obtained from inspectors (who also generally attend before the Committee) and any communications received from the Board of Trade or other Government departments, to give the owners or managers of the businesses in question an opportunity of appearing before them. The recommendations of the Committee have been (or are being) carried out in all cases by the Board of Trade.

The chairman has prepared the following summary of cases dealt with by the Advisory Committee up to June 2, 1916, and of the recommendations made therein.

Total number of cases considered by the Committee 353, and the recommendations made by the Committee were :—

(1) For orders to wind up or prohibit, 204 ; (2) for orders to vest enemy interests for sale to British subjects under sec. 4 in lieu of winding up, 50 ; (3) cases found not to be within the Act, 34 (*Note.* In three of these cases orders have been recommended vesting enemy subjects' interests for sale to British subjects under sec. 4) ; (4) cases in which, owing to one of the War Departments having notified that the business was meeting some of its requirements, no recommendation has as yet been made, 9 ; (5) cases in which for special reasons no order was recommended, 37 ; (6) for orders cancelling contracts, 10 ; and cases the consideration of which stands postponed, 9.

* * * *

Extension of Patents. The Patents, Trade Marks and Designs Committee of the Birmingham Chamber of Commerce recently reported that they had considered the position of inventors and manufacturers of patented articles which, owing to circumstances arising out of the war, it had been wholly or partially impossible to manufacture, with the result that they had been deprived of an appreciable portion of their possible term of protection, viz., 14 years.

The committee recommended that a representation be addressed to the Board of Trade urging that, on proof of non-user or only partial user owing to the war, of any patent or registered design, the terms for which the patent or copyright respectively were granted should be extended for a commensurate period, and that the renewal fees be suspended or reduced for the period of such non-user or partial user.

The Chamber concurs in this recommendation.

* * * *

Passenger "Electrics." There is no mistaking the genuine tone of the articles which are now appearing in the lay press and certain motoring journals calling for the battery vehicle as a means of relief from the present scarcity and high price of petrol. Now that the license regulations have come into force in earnest the shoe is beginning to pinch. Quite apart from the fact that it is unpatriotic to use a motor car for pleasure, the petrol regulations are depriving some motorists of the privilege, let alone the pleasure, of motoring at all. Already the journals which have voiced exclusively the merits of the petrol lorry and commercial motor, are convinced that the battery vehicle can adequately fill its particular nitch in the sphere of industrial and trade transport. They have further stated that it must be given its place in this field because it is a better machine for the purpose than either petrol or steam. On the subject of the passenger "electric" there is as yet merely the idea that it should again be brought into use, even though it is slower, much slower than petrol, and has only a limited range. When this idea is developed somewhat we shall witness a boom—a small one, it is true—in vehicles which have been lying by some time, but which, with a replated battery and an overhauled motor, will be ready for several thousand miles of service. Of course, what is really wanted is the putting of a good line of passenger "electrics" on the market by some British builder, and at a price which will make the vehicle less of a toy of the rich than it has been in the past. The present scarcity of British-made machines, and the high import duty on American vehicles, will do little or

nothing to check this tendency, but it is difficult to see quite how any large quantity of machines is to be got together to supply the immediately prospective demand. Some satisfaction may be derived from the removal from the passenger "electric" of the ban on the part of petrol motorists under which it has suffered ever since there was a petrol vehicle industry. This recognition of the passenger machine should also stimulate the financial interest of motor manufacturing firms, and it may result in the establishment of new factories, or separate departments in existing works, in which both passenger and commercial "electrics" will be built. The immediate outlook, however, gives cause for satisfaction, and so long as the lay press writers refrain from making exaggerated claims about the "electric," and also restrain their ardour in decrying it, progress will continue to be good.

* * * *

Foreign Trade of the U.S.A.

It is reported that the foreign trade of the United States for the year ended June, totalled $6,525,000,000, which is stated to be a record.

Exports amounted to $4,345,000,000 and imports $2,180,000,000, leaving an excess in exports of $2,165,000,000. The principal articles of exports were steel products, 618 millions, nearly treble last year; explosives, 473 millions, a tenfold gain; cotton, 370 millions; breadstuffs, 314 millions; meats, 270 millions; coffee, 170 millions; minerals oils, 165 millions; brass, 126 millions; autos, 123 millions; chemicals, 123 millions; and horses, 73 millions. In imports the principal amounts were: Fibres, 131 millions; copper, 52 millions; wood manufactures, 51 millions; tin, 48 millions; and cotton manufactures, 42 millions.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From July 22, 1916, *to* July 28, 1916.

IMPORTS.

GRIMSBY.—*France:* Unenumerated, 20 pkgs.

LIVERPOOL.—*U.S.A.:* Elec. motors, 5 pkgs.; electrodes, 144 pkgs. *Spain:* Elec. carbons, 49 pkgs.

LONDON. *U.S.A.:* Elec. lamps, £250; unenumerated, £9,368—52 cases. *Holland:* Elec. lamps, £705—39 pkgs.; elec. glow lamps, £2,177; elec. wire, 19 cases; wire and cable, £1,505; unenumerated, £938. *Japan:* Electro copper, 10,750 pkgs; elec. bulbs, 4 cases; unenumerated, £1,942—54 cases. *France:* Carbon candles, £391; unenumerated, £250. *Switzerland:* Unenumerated, £911. *Denmark:* Unenumerated, £602. *India:* Unenumerated, 22 cases. *Norway:* Telephone material, £7; unenumerated, £337. *Canada:* Unenumerated, £423.

MANCHESTER.—*Holland:* Elec. lamps, 4 cases. *U.S.A.:* Elec. motors, 13 cases; electrodes, 64 cases; elec. carbons, 150 cases.

SOUTHAMPTON.—*France:* Elec. cable, 16 pkgs.; unenumerated, £31.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Elec. machinery, £199; unenumerated, £299. *Melbourne:* Wire and cable, £1,360; elec. machinery, £204; unenumerated, £1,432. *Sydney:* Elec. machinery, £948; wire and cable, £27; elec. lamps, 4,116 n.o.; telegraph material, £300; unenumerated, £256. *Wellington:* Elec. machinery, £115; wire and cable, £518; unenumerated, £1,222. *Lyttelton:* Unenumerated, £171. *Dunedin:* Wire and cable, £1,875; unenumerated, £210. *Adelaide:* Unenumerated, £268. *Brisbane:* Unenumerated, £34. *Invercargill:* Unenumerated, £98. *Perth:* Wire and cable, £80; unenumerated, £20. *Fremantle:* Unenumerated, £181. *Hastings:* Unenumerated, £950. *Newcastle:* Unenumerated, £15.

AFRICA. *Durban:* Elec. machinery, £28; wire and cable £624; elec. lamps, 2,850 n.o.; unenumerated, £1,195. *Cape Town:* Elec machinery, £164; unenumerated, £263. *Port Elizabeth:* Unenumerated, £222. *East London:* Elec. wire and cable, £468; unenumerated, £786. *Beira:* Wire and cable, £35; elec. lamps, 2,700 n.o.

EGYPT. *Port Sudan:* Unenumerated £1,013. *Suez:* Unenumerated, £13.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Elec. machinery, £254; wire and cable, £1,773; unenumerated, £901. *Penang:* Elec. lamps, 4,150 n.o.; wire and cable, £130. *Singapore:* Wire and cable £17; unenumerated, £95. *Calcutta:* Elec. machinery, £488; wire and cable, £262; unenumerated, £1,842. *Madras:* Elec. glow lamps, £176; unenumerated, £625. *Colombo:* Wire and cable, £379; unenumerated, £333. *Karachi:* Elec. lamps, £59. *Rangoon:* Elec. machinery, £462. *Bankok:* Unenumerated, £281. *Rangoon:* Wire and cable, £166; unenumerated, £158.

CHINA. *Shanghai:* Elec. machinery, £1,127, unenumerated, £966. *Hong Kong:* Telegraph material, £200; unenumerated, £53. *Sabang:* Unenumerated, £12. *Balik papam:* Unenumerated, £56. *Hankow:* Unenumerated, £370. *Tientsin:* Telegraph material, £66.

U.S.A.—*Philadelphia:* Unenumerated, £15.

CANADA.—*Montreal:* Unenumerated, £32.

SOUTH AND CENTRAL AMERICA. *Buenos Ayres.* Elec machinery, £233; wire and cable, £3,028; unenumerated, £964. *Rio Janeiro:* Wire and cable, £943; telegraph material, £1,134. *Santos:* Unenumerated, £717. *Valparaiso:* Unenumerated, £39. *Pelotas:* Unenumerated, £54. *San Paulo:* Elec machinery, £473. *Coquimbo:* Unenumerated, £57. *Iquique:* Wire and cable, £193. *Arica:* Elec. machinery, £728; unenumerated, £38. *Talcahuano:* Wire and cable £14. *Tumbes:* Wire and cable, £149. *Taltal:* Wire and cable, £63. *Tocopilla:* Unenumerated, £50. *Tultupay:* Elec. machinery, £32.

WEST INDIES. *Trinidad:* Elec. lamps, 800 n.o.; unenumerated, £386.

JAVA. *Batavia:* Wire and cable, £721. *Samarang:* Elec machinery, £330; wire and cable, £115; unenumerated, £40. *Soerabaya:* Elec machinery, £1,328; wire and cable, £61; unenumerated, £431.

HOLLAND. *Amsterdam:* Unenumerated £103. *Rotterdam:* Wire and cable, £64.

FRANCE. *Dieppe:* Elec. machinery, £231; unenumerated, £254. *Paris:* Wire and cable, £29; unenumerated, £374. *Bordeaux:* Unenumerated, £73. *Havre:* Elec machinery, £175.

NORWAY. *Christiana:* Unenumerated, £729.

GIBRALTAR.—Elec. machinery, £29; elec. lamps, 975 n.o.; wire and cable, £63; unenumerated, £35.

RUSSIA.—*Vladivostok:* Unenumerated, £54. *Archangel:* Unenumerated, £548. *Petrograd:* Unenumerated, £138.

DENMARK. *Copenhagen:* Wire and cable, £1,300; unenumerated, £20.

SPAIN.—*Santander:* Unenumerated, £14. *Bilbao:* Unenumerated, £74.

PORTUGAL.—*Lisbon:* Elec. machinery, £397, wire and cable, £25; unenumerated, £230.

JAPAN. *Kobe:* Elec. machinery, £9,143. *Yokohama:* Unenumerated, £6,927.

ITALY.—*Genoa:* Unenumerated, £306.

FOREIGN GOODS (duty paid and free).

Amsterdam: Unenumerated, £100. *Auckland:* Unenumerated, £87. *Belawan:* Unenumerated, £21. *Bombay:* Unenumerated, £49. *New York:* Unenumerated, £104. *Port Sudan:* Unenumerated, £85. *Sydney:* Unenumerated, £119. *Wellington:* Unenumerated, £83. *Port Elizabeth:* Unenumerated, £14. *Brisbane:* Unenumerated, £32. *Dieppe:* Unenumerated, £16. *Lyttelton:* Unenumerated, £35. *Paris:* Unenumerated, £650. *Singapore:* Unenumerated, £12. *Yokohama:* Unenumerated, £17. *Calcutta:* Unenumerated, £54. *East London:* Unenumerated, £36.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

Thos. W. De Lasaux and Ernest J. V. Pucknell (trading as T. W. Thompson & Co.), electrical engineers, Endyne Works, Blissett-street, Greenwich, London, S.E., have dissolved partnership. Debts will be paid or received by Mr. De Lasaux, at 39, London-street, Greenwich.

Plant for Sale.—The Postmaster-General invites tenders for the purchase and removal from the P.O. Parcels Depot, Amiens-street, Dublin, of certain plant and machinery which is no longer required. Applications to the Controller, Studd-street Department, London, N. Tenders will be received up to 10 a.m. Aug. 9. *See also an advertisement.*

Messrs. Wheatley Kirk, Price & Co. have been instructed to sell by auction at the Mart, Tokenhouse Yard, London, E.C., at noon on Aug. 22, the central station electric lighting plant at 5 & 6, Bovay-street, Holloway, London, N., comprising two 46 kw. Willans-Crompton d.c. sets, two 115 kw. and one 145 kw. Willans-Siemens sets, two Babcock-Willcox boilers, one Davey-Paxman multi-tubular boiler and 40 n.p. Crossley gas engine, switchboards, cables, meters, shop plant and tools. The premises are also for sale by private treaty. On view on 17th and 18th inst., or earlier by appointment. Full particulars and catalogue may be obtained from Messrs. Guscotte & Fowler, solicitors, 1, York-place, Adelphi, London, W.C. or of the auctioneers, 46, Watling-street, London, E.C., and at Manchester and Newcastle-on-Tyne. *See also an advertisement.*

LIQUIDATIONS.

Claims against the Adnil Electric Co. (Ltd.) are to be proved to the liquidator, Mr. J. H. Stephens, 6, Clement's-lane, London, E.C., by Aug. 16.

A meeting to receive an account of the winding up of the Excelsior (Aluminium) Solder Co. (Ltd.) (in vol. liq.) will be held at 14, St. Ann's-square, Manchester, on Sept. 11

ELECTRICITY SUPPLY.

EXTENSIONS.

Fulham (London).—The Borough Council has received sanction from the L.C.C. to borrow £2,500 for the electricity department.

London County Council.—On Tuesday sanction was given to Battersea Borough Council borrowing £3,728, and to Hammersmith Borough Council borrowing £650 for electrical purposes.

Wimbledon.—The Borough Electrical Engineer is to interview the L.G. Board respecting the latter's refusal to sanction loans for mains, house services, &c., since March 31, 1915.

The General Purposes Committee has approved the proposal that the following payments should be made to the undermentioned staff of the electricity department in respect of their services in connection with the laying of mains and cables to Wimbledon Common: Borough electrical engineer (Mr. H. Tomlinson-Lee), £75; assistant engineer (Mr. W. J. Oswald), £15; clerk to electrical engineer (Mr. B. A. Larney), £20.

Woolwich.—The Borough Electrical Engineer has been authorised to relay the distribution mains in Herbert-road at a cost of £369. Circulating water piping and two coal chutes and valves are to be purchased from Babcock & Wilcox (Ltd.) for £460.

GENERAL.

Bedworth (Warwickshire).—The Leicestershire and Warwickshire Electric Power Co. has asked the Parish Council to renew for three years further the contract for the lighting of the district, which expires in August, to agree to a minimum payment of £1 a week for 12 lamps during the continuance of restricted lighting, and to resume the existing lighting arrangements when the restriction is removed. The Council has referred the matter to the Lighting Committee.

Bethnal Green (London).—The Council, which is taking a bulk supply of current from Stepney, commenced the supply of energy to some power consumers on June 19. The sub-stations are not yet

properly completed, and there will be a formal inauguration of the supply at a later date.

Electric Lighting Orders.—The Board of Trade has extended for one year from July 31, 1916, the periods of two years and 18 months, respectively, mentioned in the York Electric Lighting (Extension) Order, 1914, in the Thornton Electric Lighting Order, 1914, and in the Kingston-upon-Hull Electric Lighting (Extension) Order, 1914 (laying of mains, &c.).

Eton.—The Windsor Electrical Installation Co. have offered to reduce by £64. 6s. the charge to Eton Urban Council of £231 per annum for public lighting. The lighting has been reduced by 40 per cent., and the concession has been accepted with thanks.

Increased Charges for Current.—The charges for electrical energy are being increased at the following places :—

Ealing Corporation propose to increase their charges by 33⅓ per cent. in September. The charges are already 20 per cent. over pre-war rates.

The Trowbridge Electric Supply Co. has asked the Council's assent to an increase of 10 per cent. in their charges. The Council decided to allow the increase during war time.

At West Bromwich Corporation meeting last week the Electricity Committee reported that the allowance of 15 per cent. to power consumers had been discontinued.

London Electricity Supply Scheme.—In February, 1915, Middlesex County Council authorised their Parliamentary Committee to obtain expert advice on the proposals of the London & District Electricity Supply Bill, 1915, so far as they effected the county, and generaly as to the present electricity supply of the county. Sir John Snell, who was engaged to report on the matter, has now presented his report, but it has not yet been considered.

Manchester.—On Wednesday Ald. Ashton moved the following resolution on the question of the allocation of profits :—

That having regard to the present high rate of income tax and to the liability thereto of the profits of the trading departments of the Corporation, a special committee of this Council be appointed to review the basis on which the Gas, Electricity, Tramways and Markets Committees respectively, have hitherto made annual contributions out of their profits in aid of the city rate, and to make such recommendations in regard thereto as they may consider desirable.

Salford.—An additional supply of energy is to be given to the works of the Broughton Copper Co.

The Electricity Committee has given instructions that the two remaining reciprocating engine sets at the station should be sold, and the money realised credited to the depreciation and renewals fund.

Tottenham.—The North Metropolitan Electric Power Supply Co has declined to make the Council any allowance on the account for public lighting for the December quarter last.

Wolverhampton.—The Corporation is recommended to grant the following increases of salary :—

E. Stubbs, chief assistant electrical engineer, from £225 to £250 a year ; E. Forder, engine room superintendent and C. Bellhouse, boiler house superintendent, both from £165 to £180 ; J. H. Rothwell, chief clerk, from £185 to £200.

LIGHTING & POWER NOTES.

Chelmsford.—The Council have come to an agreement with the Electric Supply Corporation on the question of street lighting.

The Council will only pay £275 instead of £1,375 for the period extending from June 1, 1915, to March 31, 1916, during which the electric street lamps remain extinguished. While the street lamps remain extinguished during the continuance of the new contract the Council will only be liable to pay to the company at the rate of £150 per annum. The total amount payable by the Council per annum under the new contract will amount to £1,157. 10s., compared with £1,650 per annum under the old contract, excluding the reductions of 20 per cent. and 16½ per cent., respectively, obtainable if the lamps are put out at 11 p.m. or at midnight. The new contract is for a period of four years, and is conditional upon the company withdrawing their opposition to the Council's application to the Board of Trade for an order to extend for one year their option to purchase the electricity undertaking.

With regard to the Council's resolution protesting against the company's proposal to charge private consumers a minimum payment for electricity at the rate of 8s. 1½d. (7s. 6d. net) per quarter, irrespective of the quantity consumed not exceeding 15 units, the company offer to amend their minimum charges to private consumers to 10s. net for each winter quarter and 5s. net for each summer quarter, instead of 7s. 6d. net per quarter all the year round.

Electric Power in Collieries.—At the Garswood Hall Collieries, near Wigan, an electrically-driven pump is to be used in connection with the installation of a 750 kw. mixed pressure turbo-generator, which is to utilise exhaust steam from the winding engines. The installation of a second turbo-generator of the same capacity is also contemplated.

At Messrs. Newton, Chambers & Co.'s new Staindrop Colliery (co. Durham) last week an electric winding machine was started. The machine is said to be one of the first of its kind installed in the district. High-tension a.c. current is obtained by means of overhead wires from a generator driven by an exhaust steam turbine at Rockingham Colliery.

Huddersfield.—The Corporation has decided that consumers who desire to purchase electric motors on hire can do so at the then cost of a similar new motor less 5 per cent. per annum depreciation, reckoned from the time the hiring commenced.

Sheffield.—An electric furnace of 30 cwt. capacity for the production of cast steel, has recently been installed at the works of Henry Rossall & Co.

TRACTION NOTES.

Ilford.—The manager of the tramways has submitted a report in favour of the abolition of the halfpenny fare.

L.C.C. Tramways.—On Tuesday the Highways Committee reported to the Council upon the services rendered by the tramways in connection with the war.

Since the outbreak of the war the changes made at short notice in the tramways services, owing to the redistribution of the centres of industry in consequence of the development of industries connected with the supply of munitions, have been of the greatest assistance to the large numbers of workers engaged in those industries. More than 11½ millions of passengers are being carried weekly by the Council's cars. The majority of passengers use the tramcars for travelling to and from their work in connection with the industry and commerce of London, whilst tens of thousands use the cars to reach works in various parts of the areas served by the tramways system. Of the various passenger-carrying services, the Council's tramways were alone in a position to expand the normal services to an extent at all commensurate with the rapidly-growing needs of Woolwich. In July, 1914, just before the outbreak of war, the maximum number of the Council's tramcars arriving at a certain point during the busiest half-hour was 41 ; this number has now been increased to 86, an addition of 110 per cent. The number of cars arriving at the same point each day before the war was 975 ; the number is now 1,595, an increase of over 63 per cent. During the busiest hour accommodation is provided for 13,688 people, compared with 4,094 before the war. The service between Eltham and Woolwich is still being added to, and further augmentation of the services on the main route through Woolwich from City termini to Abbey Wood would also be made but for the fact that the section of tramway in one of the main Woolwich thoroughfares, which consists of only a single line with passing places, is already worked to its full capacity. The Council has for some time past been in communication with the Woolwich Metropolitan Borough Council with a view to sections of single line being doubled, and, although the Borough Council has consented to some of the projected doublings, it has declined to agree to the doublings to which the greatest importance is attached, except on the conditions, which the Council would not be justified in accepting, that costly street widenings should be undertaken at a proximate date. If the consent of the Borough Council to these doublings could be secured on the compromise terms which we have submitted to the Borough Council it would be possible at an early date to increase appreciably the existing very heavy service on the tramways in question. To enable the present additional services to be run, the tramways substation at Woolwich has had to be enlarged and additional plant installed ; new cables between the Greenwich generating station and the substation, and between the sub-station and the tramway tracks have been laid ; one section of the tramway track has been doubled, and at three additional points further doublings are in progress.

Other changes have been made enabling the tramways management to meet altered requirements arising out of the war. The authority obtained to carry an excess number of passengers has proved of considerable assistance, and to meet the shortage of men it became necessary to employ women on work formerly done by men, more especially as conductors. There are now 1,072 women conductors employed. With the same end in view, and to increase as far as practicable the accommodation required by the travelling public, the construction of trailer cars has been expedited as much as possible.

The Council's tramways have been the principal means of meeting the very considerable expansion and redistribution of the passenger transit services in various parts of London owing to the altered conditions created by the war ; and it may be stated confidently that no other form of transit could have provided so satisfactorily the modified travelling facilities rendered essential by national requirements.

Although during the past two years the problem set before the management of meeting the requirements of the travelling public has been a difficult one, the needs of the country have been borne in mind ; the services of officers and employés have been lent to the Government for national work ; from the beginning of the war men have been encouraged to join H.M. Forces ; substantial allowances have been made to the men enlisting or to their dependents, involving a charge on the undertaking of over £168,700, a sum which will be increased to over £260,000 by the end of the current financial year if the war continues until March 31, 1917.

Position of the Tramway Undertaking.—A special sub-committee, consisting of Messrs. G. M. Gillett, F. C. Harrison, T. F. Hobson, J. Little and A. H. Scott has been appointed to inquire into the organisation and working of the tramway service.

Fares.—Communications having been received from Leyton Urban Council and the West Ham Corporation with reference to a revision of fares on through running routes, which raised the question of the abolition of ½d. fares, the Highways Committee, for the purpose of acquainting the Council with the matter, asked for authority to enter into negotiations with the two bodies concerned with respect to through running.

Mr. GILLETT proposed an amendment to the effect that the Council was of opinion that no sufficient cause has been shown for depriving the inhabitants of the country of those facilities for cheap transit which are conferred by the existence of halfpenny fares.

The amendment was seconded and carried, but subsequently the Highways Committee were instructed to report, after conference with Leyton, West Ham and East Ham Councils as to the desirability or otherwise of abolishing or suspending halfpenny or other particular fares, or of varying fare stages on through routes with which those authorities are concerned.

Greenwich Generating Station.—Authority was given for the expenditure of £5,000 on capital account for alterations to four boilers, as an experiment to enable a cheaper class of coal or coke to be used.

Tramways v. 'Buses.—In reply to Sir J. Benn, Mr. Hume said the length of the tramway track was 141 route miles, and there was 'bus competition on 111 route miles. Assuming the 'buses ran 120 miles daily and used one gallon of petrol for each 7 miles, it would mean 20 million miles run per annum and 3 millions of gallons of petrol used annually.

North London Railway.—On Sunday successful trial trips were made over the newly electrified line between Broad-street and Richmond. The electric train service on this route will commence on Oct. 1, and the time for the complete journey will be reduced from 60 to 45 minutes. The work of converting the Kew and Acton line is also approaching completion.

Tramway Track Maintenance.—The city engineer of Newcastle-on-Tyne (Mr. W. J. Steele) has prepared a report on the condition of the Corporation tramway system.

The length of tramway opened for service measured as single track is 66½ miles. The maintenance of the permanent way has been £9,545. 9s. 9d. (equivalent to £143 per mile of single track, or 0·40d. per car-mile); but in addition to ordinary maintenance, £1,580. 18s. 1d. was expended in renewals (equivalent to £24 per mile, or 0·06d. per car-mile), so that the total cost of the permanent way (exclusive of capital charges) was £11,125. 18s. 10d. (£167. 6s. 1d. per mile, or 0·46d. per car-mile). A considerable length of the permanent way is in urgent need of renewal, but the great difficulty in obtaining a sufficient supply of labour has prevented that necessary work being undertaken. The greater portion of the track has been in use for nearly 15 years, consequently the fact that the present heavy service on a permanent way having many steep gradients is maintained at such a comparatively small cost is satisfactory, but it is inevitable that the cost will be greatly increased as soon as opportunity will permit of renewals being carried out.

Wigan.—A serious tramcar accident occurred here on the 26th ult., when a car from Wigan to New Springs overturned in Library-street, Wigan. About 25 persons were injured and one woman died after admission to the infirmary.

Woolwich.—The Borough Council is prepared to re-open negotiations with the L.C.C. for laying a double line of tramway track between Beresford-square and Parry-place, Plumstead, provided the County Council agree to carry out the necessary street widenings within one year of the conclusion of peace.

EMPIRE NOTES.

Australasia.—The Electrolytic Zinc Co. of Australasia Ppy. (Ltd.), was registered recently, with a capital of £1,000,000 in £1 shares.

The directors are Messrs. W. L. Baillieu, M. Cohen, A. J. de Pavay and J. L. Wharton, who are also the directors of the Amalgamated Zinc Co. The company, which is primarily formed for the production of zinc electrolytically in Australia, will be a member of the Zinc Producers Association Ppy. (Ltd.), to which all the zinc-producing companies of Australia are parties, and a special feature of its constitution is that it must remain entirely under British control.

The Zinc Producers' Association Ppy. (Ltd.) has also been registered with an authorised capital of £100,000, in shares of £1, which will be divided between the mining and treatment companies interested in proportion to their output of zinc concentrates over a term of years prior to the formation of the central organisation. The registered holders of shares at present are Mr. M. Cohen and Mr. J. L. Wharton. The association will act for all Australian producers of zinc ores who belong to it during the next 50 years, on a co-operative basis, the companies undertaking to have all their smelting done by it.

The report of the Electricity Committee of the Christchurch (N.Z.) Council on the first year during which they have taken current from the Lake Coleridge hydro-electric system states that the operations have been an unqualified success and beyond the expectations of the committee, more especially in view of the difficulties and extra expense of obtaining supplies owing to war conditions, and the natural reluctance on the part of many to incur the expense of installing electricity at present. Revenue was £27,807, working expenses were £14,646, and interest on overdraft required £365, and on loans £4,080, besides £2,181 for sinking funds, leaving £6,535 to cover depreciation and provide for extensions.

The consulting engineer (Mr. F. Black) estimated that there would be a probable loss of between £1,600 and £1,700 at the end of two years, and that the undertaking would take from four to five years to become self-supporting. Owing to war conditions, the committee was unable to embark upon an active campaign to obtain new business, but in spite of this the number of consumers increased during the year from 1,623 to 2,930. The connected load estimated by Mr. Black to be 3,700 kw. in two years is 5,592 kw.

India.—"Indian Engineering" says the Cauvery project has already made progress sufficient to store water to an extent that is a sufficient guarantee against the shortage of water required for power generation at Sivasamudram, the electric power works of the Mysore State on the banks of the Cauvery. The Kannambodi dam has been raised to the height of 51 ft. on the river bed, and from 55 ft. to 74 ft. at the flanks.

In reference to proposed improvements at the Coolie camp at Mardapam the Acting Director of Public Works, Ceylon, says in a report it is proposed to install electrical plant for lighting the camp, and also to supply power for all the pumping machinery required for the water and drainage systems.

The Karachi Electric Supply Corpn. (Ltd.) has declared a dividend at the rate of 5 per cent. per annum as the result of the first complete year's working. At the general meeting recently the Hon. M. de P. Webb stated that the demands for electrical energy had exceeded all expectations. The directors propose to raise a further Rs.2,00,000 of capital.

Darjeeling Municipality proposes to carry out Mr. Stonebridge's hydro-electric scheme, which was initiated by the late Mr. Robertson. The power station will be at Singla. The cost of the scheme is estimated at over Rs.4,00,000.

FOREIGN NOTES.

Japan.—An order was published in the Japanese "Official Gazette" of July 17 prohibiting the exportation of tungsten and molybdenum from Japan, as from July 29, except under licence granted by the Department of Agriculture and Commerce.

Russia.—A Russian contemporary states that the Pazretzky waterfalls could be profitably utilised for the generation of electrical energy.

The River Paza, on which the falls are situated, flows from Lake Ennar to the Northern Arctic Ocean, by way of the Gulf of Bek-Fiorden. It is 80 miles in length, there is a flow of about 400 cubic metres of water per second, probably throughout the length of the river, and it has about 30 waterfalls and weirs. At the two falls nearest the sea, about 24,000 h.p. could be obtained.

It is also stated there are many more rivers with falls in Murman that could be used for mechanical power.

MISCELLANEOUS NOTES.

Customs Duties.—The Jamaica Tariff (Temporary Increase) Law, 1916 (No. 3 of 1916), which is to remain in force until March 31, 1917, unless previously repealed, provides that the following amongst other articles which were duty free are now subject to import duty of 16⅔ per cent. ad val.:—

Old scrap brass, Britannia metal (pigs and bars), copper (pigs), iron (pig), locomotives and railway and tramway rolling stock, rails, and all other materials and appliances for railway and tramway construction and equipment, lead (old scrap and pig), professional plans, &c., steel (ingots and expanded bars), tin (blocks and pigs), wrought iron and steel work for buildings, zinc (blocks and pigs).

Enemy Firms Wound-up.—The Board of Trade has ordered the winding-up of 279 businesses controlled by alien enemies.

The latest list includes Charles A. Muller, 10, Arcade, Westgate, Bradford, electrical accessories merchant. (Controller: W. Durrance, 12, Duke-street, Darley street, Bradford). L. H. Simon Bros., 62, Holborn Viaduct, E.C., agents and general merchants (toys, china, hardware, &c.). (Controller: William McLintock, 158, Fenchurch-street, E.C.). Emil Busch Optical Co., 35, Charles-street, Hatton Garden, E.C., opticians. (Controller: George Ernest Sendell, 36, Walbrook, E.C.). Meister Lucius & Bruning (Ltd.), 20, Princess street, Manchester, dye

manufacturers. (Controller: Sir William Plender, 5, London-wall-buildings, E.C.).

Pacific Radio Stations.—It is announced that with the satisfactory conclusion of the official tests between the high-power wireless stations at Funabashi, Japan, and Honolulu, the Trans-Pacific scheme of wireless intercommunication is now complete. The distance from San Francosco across to Japan is some 6,300 miles, the station at Honolulu acting as a relay.

"The Russian Press."—We have received from Neyroud & Sons (Ltd.), foreign advertising agents, Regent House, Kingsway, London, a booklet which contains useful technical and other classified lists of Russian journals, towns in which they are published, &c.

TENDERS INVITED.

Telegraph and Telephone Material.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications, &c. (schedule 498, W.A.), from the Deputy Postmaster-General, Perth (W.A.).

Tenders are invited up to Aug. 16 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, Perth, requires tenders by 3 p.m. Oct. 4 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts. (Schedule No. 501 W.A.) for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General, Perth, W.A.

Turbo-Alternator, Condenser, &c.

The Town Clerk, INVERCARGILL (N.Z.) will receive tenders until 4 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 40). Specification, &c., from the Town Clerk.

Tramcar Tyres.

LONDON County Council requires tenders by 1 p.m. Aug. 22 for Supply of 1,000 Forged Steel Driving Wheel Tyres, and 500 Forged Steel Trailing Wheel Tyres. Forms of tender from the Chief Officer of Tramways, 62, Finsbury-pavement, E.C.

Wiring and Fitting.

Crook Co-operative Society (Ltd.), CROOK, Co. Durham, require tenders by the morning of Aug. 5 for Electric Light Fittings, Wires, &c., for their Waterhouses branch. Specifications can be seen at the Waterhouses stores.

Electric Crane, Air Compressor, Crane Motors, &c.

The NEW SOUTH WALES GOVERNMENT RAILWAYS & TRAMWAYS DEPARTMENT require tenders by noon Sept. 20 for the supply and erection of an Electric Overhead Travelling 50-ton Crane (specification 474); and by noon Oct. 11 for a motor-driven Air Compressor (specification 480) for Zarra-street power house. Specifications, &c., from the Electrical Engineer, 61, Hunter-street, Sydney.

The VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

Transformers.

SYDNEY (N.S.W.) Council require tenders by 3 p.m. Aug. 7 for supply of four 10,000/550 volt Transformers. (Contract No. 459.) Specification and form of tender from the City Electrical Engineer.

TENDERS RECEIVED AND ACCEPTED.

WOLVERHAMPTON.—The Electricity Committee recommends the Corporation to accept the tender of H. Morris, Ltd. (at £1,450) for the supply of a 40-ton travelling crane, and that of J. E. Perry & Son (at £540) for the supply and erection of a steel chimney at the electricity works.

LEYTON.—The Electric Lighting Committee has placed an order with the Wellington Tube Works to supply a set of boiler smoke tubes, at about £85. Out of nine firms invited to tender, only two quotations were received.

SALFORD.—The following tenders have been accepted by the Electricity Committee for the supply of stores:—

Le Carbone, motor carbon brushes, approximate value of contract £100; Reason Mfg. Co., m.d. indicators, £40; L. Andrew & Co., cable accessories, £76; Dussek Bitumen Co., joint box compound, £16; Baxendale & Co., w.i. steam tubes and fittings, £25; D. Walton & Co., wood fittings, £40; Job Holland & Co., engine oil, £36.

The offer of the British Westinghouse Co. to supply a 1,000 kw. rotary converter and transformer, has also been accepted. The committee has given approval to A. Ransome & Co., as sub-contractors in connection with the contract of the Underfeed Stoker Co., for the stokers required for the new water-tube boilers.

The Tramways Committee has also accepted the tender of J. Russell & Sons for the supply of 40 tramway poles, at £12. 17s. 2d. per pole.

ROSARIO (ARGENTINA).—A Government decree has been issued approving the contract entered into between the Director General de Arquitectura and the Sociedad Anonima Otis Elevator Co. for the supply and installation of an electric elevator in the new Federal Courts of Justice at Rosario de Santa Fé, at $7,990 (paper).

Commonwealth Contracts.—The following tenders have been accepted by the Australian Government Departments:—

Postmaster-General's Dept., Sydney.—W. G. Watson & Co., 3,000 dry cells, 3s. 9d. each; C. Glasson, 15 telephone cabinets, £12. 10s. each; and 25 ditto, £13. 4s. each; C. Monteath & Sons, 146 tons c.i. pipe, £11. 0s. 6d. per ton; F. & A. Nosworthy, 100 c.i. covers and frames for manholes, £1. 11s. each; 20 ditto, £3. 5s. each; 100 split bends for c.i. pipe, 10s. each; Oliver Co., 300 plug testing switches, 5s. 6d. each; Chown Bros. & Mulholland, 350,000 seal cups, 7s. per 1,000.

Postmaster-General's Department, Adelaide.—T. K. Steanes, increasing capacity of storage batteries, Adelaide, £511. 18s. 10d.; Western Electric Co., 3,230 yds. cable, £1,510 per mile; 1,060 yds. ditto, £1,201 per mile; 1⅛ miles ditto, £785 per mile; 3⅛ ditto, £440 per mile; ¾ mile ditto, £158 per mile; 110 yds. ditto, £2,800 per mile; 220 yds. ditto, £1,300 per mile; 220 yds. ditto, £665 per mile; 220 yds. ditto, £375 per mile.

Postmaster-General's Department, Brisbane.—J. Paton & Co., 400 micro-telephones, 19s. 2d. each; 25 ditto, £1. 0s. 2d. each; 500 heat coils, 3s. 6d. per 100; Western Electric Co., 50 translators, 25s. each; 150 cords, 2s. 3d. each; 15 trembling bells, 5s. 6d. each; 400 condensers, 2s. 5d. each; 50 telephone sets, £1. 1s. each; British General Electric Co. (Agents: Norman, Bell & Co.), 38 trembling bells, 7s. 6d. each.

Postmaster-General's Department, Melbourne.—Ramsay, Sharp & Co. 5,000 dry cells, 2s. 5d. each; Duncan & Co. Ppy., 5,000 dry cells, 3s. 4d. each; Weston Electric Co., four sections of a lamp signalling trunk line switchboard, Central Exchange, Melbourne, £1,414.

Victorian Railway Commissioners.—Australian General Electric Co., relays for point indication during five years, at rates; half-watt lamps and lanterns for same, at rates; lamps, socket reflector holders and reflectors for electric lighting of Jolimont Car shop, at rates; a.c. lever locks for Newport signal shops, a.c. 110-volt 25 ~ magnets £3. 6s. each, vulcanite rollers and springs 17s. 10½d. each, phosphor-bronze spring strip 2s 9d. per lb., commutator slotting machines for Jolimont car shops £102. 5s. each; Edison & Swan U. Electric Light Co., motor-generator and switchboard for Jolimont car shop (15 kw. motor generator and accessories £163. 16s., switchboard and connections £29. 18s. 6d.); Wormald Bros., automatic sprinklers and thermostats for car shed, Jolimont, £4,318; Gibson, Battle & Co., direct-coupled electrical rotary rock drill for State coal mine, £120; Cowley's Eureka Ironworks Ppy., mild steel masts, bridges and brackets for overhead equipment of Melbourne suburban railways, at rates; British Insulated & Helsby Cables, three-core cable for Newport workshops, £2,865. 11s. per mile; Royle & Co., elements, retarders and pyrometers (electrical or tension) for engines, at rates; Duncan & Co., caustic soda primary cells and renewals for caustic soda primary cells, at rates; John Miller, acetylene welding of rail joints on the Sandringham-Black Rock electric railway, £1. 13s. per joint.

N.S.W. Public Works Dept.—Standard Waygood Hercules, electric passenger lift for accommodation House, Jenolan Caves, £890; J. E. Toole & Co., two 15-ton electric overhead travelling cranes, £2,430, and two Liddles' patent electric capstans for Leichhardt depot, £770.

W. Australian Government Tender Board.—J. R. W. Gardam, switchgear and accessories for railway department, at rates, and copper feeder cable for railway department, £157 per mile; Chas. Atkins & Co., switchgear and accessories for railway department, at rates.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Brighton.—The accounts of the Lighting Committee for the past year, which were adopted by the Council at last week's meeting, show an increase over the year ended March, 1914, of £159 in revenue from sales of current, and an increase in total costs of £7,763, the net result of the year's working being a deficit of £3,989 (compared with £1,353).

In his report the borough electrical engineer, Mr. John Christie, says the comparison is made with the year 1913-14, because a comparison with the following year would be of little value. Units sold decreased 1,376,471, but the increase of charge, which averaged 0·29d., slightly increased the revenue, although supply to public lamps decreased £7,000. Coal cost £9,602 more, which more than counterbalanced savings which had been made in certain items. Average cost of coal was 32s. 3¼d. (against 17s. 3d.) per ton. Coal used per unit sold was 3·83 lb. (4·06 lb.)

Coun. Linfoot, in submitting the report and accounts, recommended that the deficit be charged to reserve fund. The deficit was due to no fault of the management, Committee or staff, but to conditions brought about by the war. In addition to extra cost of coal, they had to pay war allowances, plus income tax on profits to the extent of £1,600.

Coventry.—The accounts of the tramways department for the year ended March 31 show total capital expenditure £239,399 (increase £596), of which £10,620 has been repaid, and £30,000 has been temporarily paid off. The loans sinking fund amounts to £10,033 and the reserve fund to £3,647.

Revenue was £52,987 (compared with £45,105 in previous year), working expenses were £33,080 (£30,528), interest required £8,300 (£8,521) and sinking fund £5,988 (£5,755), leaving net balance £5,091 (£344). Revenue per car-mile was 12·612d. (9·902d.), and working expenses, including power, were 7·874d. (6·658d.). Passengers carried were 11,419,360 (8,730,021), car miles run 1,008,247 (1,100,553) and units used 1,677,143 (1,651,950).

The capital spent on motor omnibuses is £1,665. The omnibus service has been suspended since Sept. 9, 1914, when the War Office impressed the six chassis.

Eastbourne.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £210,926 (increase £7,226), and the amount repaid or in sinking fund is £97,182.

Revenue was £27,567 (compared with £30,474 in previous year), and working and general expenses were £15,705 (£15,230), the gross profit being £11,861 (£15,243). Capital charges and £1,466 transferred to meter, mechanical stokers, &c., suspense account absorbed £12,922, so that the net result was a deficit of £911 (compared with a net profit of £2,228). Revenue was equal to 3·62d. (3·86d.) per unit sold, works costs were 1·33d. (1·31d.), total working costs 2·01d. (1·84d.), and interest and redemption required 1·73d. (1·71d.). Units generated were 2,309,118 (2,400,750) and sold 1,773,737 (1,816,667). Maximum load was 1,371 kw. (1,412 kw.), and load factor 14·77 (14·69) per cent.

Mr. J. K. Brydges (borough electrical engineer) says in his report the number of (equivalent) 30 watt lamps connected is 189,829 (16,680 having been added during the year, compared with 13,871 in previous year). Coal cost increased from £5,931 to £6,397. It is doubtful whether the increase in the charge now made for lighting from 5d. to 5½d. per unit will cover the extra cost of coal (which is expected to be 45 per cent. more for the same class of coal when a new contract is made in November). Imperial taxes increased from £842 to £1,689, and insurance premiums from £46 to £177. Motors in use increased from 217 (772 h.p.) to 246 (865 h.p.).

Glasgow.—The accounts of the electricity department for the year ended May 31 have been approved by the Electricity Committee.

The report, which is for the 24th year of working, states that the gross revenue for the year amounted to £390,720, an increase of £125,347 (30 per cent.), compared with the preceding year, while the working expenditure was £322,651, an increase of £104,133, or 47 per cent. The gross balance was £208,068, from which was deducted: Interest on loans (£72,233) sinking fund, &c. (£72,413) and depreciation (£58,105), leaving a surplus for the year of £5,317, which has been transferred to reserve. Of the increase of revenue £55,325 is attributable to the 15 per cent. added to the consumers' accounts. The increase of working expenses is principally due, apart from the greater output, to the much higher price paid for coal, an all round advance in the cost of material, increased rates and taxes, bonuses, &c., to workmen, and to £5,976 for allowances to employes on active service. There was also a considerable increase in the amount paid for interest and the contribution to the sinking fund. Contracts have been entered into for the supply of coal for the current year at a slight increase in price as compared with the past year. Notwithstanding this, in view of the favourable result of the year's working, the Committee recommend that no change be made on the ordinary charges for current for the year 1916-17. The maximum demand made upon the stations last winter occurred on Dec. 29, and was 45,880 kw., compared with a maximum demand of 39,750 kw. in the previous year, an increase of 15·42 per cent. A central showroom in Sauchiehall-street was opened on Oct. 2. Since then good business has been done, aided to a certain extent by the active co-operation of the electrical contractors.

Hammersmith (London).—The accounts of the electricity department for the year ended March 31 show total capital expenditure £384,932 (increase £9,310), of which £148,753 has been redeemed.

Revenue was £64,117 (compared with £63,280 in previous year), working expenses were £38,271 (£34,772) and special expenditure was £1,216 (£1,512), gross profit being £24,629 (£26,994). Interest required £8,601 (£8,521), and redemption of capital £15,947 (£14,345), leaving net profit £395 (£3,717). Average price obtained was 1·28d. (1·44d.) per unit. Maximum load was 5,980 kw. (4,646 kw.). Units sold were 11,178,294 (9,717,252). Motors connected are 971 (=9,126 h.p.), compared with 711 (=6,907 h.p.).

Mr. G. G. Bell, engineer and manager, says in his report the rates for electricity are maintained at pre-war figures. The increase of sales to private consumers was 2,000,018 units. The profit was reduced by increased cost of coal and cartage and the reduction in the output of units at the higher rate. Large consignments of coal had to be accepted at Shepherd's Bush and Hammersmith-grove sidings. If it had all been delivered at Chancellor's Wharf and pumped from there by the coal-pumping plant, a saving of £391 would have been effected. The expenditure on the coal pumping plant has, however, absolutely justified itself. The coal storage tanks have more than justified their existence, no trouble having been experienced from coal catching fire, which frequently occurred in previous years. The charge for public lighting was reduced by £2,500, or more than 50 per cent. Income tax showed an increase of £716, and allowances to men serving with the Colours increased from £788 to £1,209. Employés of the department have been granted war service badges by the Ministry of Munitions. The two motor-generators at Olympia have been little used, no exhibitions having been held, which accounts for a considerable decrease in revenue. Contribution for repayment of capital increased by nearly £1,000, this year being the first to bear the full cost of the loan for the coal storage and coal-handling plant. Coal cost 0·398d. (0·323d.) per unit, works costs were 0·576d. (0·526d.), and total costs 0·811d. (0·776d.). Negotiations were satisfactorily concluded for linking-up the undertaking with the electric supply undertakings of Fulham and Battersea, but the L.C.C. could not see their way to grant a loan for carrying out the work, with the result that if anything is done in the matter at the present time the extra costs of the scheme will be about £4,000, due to the price of labour and materials.

South Shields.—The Corporation tramway accounts for the year ended March 31 show gross capital expenditure £181,606 (increase £509), of which £32,741 has been redeemed.

Revenue was £41,826 (increase £1,981), working expenses were £24,385, or £26,317 including war services, the gross profit being £15,509. Interest required £5,054 and sinking fund, &c., £3,951, leaving a net balance of £6,504, of which £4,104 has been placed to reserve and £2,400 devoted to relief of rates. Average total revenue per car-mile was 12·170d. (against 10·308d.), and working expenses, including power, were 7·015d. (6·432d.). Passengers carried were 11,163,378 (10,479,421), car-miles run 824,888 (927,728), and units used 1,197,129 = 1·347 per car-mile.

Mr. J. C. Whiteley (general manager and engineer) says, in his report, nearly 80 employés (about 60 per cent. of the staff) have joined H.M. forces. Women conductors have been engaged, and have adapted themselves to the work splendidly. Only 30 per cent. of the men who have applied for motormen's duties have proved capable of doing the work, and the service has had to be reduced when an increased service was necessary.

Swansea.—The electricity works accounts for the year ended March 31 show gross capital expenditure £249,697 (increase £10,184), of which £183,058 (£183,623) is outstanding.

Revenue was £38,295 (£33,297), working expenses were £20,190 (£18,966). Interest required £7,665 (£7,290) and repayment of principal £5,550 (£5,287), leaving net profit £4,944 (£1,786). Average price obtained was 2·48d. (2·28d.) per unit, total working expenses were 1·37d. (1·33d.) and capital charges 0·89d. (0·88d.). Units generated were 4,199,570 (4,001,788) and sold 3,523,182 (3,401,961). Maximum load was 2,330 kw.

Mr. Wm. Burt (borough electrical engineer) says in his report the increase of 197,782 units in the output was obtained with a reduction of 1,660 tons (over 20 per cent.) in the quantity of coal consumed. Average price of coal was 17s. 1d. (12s. 1d. in previous year). A contract for nine months' supply of coal at 20s. 6d. per ton was entered into in June, 1915, but the Price of Coal Limitation Act reduced the price to 18s. per ton. The showroom has been visited by a large number of residents, and two demonstrations in electric cooking, ironing and heating have been given, with good results. The advantage of having modern machinery can be seen from this year's balance sheet.

The capital expenditure on the tramways is £119,650 (increase £720), and the amount paid off or in sinking fund is £20,562. Revenue was

£7,474. Loan charges amounted to £5,746, management and stamp duty charges £104, and other charges (bank interest, &c.) £66, the surplus for the year being £1,556.

West Ham.—The capital expenditure on the electricity department for the year ended March 31 was £6,338, making a total of £662,891, of which £373,440 is expended and outstanding.

Revenue was £139,101 (compared with £128,738), and after providing for working expenses, gross profit was £23,921 (£37,818). Interest and special charges absorbed £25,241, including £4,216 allowance to men on active service (£23,093, including £1,411 allowance for similar purposes), and sinking fund required £24,882 (£23,577), the net result being a deficit of £26,202 (£8,852). Average price obtained per unit was 0·924d. (0·858d.) coal cost 0·458d. (0·328d.), total works cost was 0·770d. (0·612d.) and capital charges were 0·335d. (0·314d.). Units generated were 44,024,200 (42,595,281) and sold 35,895,393 (35,641,945). Motors connected are 1,944 (1,815)=21,877 H.P. (20,627 H.P.). Total maximum demand was 14,940 k.v.a. (14,403 k.v.a.), or 12,225 kw. (12,160 kw.) and load factor 33·52 (33·46) per cent.

The engineer and manager (Mr. J. W. Beauchamp) says in his report the number of electric vehicles garaged in the district and charged from the public supply has increased to 15, with an aggregate tonnage of 10½; also a large amount of charging is done for vehicles passing through the borough. Heating and cooking units increased from 355,877 (388,254). The whole of the year under review was subject to war conditions (compared with only eight months of the previous year), and the sharp upward tendency of coal and other costs occurred in the last half of the year. The increase in average price of coal reached 20·9 per cent. Difficulties in regard to fuel brought out clearly the advantages of centralised power supply, freeing consumers from the excessive cost of purchasing small quantities of coal and from the difficulty of retaining skilled labour for private power plants. The standard rate for lighting has been increased from 3d. to 3½d. (16⅔ per cent.) and for power and heating from 1d. to 1⅛d. (12½ per cent.). 95 members of the staff and employés had joined H.M. Forces up to March 31.

The tramway accounts show total capital expenditure £557,802 (increase £924). Revenue was £164,557 (£154,037), working expenses were £124,926 (£119,935), interest required £18,456 (£20,456), sinking fund, &c., £12,738 (£12,679), and special expenditure £5,580 (£692), net surplus being £2,855 (£272). Passengers carried were 46,734,440 (42,667,561), car-miles run 3,645,165 (3,760,361) and units used 5,860,821 (6,306,731). Average total traffic revenue per car-mile was 10·94d. (9·83d.), and working expenses, including power, were 8·22d. (7·65d.). The general manager, Mr. J. S. D. Moffet, says in his report war allowances from borough rate for the year amounted to £13,318, the total since the commencement of the war being £19,349.

COMPANIES' MEETINGS AND REPORTS.

ALDERSHOT GAS, WATER & DISTRICT LIGHTING CO.—For the half-year to June 30 the total revenue was £56,542, and expenditure £44,867, leaving £11,675. After providing for dividends on the consolidated preference stock and interest on special loan and debentures, the directors recommend the full statutory dividends of £5 18-20 per cent. on the "A" stock, £4 8-20 per cent. on the "B" stock, and £5 per cent. per annum on the "C" consolidated stock for the half-year, all less tax.

ELECTRIC SUPPLY CORPN. (LTD.)—Mr. J. G. B. Stone, who presided over the annual meeting last week, said that the increase in lamp connections had much exceeded the average growth, the increase being from 214,715 to 254,700 during the year, about 75 per cent. of which was due to demands for power in Dumbarton, leaving to their other towns approximately their usual growth, which in these times was not unsatisfactory. The Hendon Company had increased its dividend by 2 per cent., whilst the Dumbarton Tramways Co. had again paid them a small dividend of 1½ per cent. The war had proved a very disturbing factor in their revenue account, as it had increased the demand for current for power, but it had reduced the demand for lighting, particularly for street lighting. Under the terms of their contract with Chelmsford, and in view of a recent decision in the Appeal Court, the directors understood that the company were entitled to recover the full amount of the contract, and that had been included in their accounts. The contract terminated in March, and they were now negotiating with the Council for a renewal on the basis of their making a considerable allowance in regard to the payment due for 1915. They raised prices generally for the last half of the year, and this year they had found it necessary to make a further increase. The net result was that Chelmsford, Exmouth and Falmouth showed increased profits; those at Hitchin, St. Andrews and Totnes were practically the same as last year, and Dalkeith, Dollar, Dumbarton, Jedburgh and Melrose showed a decrease. The coal market was a very difficult one, and he was sorry to say that the effect of the Coal Prices Limitation Act left much to be desired. The directors proposed to declare a dividend of 2 per cent., against 2½ per cent. last year.

VICKERS (LTD.)—At the meeting last week Mr. Douglas Vickers explained that the pressure of business had been so great that they had not yet been able to get the accounts for the past year into a proper state. The position had been complicated by the fact that they were serving two masters. The Munitions of War Act made them a controlled company, and the Finance No. 2 Act (1915) dealt with excess profits. They had had to take a vast number of orders from the Government involving various conditions. Many of those had to be considered and taken into account after getting out the accounts, and it had been an absolutely impossible task to get through the work. They had paid a dividend which the shareholders must look upon as final for 1915, so that it would be possible to deal with the future in spite of the accounts. The meeting was adjourned until the accounts are ready for presentation.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

HENRI CLAES & CO. (LTD.) (144,408).—Reg. July 20, capital £10,000 in £1 shares (5,000 preference), to adopt an agreement with H. J. Claes, to carry on the business of baryta grinders, manufacturers of lithophone zinc oxide, red and white lead and other products from mineral ore, metallurgists, mechanical and electrical engineers, machinists, &c. Private company. Reg. office: Pinner's Hall, Austin Friars, E.C.

JAMES CARTER (STALYBRIDGE) (LTD.) (144,469.)—Reg. July 27, capital £30,000 in £1 shares, to take over the business of James Carter & Sons, Stalybridge, to carry on the business of iron and brass founders, mechanical and electrical engineers, tool makers, metal workers, &c. Private company. First directors are A. Denton, A. Carter and A. E. Chadwick. Secretary (pro tem.), A. S. Chadwick. Reg. office, Atlas Works, Stalybridge.

NEW PETO & RADFORD ACCUMULATOR CO. (LTD.) (144,436)—Reg. July 24, capital £30,000 in £1 shares (12,500 10 per cent. preference), to carry on in the U.K. and elsewhere the business of electricians, accumulator manufacturers, founders, electrical and water supply engineers, manufacturers of and dealers in electric meters and other electrical instruments, &c., and to adopt three agreements. Private company.

G. C. OGLE & SONS (LTD.) (144,376).—Reg. July 18, capital £10,000 in £10 shares, to take over the business carried on by Wm. Ogle at Ripley, and to carry on the business of engineers, founders, boiler and agricultural implement makers, makers and repairers of and dealers in wagons, electric cars, railway and tramway rolling stock, motor, omnibus and motor accessories, &c. Private company. First directors are W. Ogle (permanent), A. Ogle, J. H. Ogle and G. E. Ogle.

PHILLIPS' MAGNETO (LTD.) (144,456.)—Reg. July 26, capital £1,250 in £1 shares, to adopt an agreement with I. Phillips for the purchase of the business of a manufacturer of magnetos and all parts thereof carried on by him at Aldershot. Private company. Secretary (pro tem.), C. Melton. Reg. office, 10, Birchett-road, Aldershot.

MORTGAGES AND CHARGES.

HIGHFIELD CO. (LTD.)—Particulars of £750 second debentures, created June 27, 1916, have been filed, whole amount being now issued. Property charged, company's undertaking and property, present and future. No trustees. A debenture dated July 19 1916, to secure not more than £500, charged on the above-mentioned property, has also been registered. Holder, J. H. Bland. A memorandum of satisfaction in full on July 19, 1916, of a debenture dated Dec. 4, 1914, securing £300, has also been notified.

JOSEPH R. HENSON (LTD.)—Two debentures dated July 7, 1916, to secure £2,200 and £50 respectively, charged on the company's undertaking and property, present and future, including uncalled capital. Holders: Capt. H. W. Seton Karr and N. A. Heywood.

PARSONS & HODGES (LTD.)—Particulars of £600 debentures, created June 30, 1916, have been filed, the whole amount being now issued. Property charged, company's undertaking and property, present and future. No trustees.

RUSHMORE LAMPS (LTD.)—Memorandum of satisfaction in full on June 27, 1916, of a charge dated May 27, 1914, securing £2,000 has been filed.

TROUP, CURTIS & CO. (LTD.) Particulars of £3,000 debentures created July 5, 1916, have been filed, the whole amount being now issued. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees

VAUGHAN ENGINEERING WORKS (LTD.)—A mortgage dated July 19, 1916, to secure £1,600 and £500 as compound interest, charged on moneys to be received under a War Office contract, has been registered. Holder, J. Gee.

CITY NOTES.

MEMORANDA (Aug. 2).—Bank rate 6 per cent. (since July 13, 1916). Consols 58¾. Consols Pay Day, Sept. 1. Stocks and Shares Ticket Days, Aug. 15 and 30. Pay Days, Aug. 16 and 31. Price of silver, 30½d.

BLACKPOOL & FLEETWOOD TRAMROAD CO.—Payment of the usual interim dividend of 4 per cent. (tax free) is announced.

BRISTOL TRAMWAYS & CARRIAGE CO.—An interim dividend at the rate of 5 per cent. per annum for the half-year ended June 30 has been declared on the ordinary shares.

CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares of the West End undertakings for the half-year ended June 30 at the rate of 4 per cent. per annum. Warrants will be posted on the 15th inst.

CHELSEA ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend at the rate of 3 per cent. per annum (less tax) on the ordinary shares, payable 15th prox.

CITY OF BUENOS AYRES TRAMWAYS CO. (1904) (LTD.)—The directors have declared a dividend of 1s. 3d. per share (being at rate of 5 per cent. per annum), less tax, for the three months to June 30.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The company announce an interim dividend at the rate of 6 per cent. per annum (6s. per share), less tax, on the ordinary shares, payable Sept. 25.

CORDOBA LIGHT, POWER & TRACTION CO. (LTD.)—Payment of the dividend on the preference shares has been postponed.

HONG KONG TRAMWAY CO. (LTD.)—An interim dividend of 7 per cent. has been declared.

METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares of 1s. per share for the half-year to June 30, payable on the 16th inst.

METROPOLITAN RAILWAY CO.—The directors recommend payment of dividends on the several issues of preference stock and of an interim dividend at rate of 1 per cent. per annum on the ordinary stock for the year ended June 30.

TUBES (LTD.)—The accounts to April 30 cannot be prepared at the usual time, but the directors have declared a further interim dividend of 15 per cent. (tax free), making 20 per cent. for the year. It is intended to increase the capital by the creation of a further 50,000 shares of £1 each.

WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)—The directors recommend an interim dividend at the rate of 5 per cent. per annum (less tax) for the half-year ended June 30, payable Sept. 1.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date Aug. 1, the following as the present basis prices of—

New Metals.	per lb.		Per ton.
Solid Drawn Brass Tubes	14¾d.	English Lead	£29 2 6
Solid Drawn Copper Tubes	17¼d.	Antimony	Nominal.
Brazed Copper Tubes	17¼d.	**Old Metals.**	Per ton.
Brazed Brass Tubes	16¼d.	Clean Copper Scrap	£95 0 0
Brass Wire	14¼d.	Clean Brass Scrap	57 0 0
Copper Wire	18d.	Brazier Copper Scrap	85 0 0
Rolled Brass	14¼d.	Old Lead	24 0 0
Brass Sheets	15¼d.	Old Zinc	40 0 0
	Per ton.	Hollow Pewter	110 0 0
Copper Sheets	£146 0 0	Black Pewter	70 0 0
Spelter	55 0 0	Gun Metal	72 0 0

Mr. A. Joseph, Earl-street, Lonon-road, Southwark, London, S.E., quotes under date Aug. 1, the following approximate prices of Scrap Metals:—

	Per ton.		Per ton.
Aluminium Cuttings	£110 0 0	Old Lead	£3. 15s. under English lead price.
Clean Mixed Brass	62 0 0	Old Zinc	40 0 0
Clean Copper	92 0 0	Hollow Pewter	120 0 0
Brazier Copper	80 0 0	Shaped Black Pewter	85 0 0
Gun Metal	80 0 0		

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80, Commercial Tinman's Solder, £97, Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, Aug. 1. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., Aug. 1	Rate per cent. Yielded. £ s. d.	Dividend Due.
		Electricity Supply.			
10	6%	Bournemouth & Poole E.L. Ord.	8¼	6 19 2	Mar., Sept.
10	4½%	Do. 4½% Cum. Pref.	8⅛	5 11 8	Feb., Aug.
10	6%	Do. 6% Cum. 2nd Pref.	10⅛	5 19 3	Feb., Aug.
5	10%	Brompton & Kensington Ord.	6⅞	7 12 5	Mar., Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar., Aug
St.	4%	Central Elec. Supp. C. Deb St.	80	5 0 0	..
St.	4%	Charing Cross West End & City Deb.	79½	5 0 8	Jan., July
5	2 3	Do. 4½ Pref.	3¼	6 4 2	..
5	5%	Do. Ord.	3½	6 13 4	Aug., Feb
5	4½%	Do. City Pref.	2½	7 13 2	Jun., Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3½	6 8 0	Mar., Sept
St.	4½%	Do. do. Deb.	87	5 3 5	Jan., July
10	8%	City of London Elec. Lt. Ord.	1½	6 8 0	Feb., Aug
10	6%	Do. 6% Pref.	1⅝	5 14 3	Mar., July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun., Dec
St.	4½%	Do. 4½ Deb.	80	5 2 6	Jun., Dec
10	7%	County of London Ord.	10⅜	6 9 6	Mar., Sept
10	6%	Do. 6% Pref.	1⅛	5 12 11	Feb., Aug
St.	4½%	Do. 1st Deb.	85½	5 1 1	Jan., July
St.	4½%	Do. 2nd Deb.	82	5 7 9	May, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Deb.	78	5 18 10	July
5	7%	Kensington & Knightsbridge Ord.	3½	6 13 4	Feb., Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan., July
5	6%	London Elec. Supply 6% Pref.	4¼	6 17 2	..
St.	4%	Do. 4% Mort. Deb.	82½	4 17 0	Jan., July
5	3%	Metropolitan E. Supp. Ord.	2½	6 13 4	Mar., Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan., July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St.	99	5 1 0	Jan., July
..	6%	Newcastle & Dist. E.L. 6% 2nd Deb.	99½	6 0 6	Mar., Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 8	Mar., Sept
1	6%	North Metropolitan E.P. Supp. 6% Pref.	1⅝	6 3 10	Apl., Oct
4	5%	South London E.S. Ord.	2½	6 16 2	Mar., Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., Aug. 1	Rate per cent. Yielded. £ s. d.	Dividend Due.
		Electricity Supply—*cont.*			
5	8%	St. James' & Pall Mall Ord.	6 3/16†	6 9 4	Feb, Aug
5	7%	Do. do. Pref.	5 15/16†	6 0 5	Feb, Aug
St.	3½%	Do. do. Debs	74	4 14 6	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	74	6 1 7	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations	1¼	6 8 0	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6¼	5 12 0	Mar, Sept
5	4½%	Do. 4½ Cum. Pref.	4⅛	5 4 1	Jan, July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	84½	5 18 4	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	79½	7 10 11	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	74	5 8 1	..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	..
St.	4½%	Do. 4½% Pref.	81	5 11 1	Jan, July
St.	4%	Do. 4% Deb. St.	77½	5 3 3	Jan, July
St.	4%	City & S. London Deb.	74¼	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70¼†	7 1 4	Feb, Aug
10	11%	London Electric Ry. Ord.	2⅜†	5 5 3	Jan, July
St.	4%	Do. 4% Pref.	68¼†	5 16 9	Mar, Sept
St.	4%	Do. 4% Debs.	76⅛	5 4 9	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	25¼	3 19 8	Feb, Aug
St.	3½%	Do. 3½% Pref.	65⅜	5 7 0	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	59½	5 7 1	Feb, Aug
St.	3½%	Do. 3½% A Debs.	68⅝	5 1 8	Jan, July
St.	3½%	Do. 3½% Debs.	70	5 0 0	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18⅞	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	76	5 5 3	May, Nov
St.	4½%	Do. 4½ First Pref.	73†	6 3 3	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 7	Jan, July
St.	4%	Do. 4% Debs.	77	5 3 11	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	78	5 2 7	Jan, July
St.	4%	Do. 4% Guar. Stock	70†	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2 5/32	5 3 3	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅜	5 9 3	Mar
100	5%	Do. Prior Lien Debs.	92¼†	5 8 5	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12⅛	7 4 4	Aug, Feb
5	3 0	Do. 6% Cum. Pref.	5⅛†	5 14 3	Jan, July
1	6%	British L.M. Ericsson Mfg. Co. 6% Pref.	⅞	6 8 0	Mar, Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2½	6 0 0	April
100	6%	Do. 6% Prior Lien Debs.	101½	5 18 3	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	66½	6 0 4	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12¼	8 3 3	Jan, July
5	5%	Do. 5% Pref.	4⅛	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	June, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	27/32	7 2 3	Sept.
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	3/32	..	Feb, Aug
St.	4%	Do. 4% Deb.	60½	6 12 3	Jun, Dec
1	7½%	Elec. Construction Ord.	⅞	9 4 7	May
1	7%	Do. 7% Cum. Pref.	31/32	7 4 6	Jan, July
St.	4%	Do. 4% Debs.	71⅞	5 11 6	Jan, July
10	10%	General Electric Ord.	13⅛†	7 12 5	July
10	6%	Do. 6% Pref.	9 3/32	6 1 2	June, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	16	6 5 0	Feb, Aug
5	2 3	Do. 4½% Cum. Pref.	4⅛	5 9 1	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G.P. &c., Ord.	11⅛	8 8 6	Feb, Aug
10	5%	Do. Pref.	8	6 3 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	36⅝	6 4 3	Mar, July
100	4%	Do. 4% Debs.	95½	4 4 1	Jan, July
1	7½%	Vickers Ord.	1 5/32	4 1 4	May, Aug
1	6%	Do. 6% Pref.	31/32	5 3 3	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 4	June, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 2	June, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	41	10 1 2	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30 0	Anglo American 6% Pref. Ord.	102¾	5 17 0	Ft.My.Aug.N
St	14%	Do. Def. Ord.	23¼	6 17 1	Ft.My.Aug.N
St.	4%	Commercial Cable 4% Debs.	70¾	5 13 1	Ja.Ap.Jly.O
10	5%	Cuba Submarine Ord.	8¼	5 17 8	May, Nov
10	10%	Do. 10% Pref.	13¾	7 5 5	..
5	5 0	Direct Spanish 10% Pref.	7¼	6 13 4	..
10	4%	Direct United States	6 1/16	6 6 9	Ja.Ap.Jly.O
St.	8%	Eastern Tel. Co. Ord.	147¾	5 8 3	Ja.My.Jly.O
St.	3½%	Do. 3½% Pref.	68	5 2 11	Ja.My.Jly.O
St.	4%	Do. 4% Debs.	79	5 1 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	79†	5 1 3	Feb, Aug
10	8%	Do. Ord.	14⅜	5 8 0	Ja.Ap.Jly.O
10	22%	Gt. Northern Tel. Co. With Coup. 11	37½	5 16 7	Ja.My.Jly
25	13%	Indo-European	48⅜	6 19 6	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3¼	3 4 0	April
1	7%	Do. 7% Pref.	2 5/32	2 12 8	July
10	1%	West India & Panama Ord.	1 1/16	9 4 8	May, Nov
10	6%	Do. 1st Pref.	7⅛	7 12 5	May, Nov
10	8%	Western Telegh. Co.	14⅜	5 7 7	Mr.Jly.O.Dec
St.	4%	Do. 4% Deb. St.	77	5 3 11	June, Dec
..	4½%	Western Union 50-yr. Bds.	99¼	4 10 10	May, Nov
		Telephones.			
1	7 1	Mexico Valley Teleph. Ord.	1⅜	7 13 7	Nov
1	10%	Oriental Telephone Ord.	2⅜	4 18 6	Apl, Oct
St	4%	Do. Deb. St.	79½	5 0 11	Jan, July
St	4½%	Telegh. Const. Egypt Db. St.	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅜	5 19 8	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅜	5 6 8	Jan, July
St	4½%	Do. Deb. St.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12⅜	4 14 7	Sp.De.Mr.Jn
10	6%	Do. 6% Pref.	10⅛	5 10 4	Sp.De.Mr.Jn
100	8%	Marconi Company Common	85½	5 17 6	Ja.Apl.Jly.O
	4%	Do. £100 Pref.	70½	5 13 6	Ja.Apl.Jly.O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, &c.			
5	3 0	Adelaide Elec. Supply 6% Pref.	4⅝	6 2 4	Mar, Sept
St	5%	Do. 5% Debs.	94½	5 5 10	Jun, Dec
10	0 0	Bombay E.S. & T. 6% Pref.	10½	5 14 3	..
St	4½%	Do. 4½% Debs.	83	5 8 5	Jan, July
5	9%	Calcutta E.S. Corp. Ord.	6½	7 0 1	May, Nov
5	5%	Do. 5% Pref.	4½	5 11 1	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,995. [No. 19. Vol. LXXVII.] FRIDAY, AUGUST 11, 1916. PRICE SIXPENCE (by post, 7d.).
Abroad 9d., or 20 cents, or 1fr., or 90pf.

CONTENTS OF THE CURRENT NUMBER.

NOTES 619
Arrangements for the Week. 622
Lifting Magnets. Illustrated 623
Long-Distance and Cable Telephony (Underground and Submarine). By B. S. Cohen and J. G. Hill. Illustrated 627
New Low-Resistance Standards. By C. V. Drysdale, D.Sc. Illustrated 629
Investigation and Testing of Metals 633
Iron Losses in Direct Current Machines. By B. G. Lamme. Illustrated 634
PHYSICAL METALLURGY AND OTHER PROBLEMS 636
Electrically Heated Furnaces for the Laboratory. By K. Arndt. Illustrated 637
Electrical Signalling with Bare Wires. Illustrated .. 638
Precautionary Measures to Adopt to Prolong the Life of Diesel Engine Crank-shafts. By P. H. Smith. Illustrated 642
CORRESPONDENCE 643
Electric Discharges in Sub-Stations (H. Erichsen).
Demountable Bodies for Electric Vehicles.
Physical Society 643
The "Electrician" Commercial and Industrial Section .. 645–652

NOTES.

The Employment of Women.

As staunch advocates of the utilisation to the full of all classes of labour, we welcome the employment of women in all spheres of industrial activity It is likely that the advent of women in engineering works will have a refining influence. But under certain conditions for a woman to work 12 hours a day, which in many cases means rising at 5.30 a.m. and retiring at 10.30 p.m., is an act of folly, and the employment of women under the conditions we have in mind is little short of criminal. Those in a position to know tell us that healthy male children are indispensable for our future welfare. Perhaps the subject is one of the many engaging the attention of the Government at the present time. If not, we venture to suggest that it may be more profitable in the long run for the State to pay some women to stay at home for a time.

Low-Resistance Standards.

IN the laboratory and test-room accurate low-resistance standards are an indispensable part of the equipment. Such standards are to the electrical engineer what the balance is to the chemist. Like many other things of vital importance to us in our industries prior to August, 1914, low-resistance standards and balances were, for the most part, made in Germany. On the outbreak of war, owing to lack of encouragement in the past, our instrument makers, although possessing the ability to manufacture such resistance standards, were unable to do so because the materials suitable for the purpose were likewise made in Germany, and therefore unobtainable. Elsewhere in this issue we publish an article by Dr. C. V. DRYSDALE on "New Low-resistance Standards," from which it appears that the difficulty as regards material has been overcome by the use of a resistance alloy known as "tarnac," which is shown to be identical with manganin, and which is of British manufacture. Although sufficient time has not yet elapsed for any thorough investigation of the new standards, from the results of observations extending over five months it seems that the rise is fairly uniform and about equal to that of the Wolff manganin standard. An instrument bearing Dr. DRYSDALE'S name needs no further recommendation, and his work extending over many years on the design and construction of standard resistances is so well known to many of our readers as to call for no comment. We would say, however, that in this, his most recent work, he has made a careful and searching examination of the Reichstanstalt form of standard in order to discover its defects, and has set to work to design a form of resistance standard which is free from the defects of the older pattern. Provided that we move slowly, in a similar manner our instrument makers, assisted by our scientists, and assuming they be given the necessary encouragement, will be able to secure a fair proportion of the trade in instruments of precision. It is with the greatest satisfaction we note that our manufacturers are now actually working with this object in view, as distinct from sitting on committees and engaged in considering what must be done.

Electric Signalling in Mines.

IN some of our mines a feature has been made of using bare wires for electric signalling, the advantage of the method being that a signal can be given from any point by merely bringing the wires together. A good deal of discussion has taken place in regard to this system as it is liable to give rise to sparks, which, in their turn, may cause an explosion in the presence of inflammable gas. From time to time we have published information and reports upon this subject, and in our present issue we give a further report by Dr. R. V. WHEELER, of the Home Office, and Prof. W. M. THORNTON. In this report there is a lot of useful information and an analysis of the principles underlying the working of electric bells. Part of the investigation is concerned with the limiting safe current that may be used with such bells. In this connection we should like to know just how the current was measured, as it is not obvious that an ammeter measurement of intermittent current would necessarily give a measure of the effectiveness of such a current on break to cause ignition. It should be mentioned, however, that the currents used were tested with explosive mixtures, apart from ammeter readings. The conclusion is reached that safety can be obtained by adopting certain well-known constructions, such as high resistance windings, parallel winding, copper sleeves, and shunt resistances. Nothing, however, is said in regard to the use of condensers, which seems an obvious method of getting rid of the trouble, but possibly there are objections to the use of capacity.

IT is stated that the above-mentioned systems with a limiting voltage of 25 volts can be made to insure safety if wet Leclanché cells are used for the battery, as the current is then kept below the danger limit. This does not seem to be a very satisfactory way of expressing the required conditions Wet

Leclanché cells of the porous pot type undoubtedly have comparatively high internal resistance, and therefore they will be effective in keeping down current. On the other hand, the tendency of Leclanché cells, at least, of well-known makers, is for the internal resistance to be made smaller and smaller, and if Leclanché cells are taken having sack elements the internal resistance is very small. We think it would be more satisfactory in stating conditions in such a case to base these upon the use of accumulators, whose internal resistance is negligible, and then to specify the amount of series resistance (if any) that is desirable with a given bell. Unfortunately, electric bells cannot be considered as being very standard pieces of apparatus, more particularly as their properties vary with their adjustment, and, therefore, conclusions can only be stated in very general terms; but, even so, the report by Messrs. Wheeler and Thornton should do a good deal to clear the ground and to put the subject on a proper basis.

Silly Posters and Silly Officials.

Were we in charge at the Ministry of Munitions we should make it our business to discover who was responsible for sending out the "No Holidays" posters to munition works. We do not presume to criticise the particular poster we have in mind as a work of art, beyond stating that from the acknowledgment it appears to have been a cartoon at one time in a halfpenny newspaper. What we do consider to be highly reprehensible is that the walls of our factories and munition works should be covered with posters of a kind which depress rather than cheer the highly overwrought men and women engaged in the manufacture of munitions. We hesitate to use our columns for the purpose of advertising the work of any individual, and we have little experience as salesmen, but it does seem to us that posters in which humorous incidents arising out of the war are depicted would act as a greater inducement to keep men at their work than do the harrowing and even revolting posters issued by the Ministry of Munitions. For this reason we think that the humorous sketches by Capt. Bruce Bairnsfather, such as the "Well, if you knows of a better 'ole, go to it" sketch, the "So Obvious" sketch, or "The Things that Matter" sketch would be more effective than was the awful cartoon actually sent out by the Ministry. Having found the individual responsible for the outrage on the feelings of decent men and women, we would make it impossible for him to issue further official posters.

Lifting Magnets.

On account of shortage of labour and of the necessity of rapid production it looks as though the lifting magnet is coming into its own at last. An article in this issue gives a good idea of the progress that has been made in recent years. In addition to descriptions of various magnets, other subjects of practical interest are discussed, and reference is made to an ingenious scrap-loading plant. A small works, where the arrangements are such that the unloading of 5 tons of steel costs no less than 12s., will be seen to be heavily handicapped in comparison with a large works, where the weight of material handled is sufficient to warrant the installation of a magnet-crane. In such a case the cost of handling may, and often does, not exceed one penny per ton. The record of costs given in the article is, if anything, on the high side, and recent improvements in magnet construction show even more economical results in working. Interest attaches to the several safety and loading devices, and to the crane crab provided with a magnet for lifting cold metal, and with graded tongs for the handling of hot metal. These are of Continental origin, and were described in these columns some years ago. They are included now so as to make the article tolerably complete. The operation of lifting magnets by means of contactor-type switches and master controllers, which we believe is the standard practice of one firm, shows that makers, and more particularly users, are alive to the many advantages of such control.

Will.—The value of the estate of the late Prof. Silvanus P. Thompson is put at £8,444.

Engineering Research.—The North-East Coast Institution of Engineers and Shipbuilders has appointed a "Research Committee," in order to carry out tests of apparatus having for their object the economical production of power by marine steam engines.

Coal Mine Illumination.—In a Paper before the Illuminating Engineering Society Mr. R. E. Simpson expresses the opinion that the storage battery electric lamp has many advantages over other systems of coal mine illumination. When equipped with a proper reflector a lamp of 1 c.p. will project a beam of light five to ten times as great through an angle of 120 deg. As its advantages become better known it may be expected to replace the other types now in use.

The British Science Guild.—The June issue and third number of the "Journal" of this society comprises the 10th annual report. It is notable that during the year its Executive Committe has, beside continuing discussion on the "Mobilisation of Science" (the original object of the Guild), referred a fuller consideration of the subject to its "Technical Education Committee," who appointed a "Special committee" for the purpose, and with which were amalgamated the "Science and the State Committee" and the "Special conference." The appendix comprises a Paper by Prof. R. A. Gregory on "The Promotion of Scientific Research and Higher Education." the sixth annual report of the Canadian branch of the Guild, an annual report of the Australian branch, and a report of the 10th annual meeting of the Guild held on May 17th last, during which the Right Hon. Andrew Fisher delivered an address on "The Establishment of a National Institute of Science and Industry in Australia."

Wireless Telegraphy on British Ships.—A new regulation has been made under the Defence of the Realm Act specifying that every British ship of 3,000 tons gross or upwards, in respect of which a licence to instal wireless telegraph apparatus has been granted by the Postmaster-General, and which puts to sea from a port in the United Kingdom after a date to be specified in such a licence, shall be provided with a wireless telegraph installation, and shall maintain a wireless telegraph service, and shall be provided with a certified operator, together with suitable accommodation for the apparatus and operator.

Application for such a licence for a ship registered in the United Kingdom is to be made on or before the 21st inst., and the Postmaster-General will, as and when wireless telegraph apparatus and the services of operators become available for the purpose, cause licences to be issued in respect of such ships as in the opinion of the Admiralty should in the national interests be fitted with such apparatus, and the licences shall specify the date as from which the carrying of such apparatus under this regulation is to be compulsory, the character of the apparatus and the qualifications of the operator. Failure to comply with the terms of the regulation may result in the seizure and detention of the ship.

Channel Tunnel.—Under the heading "Utilities of the Channel Tunnel." Prof. J. A. Fleming contributed to "The Times" of the 7th inst. a letter in which the valuable suggestion is made that one of the possible utilities of such a tunnel is the increased facility it would afford for direct telephonic communication between Great Britain, France, Switzerland and Italy. There are at present two English Channel telephone cables, each with twin circuits, which by phantomising can be made equivalent to three circuits each. As Prof. Fleming points out, if the Channel tunnel were constructed with proper provision for it, a large number of telephonic and telegraphic cables could be laid which would afford greatly increased means of intercommunication at a less cost than by equivalent submarine cables. If these were extended by suitable coil-loaded aerial lines, telephonic communication

could be established between the principal cities in Great Britain and those of France, and possibly of Italy. In view of this Prof. Fleming submits that, in any plans for such a tunnel, ample provision should be made for telephonic and telegraphic cables of the latest type for long-distance working.

Future of Coal Tar Products.—The "Colliery Guardian" refers to a Paper read by Mr. J. H. Canning before the Monmouthshire District Gas Association at Newport. Mr. Canning stated that the decay of the coal tar industry in England was due to the apathetic attitude of all classes towards science. Scientific teaching should be added to our too literary schemes of study. The Hoechst Chemical Works, in Germany, had 307 chemists, out of a staff of 9,046 in 1912. In 1906-10 no less than 561 German patents for synthetic dyes, against 30 English patents, had been filed. Germans had habitually filed patents calculated to put research workers off the correct lines, and to prevent British subjects making any use of the processes described. After the war we were likely to be faced with organised German efforts, besides other problems incidental to the war. The action of the Excise authorities in retarding the provision of industrial alcohol was another obstacle. Mr. Canning recommended a union of the gas industry with other industries.

Automatic Electric Hoists.—In the "Bulletin" of the American Institute of Mining Engineers, Mr. H. Kenyon Burch and Mr. M. A. Whiting describe an automatic electric hoist used for raising ore at the Inspiration Copper Mine, Arizona. The depth is 630 ft., ore raised 10,000 tons per day of 14 hours, with a maximum of 14,000 tons. Two vertical shafts have been sunk lined with concrete. The hoists are of the Nordberg type, each driven by a 580 H.P. direct-current shunt-wound motor at 575 volts and 264 revs. per min. Power is supplied by a 750 revs. per min, flywheel generator set, consisting of one 850 H.P. 2,300-volt 25-cycle induction motor, two 500 kw. 575-volt generators, one 20 kw. 125-volt exciter, and a 19,700 lb. 112 in. diameter steel plate flywheel. The two hoists are of the same design, with air-operated brakes and clutches, and the automatic control system is designed, so that the engines are of standard type. The skips are loaded underground by an automatic system. To start the lifts working automatically a master controller is used, and when this is thrown on to the running position automatic working is started. A control switch can also accelerate the working of the hoists, causing them to "overlap" if necessary.

Electric Discharge in a Transverse Magnetic Field.—There is a Paper in the "Philosophical Magazine," by Prof. D. N. Mallik, B.A., Sc.D., F.R.S.E., and Mr. A. B. Das, M.Sc., on this question. It had been shown in a previous Paper by Prof. Mallik that when the pressure inside the tube was equal to that of the atmosphere the discharge at first was of the nature of a shower of sparks; when the pressure is sufficiently low these combine into a thick stream; that only in this case is there rotation under magnetic influence as in the usual De la Rive apparatus. As the pressure is still further reduced the bands gradually change into a shower again and rotation ceases. The present Paper discusses in detail the behaviour of the discharge when the rotatory stage is passed. The phenomena depends on the primary voltage of the induction coil, nature of the coil, difference of potential between the electrodes of the discharge tube, their distance, pressure of gas in the tube, nature of gas in the tube and nature of the electrodes. These questions are examined mathematically, and curves are given showing the relations obtained under various assumptions. Owing to the fact that the potential is assumed to vary uniformly from cathode to anode and that the angular position of the stream and another function are assumed to be constant, which is not realised in practice, it is not surprising that the curves actually obtained are more complex than those deduced theoretically. It is the intention of the authors to discuss the experimental results as to their bearing on some of the conclusions arising from Prof. Sir J. J. Thomson's theory of conduction in gases.

Colour Vision.—A Paper on the "Theory of Colour Vision" was read recently by R. A. Houston, M.A., Ph.D., D.Sc., before the Royal Society. This theory may be regarded as a mathematical formulation of the views of Dr. Edridge-Green, but the author had worked quite independently, and was not aware of this until his own conclusions were definitely formed. The Young-Helmholtz theory explains the facts of colour mixing, but it is very doubtful as to whether we can from these facts deduce the existence of the three primary colour sensations. As is well known to electrical engineers in the familiar equation, $d^2x/dt^2+hdx/dt+n^2x=E\cos\omega t$, x represents the displacement of a typical vibrator, and in this case $E\cos\omega t$ is the force per unit mass exerted in it by the incident light wave. The solution consists of two parts, viz., the free vibration and the forced vibration. It is shown that instead of three primary sensations the reception of light by the eye can be represented broadly by one class of vibrators. In this way Ive's visibility curve is compared with a probability curve, and a good agreement between theory and observation is obtained. The vibrators in the eye are compared to the diaphragm in a telephone which reproduces a note, the vibrators in the eye acting similarly only imperfectly reproduce the light sensation. No matter how monochromatic the incident light wave, the wave transmitted by the optic nerve is not monochromatic. In reply to the question how does this theory explain the apparent trichromatism, we must fall back on the reason given by Dr. Edridge-Green, viz., that the brain is not sufficiently developed to discriminate between the character of adjacent curves. The fact that with monochromatic incident light the sensation becomes whiter as the intensity is increased supports his theory. This is explained by the fact that when the intensity increases the vibrators are more strongly damped, and hence the energy of the Fourier components of its motion are more widely distributed over the spectrum. The method of discussing the question is certainly strightforward, and will commend itself to the practical physicist.

OBITUARY.

Dr. CURTIS.—We regret to record the death of Dr. Charles William Curtis, principal medical officer of the Eastern Telegraph & Allied Companies, which took place at Ashford on the 6th inst.

KILLED IN ACTION.—The following deaths in action or of wounds are reported :—

Capt. John Henderson-Begg (Gordon Highlanders), who was killed in action on July 23, was 25 years of age. He was educated at the Robert Gordon College, Aberdeen, and the Royal Technical College, Glasgow, where he studied engineering.

Capt. F. R. Jessing (Border Regt.), who was killed on July 1, was 29 years of age and formerly in the service of the Eastern Telegraph Co.

Lieut. J. H. Palmer (Public Schools Batt. R.F.), who was killed in action on July 20, took his degree as an electrical engineer at Manchester and was for some years with Messrs. Connolly Bros., Manchester.

Sergt. A. Ross (Public Schools Batt. R.F.) went through the electrical engineering course at Manchester School of Technology and obtained the degree of B.Sc.(Tech.) in 1914.

Private Julius Gregory (Public Schools Batt. R.F.), who was killed in action on July 20, had served an apprenticeship as an electrical engineer.

Lieut. D. S. Baker (R.E.), aged 26, who has died of wounds, was a former engineering student of the City and Guilds Central Technical College, and a B.Sc. of McGill University, Montreal. Prior to taking up his commission he was engaged with Messrs. Vickers (Ltd.).

Lieut. F. L. Cassels (R.E.), who has been killed, was 33 years of age and a son of Mr. W. R. Cassels, of Buenos Ayres and London. He was an engineer by profession.

Second-Lieut. Michael Hill (R.E.), who was killed on July 19, gained the D.C.M. at the age of 18 for bravery and devotion to duty in laying and repairing telephone wires under fire from December, 1914, to March, 1915, inclusive.

Lieut. Arthur Poynting (Machine Gun Corps), killed in action on July 25, was the only son of the late Prof. Poynting, of the University of Birmingham.

Lieut. Stuart M. Rawson (R.F.), who was killed on July 20, was 24 years of age, had taken a diploma at the Central Technical College, South Kensington.

Second-Lieut. Chas. S. Reed (Leicester Regt.), killed in action was for some years engaged in Sir Oliver Lodge's laboratory at Birmingham University. He was 28 years of age.

Second-Lieut. R. S. Robertson (K.O.S.B.), who has died of wounds, was 22 years of age, was an engineering student at Glasgow University, where he took his B.Sc. degree, and an associate of the Royal Technical College, Glasgow.

Capt. C. S. Wolstenholme (Durham L.I.), aged 43, who was killed in action on July 17, was assistant superintendent engineer in the telephone department of Leeds Post Office before the war.

Lieut. F. H. Talbot (Sherwood Foresters), who has been killed in action, was 23 years of age, and was a son of the City Electrical Engineer of Nottingham.

Lieut. Thos. Challoner (R. E.), who died of wounds on July 25, received the Military Cross for services in the present war. He was an electrical engineer of Cardiff.

Sapper J. H. L. Callaway (R.E.), whose death is reported, was in the engineering department of the Post Office Telephone Department and lived at Balsall Heath prior to the war.

PERSONAL.

The directors of the St. James's & Pall Mall Electric Light Co. have appointed Sir Alex. B. W. Kennedy chief engineer in the place of the late Mr. S. T. Dobson.

Lieut. Dan Hughes (Gordon Highlanders), who is reported wounded and missing, was assistant electrical engineer at Llandudno electricity works until he enlisted in the early days of the war.

Mr. W. C. Harmer, a student in the electrical engineering department at the Brighton Technical College, has obtained a First Honours in the recent B.Sc. Eng. (Lond.) examination.

Mr. Thomas Bowen, electrical engineer to Llandilo Urban Council, has tendered his resignation.

APPOINTMENTS VACANT AND FILLED.

An electrician, ineligible, is required for a seaside hotel. Applications to the Manager, South Eastern Hotel, Deal. *See advertisement.*

The local education authority invite applications for the position of principal of the Barrow Technical School. Candidates must be qualified in engineering subjects. Salary £400. Particulars from the Director of Education, Town Hall, Barrow-in-Furness, to whom applications by Sept. 2.

A headmaster with science degree is required for Soham Grammar School. Salary about £300. Applications to Education Secretary, County Hall, Cambridge.

Portsmouth Education Committee invite applications for the position of head of the mechanical and civil engineering department at the Municipal College. Salary £225, rising to £250. Applications to the Secretary by Aug. 23.

Barking Town Urban Council require a station superintendent. Applications to Chairman of Electricity & Tramways Committee, Public Offices, Barking, by Aug. 15.

The Royal Flying Corps requires 300 men, from 19 and 22 years of age, to train as wireless telegraphists. Applications to be made personally to the Director of Education, the Polytechnic, 309, Regent-street, London, W.

An electrician is required for the Gold Coast Government Waterworks. Salary £300, rising to £350, per annum, with free quarters. Applications to the Crown Agents for the Colonies, 4, Millbank, London, S.W.

Mr. R. B. Leach, borough electrical engineer and tramways manager of Heywood, has been appointed borough electrical engineer of Loughborough, in succession to Mr. W. H. Allen, at £300 per annum.

Mr. S. H. Fowles, of Aylesbury, has been appointed resident electrical engineer at Leek.

INSTITUTIONS AND SOCIETIES.

Municipal Tramways Association.—The programme for the annual meeting of the Municipal Tramways Association, to be held at the Surveyors' Institution, Westminster, on Sept. 21 and 22 next, has now been issued. Following a meeting of the Executive Council, the conference will open at 11 o'clock on the Thursday morning, when Mr. Peter Fisher, general manager of the Dundee Corporation tramways undertaking, will deliver his presidential address. This will be followed by a Paper entitled "Some Notes on Passenger Transportation in Large Cities," by Mr. J. M. McElroy, general manager of the Manchester Corporation tramways; and after lunch a joint Paper on "Utilisation of Tramways for Goods Traffic," by Messrs. G. W. Holford, general manager of the Salford Corporation tramways, and W. Clough, general manager of the Bury Corporation tramways, will be discussed. On Friday morning there will be another meeting of the Executive Council, and also a meeting of the Managers' Section, after which the annual business meeting of the association will be held. It has been decided that no social functions shall take place, and therefore no arrangements have been made for the usual association dinner or excursion.

The Electric Vehicle Committee.—A meeting of the Electric Vehicle Committee was held in London on July 28, 1916, Mr. R. A. Chattock presiding. It was announced that the Royal Automobile Club had nominated as their representative upon the Committee Mr. W. Worby Beaumont. With reference to the correspondence that had taken place between the B.O.T. and the Electric Vehicle Committee on "Import Restrictions," it was decided, as a request had been received from one technical paper, that a copy of the correspondence should be sent to each technical journal. [The result of this correspondence does not appear to be very conclusive.] Consideration was again given to insurance policies for electric vehicles. Correspondence with the Car & General Insurance Corpn. (Ltd.) was submitted, from which it appeared that the corporation were willing to come into line with the suggestions previously made by the Committee that their standard electric vehicle policy should be altered so as to include the risk on the battery while the vehicle is in transit by road, rail or ship. Subject to this alteration, the Committee considered that the Car & General Insurance Co.'s policy met every reasonable requirement, and they decided to give their approval to it. Arising out of correspondence that the secretary had had with the Clerk to the Urban District Council at Rugby in the matter of providing charging facilities for electric vehicles, the Secretary was directed to write and say that the Committee regretted the Council's decision not to provide such facilities at the present time. It should be noted that the British Thomson-Houston Co. are prepared, when their own arrangements admit and at times convenient to themselves, to charge electric vehicles passing through Rugby.

North-East Coast Institution of Engineers and Shipbuilders.—The importance of industrial research is becoming more and more recognised by our technical societies. As evidence of this fact it is interesting to note that the North-East Coast Institution of Engineers and Shipbuilders has recently appointed a Research Committee, and that the latter has already made a start with its work by acceding to the request of a well-known firm in the north to investigate and carry out exhaustive tests of apparatus having for its object the more economical production of power by marine steam engines. By its action it will be the first of the influential technical institutions actively to promote the progress of the industries with which its members are associated by officially making and recording tests of new apparatus developed by them, though this course has been followed for many years by the Royal Automobile Club. In the introduction and development of improved apparatus much depends on an authoritative pronouncement concerning the results claimed, and this can best be secured through the verdict of independent bodies who are not influenced by commercial considerations. Through such tests an ever increasing mass of important data would be accumulated, representing the collective knowledge of each industry, and from the publication of this data would result the incidental but highly important effect that much overlapping of experimental work would be avoided.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for August.

Headquarters and Range.—The headquarters will be closed during August, except on Tuesday evenings. The range will be open on Thursday evenings only. On these evenings the Sergeant-Major will take charge and be responsible for the maintenance of order and discipline. Recruits are urged to take advantage of this arrangement for drill and shooting.

Instruction Classes.—Instruction classes at Regency-street will be held as usual for Platoons Nos. 9 and 10.

Camp.—The camp at Otford will be available until Aug. 31. Members wishing to attend should enter their names at headquarters on the sheet provided for the purpose. The cost will be about 3s. per day. Members should provide themselves with two blankets, knife, fork spoon, plate, mug and a spare pair of boots.

Entrenching.—As many members as possible should endeavour to attend the Sunday entrenching parades, in order that the work to be done may be completed as expeditiously as possible. Parade in uniform as usual at Victoria Station (S.E. & C. Railway) Booking Office, 8.45 a.m. Members are reminded that this work is of national importance, and therefore all who are able to put in Saturdays or occasional week days are urged to do so. They are reminded that they can obtain railway vouchers from the booking clerk by showing their cap badges.

LIFTING MAGNETS.

Summary.—In this article detailed particulars of operating costs and performance of lifting magnets are given. These are followed by descriptions of various types of lifting magnets. Method of control and connection are next dealt with, and several safety devices of Continental origin are described. Illustrations are given of a crab provided with magnet and tongs for handling cold and hot ingots, and in conclusion reference is made to a magnet scrap-loading plant.

Lifting magnets may be regarded as the most valuable adjunct to an appliance intended for the handling of large quantities of magnetic material. Experience shows that such magnets, when made by firms of repute, are at least as reliable as lifting by means of slings, and at the same time promote rapid and economical handling of material. The more awkward the load the greater is the economy. Thus, in a certain works the installation of a scrap-handling magnet-crane enabled the owners to dispense with the services of 13 labourers. At 25s. per week per man this represents £845 per annum, and after deducting working expenses, interest, depreciation and maintenance charges a sum remains which is sufficiently large to pay for the equipment in a few years.

Operating Costs.—The following data give the operating costs of a 52-in. "Igranic" magnet worked under adverse conditions, the material being covered with snow and ice. The travel of the crane

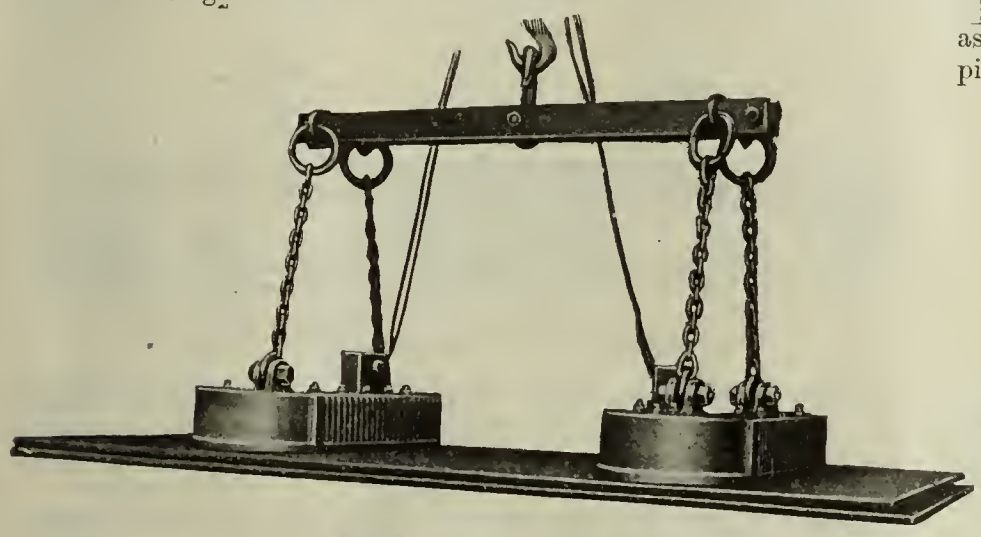


Fig. 1.—Two Magnets and Hanger Bar.

varied from nothing to 25 ft., the traverse was 15 ft. and the lift about 15 ft. Material was unloaded from railway trucks into charging boxes, and was trimmed by two stockers, except in the case of pig-iron, when only one stocker was required.

Handling Light Angles, Beams and Rail Scrap about 3 ft. to 5 ft. long.

Total weight handled	66,700 lb.
Weight per lift	1,058 lb.
Lifts per hour	122
Weight per hour	54·8 tons

Handling 6 in. by 6 in. by 3 in. Blowing mill Crop Ends, Snow-covered and Frozen.

Total weight handled	56,600 lb.
Weight per lift	1,530 lb.
Lifts per hour	106
Weight per hour	75·8 tons

Handling Pig-iron, Snow-covered and Frozen.

Total weight handled	26,200 lb.
Weight per lift	1,091 lb.
Lifts per hour	120
Weight per hour	56·5 tons

On the assumption that the crane ran 50 per cent. of the time only, the owners gave the costs set out below:—

Magnet interest at 5 per cent.	£12	10	0
Magnet depreciation at 10 per cent.	25	0	0
Electric energy for magnet	24	6	0
Crane interest at 6 per cent.	37	10	0
Repairs	329	7	6
Electric energy for crane	37	10	0
Two cranemen	360	0	0
Four stockers	750	0	0
Total	£1,576	3	6

The cost per ton, therefore, of handling the material is: Light scrap, 1·57d.; heavy scrap, 1·14d.; and pig iron, 1·53d. This includes labour for trimming the charging boxes.

Rough figures obtained subsequently showed that the loading of pig-iron from a pile into charging boxes could be carried out at a cost somewhat less than 1d. per ton, covering all the irregularities and disadvantageous conditions that might arise.

In analysing the above figures it should be noted that the costs refer to American practice, and that almost one-half of the total cost is contained in the item covering stockers' wages. The makers point out that the cost of unloading pig-iron, which used to be contract work at 4d. per ton, would therefore be in the neighbourhood of 0·5d. per ton. Wages in the United States are greater than in this country, and the amount for repairs is higher than one would allow for a small crane working under the conditions ruling at home. A factor of greater importance than the reduction of operating costs is the elimination of unskilled labour.

It is reported by the Inland Steel Co. that a cargo of 1,960 tons of pig-iron was unloaded in 10½ hours by means of two 62-in. magnets and two men, the average lift per magnet being 1·53 tons. Formerly it took two days and two nights to clear such a load, and 28 men were required for the work. The unloading of 55 tons of pig-iron in half-an-hour by a 52-in. magnet, with an average load per lift of about 0·84 tons, is another creditable record.*

Rating.—The lifting capacity of a magnet depends entirely on the materials which it has to handle, particularly, however, on the following: (*a*) The magnetic quality of the load; (*b*) the temperature of the material, which should not be above black heat; (*c*) the shape of the load and whether it consists of one solid piece or a number of small parts; and (*d*) the manner in which the material to be lifted is stacked.

Although the lifting capacity cannot be calculated, it may be assumed that a well-designed magnet is capable of lifting a solid piece of steel, with machined surface, of not less diameter than the

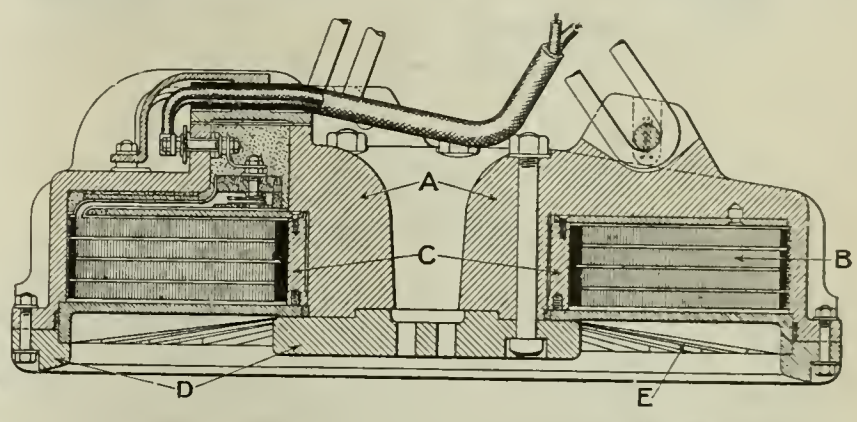


Fig. 2.—Section of "Igranic" Lifting Magnet.

magnet itself, weighing approximately 15 times the weight of small magnets, 8 to 12 times the weight of magnets from 2 ft. to 3 ft. in diameter, and 5 to 6 times the weight of magnets from 3 ft. to 5 ft. diameter.

When dealing with materials such as sand-cast pig-iron or heavy scrap, the lifting capacity decreases considerably, depending entirely on the amount of material covered by the contact surface of the magnet. The larger the contact surface, the greater the load attracted. With magnets of large diameter, in addition to the first layer, further material is in some instances attracted by the centre pole. When the load consists of iron plates the load depends on the size of the plates, but up to six layers can be lifted according to the thickness and weight of each plate and the type of magnet. The weight of loose materials, such as stampings and drop forgings, attracted by a magnet varies greatly, and is relatively small, in some cases only reaching up to about one-half the weight of the magnet.

In order to increase the weight of material handled per lift, a battery of two or more magnets may be used, as shown in Fig. 1. In such cases the magnets are so suspended from a common bar or frame as to obtain the best results. This arrangement is advisable when handling long pieces or sheets, as the overhang tends to pull the load away from a single large magnet.

Construction.—Lifting magnets are only constructed for direct-current, and when the supply is alternating-current it is necessary to have a motor-generator set or other source from which direct-current can be obtained. The supply pressure should not exceed 220 volts.

In common with most of the electric equipment of cranes, the construction of lifting magnets is work for specialist firms, and users cannot do better than specify magnets by such firms. We shall here briefly describe three typical magnets.

"Igranic" Lifting Magnet.—A section of this magnet is depicted in Fig. 2. The body or frame A, made of magnet cast-steel, is provided with heavy lugs cast integral with it for the suspension

* Recent improvements in the design of these lifting magnets have increased the lifting capacities from 20 per cent. for some sizes up to 60 per cent. for others, without increasing their weight. Correspondingly better results are, therefore, to be expected.

chains, and the terminal box is likewise part of the casting. Both the inner and outer pole-shoes D are strong steel castings, and are secured to the frame by through bolts. The coil-shield E is a flanged disc of manganese-steel, ribbed on the under side as shown.

Copper strip is used for the coil winding. The spool C is of steel, and forms part of the inner pole. A tight joint between spool and magnet body is obtained in order to eliminate all dead air spaces and to facilitate rapid radiation of heat. The coil is clamped tightly between the body and coil-shield. To ensure the rapid transference of the heat to the outside of the magnet body, dead-air heat-insulating spaces are eliminated, and the number of joints is reduced to a minimum. Sheet-mica is used for insulation between the various layers of the coil and for insulating the upper and lower faces of the coil from the magnet body and shield. After assembly the coil and the whole interior of the magnet are filled under vacuum with water-

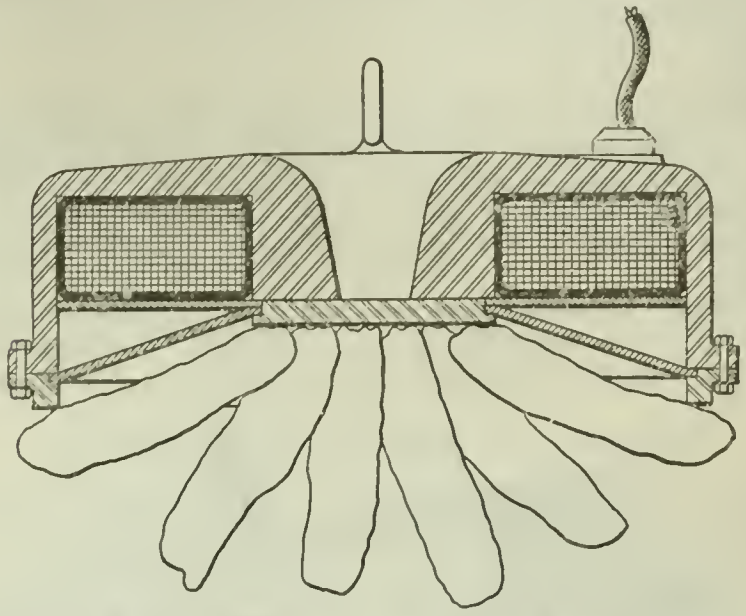


Fig. 3.—"Witton-Kramer" Pig-Magnet.

proof insulating compound. This not only prevents access of moisture to the coil from outside, but it also eliminates internal sweating, to which breakdowns can often be traced. A principle followed by the makers is that every magnet must be capable of withstanding submersion without sustaining damage, and, as an indication of the permanency of the insulation, it is claimed that no magnet supplied since 1909 has developed an earth or short-circuit in its windings.

It is essential that the terminals of a lifting magnet be so protected as to be able to withstand rough usage, and that they shall be absolutely watertight. The terminal block construction is shown in Fig. 2. The leads from the magnet coil are brought up into the heavy cast-steel terminal box set between two flanges, which form part of the magnet-frame casting. In this box the connection is made by means of flexible leads to the terminal studs which emerge from the side of the box. Connection is here made to the lead wires brought down through armoured hose which is clamped to the magnet body by a heavy casting formed as a protective hood covering the terminal studs.

Particulars as to sizes and ratings of these magnets are set out in Table I.

"*Witton-Kramer*" *Lifting Magnets.*—A magnet for handling pig-iron is shown in Fig. 3. Magnet cast-steel is used for the body and the former-wound coil is mummified and heavily insulated from the body by means of mica.

The constants of the standard lifting magnets are given in Table II.:

"*Phœnix*" *Lifting Magnets.*—These were developed by Messrs. Steel, Peech & Tozer for use in their own works, and embody all the improvements that have been suggested to the manufacturers in consequence of their experience with the use of these magnets under actual working conditions.

The sectional drawing, Fig. 4, shows the design of the latest type. The casing A, C and poles N, S are made from high permeability cast-steel. Between the central block or pole and the outer wall an intermediate annular wall, D, is provided which divides the wiring space into two compartments, E and F, one coil being round the central block and the other round the annular piece. This simple improvement extends the area of the pole and materially increases the lifting capacity of the magnet. The impregnated coils are wound on brass formers to ensure the windings being kept rigid, as there is a

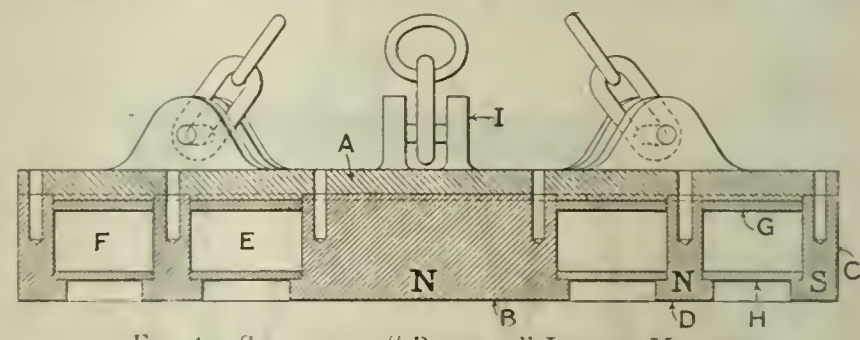


Fig. 4.—Section of "Phœnix" Lifting Magnet.

tendency for the turns to move slightly on switching the current on and off. Such movement would in time break down the insulation. Hard phosphor-bronze bumping plates H protect the coils from injury.

Table III. gives the sizes of the circular type magnets with approximate ratings under favourable conditions.

Method of Control.—Since a circuit containing an electromagnet is highly inductive, in order to prevent the insulation from breaking down provision must be made on switching-off for guarding against the induced voltage and for dissipating the energy stored in the magnetic field. The common method is to shunt a discharge resistance across the magnet terminals prior to the opening of the circuit and to disconnect the resistance before switching-on.

One form of controller made by the "Igranic" Co. is of the drum type, and is fitted with a magnetic blow-out. It has three positions—on, off and reverse. In the off position the magnet coils are discon-

Table I.—*Dimensions, Current Consumption and Ratings of "Igranic" Lifting Magnets.*

Magnet size	Net weight	Current required at 220 volts	Approximate lifting capacity	Dimensions, three-point chain suspension.		Adaptation.
				Head-room	Outside dia. of magnet	
in.	lbs.	amps.	lbs.*	in.	in.	
18	350	2·5	...	12	19½	Handling light finished parts, also light iron or steel castings. A pair of these magnets will handle economically pipe up to 2 in. diameter.
24	750	7·5	...	23	24	Similar to the 18 in. Can also handle skull-cracker balls up to 8,000 lb.
36	1,800	26	1,000 to 1,400	42	36	For general service in handling pig-iron, scrap, &c., where a large capacity is not required. Sometimes used with loco. cranes.
43	3,300	35	1,500 to 1,800	45	43¾	Primarily designed for use with loco. cranes. Handles a fair average load and yet is not a heavy magnet, and does not take so much energy as to cause an undue drain on the crane boiler, which must supply the magnet engine generator set.
52	5,200	50	2,700 to 2,800	50	52	For general work. Used extensively in open-hearth steel plants for handling stock.
62	7,500	72	4,000 to 4,500	56	62½	Used where a large tonnage must be handled. Designed as the largest magnet which can be used satisfactorily with a 5-ton crane.

* The lifting capacity ratings are conservative averages based on handling pig-iron, bloom and axle butts, crop ends of rails and billets, miscellaneous scrap and similar material. With large single pieces, such as castings and skull-cracker balls, the lifting capacity is many times greater becoming, for example, 60,000 lb. in the case of the 62 in. magnet.

Table II.—*Properties of "Witton-Kramer" Lifting Magnets.*

Diameter of magnet .	15 in.	18 in.	24 in.	36 in.	42 in.	48 in.	60 in.
Approximate rating in tons (based on favourable conditions when lifting).							
Single solid steel ingots, or heavy armour plate	1	2	4	6	7	8	10
Steel plates	0·3 –0·4	0·4 –0·5	0·6 –0·9	1·0–1·5	1·25–1·75	1·75–2·25	2·5 –3·0
Shafting, bars, billets, rails and girders ...	0·25–0·5	0·5 –0·75	0·75–1·0	1·0–1·25	1·25–1·5	1·5 –2·0	2·0 –2·5
Pig-iron.....	0·05–0·1	0·1 –0·15	0·25–0·3	0·3–0·4	0·4 –0·45	0·5 –0·75	0·75–1·0
Cast-iron scrap.....	0·05–0·1	0·15–0·2	0·25–0·4	0·4–0·6	0·6 –0·75	0·75–1·0	1·0 –1·5
Sheet iron stampings, small forgings, turnings and the like ...	0·03–0·05	0·05–0·1	0·15–0·25	0·3–0·4	0·4 –0·75	0·6 –0·75	0·75–1·25
Approx. weight, tons.	0·125	0·188	0·325	0·9	1·4	2·0	3·4
Approx. energy input, kw.	0·8	1·5	2·0	4·0	5·0	6·0	8·0

Table III.—*Properties of "Phœnix" Lifting Magnets.*
Approximate rating, in tons (based on favourable conditions when lifting).

Diameter of magnet	30 in.	36 in.	48 in.	52 in.
Single solid steel ingots, or heavy armour plate.	5·5	8	11	15
Steel plates and tin plate bars	1·0 –1·5	1·5–2·0	2·0 –2·5	2·5–3·0
Shafting, bars, billets, rails and girders.....	1·5 –2·0	2·0–2·5	2·5 –3·0	4·0–5·0
Pig-iron.....	0·3 –0·4	0·6–0·75	0·75–1·0	1·0–1·5
Scrap-iron (broken castings) or heavy steel scrap	1·0 –1·5	1·0–3·0	1·0 –4·0	1·0–6·0
Scrap sheet-iron, scrap stampings, small forgings, bolts, heavy turnings, filings and the like	0·25–0·5	0·4–0·6	0·5 –0·8	0·5–1·25
Approx. weight, tons.....	0·325	0·75	1·3	2·5
Current consumption, in units per hour, allowing for 60 lifts each of 1 minute duration	1·5	2·0	4·0	7·0

nected from the supply and the non-inductive discharge resistance is shunted across its terminals as described above. When the controller handle is placed in the working position the magnet winding is

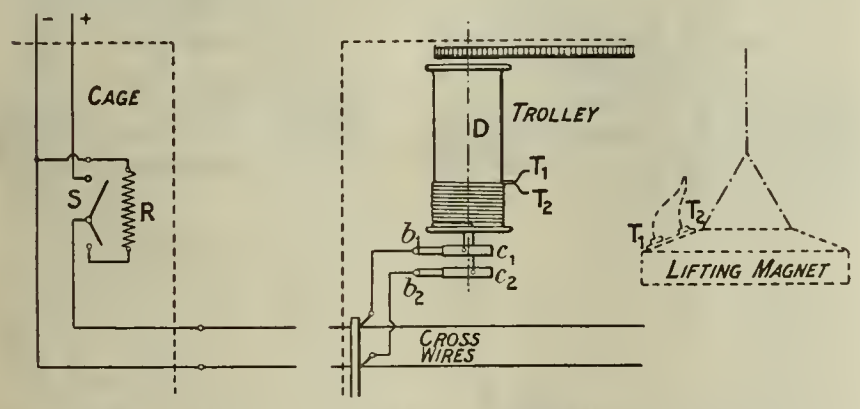


Fig. 5.—Wiring Diagram for Lifting Magnet Circuit.

connected direct to the supply, and in turning the handle to the reverse position a small current flows through the winding in the reverse direction in order to make the magnet lose its residual magnetism and quickly release the load. The handle can only remain in this reverse position as long as the operator holds it there, and when he releases the handle it automatically returns to the off position.

The most recent practice of the "Igranic" Co. is to use contactor type controllers for magnets of 32 in. diameter and larger.

It takes time for the magnetic flux to die down after the magnetising force has been removed, and this is made use of when plates are being handled. A number of plates may be lifted at one time, and dropped singly in any place desired simply by opening and closing the control switch. Resistances inserted in the circuit bring about the same result.

Current is supplied to the magnet through a suitably protected plug connection, and the plug is pulled out when it is desired to detach the magnet from the crane hook. A "tell-tale" or, preferably, a magnetic lock of some kind should be fitted to the plug so as to make it impossible to remove the latter while current is passing. The cable should be permanently secured to the hook-block.

Connection.—In one method a spring drum is fitted on the crane trolley for automatically coiling and uncoiling the flexible cable through which the current is transmitted to the magnet.

Some users prefer to drive the cable drum from the main drum. Such an arrangement is depicted in Fig 5. The drum D, geared to one of the shafts of the lifting mechanism and provided with two collector rings, c_1, c_2 is mounted on the trolley. The brushes b_1, b_2 are connected to two cross-wires, and it is desirable to connect these wires on the live side of the main circuit-breaker or fuses.

In some cases the flexible cable is coiled upon a motor-driven drum in which the series-wound motor is made to exert a pre-determined torque just sufficient to keep the cable taut at all times.

A further arrangement is to use a counter-weight. The method is depicted in Figs. 6 and 7. From Fig. 7 it will be seen that the twin conductor cable is passed over a sheave attached to the trolley and carried along the bridge over a set of sheaves in the operator's cage, the free end being finally taken to the control switch.

Safety Devices.—In certain cases it is advisable to provide safety tongs which close under the load at the end of the lift. With the arrangement depicted in Fig. 8 when the tongs are opened the magnet raises the material and the tongs then close under the magnet, thus preventing any of the material being accidentally dropped,

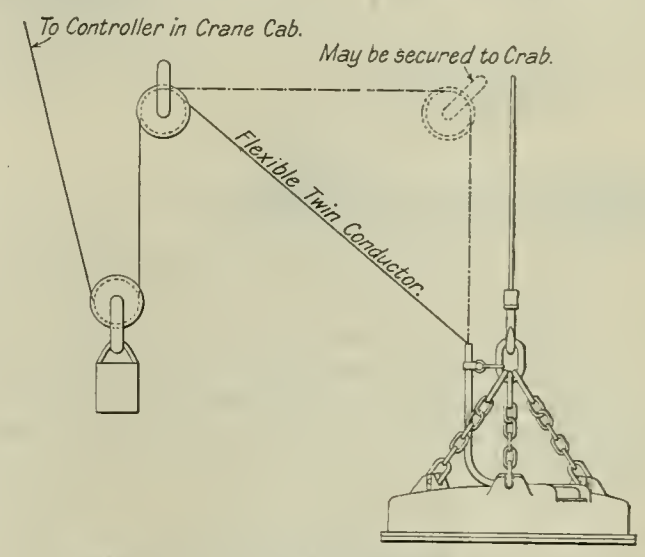


Fig. 6.—Method of Taking Charge of Slack Cable.

even in the event of interrruption of the current supply. It is evident that the tongs may be of such a form as to support the load, and under these conditions the magnet is required only for lifting purposes.

Large lifting magnets, apart from their great cost, are of considerable size and weight. This impairs the efficiency of the lifting mechanism. The appliance shown in Fig. 9 has been used in order to work a crane at its full capacity, and at the same time employ a comparatively small lifting magnet. To unload, the tongs are tilted by means of the second rope which winds on to the auxiliary drum.

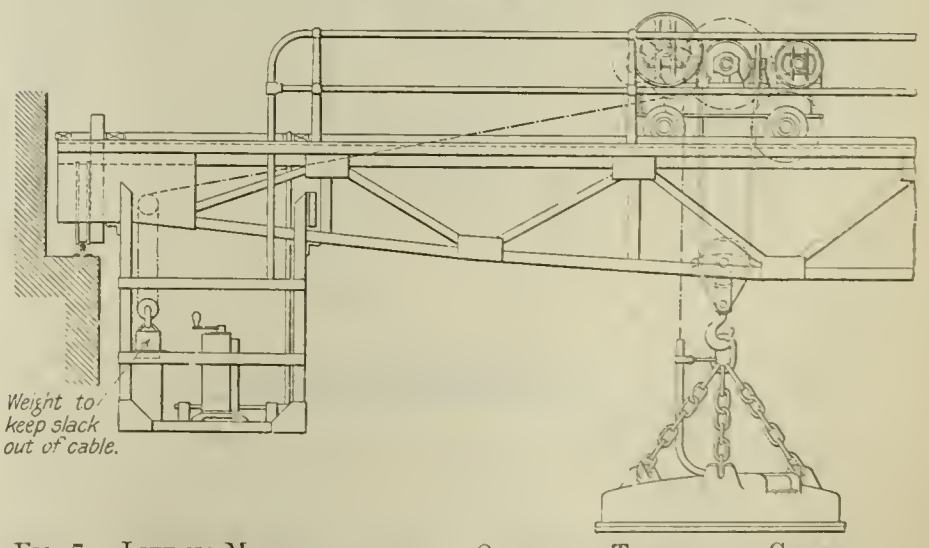


Fig. 7.—Lifting Magnet applied to Overhead Travelling Crane.

Handling Hot and Cold Metal.—Apart from the fact that high working temperatures destroy the windings of lifting magnets, it is well-known that the lifting capacity of a magnet depends upon the temperature of the material that is being lifted. Up to 300°C. the lifting capacity is practically constant, but as the temperature increases the capacity diminishes rapidly, until, at a temperature of

about 700°C., the effective pull is zero. For handling either hot or cold ingots use has been made of the arrangement depicted in Fig. 10.

Referring to the drawing it will be seen that the lifting motor drives a shaft fitted with rope drums and a check drum, which is half the diameter of the rope drums. Two lifting ropes, reeved double, support the load, and in the loops are suspended the sheaves which carry the cross-beam. The lifting magnet is controlled in the manner described above.

The two arms of the tongs are pivoted on the parallel plates which form the steering beams and the claw-shaped jaws are provided with two pairs of hardened steel points, arranged step fashion, to enable ingots of different lengths to be gripped. The upper straight arms of the tongs rest on friction-rollers, supported in the cross-beam. One

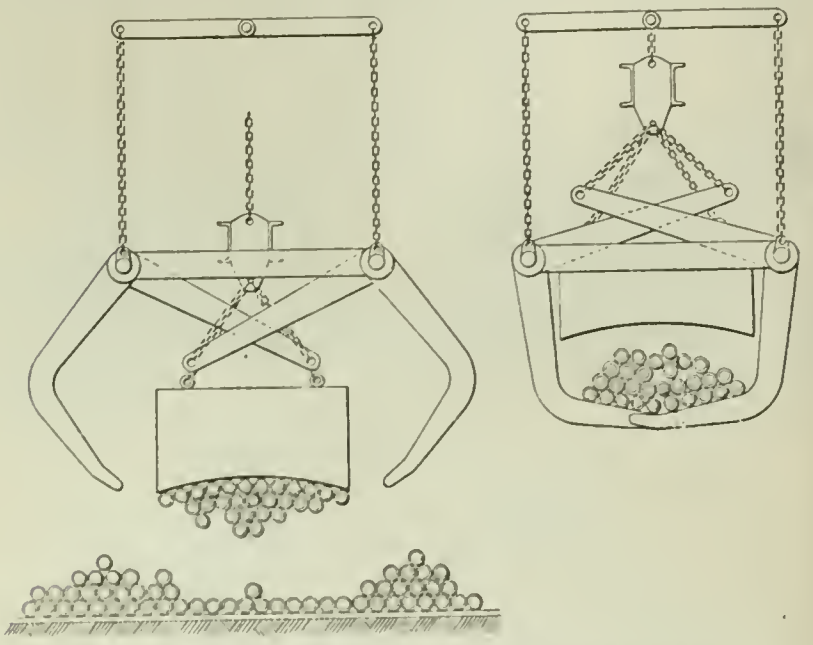


Fig. 8.—Lifting Magnet with Tong Attachment.

end of the double steering-rope is passed over a sheave to the check drum, and is kept taut by a weight. The other end of the rope is fixed. A hand rope from the cab enables the operator to move the steering-rope sheave downwards, and by so doing the beam is lowered to double the extent.

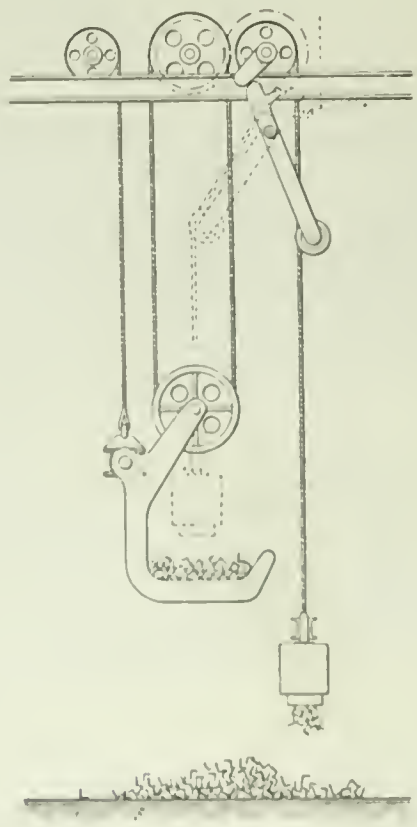


Fig. 9.—Small Magnet for Loading, together with Tilting Device for Unloading.

In order to grip an ingot by means of the tongs, the magnet is removed without changing the relative position of the cross-beam and steering beam, and the tongs are lowered until the projections on the jaws rest upon the ingot. Raising the cross-beam and simultaneously lowering the steering beam makes the gripping points approach each other, until they seize the ingot, and hold it with a force that increases with the weight of the ingot.

Magnet Scrap-loading Plant.—A typical arrangement of the "Phœnix" scrap loading plant is illustrated in Fig. 11. The object of the plant is to transfer scrap metal from railway trucks to steel furnaces in the most expeditious manner and at minimum cost. In the arrangement shown, an overhead travelling crane is fitted with a lifting magnet which unloads the scrap from trucks and drops it down

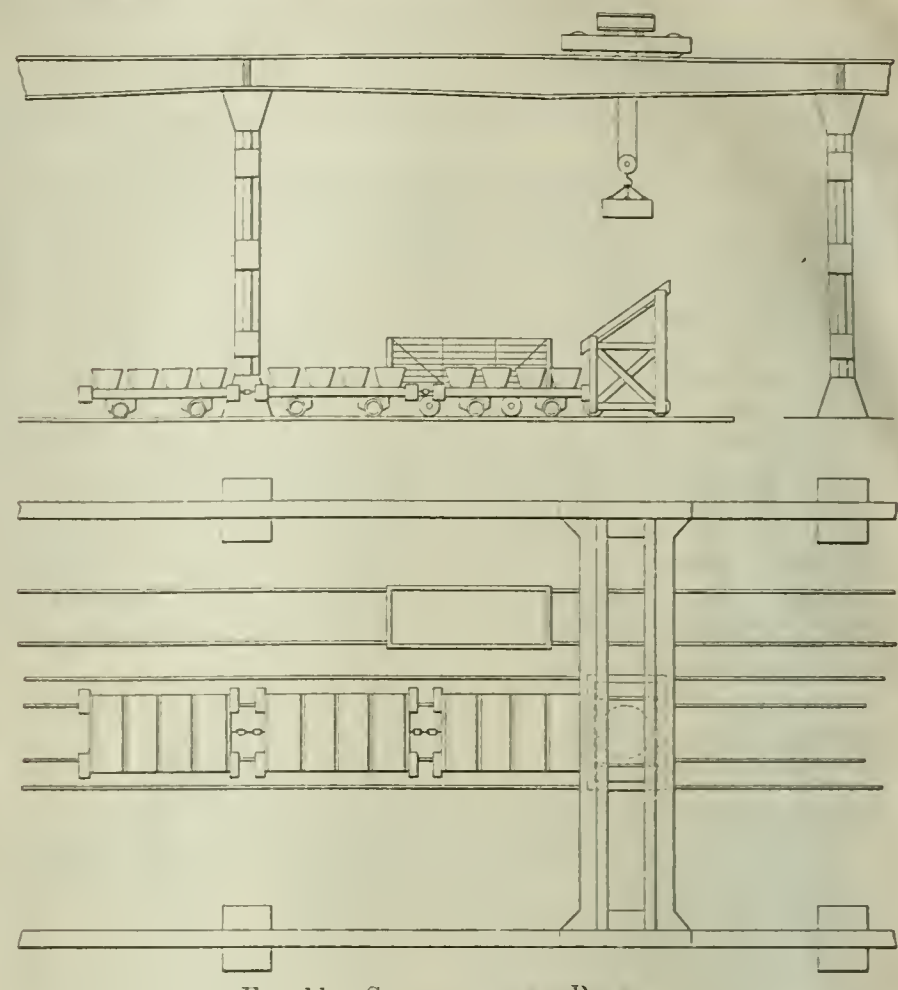


Fig. 11.—Scrap-loading Plant.

the shoot into the charging boxes. The shoot is made of iron or steel, and is carried upon a portable travelling frame on rails laid outside the track for the bogies carrying the charging boxes, so that the latter can pass under the shoot. The magnet in addition to lifting the scrap is used for adjusting the position of the shoot over the next

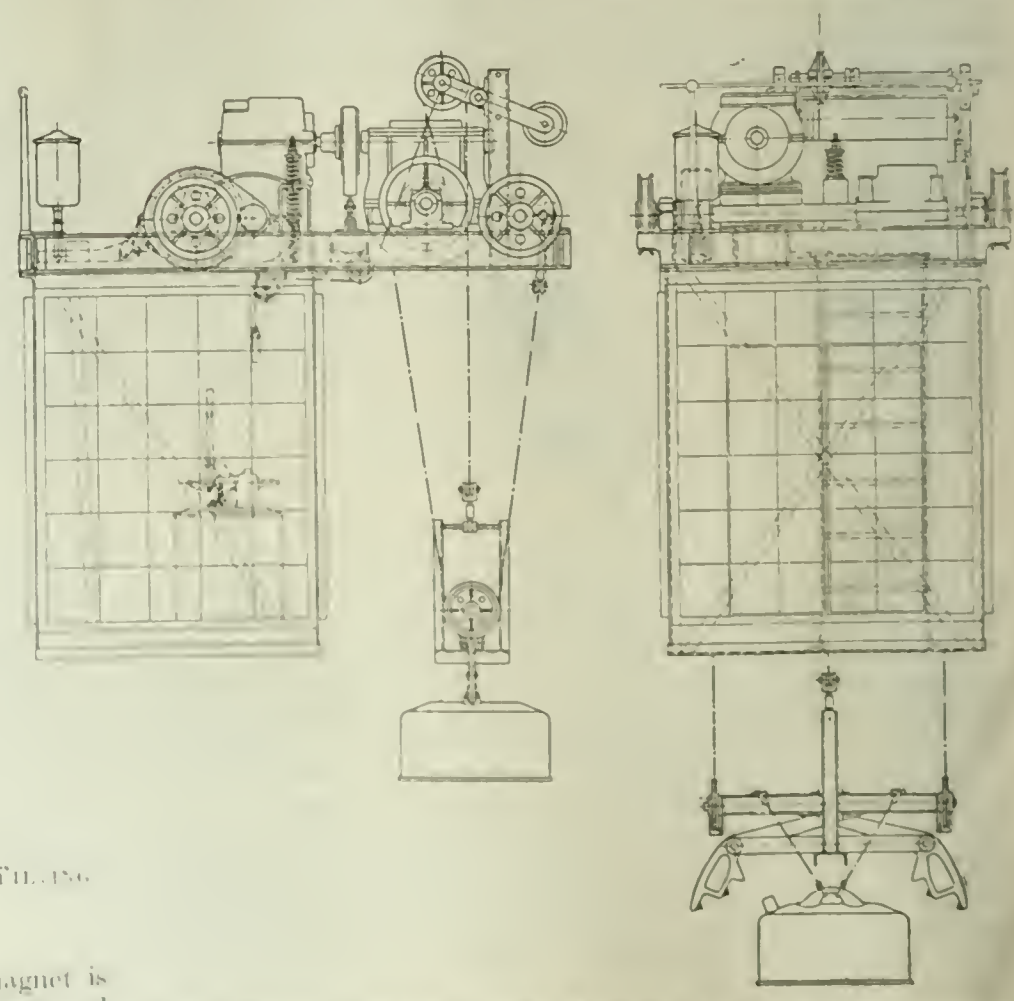


Fig. 10.—Crab provided with Magnet and Tongs for Handling Cold and Hot Ingots.

charging box to be filled. Thus the crane driver alone is able to accomplish with rapidity all the movements necessary for transferring the scrap from the railway trucks to the row of charging boxes, which results in a speeding-up of the process and eliminates shunting of the trucks.

LONG-DISTANCE AND CABLE TELEPHONY (UNDERGROUND AND SUBMARINE).*

BY B. S. COHEN AND J. G. HILL.

Part I.

1. It will be convenient to deal with the subjects named in the title in the order named.

2. As a preliminary observation it may be remarked that the distance over which speech can be conducted on a given uniform circuit having a definite attenuation constant per unit length, is largely dependent upon the type of telephone used, also upon whether speech is conducted from a silent or noisy room, and whether the correspondents making use of the line are able to make efficient use of the facilities placed at their disposal, both as regards transmission and reception.

3. Before entering upon the question of the long-distance properties of lines it will, therefore, be advantageous to refer to the apparatus to be used in speaking over them. The apparatus used in England as a standard of comparison is the Western Electric Company's common battery set as defined in detail at a later stage. It is found that normal speakers in silence cabinets can, by means of this apparatus, communicate with each other over a standard cable of a length such that the attenuation constant multiplied by the circuit length (the attenuation length) =5·0; or, alternately, over any combination of line and apparatus where the total attenuation does not exceed 5·0.

4. In order to communicate satisfactorily over the length of line tipulated, favourable conditions must be assumed which are frequently not obtainable in practice, such, for example, as a silent line and efficient apparatus in perfect condition, but a suitable allowance can be made for these This matter is dealt with fully at a later stage.

5. The standard of 5·0 as above defined gives a basis of comparison which is found in practice to be of great service. In applying the standard, however, many factors must be taken into account, among the most important being the following. If the standard apparatus is used on lines having characteristic impedances different from that of the standard cable, allowance must be made for the resulting losses or gains, and this can be done by means of curves such as those embodied in this Paper. Effects of losses between lines of different impedance, apparatus, bridges, &c., must also be allowed for, and some details of the losses to be expected under these heads are also given. On the basis of the standard laid down, communication in the best conditions will only be possible when the total circuit, including all losses, has an attenuation length not exceeding 5·0. The question of distortion also requires consideration. If alternating currents of different frequencies are unequally attenuated in a given circuit, distortion of speech results. Now, speech on an unloaded aerial line suffers less distortion than speech over an ordinary underground cable, and consequently, although comparison between similar lines is easy, a rigid comparison between overhead and underground circuits by means of speech tests is difficult. In practice, however, if great care is taken, such a comparison can be made sufficiently close for practical purposes.

6. Having now defined the standard to be used, and indicated a few of the important points to be taken into account in applying it, we are in a position to study the properties and limitations of open lines.

7. The general properties of such lines are well known to telephone engineers, thanks to the work of Heaviside, Pupin, Breisig, Kennelly and many others, and it is therefore proposed only briefly to refer to them. If it be assumed that the electrical constants of a telephone line may be regarded as fixed and uniform, there is no difficulty in calculating the attenuation constant and length, and therefore the distance over which speech is possible. In practice, however, the efficiency of a line is subject to fluctuation on account of variation in leakance, and owing to disturbances caused both by electrostatic and electromagnetic induction, &c. These, in addition to the transmission losses already referred to, require to be carefully considered in determining the length of line over which speech is possible. This aspect of the question has been the subject of considerable study in England, and it is proposed to give briefly the results of some tests which have been recently made, with a view to elucidating this somewhat obscure part of the subject.

8. The following formulæ are well known, and are only stated to give precision to what follows :—

The attenuation constant of any circuit is :

$$(1) \qquad \sqrt{\tfrac{1}{2}\sqrt{(R^2+\omega^2L^2)(G^2+\omega^2C^2)}+\tfrac{1}{2}(RG-\omega^2CL)}.$$

Where R is the Resistance per unit length.
L ,, Inductance ,, ,,
G ,, Leakance ,, ,,
C ,, Capacity ,, ,,
ω is $2\pi f$ where f is the number of cycles per second.

The characteristic impedance of the circuit, *i.e.*, the impedance of a so-called infinite line, is

$$(2) \qquad \sqrt[4]{\frac{R^2+\omega^2L^2}{G^2+\omega^2C^2}}.$$

If ωL is large compared with R and ωC large compared with G, this reduces to $\sqrt{(L\ C)}$.

In the case of unloaded aerial wires suitable for long-distance communication, formula (1) may be reduced to the simplified form,

$$(3) \qquad \text{Attenuation constant} = \frac{R}{2}\sqrt{\frac{C}{L}}+\frac{G}{2}\sqrt{\frac{L}{C}}.$$

The constants R, L and C show only a small variation with change of frequency or change of weather, but the quantity G is subject to considerable variation both with frequency and weather. It is evident from the formula that the effect of this is to cause variation in the attenuation constant, and this must be taken into account in estimating the distance to which communication is possible. The distance will obviously be, to a certain extent, dependent upon the climatic conditions of the country through which the wires pass.

9. A series of observations on the variation of the electrical constants of unloaded 300 lb. aerial circuit lines at telephonic frequencies was recently made in England during the winter months, and the following results were obtained.

10. The mean attenuation constant observed at a frequency such that $2\pi f$=5,000 was 0·0058. The maximum was 0·00627 and the minimum 0·00522. The constant calculated (assuming 1 megohm insulation per mile) was 0·0057. Although it will be seen that the mean figure obtained was very near to that usually taken, it will be noted that in different weather conditions the attenuation constant varied nearly 10 per cent. above and below that figure, giving a total variation of nearly 20 per cent. This was due to variations of leakance. It may also be observed that the leakance at alternating-

* A Paper prepared for presentation at the International Telegraph and Telephone Engineers' Conference, Berne, Sept., 1914, abandoned owing to the outbreak of war. Reproduced, with permission, from the Post Office Electrical Engineers' "Journal."

Schedule Showing Mean Value of Electrical Constants of an Unloaded Aerial Circuit (Loop) at Alternating-current Frequencies, during the Winter Months, in England.

Details of copper conductor.		Length of circuit loop tested.		Direct-current tests.				Alternating-current tests.										
Weight in lb. per mile per wire.†	Diam. in mm.			Resistance ohms.		Leakance 1/Ω		Frequency. $2\pi f$.	Attenuation constant.		Resistance ohms.		Inductance millihenrys.		Leakance micromhos.		Capacity microfarads.		G C.
		Miles.	Km.	Per mile.	Per km.	Per mile.	Per km.		Per mile.	Per km.	Per mile.	Per km.	Per mile.	Per km.	Per mile.	Per km.	Per mile.	Per km.	
300	3·48	30	48	6·68	4·18	0·8	0·5	3,000	0·00555	0·00347	6·66	4·16	3·79	2·37	1·20	0·75	0·0098	0·0061	123
300	3·48	30	48	6·68	4·18	0·8	0·5	4,000	0·00566	0·00354	6·75	4·22	3·82	2·39	1·34	0·84	0·0098	0·0061	136
300	3·48	30	48	6·68	4·18	0·8	0·5	5,000	0·00578	0·00361	6·78	4·24	3·83	2·39	1·46	0·91	0·0098	0·0061	149
300	3·48	30	48	6·68	4·18	0·8	0·5	6,000	0·00590	0·00369	6·79	4·24	3·82	2·39	1·55	0·97	0·0097	0·0061	160
300	3·48	30	48	6·68	4·18	0·8	0·5	7,000	0·00640	0·00400	6·84	4·37	3·80	2·38	1·58	0·99	0·0095	0·0060	166

Note.—The capacity measured with direct current was 0·0098. The inductance measured with direct current is not available. The values given above are near to the calculated value.

† The principal weight of conductor was 300 lb. per mile per wire, but the circuit contained some relatively short lengths of copper weighing 150 lb. per mile per wire (2·46 mm. diameter).

current frequeneies was considerably greater in fine weather than that obtained by direct-current measurements. It is of interest to note that the mean insulation measured at a frequency such that $2\pi f=5{,}000$ was of the order of two-thirds of a megohm per mile or 1 megohm per kilometre. It is, however, some point towards the minimum insulation which determines the practical efficiency to be assigned to a line, and therefore the efficiency which can be relied upon in England in winter weather is a little less than half a megohm per mile, or 0·8 megohm per kilometre. The following Table and eurves (1 and 2) show the results which were obtained during the experiments. The investigation brings out clearly the deleterious effects of leakance both on the attenuation constant and the quality of speech. Although good insulators are used in England, the relatively damp elimate makes it very diffieult to obtain insulation as high as is obtained in some countries, notably America. The matter is, however, being specially investigated. The question is important, beeause if it be given that relatively high insulation on an aerial line can be maintained, this is the most effieient type of line available, and it must be relied upon for very long-distance communication.

11. The principal conductors used in England for long-distanee communication weigh 400 lb. (4 mm. diameter) and 600 lb. (4·92 mm. diameter) per mile. In exceptional circumstances eonductors weighing 800 lb. per mile (5·68 mm. diameter) are used. The wires are spaced on the poles 12 in. apart in all cases (30·5 cm.), the arms also being 12 in. apart. The wires are continuously revolved together in sets of four, each wire changing its position on every successive pole, the revolution being completed in four spans. The range of communication in England is limited by the necessity of running wires underground in large towns and the near proximity of towns to each other.

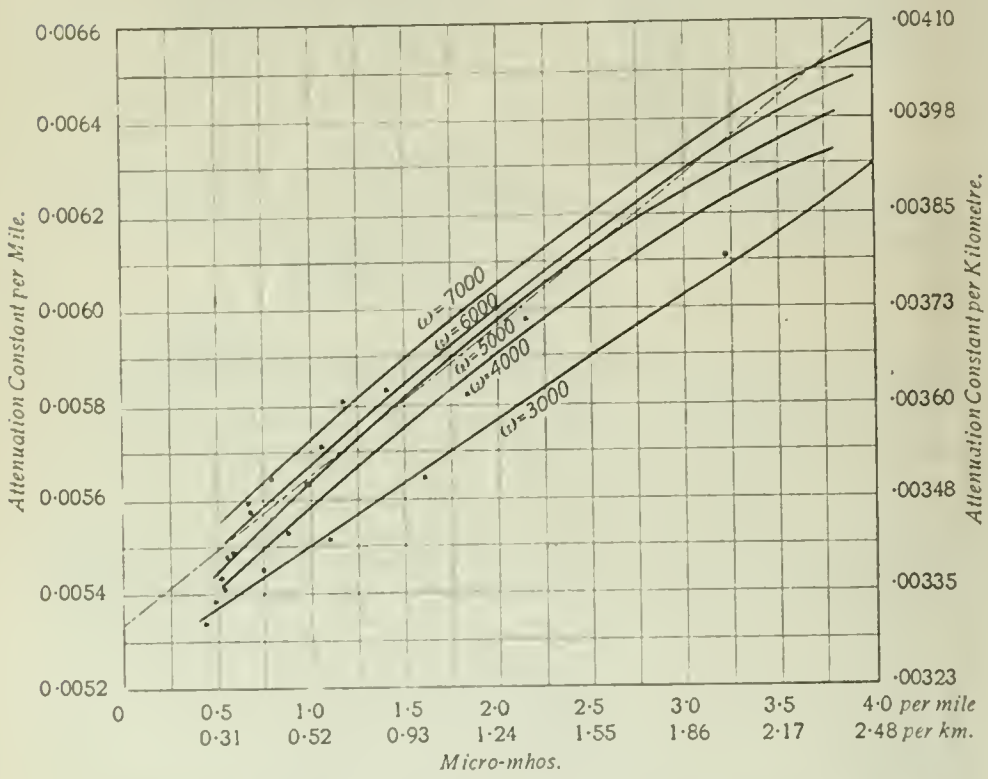


Fig. 1.—Experiments on 300 lb. Aerial Lines. Relationship between Leakance as Measured by Franke Machine and the Attenuation Constant. Frequencies ranging from $3{,}000/2\pi$ to $7{,}000/2\pi$.

12. The longest circuits in England are the London-Glasgow lines, 450 miles (720 km.) in length. One of these circuits has conductors weighing 800 lb. per mile per wire. The attenuation length is 1·15. This is considerably greater than the theoretical attenuation length value of an 800 lb circuit, in which no underground cable or wires of lesser gauge are included, but owing to the necessity for long length of underground cables in London and Glasgow the attenuation length is that stated.

13. The following table shows the electrical constants of the heavy gauge circuits referred to above.

Means of Extending the Range of Communication on Aerial Lines by (Coil) Loading.

14. A series of experiments on loaded aerial lines has recently been made in England to determine the reduction in attenuation, and the reflection losses involved, in this type of loading. The tests covered a long period of time and included variations due to summer and winter weather. The general results are given in the following notes.

15. The theory of loaded lines is, of course, well known. The general formula for the attenuation constant of loaded lines is that already given by formula (3), *i.e.* $\frac{R}{2}\sqrt{\frac{C}{L}}+\frac{G}{2}\sqrt{\frac{L}{C}}$. It is obvious by inspection of this formula that as L is increased (*i.e.*, the more heavily a circuit is loaded) the greater will be the increase in attenuation loss. The practicability of loading, therefore, largely depends upon the insulation which can be maintained in any country, and this makes experiments necessary. Further, loading increases the characteristic impedance of such circuits, as is shown by formula (2), and involves transmission losses as shown by the curves in 13 and 14 (*see* Part II.). It is evident from these curves that unless aerial lines are of sufficient length, the reflection losses involved will neutralise the reduction in attenuation brought about by loading. Again, the distortion of unloaded aerial lines is very small, as shown by the details already given. Loading, however, involves an increase in the distortion, due to the fact that the resistance of loading coils increases with frequency. The placing of coils at fixed distances or so-called "lumped" loading also tends in the same direction.

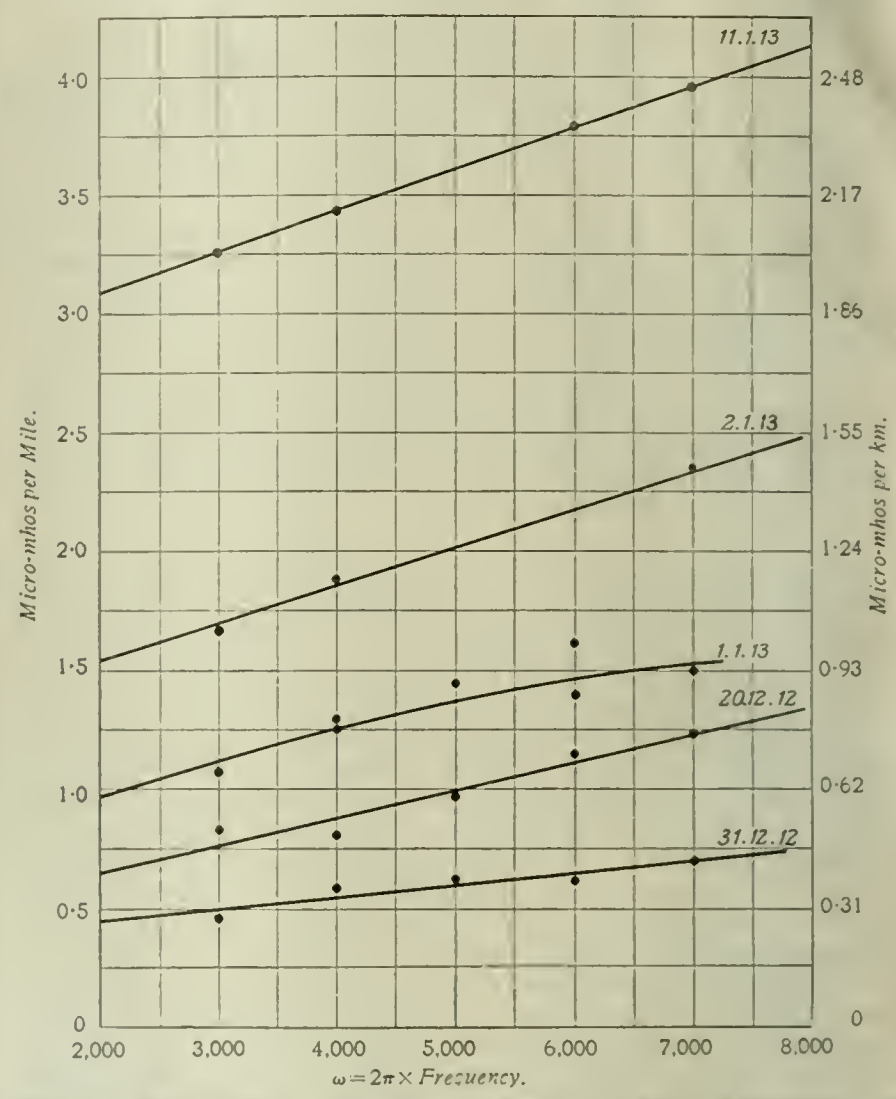


Fig. 2.—Experiments on 300 lb. Aerial Lines. Variation of Leakance with Frequency on Various Dates.

16. The lines selected for loading weighed 300 lb. per mile (3·48mm. diameter), the length loaded being 200 miles (320 km.). Two circuits were loaded on the same poles, and these could be doubled back to give a total length of 400 miles (640 km.). Two types of coils were

Data of Heavy Gauge Telephone Conductors (Frequency 800 Periods per Second).

Values of Electrical Constants per Mile.

Weight in lb. per mile per wire.	Diam. of wire in mm.	Constants per mile loop. R. ohms.	L. hys.	G. mhos.*	C. mfs.	Attenuation constant.	Characteristic impedance. Zo.
400 copper	4·18	4·40	0·00344	10^{-6}	0·0092	0·00387	620·9\6° 32′
600 ,,	4·921	2·93	0·00331	10^{-6}	0·0096	0·00279	591·6\4° 25′
800 ,,	5·683	2·20	0·00322	10^{-6}	0·0099	0·00221	572·8\3° 19′
		Values of Electrical Constants per kilometre.					
400 ,,	4·18	2·75	0·00215	$0{\cdot}625\times10^{-6}$	0·00575	0·00241	620·9\6° 32′
600 ,,	4·921	1·83	0·00206	$0{\cdot}625\times10^{-6}$	0·00600	0·00174	591·6\4° 25′
800 ,,	5·683	1·375	0·00201	$0{\cdot}625\times10^{-6}$	0·00618	0·00138	572·8\3° 19′

* The mean winter value in England is somewhat greater.

used, with the object of finding the most suitable inductance for use in the somewhat humid climate of England. 3 shows how the loaded and unloaded circuits might be expected theoretically to vary with the weather, and this was found to be approximately the case. Extended observations indicate that in summer weather the attenuation constant of an open line of this type can be reduced in England to the extent of 50 per cent. by loading. In damp, but not very wet weather, the decrease in the attenuation constant would amount to 40 per cent., and in wet winter weather 30 per cent. The reflection losses were found to correspond approximately with those indicated by the curves 13 and 14. These losses were determined by speech tests. Some degradation of articulation was observed, as might be expected from the considerations outlined above, but the quality of speech on the loaded circuits was quite satisfactory. As a result of the experiments the range of loading is being extended to some London-Glasgow circuits having a length of 450 miles (720 km.). These are the longest circuits in the United Kingdom, and when doubled back will give a length of 900 miles (1,440 km.) available for further experimental observations.

17. As the result of the previous experiments it was found that the 260-millihenry type of coil placed 8 miles apart, gave better results than the 160-millihenry type spaced 12 miles apart. The whole of the 900 miles circuit length will, therefore, be equipped with coils of the former type. Coils of a cheaper type than in the previous experiment will be used, the proposed R/L having the value 35 instead of 25 as in the previous case. The difference in first cost of the two types is considerable, and out of proportion to the benefit obtained in winter conditions in England from the more efficient coil. The chief point brought out by the investigations on aerial lines is the fact that before a reliable attenuation constant can be applied to any line, detailed observations of the leakance at alternating-current frequencies covering winter as well as summer conditions are

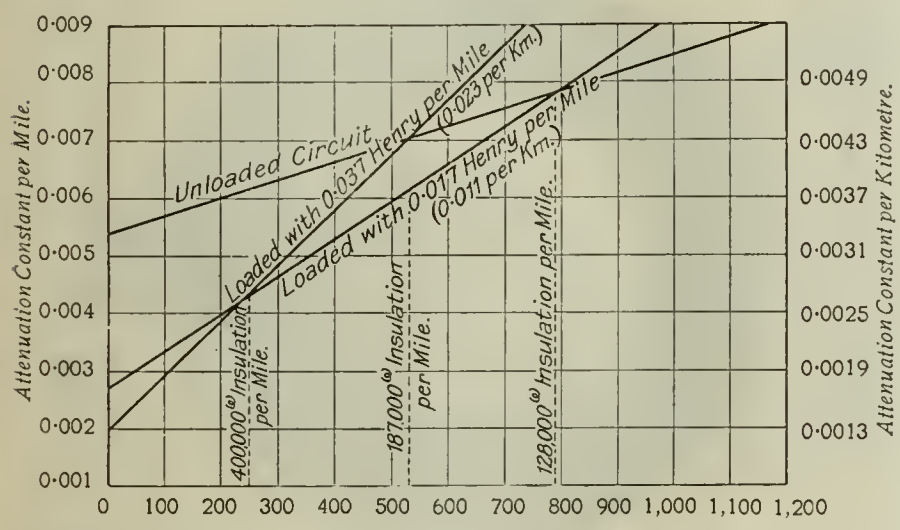


Fig. 3.—Aerial 300 lb. Circuit (3·48 mm. diameter) Curves showing Variation of Attenuation Constant with Inductance and Leakance.

necessary. The results will be different in different countries, according to the type of insulator used.

18. Improvement in the insulation of open lines is a matter which well repays careful study.

19. If the leakance to be expected is known within reasonable limits it will be possible to determine the most suitable type of loading coil to be used in any circuit.

Extension of the Range of Telephonic Communication by Means of Telephone Relays.

20. A considerable number of experiments have been made in England with telephone relays. There are several types of relay in progress of development, and two of these types call for special mention.

21. (i.) *The Mechanical Relay.*—This consists of a combination of a receiver and augmenting telephone transmitter, placed at some intermediate point on the line. The receiver acts on the moving electrode of the transmitter, the latter being arranged to augment the received sound and a suitable arrangement made for transmitting it to the receiving point (examples: Shreeve relay, S. G. Brown's relay). This type of relay in the most favourable conditions is capable of augmenting received speech to a degree equivalent to an attenuation length of 3, the clearness of speech being sufficient for commercial purposes. (As explained below, however, the augmentation obtained in commercial practice is usually less than 3.)

22. Several practical forms of mechanical relay have been produced. Difficulty has, however, been experienced in working the relays in both directions. Two main methods have been tried; the first depends upon balancing the lines on each side of the relay. The second depends upon mechanical switching arrangements. The balanced system renders the relay much more stable in working, but the augmentation obtained is then much less than that given above (sometimes not more than half) owing to the attenuating effect of the balancing devices. If the balance is not sufficiently good the relay "howls." The switching systems render the communication liable to interruption by disturbances on the line, by interference with the working of the switches. This system, however, is not subject to "howling."

23. At the present time experiments are being made with the object of overcoming these difficulties, but the relay requires expert attention, and has not passed the laboratory stage.

24. (ii.) *Gas Discharge Lamps.*—The magnification obtained by this device corresponds approximately to that produced by the type referred to above. The principal advantages and disadvantages as compared with the mechanical type dealt with appear to be as follows: (1) The principal advantage is, of course, the absence of inertia in the speaking circuit, and this should result in better articulation; (2) the absence of mechanical adjustments. The principal disadvantage appears to be the high voltage required, 200-240 volts.

25. Experience of this lamp had not at the time of writing been obtained in England sufficient to make a detailed criticism possible. Various types of gas discharge relays are, however, under test by the English administration.

26. The general conclusion as regards the present position of the telephone relay in England is that although it will work satisfactorily in favourable conditions on aerial lines, yet in bad weather conditions it fails before the line would otherwise become unworkable. In the case of underground circuits, however, there is a much more favourable field, as the circuit conditions are decidedly more stable and less liable to disturbance. Usually, however, underground circuits of sufficient length are not at present available.

Up to the time of writing there had been no opportunity of testing Mr. Van Kesteren's method.

(To be continued.)

NEW LOW-RESISTANCE STANDARDS.

BY C. V. DRYSDALE, D.SC.

Summary.—After stating the essential features of a well-designed low-resistance standard, several such resistances having negligibly small time constants are described. The results of searching tests are given, and it appears that the Tarnac alloy used in the construction of the resistances is identical with manganin. In conclusion it is claimed that as regards resistance alloy, British manufacturers are now able to rival German products, and it is hoped that in design and construction the new standards will prove to be a material advance upon the Reichstanstalt forms.

One important matter in which Germany has almost secured a monopoly in recent years has been the supply of accurate standards of low resistance for current measurement by potentiometer. The forms of manganin plate resistances first designed by the Reichsanstalt in 1893, and since developed by O. Wolff, Siemens & Halske, and other firms, were certainly a great advance on anything which had previously been produced, and although a good deal has been recently done in Great Britain as regards the construction of shunts of moderate accuracy, portability and economical construction, the German forms are still almost universally used wherever the highest accuracy is required. Nevertheless, they have some quite definite defects which give scope for a material advance in design. No attempt has been made to render them suitable for alternating-current measurements, nor have their terminals been well designed with a view to facilitating accurate standardisation by a Kelvin double bridge. In fact, it is only in the smaller sizes that mercury contacts are provided, and these are actually wrongly placed, as they are fixed on the main current electrodes instead of on the potential terminals. In the large resistances, connection can only be made to the standardising bridge by copper connections clamped to the potential terminals, which is decidedly objectionable when high accuracy is aimed at.

The essential features of a well-designed low-resistance standard are as follows:—

1. Permanence. Secured by employing suitable alloy well annealed and silver-soldered to large copper lugs firmly

clamped to the terminals and sweated to them by zinc-free solder. The strip should also be rigidly supported to avoid deformation and be protected from oxidation or chemical action.

2. Low temperature variation. } Best secured by good
3. Low thermo E.M.F. } quality manganin.

4. Lowest possible time constant for alternating-current measurements, and lowest external field to avoid disturbance of adjacent instruments.

5. Large radiating surface, combined with oil cooling, water cooling and mechanical stirring, in the larger sizes.

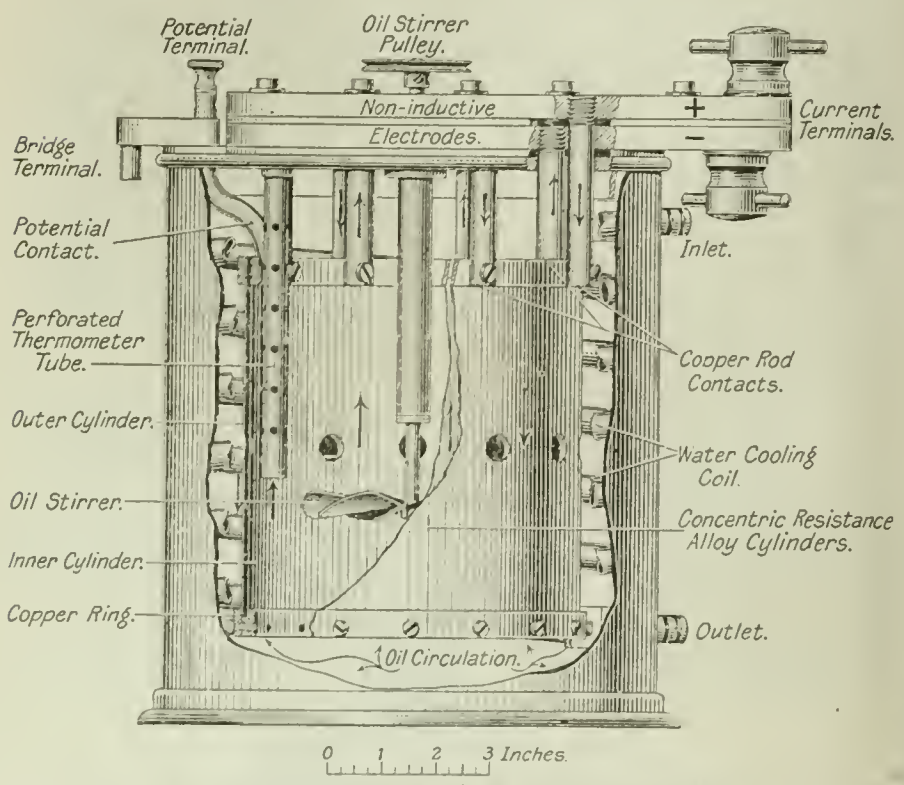


Fig. 1.—Section of 0·0005-ohm Concentric Type Non-inductive Standard.

6. Main current terminals conveniently arranged for the reception of heavy current loads, and so designed as to avoid any appreciable variation of stream line distribution in the strip.

7. Potential leads of low resistance attached at the junction of the main current electrodes with the manganin strips. Each potential lead should carry a potentiometer terminal and a mercury contact for a standardising bridge, the distance between the bridge contacts being of a standard gauge.

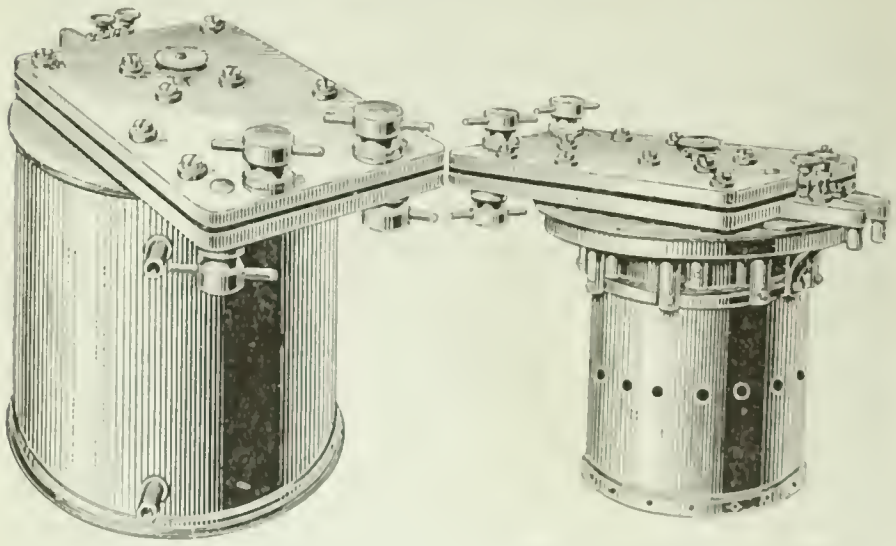


Fig. 2. Fig. 3.—Internal View.

0·0005-ohm, 1,000-ampere Standard Resistance, Type D.
(Size, 14 in. × 13 in. × 11 in. Weight, 50 lb.)

In The Electrician for Dec. 9, 1910 the writer gave a description of a new form of sub-divided non-inductive low resistance which fulfilled these conditions fairly completely. These have since been made by Messrs. H. Tinsley & Co., and various constructive improvements have been introduced. It is difficult to make a thoroughly satisfactory piece of work with straight or bent strips, as, even when well made in the first instance, they are liable to buckle when silver-soldering them to the lugs. Messrs. Tinsley, therefore, introduced the important improvement of employing vertical concentric manganin tubes screwed and soldered at the upper end to plate electrodes and silver-soldered together at the lower end. This made a remarkably robust and permanent resistance of extremely small and easily calculable time constant. The tubes were of about 1 in. and $1\frac{1}{8}$ in. diameter respectively and 12 in. long, each section being about 0·005 ohm. Lower resistances were formed by putting two or more of these elements in parallel.

This type, however, demanded rather too much mechanical accuracy for commercial construction, and the writer has, therefore, again modified it by employing two tubes of large diameter silver-soldered above and below to copper rings which are screwed and sweated to a series of copper lugs projecting from the plate electrodes. Fig. 1 shows a section of one of these resistances, usually made of 0·001 Ω or 0·0005 Ω, to carry 700 or 1,000 amperes respectively. The main current terminals are two large horizontal plates with a thin layer of insulation between, thus being nearly non-inductive in themselves. From each of these plates eight lugs project (those from the upper plate passing through clearing holes in the lower plate). The two tubes are of 6 in. and $6\frac{1}{4}$ in. diameter respectively, 6 in. long, and of 10 or 20 mils or more in thickness as may be necessary for the required resistance. Each of them is silver-soldered to two copper rings which are thoroughly tinned and screwed at the top to the faced-off ends of the copper lugs. At

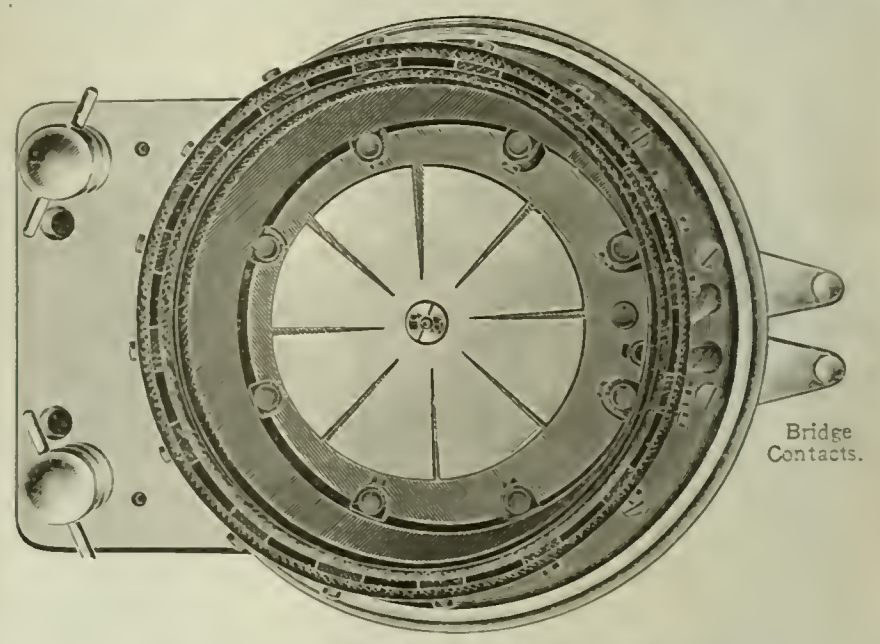


Fig. 4.—0·0005-ohm 1,000-ampere Standard.
(View from below, showing spaces between rings and rotary stirrer.)

the bottom the two rings are screwed together with eight tinned copper distance pieces between, and the whole of the contacts are then sweated up thoroughly with specially prepared solder. The spaces between the copper distance pieces at the bottom and between the lugs at the top enable the oil to enter freely between the two tubes and stream upwards by convection, thus giving the most effective possible cooling. Two short potential leads of large diameter are screwed and soldered to the upper two rings and are connected to two copper blocks carrying potential terminals and mercury bridge contacts as shown, the latter of which can be either of the B.A. gauge ($1\frac{1}{4}$ in.) or of the Reichsanstalt gauge (160 mm.), as desired. A spiral copper worm for water cooling is also provided, and a turbine type stirrer of large diameter. Fig. 2 is an external view of a 500-watt resistance of this type, and Figs. 3 and 4 show the robust internal construction. The time-constant of such a resistance can be readily calculated with a very fair degree of approximation.

If d_1 and d_2 are the diameters of the inner and outer tubes respectively in centimetres, $d=(d_1+d_2)/2$, l their axial length, t their thickness, and ρ the specific resistance of the material, then we have approximately :—

$$\text{Resistance } R=\frac{2l\rho}{10^6 d.t} \text{ ohms.}$$

If a current I C.G.S. units passes through the arrangement

the space is so narrow compared with the diameter of the tubes that the field H may be taken as uniform and

$$\pi dH = 4\pi I, \text{ or } H = \frac{4I}{d},$$

from which the total flux $N = HA = \frac{4I}{d}\,\frac{d_2-d_1}{2}\,l = 2Il\,\frac{d_2-d_1}{d}$,

and the inductance $L = \frac{N}{I} = 2l\,\frac{d_2-d_1}{d}$ cm. $= 2\times10^{-9}l\,\frac{d_2-d_1}{d}$ henries, from which the time-constant $T = \frac{L}{R} = \frac{(d_2-d_1)t}{1{,}000\rho}$ seconds.

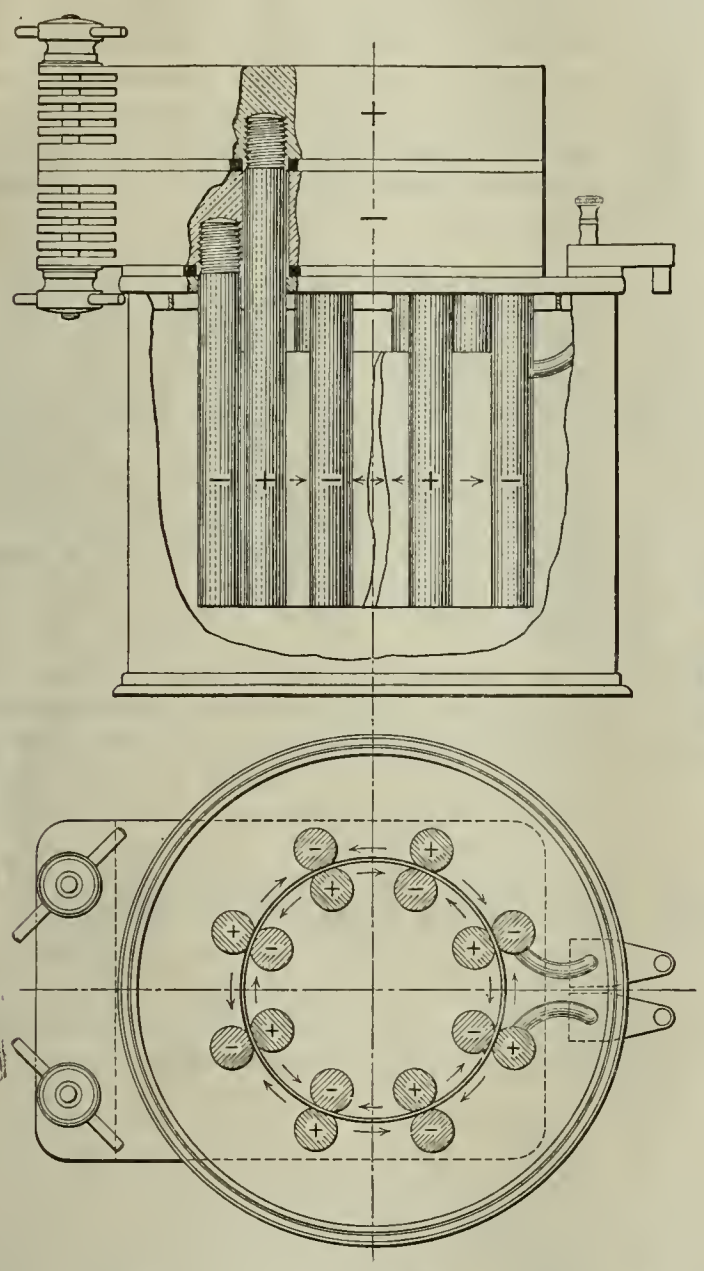


Fig. 5.—Concentric Tube Resistance for 10,000 amperes.

For example, if we take the case of $d_1 = 6''$ and $d_2 = 6\frac{1}{4}''$, $t = 20$ mils $= 0{\cdot}05$ cm., $C = 40$ microhms per centimetre cube, then $d_2 - d_1 = 0{\cdot}6$ cm. approx., and $T = \frac{0{\cdot}6\times0{\cdot}05}{1{,}000\times40} = 0{\cdot}75\times10^{-6}$ seconds.

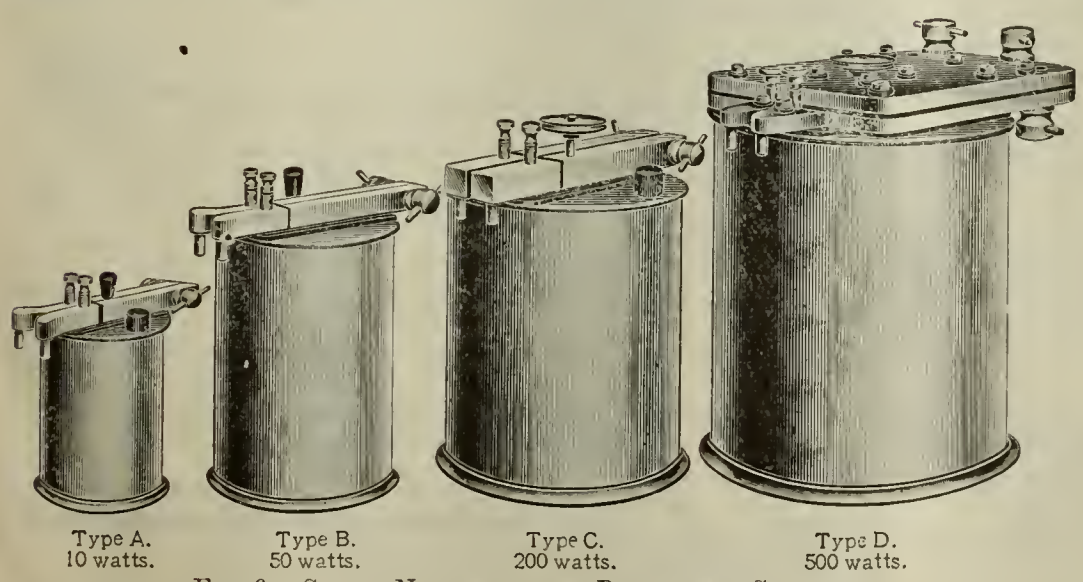


Fig. 6.—Set of Non-inductive Resistance Standards.

This means that even with a frequency of 1,000 cycles per second the phase displacement would be only $T\omega = 0{\cdot}75 \times 10^{-6}\times6280 = 0{\cdot}0047$ radian, or 0·27 deg., and the error in the magnitude of the P.D. due to the impedance would be only $\frac{1}{2}T^2\omega^2 = 11\times10^{-6}$, or 11 parts in a million.

The capacity time-constant can similarly be calculated from the approximate formula,

$$C = \frac{\text{area}}{4\pi\ \text{distance}} = \frac{ld}{2(d_2-d_1)}\text{cm.} = \frac{ld}{1{\cdot}8(d_2-d_1)} \times 10^{-12} \text{ farads.}$$

This gives the time-constant $T = \frac{1}{2}CR = \frac{l^2\rho}{1{\cdot}8(d_2-d_1)} \times 10^{-18}$ second. With the same dimensions as above and tubes 15 cm. long, this gives the capacity time-constant as $1{\cdot}67\times10^{-11}$ second, which is negligible under all circumstances.

At ordinary supply frequencies the inductive errors are, of course, quite undetectable, while even at much higher frequencies than the above they can be made negligible either by reducing the interval between the tubes or, more simply, by looping back one of the potential terminals through the tubes so as to encircle the flux in the reverse direction. With the latter device, considerable accuracy even at radiotelegraphic frequencies should be attainable.

For very low resistances to carry the highest currents, the design is almost identical with the above, but the top plates are made thicker with laminated contacts for the lugs, and the copper electrodes to the strips are longer and are attached alternately to the upper and lower plate as shown diagrammatically in Fig. 5, so that the current is flowing in opposite directions in various sections of a single tube, each current, however, being neutralised by its proximity to an opposite current in the adjacent tube. This design lends itself to the employment of any number of concentric tubes and thus to the construction of the lowest possible resistances.

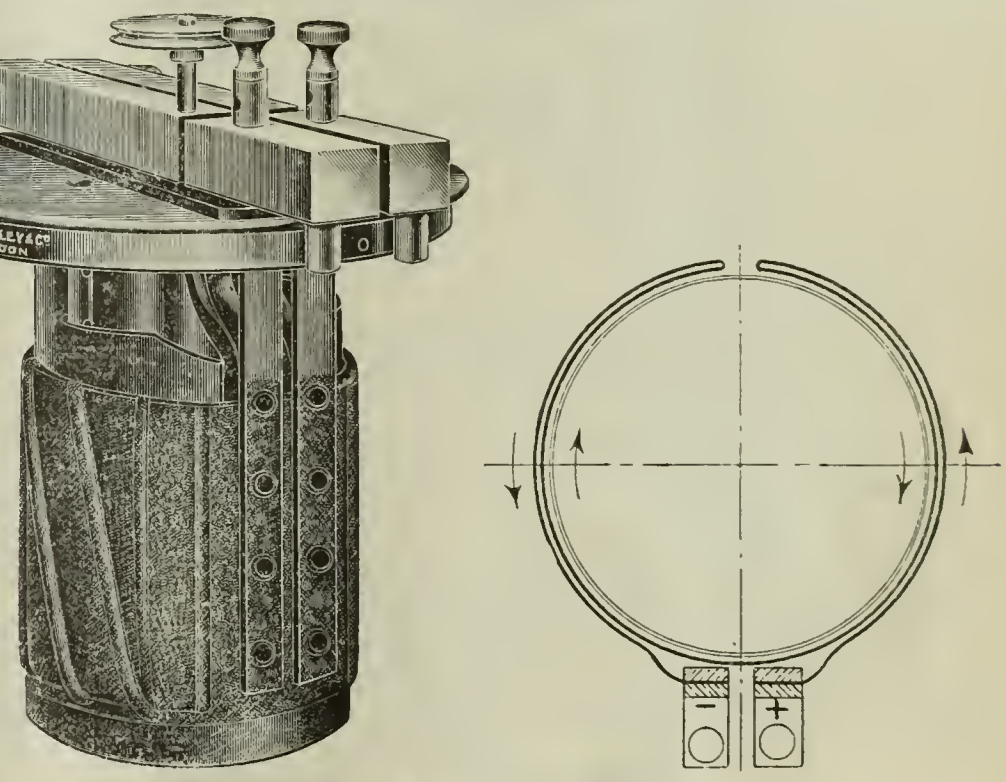


Fig. 7.—0·01 ohm Non-inductive Standard.

Fig. 6 is a photograph of the first four types of the series, and shows the forms of the current and potential terminals in each case. A thermometer pocket and oil-filling plug is provided in each case, the former being of such a depth that the centre of the bulb of an average thermometer is on a level with the centre of the resistance. The whole of the exposed metal and case is heavily nickelled and the cover is of metal, so as to avoid warping.

For resistances of 0·005 ohm and higher the resistance strip is folded and bound on a former as shown in Fig. 7, and for the higher resistances it is cut in grid form and similarly mounted.

Tests.

The following are some tests on a few different sizes of these resistances, which have all been made with the "Tarnac"

alloy which has been put on the market since the commencement of the war by Messrs. Wiggins :—

Temperature Variation.—Fig. 8 is a collection of resistance-temperature curves for these Tarnac resistances, the curves of two manganin resistances being given for comparison. Although there are certain variations in the Tarnac alloy it is more uniform and of better coefficient than the bulk of the manganin sheet supplied to the country before the war, and it is very clean and uniformly rolled.

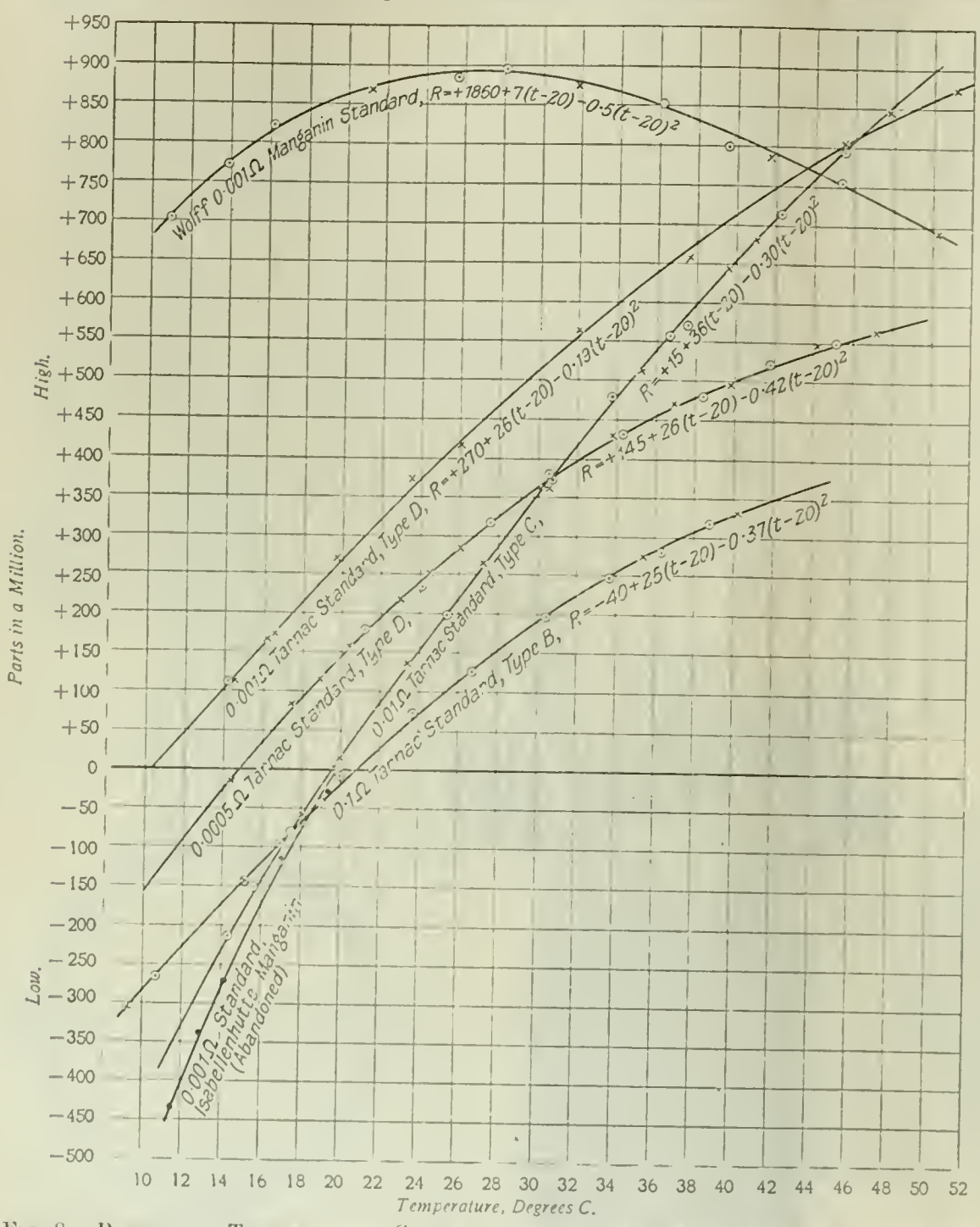


Fig. 8.—Resistance-Temperature Curves for Tarnac and Manganin Low-Resistance Standards.

× Ascending readings. ⊖ Descending readings.

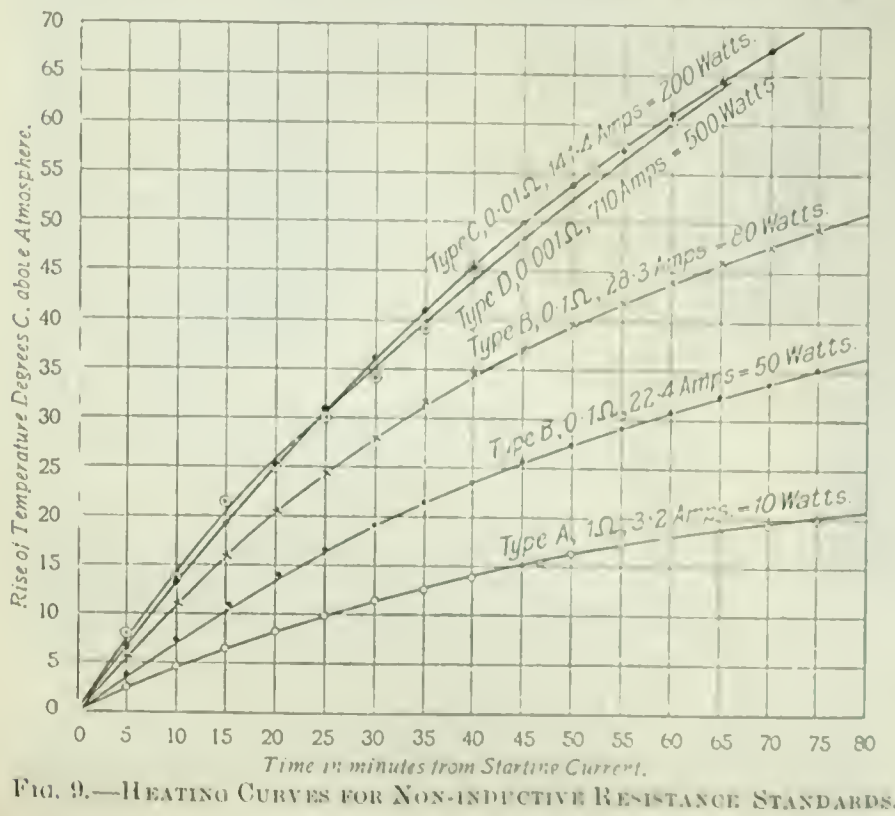


Fig. 9.—Heating Curves for Non-inductive Resistance Standards.

A good average formula for the resistance of this alloy is $R_t = R_{20} + 25 \times 10^{-6}(t-20) - 0{\cdot}25 \times 10^{-6}(t-20)^2$, the coefficient, therefore, being 25 millionths at 20°C.

From the form of the curve it appears that the Tarnac alloy is identical with manganin (as claimed by its makers) and that its maximum resistance is at about 70°C. It is certainly a very great improvement on the manganin sheet recently obtainable from Germany.* Its thermo E.M.F. to copper has been tested, and was found to be almost exactly 2 microvolts per 1°C. for temperatures up to 30°C.

Heating Tests.—Fig. 9 is a collection of heating curves on the four sizes of resistance shown in Fig. 6 at full load, but without any water cooling. In the two larger sizes the rise of temperature at full load is almost exactly 60°C. in the first hour. The observations marked by rings are for the type D 500 watt standard and are somewhat irregular, as no mechanical stirring arrangements were available when they were taken.

Resistance of Potential Leads.—Tests have been made of the resistance of the potential leads in the different resistances, by the simple device of passing a fairly heavy current through them and finding the drop of potential between the contact and the main strip. The resistance of each potential contact is approximately 50 microhms in all the types, so that it requires a correction of only 5 parts in a million to be added to the resistance of the standard when testing on a bridge with 10 ohm ratio coils.

Inductance Tests.—Rough tests have been made of the time constants of the larger sizes of these standards, by comparison with a carefully made non-inductive resistance upon the writer's new form of inductance testing bridge. The connections were made as in a Kelvin bridge, using a high-frequency alternator and telephone, and balance was secured by shunting one of the resistances with a variable condenser. In the case both of the 0·01Ω and 0·001Ω standards the best balance was obtained with 0·1 mfd. shunting a 10Ω ratio coil, giving the time-constant in each case as 1×10^{-6} second, which is as close

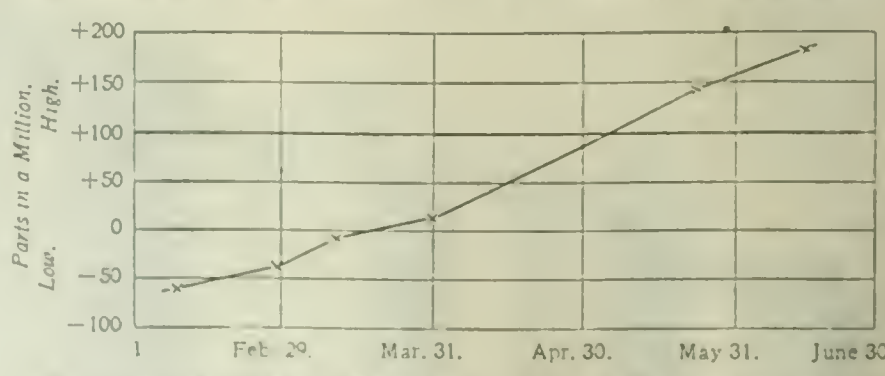


Fig. 10.—Increase of Resistance of 0·1 ohm Tarnac Standard from Date of First Adjustment.

as could be expected to the value calculated above for the 0·001Ω resistance.

Permanence.—The coils are all very carefully annealed on alternating current before final adjustment, but like nearly all

* In some samples of Tarnac a well marked *negative* hysteresis loop has been obtained, which sometimes disappears on re-annealing.

resistances when first made they tend to rise in value. For example, the Wolff 0·001 Ω standard, for which a temperature curve is given in Fig. 8 was certified by the N.P.L. as having a value 1,800 parts in a million high two or three years after it was made. Sufficient time has not yet elapsed for any thorough investigation of the new standards employing the Tarnac alloy, but the following curve, Fig. 10, represents the results of five months' observations of a 0·1 Ω standard, from which it will be seen that the rise is fairly uniform and at the rate of about 2 parts in a million per day, or 7 parts in 10,000 per year. This is probably about the same rate as in the Wolff manganin standard. This shows the importance of thoroughly ageing to secure constancy, and the correct practice for permanent standards should be to adjust about 0·1 per cent. low, and to keep the coils at least a year before standardising. It also shows the importance of a periodic checking of all standard resistances against a known constant standard, until they have attained a steady state.

Further investigations on this point, and on the effects of temperature change will be published later.

It may be claimed, however, from the foregoing that as regards the resistance alloy, British manufacturers are now able to rival German products, and it is hoped that in design and construction the new standards will prove to be a material advance upon the Reichstanstalt forms.

The resistance measurements given above have been made by means of the universal standardising bridge on the combined Kelvin Carey-Foster principle described in THE ELECTRICIAN for Sept. 25, 1907. A complete bridge outfit for the standardisation and inter-comparison of coils of all values has been installed at the laboratory of Messrs. H. Tinsley & Co., at South Norwood, where the above measurements have been made.

INVESTIGATION AND TESTING OF METALS.

Entitled "Some Problems in Physical Metallurgy at the Bureau of Standards," an informative address was presented for Dr. G. K. Burgess at a recent meeting of the Mining and Metallurgical Section of the Franklin Institute by Dr. P. D. Merica.

Dr. Burgess gave the following summary of the various activities relating to metals that have been executed or are being carried out at the Bureau, and stated that each of the items mentioned has been or now is an object of experimental study in one or another of the technical divisions of the Bureau.

Investigation and Testing of Metals at Bureau of Standards.

PUBLICATIONS: T=Technologic Paper, S=Scientific Paper, C=Circular of Information; referred to by number.

A. MATERIALS ... C 45

1. *Metallic Elements:* Iron, nickel, copper, zinc, &c.
2. *Alloys:* (*a*) Two components: Iron-carbon (steels), copper-zinc (brasses), &c.
   (*b*) Three or more components: Alloy steels, complex bronzes and brasses, &c.
   (*c*) Commercial metal alloy products.
3. *Plated Metals:* Galvanised iron, copper and nickel plating, &c.
4. *Auxiliary Products:* Metallurgical slags, fire-clays, moulding sands, deoxidisers, &c. C 45; T 10.
5. *Apparatus:* Instruments, manufacturing accessories, furnaces, &c. S 219.

B. METHODS:

1. Preparation illustrated by

(*a*) *Production of Pure Metals:* Examples, electrolytic iron, gallium, &c. S 263.

(*b*) *Standards for Pyrometry*, electricity, chemical analysis, metallography, &c. S 107, 143, 194, 195, 256; C 1, 2, 3, 7, 14, 18, 25, 26.

(*c*) *Mixing Pure Metals* (in foundry and laboratory): Examples, pure iron-carbon series, Government bronze (88 Cu—10 Sn—2 Zn), &c. T 59.

(*d*) *Treatment of Alloys:* Thermal, chemical, mechanical, magnetic, electric, &c. C 6, 17, 42; T 60.

(*e*) *Commercial Samples*, including methods of sampling.

(*f*) *Co-operative Production and Tests on a Commercial Scale:* Examples, ingots for rails, structural brasses and bronzes, statutory bronze, moulding sands, test ingots of steel, &c.

2. Constitution as determined by: C 42

(*a*) *Chemical Analysis:* Bureau is equipped for chemical analysis of all metal products: Example, segregation in steel and bronze ingots, T 6, 8, 24, 33, 69; S 161, 186; C 14, 25, 26 42

(*b*) *Thermal Analysis:* Heating and cooling curves for location of melting and critical points: Examples, alloy steels, new alloys, &c. S 99, 213; C 7. Variation of physical properties with temperature.

(*c*) *Microscopic Analysis* (*i.e.*, characteristic microstructure as determined by)
1. Chemical composition.
2. Thermal history.
3. Mechanical work, hot or cold.
4. Manufacturing methods.
5. Metallographic methods and apparatus, etching reagents, &c.; photomicrographs furnished.

(*d*) *Other Physical Methods of Examination:* Examples, expansion, thermo-electric, magnetic, spectroscopic, &c S 19, 108, 109, 117, 120, 251
1. Thermo-electric determination of platinum purity. S 254, 280.
2 Spectroscopic analysis for rare elements in steels.

(*e*) *Nomenclature*
1. Non-ferrous alloys.
2. Constituents of steel.

3. Properties ...

(*a*) *Chemical and Physico-chemical:* Examples, solubilities, attack by acids, improvement of analytical methods, &c. S 53, 82.

(*b*) *Physical* at high, ordinary and low temperatures:

1. Mechanical ...
- Density.
- Hardness. T 11.
- Fatigue.
- Tensile, &c.
- Elastic.
- Torsion, shear, &c.
- Bending.
- Hydraulic.

2. Thermal.....
- Melting-point. S 62, 143, 205; C 35.
- Critical point. C 7; S 236, 213.
- Specific heat. S 231.
- Heat of fusion.
- Heat of vaporisation.
- Conductivity. S 68.
- Expansion, &c.

3. Electrical, magnetic, optical:
- Capacity, &c. S 64, 252.
- Resistance. S 73, 94, 124 147, 148, 236.
- Thermo-electric. S 229.
- Susceptibility, &c. S 252.
- Permeability. S 38, 78, 80.
- Radiation. S 24, 40, 55, 105, 121, 128, 131, 156, 191.
- Absorption.
- Emissivity. S 97, 152, 196, 224, 242, 243.
- &c.

(*c*) *Miscellaneous.* T 2, 15; C 58; S 272.

(*d*) *Effect of Impurities:* Examples, occluded gases, slag, oxides, cadmium in brass, &c. T 6, 8, 24; S 161.

(*e*) *Effects of Outside Agencies, i.e.*, pressure, magnetic field, &c.

(*f*) *Corrosion*
1. Iron and steel.
2. Brasses, &c.
3. Structures. T 15.
4. Electrolytic surveys of cities, &c. T 25, 26, 27, 28, 32, 52, 54, 55.

4. Applications

(*a*) *Built-up Structures:* Examples, bridge columns. T 2.

(*b*) *Substitutes for More Costly Metals.*

(*c*) *Miscellaneous Improvements.* C 50, 51, 52.

(*d*) *Metals Best Adapted for Given Purpose.*

(*e*) *Effect of Time in Testing Operations.*

5. Manufacturing processes

Replies to innumerable requests for information. T 38.

6. Metallurgical processes and treatments, such as theory and practice of:

(*a*) *Annealing:* Examples, ordnance, bronzes, cast iron.

(*b*) *Forging and Rolling:* Examples, rails, axles, &c.

(*c*) *Tempering:* Examples, springs.

(*d*) *Quenching and Hardening:* Example, various steels.

(*e*) *Cementation:* Example, automobile parts.

(*f*) *Cold and Hot Working:* Examples, steels and bronzes.

(*g*) *Casting:* Examples, rail ingots, various alloys.

(*h*) *Plating, &c.:* Examples, copper, zinc, tin, nickel, &c.

(*i*) *Alternating Stress.*

(*j*) *Welding:* Examples, castings, rails.

(*k*) *Miscellaneous:* Examples, finishing temperatures of rails. T 38. Coatings for metal structures.

7. Special problems, such as
   - (*a*) *Electric fuses.* T 74.
   - (*b*) *Bonding of Rails.* T 62. 63.
   - (*c*) *Improvement of Locomotive Springs.*
   - (*d*) *Transverse Fissures in Rails,* investigated by (as example of methods used):
     1. Mechanical.
     2. Thermal.
     3. Optical.
     4. Chemical.
     5. Metallographic.
     6. Magnetic.
     7. Statistical.
     8. In co-operation with railroads.

8. Specifications for:
   - (*a*) *Government Departments.*
   - (*b*) *Cities, Commissions, &c.*
   - (*c*) *In Co-operation with Technical Societies.*
   - (*d*) *In Response to Private Requests.*
   - (*e*) *Compilation of :* Examples, foreign specifications of railway materials. T 61.

9 Metal failures, determination of causes such as of:
   - (*a*) *Railway Materials :* Rails, wheels, axles, &c.
   - (*b*) *Castings :* Forgings, &c.
   - (*c*) *Structural Bronzes and Brasses :* Examples, Catskill Aqueduct bronzes.
   - (*d*) *Fusible Boiler Plugs,* for Steamboat-inspection Service. T 53.
   - (*e*) *Miscellaneous :* Boiler plates, tubes, galvanised ware, &c.

10. Testing : Includes items in all of above schedule.
11. Correspondence and advice given on all of above items.
12. Compilation of physical constants of metals.
13. Bureau serves as referee in disputes concerning metals.

14. Co-operation with technical and scientific societies, such as committees of:
   - (*a*) *American Chemical Society.*
   - (*b*) *American Society for Testing Materials.*
   - (*c*) *American Foundrymen's Association.*
   - (*d*) *American Institute of Metals.*
   - (*e*) *American Electrochemical Society.*
   - (*f*) *American Society of Civil Engineers.*
   - (*g*) *American Institute of Mining Engineers.*

15. Metal Museum : *Exhibits of Metals.*

IRON LOSSES IN DIRECT CURRENT MACHINES.*

BY B. G. LAMME.

Summary.—The Paper discusses the various losses taking place in the rotating parts and magnets of a generator. It is shown that it is practically impossible to calculate the loss even at no-load with any degree of accuracy.

The principal object of this Paper is to show the causes for some of the principal losses. These are generally related to two sets of frequencies—namely, the normal frequency (revolutions per second multiplied by the numbers of pairs of poles), and some very high frequencies which depend upon number of slots, commutator bars, &c. The hysteresis losses are undoubtedly affected by these higher frequencies, but apparently not to the same extent as the eddy current losses. These high frequency losses are present in most classes of rotating machines. While in some instances they may overshadow all other losses, certain of them are characteristic of certain types of machine only, while others are liable to be present in any type of rotating machine. In most rotating machines only the no-load core losses can be measured with any accuracy by ordinary convenient methods of measurements. However, if the various components of the no-load loss can be approximately determined then it is possible to indicate in what way these same components will be affected by load. The quantitative determination of the component losses with load is, however, very difficult to determine, except in a very few classes of machinery. In direct current machines the no-load armature core losses are the hysteresis loss in the iron, eddy loss in the iron and copper and eddy loss in adjacent conducting parts which may be seats of E.M.F.s. The relative values of these losses depend upon many conditions. In a thoroughly well designed machine the eddy current loss in the copper and in other parts than the iron should be relatively small compared with the iron loss proper. Again the percentage of hysteresis loss in the iron itself depends upon many conditions, such as various frequencies in the machine, the grade of material, degree of lamination, the perfection of insulation of the laminæ from each other, the distortion of the material in handling and building, the conditions of punching treatment during assembly, grinding, filing, &c. Here we see so many variables that one cannot reasonably expect any great accuracy in any predetermination of eddy loss in the iron itself. Hysteresis loss is also affected by these conditions.

*Abstract of a Paper read before the American Institute of Electrical Engineers.

It is a fact well known to designers that the iron loss tables used by transformer engineers do not apply directly to rotating machinery, but that an increase of 100 per cent. or more is necessary dependent upon the type of machine. This increase is due largely to additional causes of loss which do not occur to any appreciable extent in transformers. Some of these additional losses are as follow :—

(*a*) In handling iron, experience shows that an armature may have its losses materially increased by springing and bending. A decided bend in a lamination beyond the elastic limit causes a loss in the part that has been bent 100 per cent. greater than its normal loss. This affects machinery with armatures which have light teeth. Even if the iron is bent with a small angle and not beyond the elastic limit the loss is materially higher with the iron in this strained condition. Also if the iron is strained in building up the armature the loss is increased.

(*b*) Another source of loss in the iron is due to the burrs of punching and in shearing iron small amounts adjacent to the sheared part are affected much in the same way as when iron is bent beyond the elastic limit. Consequently, in armatures with many comparatively long narrow teeth this sheared part may represent a relatively large percentage of the whole plate, and in addition this is a portion which has the largest losses. Burrs should be avoided and dies should be kept sharp and in good condition to keep the burring below 2 mils. In high-speed machines some means are necessary for removing the burr before insulating individual armature plates. Otherwise they may cut through the insulation and increase the eddy losses.

(*c*) Another source of loss is due to the filing of armature slots and cores. In ideal armatures with perfect punchings and assembly, there should be no filing, but in many cases in practice the armature iron does not build up with a perfectly smooth surface in the slots, and a limited amount of filing has to be done. Filing is most harmful in machines having a relatively high voltage per unit length of core. A milling cutter for cleaning out slots is usually worse than a file, as it produces greater burring of the edges, but the milling cutter may be followed by filing with a very coarse file, and the result may be just as satisfactory as with filing alone. Here again no method of calculation can show readily the loss due to such burring.

(*d*) The iron losses are affected by pressure to a certain extent, such as tightness with which the core is clamped, and this loss is probably related to some of the preceding losses, such as bending and springing to plates, effects of burrs, &c. The writer has known of a case where the temperature in the end section of the iron has been reduced 30 to 50 per cent. by "easing off" the end plates. The reduction in pressure usually affects only the end sections to any great extent. In connection with pressure the effect of heating the core may be considered. Cases have been noted where the effect of high temperature of the core has been to increase the pressure between the laminations due to expansion. This, in turn, increases the loss and still further increases the temperature. This effect has not been uncommon to a minor extent, but a few cases have occurred where the combined pressure and temperature together have resulted in excessive core temperature. A large machine showed this effect. After two years' working it developed an excessive core temperature, and on easing off the end plates the temperature fell to its normal value. In this case the armature teeth at each end of the core had been breaking off, although stout brass supporting fingers had been used. We notice here again that no great accuracy in calculation of such loss is possible. In moderately sized machines, however, the effect of pressure is not very serious within a reasonable range.

(*e*) Another source of iron loss is that of the pole face due to the tufting, or bunching, of the magnetic flux between the field pole and the armature teeth where slotted armatures are used. Obviously with all other conditions the same, these pole-face losses will depend upon a number of variables in the laminations of the material itself. The effect of burrs from punching, the burring over all the surface due to turning, the effect of pressure, &c., all appear in the pole-face loss, therefore it is again evident that great accuracy in the calculation of such losses is impossible in commercial apparatus. Sundry other conditions that affect this loss will be considered later on.

Armature Ring Loss.—The true iron loss in the armature ring is dependent upon the total flux per pole, distribution of flux, rate of change of flux, &c. The problem is considerably complicated by the fact that the distribution in the ring is not uniform, certain parts of the core having higher maximum densities than other parts. In ordinary practice, however, the core densities are relatively low, so that the loss can be approximated by averaging the inductions in certain parts. The rate of change of flux in the ring depends to a considerable extent on the flux distribution in the air-gap and armature teeth, and this induces increased losses and error.

The distribution of flux in the armature ring depends on the effec-

tive lengths of the various flux paths. These will only depnd upon various conditions such as the number of poles, diameter of armature, flux distribution in the air gap and teeth, &c. For any method which does not take this distribution into account is necessarily only approximate. In practice, however, there are many other variables as already pointed out, in connection with manufacturing conditions, and empirical rules have been developed which are, no doubt, as accurate as any attempt towards exact calculation.

Armature Teeth Loss at No Load.—The flux densities in the armature teeth can be calculated with more accuracy than in the various parts of the core, because in the teeth the fluxes are limited to fairly definite paths. The tooth loss may be considered as follows: The flux-density in each tooth passes through a cycle indicated by the shape of the field formed (*see* Fig. 1).

In this case the tooth density will be a maximum at A and remains practically constant until the point B is reached. It will then decrease until it reaches zero value at C. The cycle of flux change is not sinusoidal, and therefore the actual tooth iron loss should not agree with that represented by the usual iron-loss curves based upon sinusoidal changes in induction. This, however, may not be very great, and may be corrected by some suitable correcting factor. The density in the armature teeth is involved in the iron loss. This density is not uniform for the entire depth of the tooth, because the section of the tooth tapers off. This difference in sections may be considerable, and in small machines, however, high density at the base of the tooth tending to give higher iron loss is compensated for to some extent by the reduced volume of material. Consequently, at some point from one-half to two-thirds the way down the tooth the mean section may be taken, and the mean density and volume of material based upon this section may be used in approximating to the iron loss. The accuracy will be dependent upon the actual density used.

Armature Copper Eddy-current Loss at No Load.—There are a number of these same losses which are of quite a minor nature, but there are two of them which are relatively large losses. One of these is due to the flux from the field poles entering the armature slots and cutting the conductors. This is to a certain extent the function

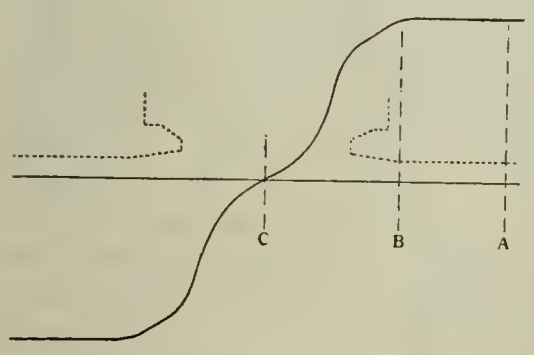


Fig. 1.

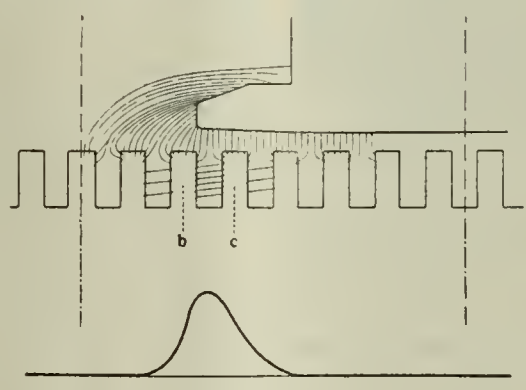


Fig. 2.

of the saturation of the tops of the armature teeth, and is also dependent upon the width of the slot opening compared with the iron-to-iron clearance. At first sight one would say that the larger the air-gap the more would the lines from the pole pass into the tooth top. The opposite is the case, however, In moderate sized machines with relatively small air-gaps and moderate slot widths the eddy loss from fringing into the top of the slot is comparatively small. This loss is usually greater in higher voltage large-capacity turbo-alternators, where relatively wide slots up to 1·5 in. or more are used, and where the air-gaps are very large. In such cases lamination of the top conductors to avoid loss from this cause may be desirable.

The second source of eddy loss in the copper is due to the peculiarities of flux distribution in the armature teeth. Suppose that Fig. 2 represents the magnetic conditions in a given machine under the central flat part of the field form, the armature teeth are working at the uniform induction, assuming there is no field distortion, but at the edges of the pole tooth density decreases slightly. If the saturation of the tooth under the flat part of the field is very high, say above 120,000 lines per square inch, the ampere-turns required to magnetise the tooth may be very considerable. However, at the edge of the pole the small decrease in the flux density (15 to 20 per cent.) will mean relatively enormous decrease in the ampere-turns for the tooth. For instance, the tooth c in Fig. 2 may require 2,000 ampere-turns, while the next tooth, b, under the pole edge, which is worked at 20 per cent. lower density, may require only 10 to 20 per cent. as many ampere-turns. Under this condition there will be a very considerable flux across the slot between c and b. Consequently the armature conductors which are cut by this flux will set up local currents, the value of which will be some function of the E.M.F. producing the current and of the dimension of the conductor, &c. Owing to the shape of the permeability curves of steel at very high saturation, the difference between the ampere-turns of two adjacent teeth may increase faster than the square of the terminal of the E.M.F. Consequently the eddy-current loss due to this cause may decrease faster than the *fourth power of the total induction per pole.* Consequently it is desirable that these eddy currents be kept at a low value at no load, because the high tooth ampere-turns under full load conditions would tend to increase the percentage of these losses very greatly. Fig. 3 illustrates these. Fig 3 shows the characteristic core loss for a generator in which the copper loss due to the above cause is very large at the higher E.M.F.s. From data obtained several years ago the following formula was derived, but it applies only to windings with two conductors in the depth of the slot. This formula for the loss in conductors is

$$\text{Watt loss} = 180 V_c R_s p (1000+a)^2/10^8,$$

a is the maximum ampere-turns for one tooth, V_c the total volume of copper in cubic inches in one slot, R_s the revolutions per second, p number of poles. The values for the eddy-current watt loss in the copper were approximated to by taking the iron-loss curves at the lower E.M.F. values and then projecting them for the higher values according to the loss which the iron loss alone should follow. The difference between this corrected iron loss and the actual test curves was assumed to consist largely of eddy-current loss. As this difference usually increased very rapidly at higher inductions, the above assumption was in agreement with the statement above that the eddy-current loss may increase much more rapidly than the square of the flux. In this case the pole-face loss would have to be taken into account. This was taken care of by tests with relatively large air-gaps, the pole-face loss thus being very small. Another formula

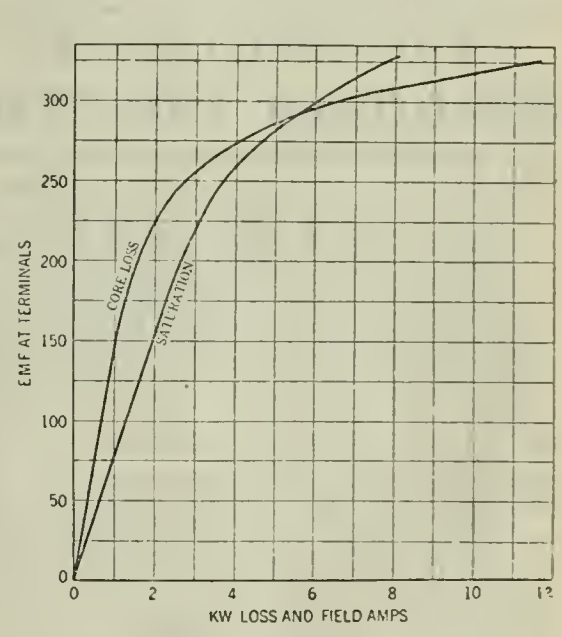


Fig. 3.

which agrees with the above fairly closely at high saturation, but which gives no loss at zero saturation, is as follows

$$\text{Watt loss} = 135 V_c R_s p (4000+a)/a 10^8.$$

Various attempts were made to involve different factors, but one of the resulting formulæ gave as consistent results as the above. This formula is an extremely crude one, but it appeared to fit most of the cases the writer was able to analyse. The table following shows the value of the copper eddy loss compared with the calculated loss by the first formula above for a number of machines. In these tests old machines were used, so that the losses might be fairly high and more or less exaggerated values obtained. In the newer machines the losses are, of course, much smaller, and they are less suitable for use in testing this way.

Output, kilowatts.	Terminal E.M.F.	R.P.M.	No. of poles.	Eddy loss from test curve.	Eddy loss calculated.
340	600	685	6	2·7	3·4
	700			10·0	9·7
500	600	225	10	7·5	6·15
	625			17·5	12·5
750	550	514	8	4·5	3·3
	700			33·0	36·5
1,000	600	514	10	4·5	4·6
	700			10·0	11·3
2,000	575	300	14	12·0	7·1
	675			36·0	28·2

(To be concluded.)

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury, court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential circulation all over the World.** *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books
can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preporotion.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

COMMON BATTERY TELEPHONY SIMPLIFIED. By W. Atkins. *Third issue.* 3s. nett., postage 3d.

ELECTROMAGNETIC THEORY. By Oliver Heaviside. Vol. I. Price 12s. 6d. Vol. II Price 12s 6d. Vol. III. 21s. nett.

ELECTRIC CRANES: THEIR DESIGN, CONSTRUCTION AND APPLICATION. By H. H. Broughton, M.I.E.E. Price 25s. nett, postage 9d. (abroad, 1s. 8d.)

ELECTRICAL TESTING FOR TELEGRAPH ENGINEERS. By J. Elton Young. Price 10s. 6d. nett, post free 11s

STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Price 7s. 6d nett.

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie, A.M.Inst.C.E. *New Edition in preparation.*

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation.*

"THE ELECTRICIAN" PRIMERS (84 Primers in all, and a GLOSSARY). Single Primers 3d. each post free. *In One Complete Vol.*, 10s. 6d. *nett, or Three Separate Vols. (Vol. I.* 3s. 6d. *nett ; Vol. II.*, 6s. *nett ; Vol. III.*, 4s. 6d. *nett*). Prospectus free. The Primers are revised or re-written as new printings are called for, and new Primers are added from time to time. Five New Primers: Gas Engines (No. 52), Oil Engines (No. 52A), Common Battery Telegraphs (No. 60A), Electric Clocks (No. 79), Electric Impulse Dials (No.79A), now ready. Revised Primers, 1914 and 1915: No. 29 (Management of Dynamos and Electric Machinery); No. 46 (House Wiring for Electric Light) ; No. 63 (Repairing Submarine Telegraph Cables); No. 42 (Electric Ignition) ; No. 49 (Steam Engines) ; No. 54 (Comparative Advantages of Steam and Producer Gas for Power Production) ; No. 59 (Diplex and Quadruplex Telegraphy) ; No. 61 (Automatic Telegraphic Apparatus).

ELECTRIC TRACTION ON RAILWAYS. By Philip Dawson, M.I.C.E., M.I.E.E., &c. Handsomely bound ; fully illustrated. Price 25s. nett, postage 6d. U.K., abroad, 1s. 6d.

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM): A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d. each, post free. Hanging Cards : 1/- each post free. Pocket Books, complete in envelope, 2s. 6d., post free.

Now Ready.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s.** nett, post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

PHYSICAL METALLURGY AND OTHER PROBLEMS.

An address on "Problems of Physical Metallurgy," presented at a recent meeting of the Mining and Metallurgical Section of the Franklin Institute, serves to give an excellent idea of the nature of certain of the problems which confront the metallurgist and which are engaging his attention. The address, which was delivered by proxy for Dr. G. K. BURGESS, has a direct bearing on the subject of industrial research, and indicates the thoroughness with which many problems are being systematically investigated at the present time. Elsewhere is given a summary of the various activities relating to metals that have been executed or are being carried out at the Bureau of Standards, and in the Address it is stated that each of the items mentioned has been or now is an object of experimental study on the part of one or another of the several scientific and technical divisions into which the Bureau is divided.

"In planning an experimental attack on any comprehensive problem in physical metallurgy," states Dr. BURGESS, "it is . . . essential to keep constantly in the foreground the inter-relations of those various factors dependent upon manufacture and previous history of the material studied ; which is another way of saying that, while physical metallurgy may be said to be that branch of science which treats of metals in their physical aspects, yet it takes cognisance also of chemical metallurgy—the only metallurgy of a few years ago—chemistry and physical chemistry, including crystallography and metallography, and expresses itself largely in the language and uses the instruments of physics."

A noteworthy feature of the Address is the section in which reference is made to the co-operation with manufacturers. Such co-operation has a threefold effect on research. In the first place, it permits of the utilisation of manufacturing plants for the carrying out of investigations on a commercial scale under commercial conditions and at relatively little cost ; in the second place, valuable experience—the experience of the practical man—is brought to light that might otherwise pass unnoticed ; and finally it brings home to the manufacturer the value of the systematic and scientific investigation of a problem. This is confirmed by Dr. BURGESS, and we note with pleasure that manufacturers have placed at the disposal of the investigators, without restriction, the facilities afforded by manufacturing plants. Another item of interest is the metal museum that has been established. Such a museum, when fully developed, will be invaluable to those engaged in metallurgy. The people of this country have yet to learn the influence of the technological museum on their welfare.

In addition to the co-operation with manufacturers, stress is laid upon co-operation with technical and scientific societies. The extensive programme outlined by Dr. BURGESS is being carried out in co-operation or after consultation with committees representing the several scientific or technical societies interested in the particular subject. At the present time, in the work on physical metallurgy, there is active co-operation between the Bureau and the following societies and institutions : Chemical Society, Society for Testing Materials, Foundrymen's Association,

Institute of Metals, Electrochemical Society, Society of Civil Engineers and the Institute of Mining Engineers.

The results of the investigations are published at frequent intervals in the form of technological and scientific papers and as circulars of information. These papers and circulars are in reality authoritative treatises on the subjects with which they deal, and they deservedly enjoy a world-wide reputation. If we remember rightly, they are distributed free of charge to the libraries and technical and scientific institutions of the United States, and are obtainable by the general public at a cost which seldom exceeds a few pence per copy, as it is a law that all public documents shall be sold at cost price. This means that paper and printing alone are charged against the purchaser.

Thoughts of the future crowd in on us in writing the above disjointed paragraphs. In the past our metallurgists have succeeded in spite of faulty legislation, and to their credit stand many, if not most, of the fundamental discoveries that have been made in the metallurgical arts. We applaud the co-operation between the Bureau of Standards and the learned societies, not only in connection with the researches in physical metallurgy, but also in practically all researches that have been made or contemplated, and we would have the principle extended so as to make all research work in the future international in character. The existence of international commissions, such as the International Electrotechnical Commission, may be taken as evidence that the wider co-operation is possible.

For nearly as long as we can remember we have allowed ourselves to be soothed and flattered by those who proclaim the loveliness of everything in the garden, and it has taken the bloodiest war of all time to remove the scales from our eyes. Now that our vision is clear, we perceive that weeds characterise the garden. Apart from the heroism of a section of our people and the profit derived from patriotism by another section, the one great fact brought to light by the war is that, whilst our Empire is founded on the rock, certain of the structural details are faulty. With this knowledge, and armed with the evidence of our unpreparedness two years ago; strong in our determination to make those responsible for a catastrophe, second only to Calvary, pay the penalty to the full, we can continue during this, the third year of the war, manfully to uphold with our whole might the cause of the weak and of the oppressed.

We must see to it that we do not run into the danger of taking the will for the deed. As part of the penalty, it is the will of our people that the enemies of civilisation shall be deprived of much of their trade and of the fruits of their industry. For two years fatuous optimists have been raising the cry "Capture the trade of the enemy," and they have urged the passing of Acts of Parliament intended to secure for our traders a large proportion of the trade enjoyed, and assuredly earned, by our enemies.

The stern lesson we have to learn lies like an open book for all who wish to read. The lesson is that capturing the trade of the enemy will demand the same self-denial and sacrifice of our traders as capturing the trenches of the enemy demands of our soldiers. After two years of war many of our people are beginning to realise that Acts of Parliament alone do not suffice to deprive the enemy of his trenches. Just as the capture of a trench necessitates sacrifice on the part of our soldiers abroad and incessant toil on the part of our artisans at home, so will the capture of enemy trade necessitate sacrifice and incessant toil, and as surely as in war we beat the enemy by capturing trench by trench, so in trade we shall have to beat him by capturing trench by trench. Just as in war the wise general pauses after capturing a trench in order to consolidate the position, so in trade our leaders in industry, after securing a slight advantage over their trade rivals, will have to pause in order to consolidate.

We regard many of those who would have us capture the trade of the enemy as "get-something-for-nothing" people—as people who waste their own and other peoples' time in looking for the philosopher's stone in the hope of turning everything into gold. To such people we would say that not without reason was it written "Be not deceived; . . . for whatsoever a man soweth, that shall he also reap."

ELECTRICALLY HEATED FURNACES FOR THE LABORATORY.*

BY K. ARNDT.

Resistance furnaces, employing platinum, have long been used to obtain temperatures up to 1,400°C. or even 1,500°C. in a confined space of small dimensions; wire or foil is generally used. The firm of W. C. Heraeus, at Hanau, has constructed many furnaces of this type, both large and small, and of different shapes. When a heavy current at low voltage is used, and the cost of platinum is no consideration, a platinum tube is very convenient, and serves the purpose of forming the wall of the furnace. The packing often consists of burnt magnesia. Below 1,000°C. wire of nickel or nickel-chrome is often used, but this necessitates a packing of carbon powder in order to exclude the effects of oxidation. Above 1,600°C. platinum cannot be used, because it volatilises too much; it fuses at 1,750°C. Iridium tube furnaces have been used in the Nernst institute, and have done very useful work in the Reichsanstalt. But they last only a very short time in spite of all precautions; working with such furnaces is therefore a very costly business. Tungsten fuses at 3,000C°., and can be used either in the form of wire or tube; but it can only work in a vacuum, because it oxidises in the air and forms a carbide with carbon. For the highest temperatures, carbon alone is suitable. It can easily be obtained in the form of tubes; such tubes are made of the best material for electro-chemical purposes, especially of Acheson graphite. The walls of the tube must not be too thin, on account of the lack of mechanical strength. Arsem has devised a method of cutting the tube spirally, which gives it a very desirable elasticity. The oxygen of the atmosphere is removed by surrounding the furnace with a gas-tight covering, which is pumped free of air or filled with an indifferent gas. An unfortunate feature of carbon furnaces is that the hot carbon permanently gives off gases, and all bodies, heated in the furnace, take up carbon. If the temperatures are not too high, some sort of protection against these impurities can be had by inserting a quartz tube within the carbon tube. Still better is it to insert several concentric tubes, and to introduce a stream of hydrogen through the ring-shaped spaces between them. But above 1,600°C. there is no material suitable for these protecting tubes. Still the carbon-tube furnace has become a part of every properly-equipped research laboratory. Tucker, Ruff, Goecke, Stähler and Elbert have all done good work in designing such furnaces. (Some notes in the original Paper give references to their various publications.)

The carbon-tube furnace, constructed by Stähler and Elbert, is intended for temperatures up to 2,000°C, and pressures up to 50 atmospheres. It is shown in Fig. 1, and consists of a thick steel vessel *A*, closed by a cover *B*, which is fixed by six large hexagonal screws on a conical seating *C*. The current enters the phosphor-bronze tube *E* at *D*, which is insulated by the vulcanised fibre rings *F*; it passes through the hot tube *K*, and thence through the sides of the vessel to the other terminal *L*. The vulcanised fibre rings are pressed together by the rings *G* and *H*, and form a gas-tight gland, which also holds the tube *E* in position. The furnace is used, for instance, for the preparation of boron nitride out of boracic acid, carbon and nitrogen; in that case the materials are introduced into the graphite receptacle, *M*. Nitrogen is admitted through the valve *N*, till the desired pressure is reached, and care must be taken, as the pressure is greatly increased by the heat. The lower part of the furnace is cooled by standing in water, which also drips over the upper part. A pyrometer of the Le Chatelier type is introduced through the opening *O* in the tube *E*, and made gas-tight by the plug *P*. In order to measure temperatures above 1,500°C., some preliminary curves must be constructed, and there is no difficulty in

* Translated from the "Elektrotechnische Zeitschrift," Heft 9, 1916.

doing this up to 2,000 C., as the relation between temperature and current almost follows a straight-line law.

The vacuum furnaces of Arsem and of Ruff are also upright, and surrounded by a cooled metallic vessel. Ruff also designed an arrangement by which the vessel, containing the heated materials, could be dropped into water, and so suddenly cooled. This prevented any chemical change, which otherwise usually takes place, if the substance is allowed to cool gradually.

The newest type of furnace of this kind is the vacuum furnace, designed by J. Wolff and E. Müller. Fig. 2 gives a longitudinal section of the furnace. The carbon tube, *e*, is 30 cm. long; it has an external diameter of 5 cm., and an internal diameter of 2 cm. In

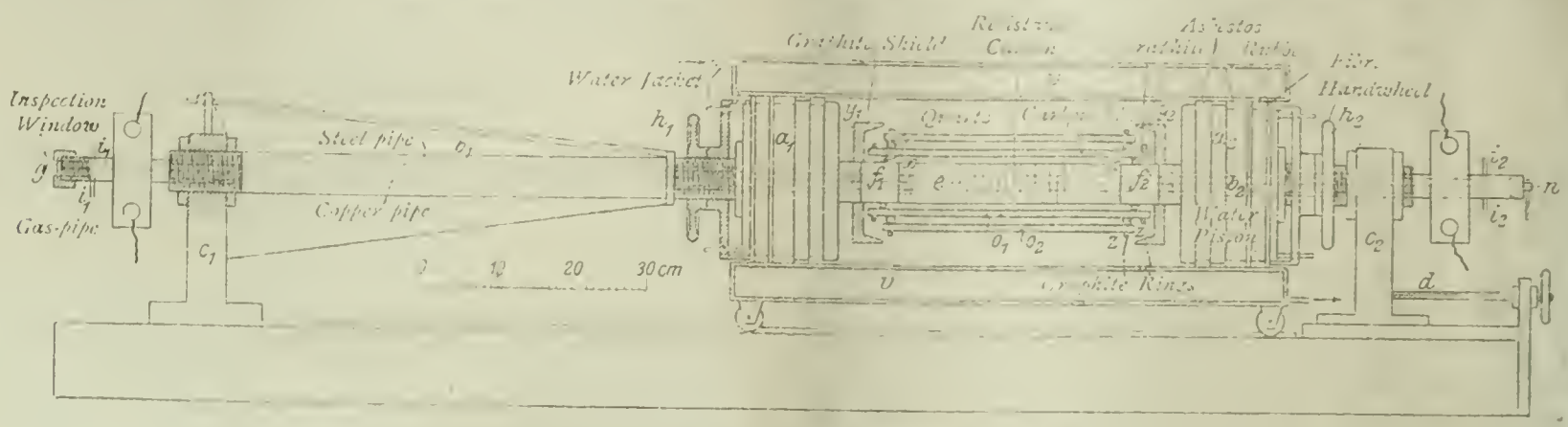


FIG. 2.—WOLFF AND MÜLLER'S VACUUM FURNACE.

order to increase the electrical resistance, 15 cuts are made in it, alternately from opposite sides, in radial directions, cutting through two-thirds of the thickness of the walls; these cuts are 10 mm. apart, and 1 mm. or 2 mm. broad. This also adds to the elasticity of the tube, so that it does not break so easily. Short pieces of graphite tube, f_1 and f_2, serve to introduce the current; one of them is screwed into the hot tube, while the other is very carefully bored so that it makes a good fit of such a kind that a small amount of longitudinal movement can take place, thereby allowing for expansion. In order to conserve the heat, the hot tube is concentrically surrounded by two other carbon tubes, o_1 and o_2, which at the outer ends are insulated by quartz bearers. It is necessary at times to remove these outer carbon tubes, and convenient arrangements for this

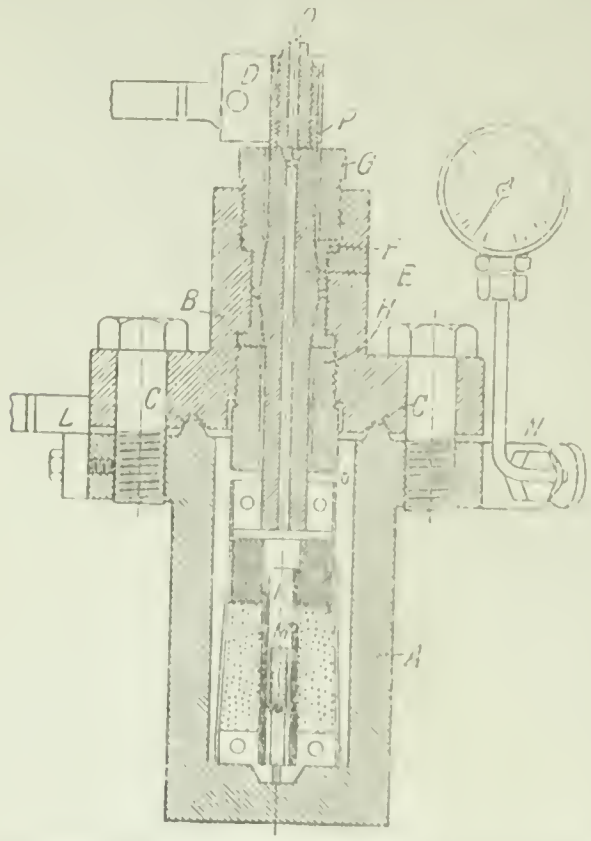


FIG. 1.—STAUDER AND EBERLE'S ELECTRIC LABORATORY FURNACE.

purpose have been devised. They are divided longitudinally into two half cylinders, and are held together by two graphite rings, *zz*, slipped over them, which are externally turned out of conical section. End-motion is limited by the graphite discs, a_1 a_2. The outer covering of the furnace has double walls, and cooling water is passed between them. The "water pistons," a_1 a_2 are inserted within the cylindrical water jacket, *c*. These water pistons are packed with rings of "steam rubber"; the rings, which allow a certain amount of play, are held on the one side by rings of vulcanised fibre, and on the other side they are pressed to the bandwheels, h_1 and h_2, so tightly against the walls of the containing chamber, that they are able to withstand a pressure of several atmospheres. The rubber is protected against the temperature of the furnace by rings of asbestos. The water jacket is able to slide to one side on rails; this exposes the hot chamber, and it is then possible to replace a burnt tube, without running the risk of breaking a delicate tube when the apparatus is reassembled. The materials, which are to be heated, are contained in a small graphite boat, which is attached to a long graphite rod: this is introduced at *n* and pushed through b_2 into the furnace; the opening *n* is then screwed to. On the left-hand side is the inspection-glass *g*, which enables the operator to see the inside of the furnace: with an optical pyrometer, the temperature can be determined. An arrangement is also possible by which the boat can be introduced into the vacuum, the space having been already heated to the desired temperature: this makes continuous working possible. If the tubes, i_2, are closed, two oil vacuum pumps can be connected to i_2, and in seven minutes can create a vacuum corresponding to a pressure of 3 mm. of mercury. When the furnace is heated for the first time, the tubes must be heated very slowly, so that the volatile impurities, such as tar products, silicon, &c., are not distilled too quickly, which might crack the tubes. At a later stage, it is possible to proceed more quickly. If used for a long time at high temperatures, the carbon tube is converted into graphite and loses in strength. Tubes of Acheson graphite are, of course, free from this peculiarity, but on account of their higher conductivity they require much heavier currents to produce the same temperature. If the boat is 10 cm. long it can be kept at a uniform temperature of 2,300 C. throughout its length. The furnace is able to withstand temperatures from 2,400° C. to 2,500° C. for hours together. At 2,000 C. it takes about 200 amperes at 30 volts; at 2,500 C. it takes 380 amperes, and at 2,850° C. it requires 500 amperes. It requires two hours to cool down from 2,800 C. before it can be conveniently handled.

ELECTRICAL SIGNALLING WITH BARE WIRES.*

A report, of which we give an abstract below, has been prepared on this subject by Dr. R. V. Wheeler (of the Home Office Experimental Station, Eskmeals) and Prof. W. M. Thornton (of Armstrong College).

A previous report, dealing with battery-bell signalling systems, has shown that, contrary to general expectation, the break-flash that occurs at uncovered signal wires when a signal is given can, in the majority of cases, ignite inflammable gas and must therefore be regarded as "open sparking." The object of the present report is to define the precautions necessary in order that the bare-wire signalling system shall be rendered safe.

PRESENT PRACTICE.

Battery Bells.—The conclusions reached respecting battery-bell systems of signalling as a result of the investigations described in the report already referred to, have been amply confirmed by further experiments. Further examples of bells have been received at the Experimental Station from different makers and tested, and it is clear that the ordinary type of bell causes dangerous break flash at the signal wires when a battery of either dry or wet Leclanché cells, of voltage in some cases as low as 4 to 6, is employed. On the other hand, examples of bells were received which could be used safely with a battery of dry cells at 25 volts.

Following the method of testing previously adopted, what may be termed the "battery efficiency" of all the bells received were determined. The measure of the battery efficiency adopted was the resistance (in ohms) that had to be included in the circuit in order to render the bell only just capable of ringing. This was determined with batteries of 25 and 15 volts dry cells ("Leclanché," size C), and 25 and 15 volts wet

* Issued by the Home Office. Price 5d.

Leclanché cells (quart size). The results are recorded in a table in the report, where are shown also the maximum currents obtained in each case when the resistance of the bell only was included in the circuit; the currents required to cause the ignition of an 8 per cent. methane-air mixture by the break-flash at the signal wires; and the inductances of the bells at these igniting currents. From these results several conclusions can be drawn.

As was shown in the previous report, the usual types of bells are all capable of giving a dangerous break-flash at bare signal wires. The fact must be emphasised that nearly every flash that occurs when the bare wires are separated after a signal has been given would ignite a firedamp-air mixture that contained between 7·5 and 9·5 per cent. of methane were such a mixture accidentally to surround the wires at the time. With a given bell in the circuit, the only break-flashes that cannot ignite such mixtures are those that occur so far along the signal wires that the resistance of the wires reduces the current available at the flash below the minimum igniting current. With many bells the minimum igniting current is but little greater or is even less than the minimum ringing current.

The battery efficiencies of the bells vary considerably and are dependent largely on their mechanical construction. The maximum battery power permissible under the Coal Mines Act is 25 volts. The battery efficiency at this pressure when dry cells are used varies from 400 to 72 ohms, the mean value for all the bells being 200 ohms; that is to say, 200 ohms resistance can be included in the circuit before the bell ceases to ring. If a battery of dry cells at 15 volts is used, the mean efficiency drops to about 120 ohms, with a minimum of 40 ohms; while with wet Leclanché cells at 15 volts it drops to about 90 ohms with a minimum of 25 ohms.

Inquiries as to present practice as regards the type of battery usually employed show that wet Leclanché cells are generally favoured. Reports from H.M. Inspectors of Mines are agreed in stating that, except in North Staffordshire where 10 per cent. of the battery bells used are actuated by dry cells, the use of wet Leclanché cells is practically universal. There should, therefore, be no great inconvenience caused if the use of wet Leclanché cells were made compulsory. The tests show the desirability of such a restriction.

It is questionable, however, whether it would be wise to reduce the voltage allowable from 25 to 15 or less. Even with 3 or 4 volts some types of bells at present in use are unsafe, whereas the introduction of "anti-sparking" devices would allow a battery at 25 volts safely to be used. While, therefore, no gain in safety would be experienced by stipulating a maximum voltage of, say, 15, the ringing efficiency of most of the bells would be seriously affected thereby. On the other hand, a battery of wet Leclanché cells at 25 volts has little greater danger than any battery necessary to give a reasonable working current.

The bells examined were of a variety of patterns. There are three common types. In bell type A, the commonest type, the hammer is a continuation of the armature, the whole being attached by means of a flat spring to a pillar near the magnet. In bell type B, the pivot of the armature, which is held back by a spiral spring, is formed by a revolving pin which passes through a flame-tight joint in the bottom of the casing. Bell type C consists of two separate parts, the electrical portion and the gong portion. The electrical portion is completely enclosed and the casing is flame-proof. The hammer, actuated by the armature, is within the casing and strikes one end of a steel stud which passes through a flame-tight joint in the casing and nearly touches the rim of the gong. The impulses of the hammer are transmitted by the steel stud to the gong.

Relays.—As a considerable amount of mechanical work is expended in ringing a bell, a corresponding amount of additional battery power is required beyond that necessary to overcome the total resistance of the circuit. A relay introduced into the main signalling circuit reduces the battery power required to give a signal by reducing the mechanical work that has to be performed on that circuit, a usual practice being to cause a subsidiary circuit, containing the bell and a separate battery, to be closed by the action of the relay.

Since relays contain electro-magnet coils, often highly self-inductive, the same consideration respecting the possible danger of the break-flash at the signal-wires apply as with bells. A number of relays obtained from different makers have been examined, the mode of procedure being similar to that adopted for bells. The main results of the tests are given in the original report.

The battery efficiencies with relays are greatly superior to those of most bells, a battery power of 10 volts in most cases allowing ample margin for the resistance of bad connections on the signal wires. This superior battery efficiency is unfortunately discounted by the higher inductances of relays compared with bells, due to the larger number of turns of wire with which the relay magnets are wound. It thus results that though relays can be worked with a smaller battery than most bells, they have, in general, a lower "igniting current" at which the break-flash on the signal wires becomes dangerous.

As regards present practice in respect of the use of relays, more particularly as regards the battery power usually employed, it would appear from reports obtained from H.M. Inspectors of Mines that although in the majority of mines smaller batteries are employed to actuate relays than would be used for bells over the same length of line, yet, with few exceptions, the battery power is in excess of what is sufficient to give a dangerous break-flash at the signal wires. The commonest types of relays are dangerous when used with a battery of more than four wet Leclanché cells, while the reports of H.M. Inspectors of Mines show that a battery of less than six such cells is used comparatively rarely.

After a section on the theory of bells the subject of safety is considered.

Safety.—The degree of "safety" of a bell can be measured by its liability when used with a given battery of causing, through self-induction, a dangerous break-flash either at the trembler contacts or at the signalling point. As already stated, the break-flash that occurs at the signalling wires can be as intense as that at the trembler contacts; viewed in a rotating mirror the flashes that occur at the trembler contacts have the same nature as break-flashes at the signal wires, their duration being short compared with the period of the bell. The duration of any break-flash depends upon the voltage of the circuit and the voltage added by self-induction.

Experiments show that ignition by a rapid break-flash at a low circuit voltage depends on the inductance voltage at which the flash is formed, and the igniting power of the flash is proportional to the product Li. When the break of circuit is made slowly, the igniting power of the flash has been found to depend upon its energy, $\frac{1}{2}Li^2$. There are thus two limiting conditions for the igniting power of the flash; at the one the inductance voltage is of importance, at the other the energy. For any given gaseous mixture there is a range of rapidity of break over which the two types of ignition blend, so that under certain conditions the igniting power of the flash may be proportional neither directly to i nor to i^2, but to some intermediate value of i. Thus in the previous report the relation between L and i was determined when L varied between 0·608 henry and 0·09 henry and the current was at 90 volts pressure. In this case $Li^{1\cdot4}=k$, so that the igniting power of the break-flash fell between the conditions under which it would be proportional to the inductance voltage (Ldi/dt), and thus proportional to Li, and the conditions under which it would be proportional to its energy ($\frac{1}{2}Li^2$).

The inductance voltage $E_s=Ldi/dt=kLi$, where k is a constant. Since $i=E/r$, therefore, $E_s=kL.E/r$. The inductance voltage is thus inversely proportional to the resistance of the circuit when, as can be considered roughly the case in practice, the battery voltage and inductance are constant. In so far, therefore, as the ignition of inflammable mixtures is dependent on the product Li, ignition can be prevented by the use of high resistance windings and high resistance batteries. The energy of the break-flash, $\frac{1}{2}Li^2$ or $\frac{1}{2}LE^2/r^2$, is even more dependent on the circuit resistance, being inversely proportional to its square.

Mechanical and Electrical Efficiency.

The efficiency of a bell-signalling system can be estimated in two ways: (1) by the magnitude of current required just to actuate the bell; and (2) by the loudness of sound or rate of ringing for a given current. When the circuit is simple, without relays, both of these criteria of efficiency depend upon the mechanical and electrical characteristics of the bell and line.

Mechanical Efficiency.—The current at which ringing just ceases depends upon the adjustment of the mechanical tensions (of the armature spring, and, in most bells, of the lighter spring control derived from the contact strip on the armature), and upon the length of air-gap, as well as upon the electro-magnetic pull.

An attempt was made to determine experimentally the most efficient setting for bells, having regard to (1) the tension on the armature spring; (2) the mass of the moving parts; (3) the length of the air-gap; and (4) the setting of the hammer relative to the gong. The results bore reference particularly to bells of type B, but many of them are of general application.

It can be stated generally that so far as the minimum ringing current is a measure of the efficiency of a signalling bell, the best results are obtained with a low tension on the armature spring. For example, with an experimental bell of type B, a tension equal to 7 oz. or 8 oz. was found to be ample, tensions ranging from 2 oz. to 36 oz. having been tried. The rate of ringing for a given current is over a long range independent of the tension on the armature spring or the length of the air-gap, though the most rapid rates of ringing are obtained with very low (2 oz.) or very high (32 oz.) tensions. The ringing force, as estimated by measuring ballistically the energy of the blows given by the hammer, is practically independent of the tension on the armature spring or the length of the air-gap, and is most affected by the distance of the hammer from the gong.

On the whole, therefore, it would appear to be advisable to use as light a spring on the armature as will suffice to maintain good contact at the trembler in readiness to ring and to return the armature to its first position after the ringing blow has been given. Any slight sacrifice in the rate of ringing or loudness of sound that may be caused by using a light spring on the armature is more than compensated for by the fact that the bell can be actuated by a small current.

Electrical Efficiency.—Reverting to the effects produced by a current in passing round the bell coils. The chief effect is the magnetisation of the cores. This magnetisation grows with the current and is proportional to the ampere-turns of the windings.

The number of blows per second made upon the gong depends upon the duration of the current at each make of circuit (that is, upon the point in the curve of growth of current at which the circuit is broken by the trembler). From actual records taken from a number of bells an average period when the bell is actuated by a battery of 10 wet Leclanché cells may be taken as three times L/r. The number of blows per second would thus be $\frac{1}{3}r/L$. Let this equal n. The product Pn may be taken as a measure of the total mechanical energy of continuous ringing. From the foregoing Pn varies as $E^2T^2r^2/rL$. The inductance, L, is equal to $4\pi T^2/R$, where R is the reluctance of the magnetic circuit; so that, omitting constants, Pn varies as E^2/r. (Here P=magnetic pull and T=number of turns.)

Consequently, with a given battery voltage, the ringing power of a bell varies inversely with the resistance of the circuit. It is not possible, however, to work with a very low resistance in circuit, since the current

is limited both by the kindof battery used and by considerations of danger due to sparking at the bell or point of signalling.

Safety Combined with Efficiency.

It is necessary now to consider together the conditions requisite to obtain the maximum ringing power of the bell and the minimum igniting power of the break-flash.

Number of Turns.—The authors reach the conclusion that a bell with many turns of wire gives the greatest ringing power per igniting-current ampere—is, in fact, the "safest-efficient" bell (apart from the use of special devices)— on a circuit of given voltage and constant resistance.

To test this conclusion a series of experiments was made to see how the ringing power and minimum igniting-current were affected by the number of turns of wire in the magnet windings. The bell was of type B and had a single bobbin wound with 32-gauge silk-covered copper wire, 112 turns per layer. To obtain a measure of the ringing power a method similar to the photometric method of comparing the intensities of lights was used. A bell of the same pattern and tone of gong as the experimental bell was kept ringing under constant conditions, and the experimental bell moved until it was judged by observers at a fixed point to have the same intensity of sound as the standard. The result showed that for every bell and size of winding wire there is a definite number of turns at which efficiency of ringing combined with "safety" of the self-induction break-flash reaches a maximum.

Diameter of Core.—Throughout this report the value recorded for L, the coefficient of self-induction of the circuit, has been that obtained at the minimum igniting current—the least current at which the break-flash at the signal wires causes ignition of an 8 per cent. methane-air mixture. In the case of bells, the armature of the magnet during the measurement of inductance has been held in such a position that electrical circuit at the trembler was just established; and in the case of relays the armature has also been held in its nearest working position to the magnet.

These determinations of inductance give a measure of the magnetic state of the circuit at the moment of formation of a break-flash that is just capable of igniting the most sensitive methane-air mixture. At other times, as the current passing through the bell changes during the ringing, or as the resistance of the circuit is changed, the inductance does not necessarily have the same value.

Changes in the position of the armature vary the magnetic resistance or "reluctance," R, of the circuit, so that, since $L = 4\pi T^2/R$, L also varies. This reluctance is composed of that of the air-gap between the armature and the magnet and that of the iron parts of the bell, in series, and, when the intensity of magnetism is low, the magnetic permeability of iron is so high that its reluctance is negligible compared with that of the air-gap. The determinations of inductance given in Table I. in the case of bell No. 1 illustrate the effects of altering the air-gap between the armature and the magnet. The current passing through the bell was 0·20 ampere in each case:—

Table I.

Air-gap.	Coefficient of self-induction, L.	Air gap.	Coefficient of self-induction, L.
0·5 mm.	0·48 henry.	6·0 mm.	0·36 henry.
1·5 ,,	0·43 ,,	9·0 ,,	0·35 ,,
3·0 ,,	0·39 ,,		

Apart from changes in the inductance due to changes in the position of the armature, it would appear that mining bells and relays have iron cores of such small cross-section that the iron becomes saturated at quite low currents, and the consequent fall in permeability as the current is increased reduces the coefficient of self-induction. The values of the coefficient for bell No. 1 at different currents, as given in Table II., the air-gap being kept constant, are typical:—

Table II.

Current.	Coefficient of self-induction, L.	Current.	Coefficient of self induction, L.
0·02 ampere	0·55 henry.	0·25 ampere	0·36 henry.
0·03 ,,	0·70 ,,	0·30 ,,	0·33 ,,
0·04 ,,	0·88 ,,	0·35 ,,	0·30 ,,
0·10 ,,	0·55 ,,	0·40 ,,	0·28 ,,
0·15 ,,	0·47 ,,	0·45 ,,	0·26 ,,
0·20 ,,	0·40 ,,		

These results are shown plotted as a curve in Fig. 1, and for comparison the curve representing the change of permeability, μ of iron with magnetic field H ($= 4\pi/10$ times the ampere turns per centimetre of magnetic circuit). The two curves are identical in form, and it is clear that the magnetisation of the iron cores of mining bells and relays dominates their inductance, and that, contrary to expectation, the reluctance of the air-gap is not the controlling factor of the magnetic circuit.

From this it can be concluded that, probably for economy in winding, the iron magnet cores of mining bells (in particular) and relays are too small, being saturated too easily. For a given outside diameter of bobbin there is evidently one diameter of core which will give the best effect. Consider the influence of the diameter, d, of the core on the magnetic pull P on the armature. It can be shown that P is proportional to AB^2, where A is the area of the field between the poles and armature and B the mean flux density in the gap. Let μ be the average permeability of the circuit, and as a first approximation assume no magnetic leakage, and that all the turns are equally effective. Then, since $A = \pi d^2/4$ and $B = \mu i 4\pi/10$, $iT/l : P = (\pi d^2/4 . \mu^2/l^2 . 16\pi^2/100) . i^2T^2$.

The ampere-turns, iT, are proportional to the winding-space on the bobbin, that is to say to $(D - d)$, so that $P = k'd^2(D - d)^2$, where k' includes all the constant terms. On differentiation it is found that P is greatest when d is one-half of D.

The best diameter of core to give the maximum pull on the armature for the least igniting-current is given by the relation

$$P/i = k'd^2(D-d)^2/i = K(d^2D - d^3)(D+d).$$

The ratio P/i has a maximum value when $d = 0{\cdot}62D$.

Approximately, therefore, it would seem that in order to obtain the maximum efficiency the diameter of the core should be between 0·5 and 0·6 times that of the bobbin. It has been assumed, however, that the mean value of μ is not affected by change of area of the core, whereas in reality μ increases with the area. Further, the calculations make no allowance for eddy currents in the core. Experiments show that these factors combine to reduce the diameter of core requisite to give the maximum efficiency. Cores of soft iron of different diameters were wound with 26-gauge silk-covered copper wire until the diameters of the bobbins measured 1·25 in. Determinations were then made of the

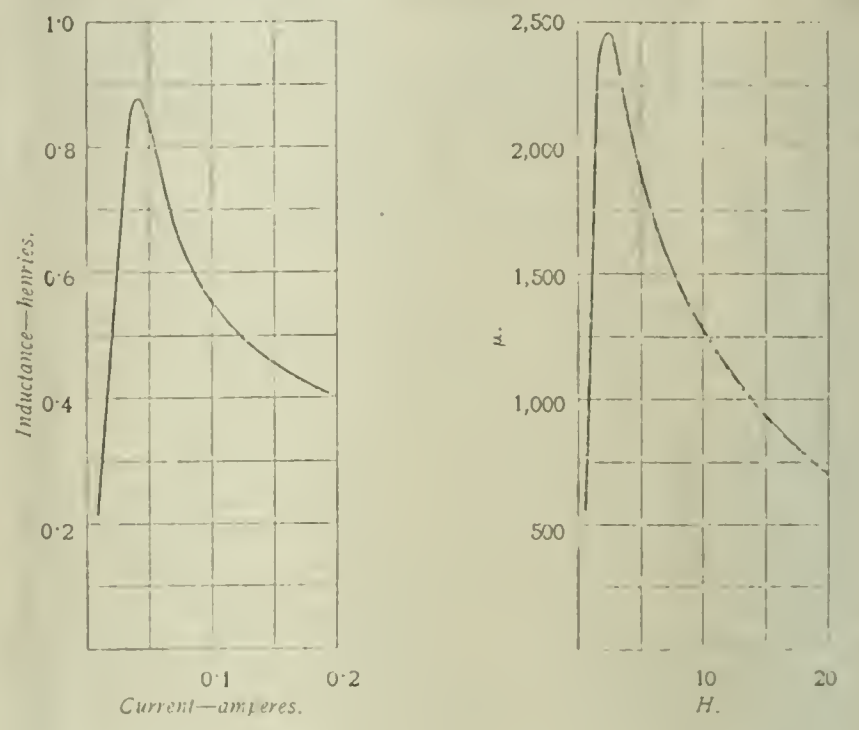


Fig. 1.

igniting-currents when a bell fitted with each of the bobbins in turn was included in a circuit with a battery at 25 volts; and of the "sounding-powers" of the bells at the igniting currents. The results are given in Table III.

Table III.

Diameter of core.	Igniting current. (i.)	Relative sounding power, S. (Measured at i.)	S/i.
	Ampere.		
0·250 in. (0·21)	0·12	0·07	0·58
0·375 in. (0·31)	0·14	0·32	2·28
0·500 in. (0·41)	0·16	1·00	6·25
0·625 in. (0·51)	0·18	0·63	3·50
0·725 in. (0·61)	0·21	0·56	2·66

Taking all the factors into consideration, the general conclusion can be drawn that the most efficient mining bells should have bobbins wound with from 25 to 30 layers of fine wire, and that the diameter of the core should be between 0·4 and 0·5 times that of the bobbin.

Methods of Rendering Bells and Relays Safe.

It is possible to construct good ringing bells and efficient relays without having recourse to special devices for overcoming the effects of self-induction. The chief factor in rendering the break-flash at the signal wires dangerous is the amount of current available. Given a definite battery power that is not to be exceeded, the resistance of the bell or relay can be so proportioned that the maximum current obtainable on short circuit does not exceed the "minimum igniting current" for the system.

High Resistance Winding. The required resistance can be obtained either by means of a non-inductively wound coil in series with the magnet coils, or by winding the coils with a high resistance wire. The latter is the simplest method of dealing with the problem.

There are several ways of overcoming the effects of self-induction. Any device, therefore, which retards the change of magnetism on break of circuit lessens the break-flash voltage. In this respect parallel-winding, copper sleeves, shunt resistances, and tin-foil layers are identical in their action.

Parallel Winding.—Two windings on the bobbins are carried in parallel throughout, only one winding is used as the exciting winding for the magnet, the other is short-circuited on itself. When a current is passed through the exciting winding a current is induced in the short-circuited winding, and when the main current is broken the induced current opposes the change of magnetism which causes the E.M.F. of self-induction

of the exciting winding, so that the intensity of the break-flash is greatly reduced.

Copper Sleeves.—A copper sleeve is, in effect, a short-circuited secondary winding. The core-flux is always proportional to the total ampere-turns of both the magnetising coil and the sleeve, and the sum of these can be made to suit any desired rate of decay of magnetism. A calculation is given of the proper thickness of such a sleeve.

Shunt Resistances.—A simple method of suppressing the break-flash at any point at which the circuit is to be broken consists in shunting the magnet-coils by a high resistance. The break-flash either at the bell- or relay-contacts or at the signalling point has now much less igniting power. The shunt resistance provides a path for the extra current from the coils without that current having to cross the break.

Let r be the resistance of the magnet coils, r' that of the shunt. When the circuit is broken at C the current in the magnet coils circulates through r' and falls according to the law $i=E/r\,.\,\epsilon^{-(r+r')t/L}$, L being assumed to be constant. When t (the time) is zero $i=I$, the maximum steady current in the windings; but $di/dt=-I(r+r')/L$, so that $e_s=Ldi/dt=E(1+r'/r)$.

By increasing the value of r' the inductance voltage is increased, but its duration is shortened, as the following considerations show. When $r'=0$, the current falls at its slowest possible unaided rate; that is to say, according to the law $i=I.\epsilon^{-rt}$. When $r'=r$ (the resistance of the bell) the current falls to $1/e$th or $1/2{\cdot}7$th of its initial value in one-half the time that it took when r' was 0; when $r'=2r$ in a third of the time; and when $r'=10r$ in one-eleventh of the time.

To form an arc at break between metal or carbon poles takes a perceptible time when the voltage across the break is not disruptive, and the spark, or arc, starts by the heating of the poles to a temperature at which the electric discharge forming the arc begins. The higher the voltage the more rapidly does this take place; but, on the other hand, if the voltage across the spark-gap is not maintained, there may not be sufficient time for the arc to be formed.

The formation of the spark at the break C does not, however, depend only on the magnitude and duration of the voltage, for the lower the resistance r' the smaller the fraction of the initial current that will attempt to cross the break. The current in the magnet coils when the circuit is broken divides between the resistance r' and the resistance of the circuit, consisting of the line, the battery, and the spark at C. The smaller the spark the higher its resistance, and in the limit when the spark

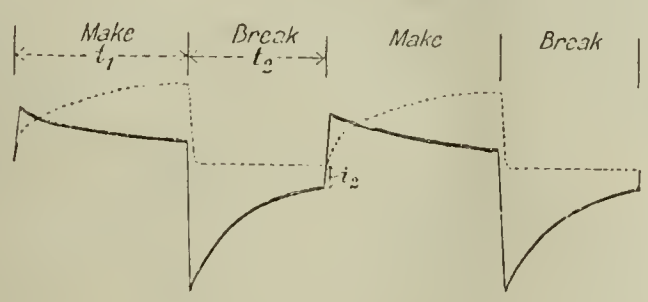


Fig. 2.

is negligibly small its resistance can be regarded as infinite. The magnitude of the spark at C can, therefore, be greatly reduced by shunting the magnet coils.

Oscillograph records of the current in a shunt fitted across the magnet coils of a bell have the form shown in Fig. 2, the current in the bell coils at the same time being indicated in dotted line. If at the end of time t_2 of break of the ringing circuit by the trembler, the current in the circuit $r+r'$ has not fallen to zero, the remaining current i_2 has to be neutralised before the ringing current can begin to rise. This delays the ringing stroke. It is best to arrange that the current in the circuit $r+r'$ shall fall to some small proportion of the ringing current, say, one-twentieth, at the moment that contact is made at the trembler at the end of time t_2. In such a case, since $i/I=\epsilon^{-(r+r')\cdot t/L}$, $\epsilon^{-(r+r')\cdot t_2/L}=20$, and $(r+r')t_2=L\log\epsilon 20$. The resistance r' necessary to give the desired ratio is thus dependent on the inductance L, of the circuit, and upon the time t; that is to say, upon the mechanical setting of the bell. If the resistance r' is chosen to suit the largest value of t_2 that the construction of the bell allows it will have a suitable value for other settings, and the rate of ringing of the bell can be adjusted by regulation of the armature springs without affecting the safety of the arrangement.

In choosing the value of r' requisite to render the break-flash harmless it must be borne in mind that the resistance of the magnet coils is proportional to the number of turns of wire, whereas the inductance, which mainly determines the value to be given to r', is proportional to their square. The most satisfactory method of determining whether a suitable value has been given to the shunt resistance, as it is also the best method of determining the efficiency of any anti-sparking arrangement, is to test the igniting power of the break-flash in an explosion chamber with the circuit arranged as in practice.

Another method of reducing a break-flash is to shunt the break itself by means of a resistance high enough to reduce the circuit current, which is never completely broken, to the desired minimum. In the case of signalling bells or relays actuated by short-circuiting bare wires at any point along a roadway this arrangement is not to be recommended, for, although sparking at the trembler of the bell or at the contacts of the relay can be reduced in this way, the inductance voltage is transmitted through the shunt to the signalling point, and a dangerous break-flash may be produced there.

Oscillograph records show clearly the efficacy of the several methods of suppressing inductance voltage just described. In Fig. 3 are reproduced oscillograms taken during the ringing of bells fitted with the following "anti-sparking" devices: (A) parallel winding, (B) copper sleeve, (C) tinfoil layers, and (D) shunt across the magnet-coils. The photographs were taken on plates moving at a uniform speed of 150 cm. per second, and in each case the changes in the current passing in the bell, and the changes in pressure across the spark-gap are shown above and below a common zero-line. The battery voltage was 15 in each case, and the current about 0·5 ampere. It will be seen that the inductance voltage is either suppressed entirely or reduced to neglible proportions.

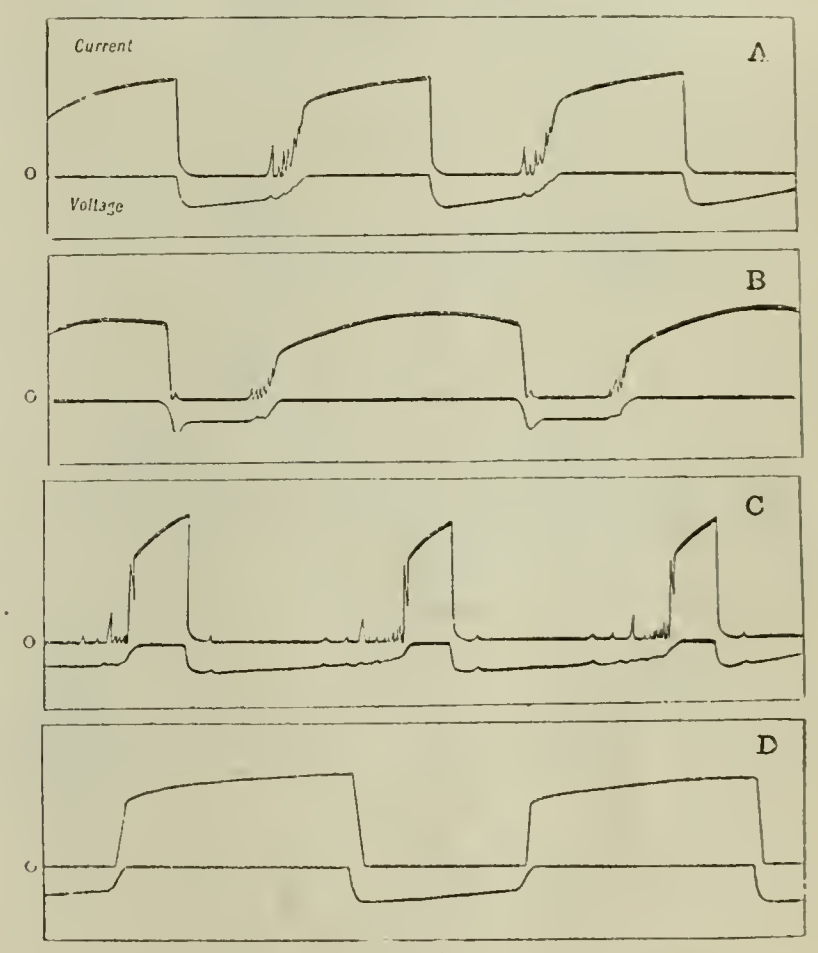


Fig. 3.

Current Supply.

Hitherto we have considered mainly the signalling instruments, bells and relays, and the methods by which such instruments can be rendered incapable of causing a dangerous break-flash at the signal wires, a source of current of limited strength being assumed. The means of supply of electric current also require consideration.

The following methods are in use for the supply of current to signalling circuits: (1) Primary batteries of wet or dry cells, used chiefly on local circuits ringing one or more bells. (2) Storage cells, used either in the same way as primary batteries or as a central battery actuating the bells and relays throughout the pit, and sometimes in addition actuating the shaft signalling system. (3) Continuous or alternating current motor-generators, acting in the same manner as a central battery. (4) Transformers, having a medium voltage primary supply and a low secondary voltage.

Primary batteries consisting of wet Leclanché cells form the usual source of current. Such cells have a voltage about 1·5 and a resistance of about 3 ohms. Dry cells of the Leclanché type also have a voltage about 1·5, but their resistance may be less than 0·1 ohm. Secondary batteries have a voltage on open circuit of a little over 2, and their resistance may be as low as 0·01 ohm. Generators and transformers differ from secondary cells chiefly in having self-induction: their resistance may be even lower than that of a central battery of secondary cells of the same terminal voltage. An objection to the use of transformers is that, in the event of failure of the insulation between the primary and secondary windings, the pressure of the power circuit might be transmitted to the signalling circuit.

A central battery or generator system is advantageous from the point of view of simplicity of subdivision for different circuits, but such systems require precautions to be taken to avoid heavy currents being obtained on giving a signal; and, from what has been said regarding the necessity of limiting both the amount of current in the circuit and its inductance, if the danger of ignition of inflammable gases at the signal-wires is to be eliminated, it will be realised that the advantage so far as safety is concerned lies with the wet Leclanché primary battery as the source of current.

Conclusions.

1. As a result of our investigations we are satisfied that the bare-wire system of electrical signalling as commonly employed can be rendered quite secure from any danger of the ignition of inflammable gases by the break-flash at the signal wires or at the contacts of the signalling instruments.

2. In order to procure safety it is necessary, in the first place, to limit the battery power that is to be employed on any one circuit; and, in the

second place, to ensure that the signalling instrument, whether bell or relay, shall comply with certain requirements.

3. The present statutory voltage, 25, sets a reasonable limit to the battery power provided that wet Leclanché cells be used. Systems in which the battery used consists of dry primary cells or of secondary cells, or in which continuous or alternating-current generators are employed, could be rendered safe if, in addition to the use of "anti-sparking" devices embodied in the signalling instruments, sufficient non-inductive resistance were permanently included in the bell circuit.

4. The signalling instruments, bells or relays, should have flame-tight covers, and must be so constructed that when included in a circuit with a battery at 25 volts the break-flash produced when bare signal wires are separated after giving a signal is incapable of igniting an 8 per cent. methane-air mixture. There is no difficulty in constructing either bells or relays to conform with these requirements.

PRECAUTIONARY MEASURES TO ADOPT TO PROLONG THE LIFE OF DIESEL ENGINE CRANKSHAFTS.*

BY P. H. SMITH.

The object of this Paper is to show that the life of a Diesel engine crankshaft is mainly dependent upon the engineer-in-charge, who may take certain precautions to prolong its life.

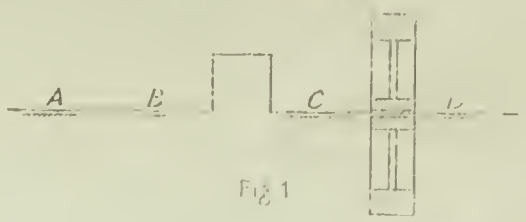


Fig. 1

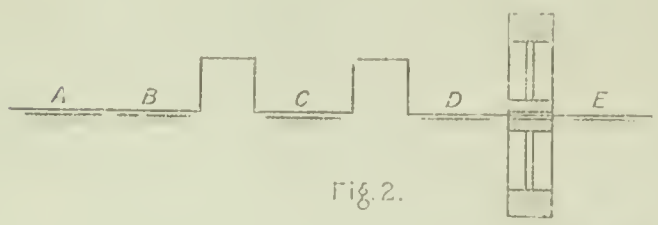


Fig. 2.

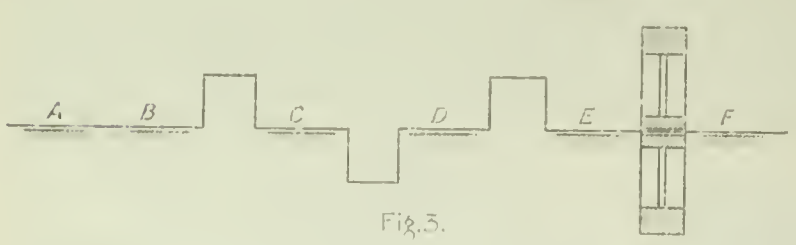


Fig. 3.

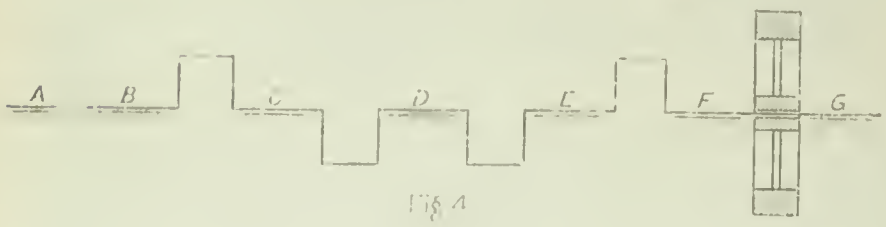


Fig. 4

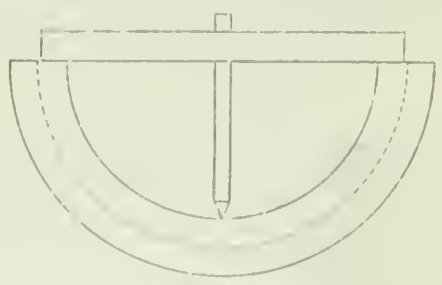


Fig. 5.

All such shaft failures investigated by the author owe their origin to lack of alignment of the main bearings, and generally result from unequal rates of wear in the bearings supporting the shaft.

The Paper relates only to four-cycle vertical engines. Engines driving through a belt appear to be less liable to fracture than when coupled direct, because the reversal of thrust on the shaft then takes place without shock. The engine least liable to shaft fracture is the three-cylinder, and the worst is the four-cylinder normally, though the two-cylinder runs it a close second if fitted with a very heavy flywheel.

Almost without exception Diesel shafts have failed through the webs, the crack starting at the centre and gradually working outwards during many weeks. As regards location of fracture, either web may fail in the single-cylinder units. In two-cylinder engines, web four fails most frequently. (The webs being numbered consecutively commencing from the end farthest from the flywheel). In three-cylinder units the fracture occurs either in web one or six, and sometimes both fail simultaneously. In four-cylinder units, it is an almost invariable rule that web four fractures. On account of its extra susceptibility to failure, and particularly because it always appears to fail in the same place, most attention has been paid to obtaining data from four-cylinder engines, and they extend over four years of continual observation on two engines of the four-cylinder type.

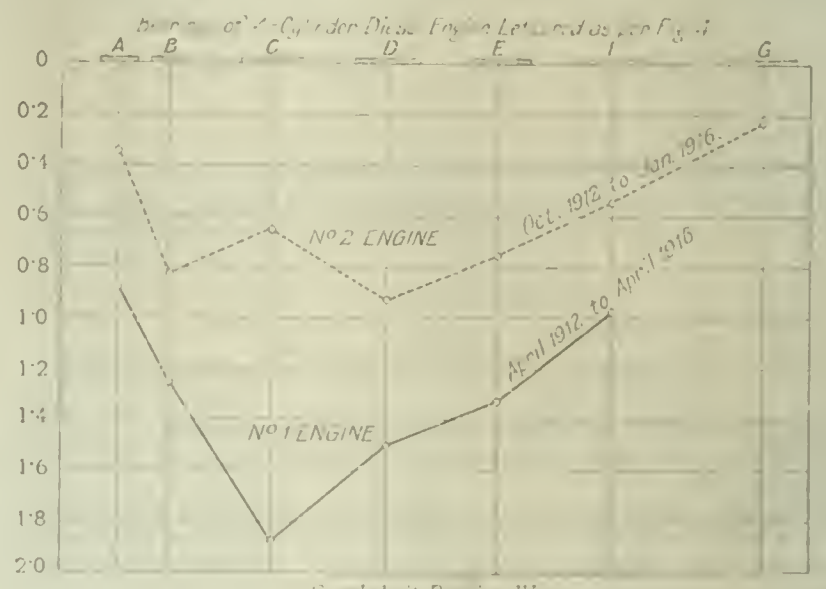
Description of the Diesel Engine Plant.—The plant was installed about nine years ago, and comprised two Continental engines of four cylinders each, the cranks being arranged as shown in Fig. 4, viz., up, down, down, up, as contrasted with the usual arrangement in this country, up, down, up, down. The cylinder dimensions were 415 mm. × 600 mm., and the engines ran at 170 revs. per min., developing 320 B.H.P. each. The flywheels weigh about 8 tons each, and a bearing is interposed between the flywheel and a direct-current generator. Expressed in relation to the cylinder bore (D), the main dimensions of the shaft are :—

Diameter of journals and crank pins	0·53D.
Thickness of crank webs	0·265D.
Length of pin	0·53D.
Length of main bearing	1·1D.

The shaft is therefore on the weak side. No analysis of the steel is obtainable, but analysis of a similar shaft which failed about 11 years ago was made, and is as follows :—

Carbon	0·327 per cent.
Silicon	0·169 ,,
Manganese	0·767 ,,
Phosphorus	0·057 ,,
Sulphur	0·086 ,,
Copper	Trace.

Tensile strength was 32·88 tons per sq. in., elongation on 3 in. 19·3 per cent., and reduction in area 20·4 per cent., so that the metal was quite good of its class.



Crankshaft Bearing Wear.

FIG. 6.—CRANKSHAFT BEARING-WEAR DIAGRAM.

As regards the history of the plant, the engines ran for the first four or five years on a very irregular load, and then a buffer battery was introduced which had beneficial results; smoothing out the irregularities usually accompanying a comparatively small tramway load.

One engine broke its shaft about four years after its installation, and the other after about five years. In both cases web No. 4 failed. These shafts were replaced by others obtained in England. The tensile strength of that now in No. 2 is about 32 tons while that in No. 1 is 40 tons per sq. in. After the new shafts had been bedded in, the engineer took out the under halves of the bearings, and measured down from the facings to the white metal in the manner shown in Fig. 5.

Thereafter, the bearings were measured every year, and thus the actual wear has been regularly recorded for three and a-half years in the one case, and for four years in the other; the results being submitted in Fig. 6 for your consideration. A casual glance at the lower curve taken from No. 1 engine explains why the four-cylinder engine with this arrangement of cranks fractures through the webs of the second cylinder, and this curve is characteristic of four-crank engines. The upper curve relates to No. 2 engine, and instead of bearing C showing the greatest wear, the wear is actually less than in the adjacent bearings B or D, and it was not possible to understand this until the shaft was recently re-aligned. Then it was noticed that bearing C is appreciably eccentric to bearings B and D. Hence, in the usual way of bedding in a shaft the probability is largely in favour of bearing C having been scraped too low, and thus, for some time, bearing C was not submitted to its fair share of the

* An abstract of a Paper read before the Diesel Engine Users' Association.

load, and therefore did not wear away as fast as the adjacent bearings. It may be asked why the rate of wear is so much greater in the one engine than in the other, and the only explanation which can be given is that one engine is situated right opposite double doors leading into a dusty yard paved with ashes. A similar case where bearing troubles have been experienced was encountered in the South of England, only in this case sand replaces ashes.

As regards precautions to be taken to prevent a shaft from breaking, it was first explained how the shafts of the two engines under consideration were re-bedded in order that the application of the principle might be made general. The engine was stripped right down, excepting only that the flywheel was not taken off the shaft until it was definitely proved that its weight distorted the shaft. Then it also was removed. The bearings were found to have the metal loose and cracked, and the spare set was substituted, care being taken to employ one grade only of white metal throughout. The shaft was bedded in the usual way up to a certain point, but to complete the work, bearing C was left a shade high and bearing A was left a shade low. Finally (and this is very important) the top caps were filed down so that the journal ran in the bearing with running clearance only, so that correct alignment of the shaft was assured. Before reassembling the engine the thickness of metal between the shaft and bedplate in each bearing was micrometered and recorded, and now from year to year is remeasured and the relative rates of wear in each bearing obtained. That which is worn most will constitute the datum, and the data will show exactly how much must be scraped off the "high" bearings in order to reintroduce conditions of minimum stress on the shafts.

The micrometer method is recommended as being less liable to error than the other method described, but care must be exercised even with the micrometer method, because loose white metal falsifies the reading, which would then appear too large. This system of aligning the shaft will appeal especially to those engineers who have no reserve plant and who must get repairs done during the week-end. Thus, if the engine were a four-cylinder, one would take out bearing C first and micrometer it, and look up the log-book and ascertain how much it has worn since the shaft was last realigned. Then take out bearing A, micrometer it, and ascertain the extent of wear in the same period. If it has worn down 8/1,000 in. and bearing C has worn down 12/1,000 in., then scrape down bearing A 4/1,000 in. more, re-bed it to the shaft or, preferably to a special dummy journal, and then replace it, treating all the bearings in like manner.

If the engine is a two-cylinder, or a single-cylinder unit, then probably the bearing adjacent to the flywheel is most worn. It therefore should be taken out first, measured and replaced, scraping only if found "high" at one end, then taking out the other bearings and scraping them in accordance with the data obtained. In the case of a three-cylinder engine, the probability is largely in favour of bearing B being the lowest and this therefore should be taken out first. Thus, where plant is not in excess, the engineer can readjust a bearing each week-end until the whole set is completely put in order, and he runs very little risk of heated bearings if he is careful. The system has its limits; it would not do to apply it in this manner if rate of wear were very variable.

As regards subsequent adjustment it is not usually feasible to measure running clearance of main bearings with feelers, so one has to have recourse to other methods. Where possible feel the lift in each bearing, and let the cap closer and closer until the bearing either heats (in which case scrape out the cap), or until the lift just disappears. However, one may have recourse to leads so long as they are considered only as a means of obtaining the *relative*, and not the absolute clearance in a bearing. In the ordinary way, if one use 20 or 21 gauge lead wire, running clearance will be right if the lead squeezes out to 8 or 9/1,000 in. thick. If one uses 16 gauge then this may squeeze to about 10 or 12/1,000 in. thick. The actual clearance is probably only 4 to 6/1,000 in. The difference between real and apparent clearance depends upon a multitude of factors, but it must be borne in mind that leads do not show the true clearance in a white metal bearing.

Regarding the best proportion of shafts, the cylinder bore being expressed as D, the most amply proportioned shafts yet measured are as follows :—

Diameter of journals and pins	0·6D.
Length of main bearing	0·9D.
Length of big end pin	0·6D.
Thickness of web	0·33D.

At least two of these have broken through bad initial erection.

The original Diesel shafts were made in 32-ton steel to the following proportion :—

Diameter of pins and journals	0·51 to 0·525D.
Length of main bearings	1·1 to 1·2D.
Length of big-end pin	0·51 to 0·525D.
Thickness of web	0·25 to 0·27D.

The shaft proposed is as follows :—

Tensile strength, not less than 31 tons.	
Ductility, not less than 25 per cent. in 2 in.	
Diameter of pins and journals	0·525 to 0·54D.
Length of main bearings	0·75 to 0·8D.
Length of big-end pin	0·525 to 0·54D.
Thickness of webs not less than 0·32D, but centre to centre of cylinder made the minimum possible, and any excess over the proposed length of pin and journal to be put into the webs.	

Fillets to be not less than one-tenth the diameter of the shaft. Such a shaft is comparatively light, but in the opinion of the author possesses the following advantages :—

1. The fuel consumption of the engine is reduced.
2. Initial cost and cost of upkeep are reduced.
3. The bearings will run cooler, other things (excepting pressure per square inch) being equal.
4. Lubrication costs are reduced.

However, the success or failure of such a shaft depends upon proper attention being given to its adjustment from time to time, and if this is not given, then it is merely a question of time before even the heaviest shaft will fail.

CORRESPONDENCE.

ELECTRIC DISCHARGES IN SUB-STATIONS.

TO THE EDITORS OF THE ELECTRICIAN.

Referring to the letter on the above subject in your last issue, I am of the opinion that the flashes shown in the photograph are not due to any real discharges between the lighting wire and the iron plate, for, if they were, how could one account for the discharge beneath the one immediately above the iron plate ? The following experience might account for the discharge.

About 15 years ago I had a film roll of 12 exposures, on most of which discharges appeared similar to the ones shown in the photograph on page 605, although the exposures were of groups of men in an open field, there being no electric power in the neighbourhood. The film dealer gave the explanation that such flashes may occur when the film is pulled up quickly (when after one exposure has been made a new film is being brought into position), owing to the friction between the film and the metal rollers giving rise to frictional electricity.

The likelihood of this being the correct explanation is increased by the fact that the single rays of the flashes diverge in a direction opposite to the movement of the film, and never in a direction perpendicular to this movement.

London, August 7. H. ERICHSEN.

[Discharges of the kind referred to by our correspondent are frequently observed in the manufacturing of paper and from quick-moving leather belts.— EDS. *E.*]

DEMOUNTABLE BODIES FOR ELECTRIC VEHICLES.

TO THE EDITORS OF THE ELECTRICIAN.

With reference to the description of a demountable body for electric vehicles, illustrated on p. 27 of the Supplement to your issue of the 28th ult., I write to say that similar bodies have been in use by Messrs. Ransomes, Sims & Jefferies of this town for years past in connection with the steam wagons that they use. In this case the lifting arrangements are worked from the engine of the steam wagon.

Ipswich, Aug. 2. DEMOUNTABLE.

PHYSICAL SOCIETY.

At a meeting held on the 30th ult., at the Imperial College of Science, Prof. C. V. Boys, F.R.S., President, in the Chair, a Paper, entitled

"A Sensitive Magnetometer,"

by Dr. P. E. SHAW and Mr. C. HAYES, was read by the former.

A torsion balance of extreme delicacy carries a pair of purest silver balls, each 3 gm. weight. A solenoid with horizontal axis passing through one of the silver balls, is brought close to the balance. On exciting the solenoid, divergent fields of known strength are obtained in the region of the ball. The resulting attraction of the ball to the solenoid is shown by a mirror reflecting a distant scale to a telescope. The couple on the torsion beam required to produce

1 mm. scale deflection is 4.5×10^{-7} dyne cm., and this torsion balance is 10^6 times as sensitive as any known to have been used previously in this kind of work.

The results of these experiments are :—

1. The magnetic properties of the silver are ascertained even for weak fields of 1—10 gauss.

2. The silver has a pronounced retentivity ; this effect being presumably due to the small trace of iron impurity.

3. The relation of susceptibility of the silver to the field used is found. The susceptibility of each of the constituent materials (*a*) pure silver, (*b*) residual pure iron, appears to be greatly modified by the presence of the other material.

Dr. S. W. J. Smith thought that the results obtained by the authors, showing the susceptibility of nearly pure silver in weak fields, were both interesting and instructive. He thought the authors, in discussing their significance, had overlooked the fact that the minute amount of iron (not exceeding 30 parts per million) shown to be present by chemical analysis, would not have the same effective susceptibility as iron in the form, for example, of long rods magnetised in the direction of their length. It was true that iron, when alloyed with other substances, could lose its characteristic ferromagnetic properties ; but there was no reason to suppose that it would do so when present in silver, except in so far as the properties of a very minutely divided substance might differ from those of the same substance in bulk. So far as he knew, iron and silver were mutually insoluble. In that event the impurity found to be present should be regarded as minute particles of iron scattered about in a matrix of silver. To obtain an approximate idea of the effect of these particles upon the susceptibility of the material as a whole, it would be sufficient to regard them as spheres. Since the apparent susceptibility of a sphere is equal to $K/(1+\frac{4}{3}\pi K)$, where K is the true susceptibility, and since the true susceptibility of iron in weak fields is considerable, the apparent susceptibility of such spheres would be practically constant in weak fields and equal to $3/4\pi=0{\cdot}24$. Hence, if the fraction of the total volume occupied by the iron were $n\times10^{-6}$, the observed susceptibility of the material would be of the order $K_a=(0{\cdot}24n-2)10^{-6}$, where -2×10^{-6} represents the susceptibility of the silver. It was found by the authors that the susceptibility was practically constant over the range $H=4$ to $H=12$ c.g.s., and approximately equal to $0{\cdot}25\times10^{-6}$. This would agree with $n=9{\cdot}4$. In other words, the results would indicate that the amount of iron present as impurity was of the order 10 parts per million (by volume). The curves given by the authors seemed to show that the apparent susceptibility varied considerably in fields lower than $H=4$; but part of the appearance of variability was due to the fact that, by inadvertence, the curves had been made to pass through $K_a=0$ at $H=0$. A possible source of uncertainty in the measurements in the weaker fields was the relatively great importance, under these circumstances, of P, the (assumed) permanent magnetism of the sphere. It seemed unlikely that the value of K for the iron in the weaker fields would be such as to make the effective susceptibility much less than $3/4\pi$, although there would be some tendency in this direction. The conclusion which he would draw from the data would be that the magnetic analysis of the material agreed with the chemical analysis and supported the inference, from other experiments, that iron and silver are mutually insoluble. The results obtained in strong fields (by Honda and others) did not, as the authors suggested, conflict with this conclusion, but confirmed it. The diamagnetic susceptibility of silver probably remains constant as the field strength is increased (within experimental limits) : but, in intense fields, the susceptibility of iron is small compared with $3/4\pi$. For instance, in fields of the order 25,000 c.g.s., the value of K may be of the order 0·1 to 0·05. Taking the latter figure, the effective susceptibility of the iron spheres would be approximately 0·04. The observed susceptibility of the material as a whole would be of the order $K_a=(0{\cdot}04n-2)10^{-6}$. Hence, assuming the value of n already deduced, we should expect K_a to be of the order $-1{\cdot}6\times10^{-6}$. Therefore, we should expect that the material used by the authors would become diamagnetic in strong fields. That it would, in fact, behave in such fields like the silver, of similar purity, examined by Honda.

Dr. Chree said it was of the utmost importance in working with weak fields to get rid of effects due to electric tram and railway systems. This was not an easy matter nowadays. He would like to know if the magnetic experiments had caused any modification in Dr. Shaw's conclusions on the effect of temperature on gravity.

Prof. Boys said that in his own experiments on gravitation and also in the design of the radio-micrometer, the magnetism of impurities had always to be considered. In the case of his gravitation experiments, he had used gold balls, of the greatest purity the Mint could supply, cleaned with nitric acid, and no consistent magnetic disturbances were detected.

Dr. Shaw, replying for the authors, was gratified that Dr. Smith's calculations had confirmed their numerical results. In reply to Dr. Chree, he said that in order to test whether the magnetic force would vary appreciably with temperature in the gravitational experiments he had inserted an iron bar in one of the lead spheres, but even then he had been unable to detect any variation in the force exerted on the silver when the lead and its contained rod were heated to 200 C.

A Paper, entitled

"The Latent Heat of Fusion of a Metal, and the Quantum-Theory,"

was read by Dr. H. S. Allen.

A criticism is given of a theory of the process of fusion recently put forward by Ratnowsky. The author of the theory obtains an expression on certain assumptions for the entropy of a substance in the solid state. He then proceeds to deduce a simple formula suitable for use at high temperatures. It is shown that this formula is incorrect in consequence of the omission of a term in the expansion. Assuming, with Ratnowsky, that the entropy of the liquid state can be calculated in the same way as that of the solid, a corrected expression is deduced for the atomic heat of fusion which is equal to the difference between the entropies multiplied by the temperature of the melting point. Ratnowsky, taking the values of the atomic heat of fusion determined experimentally, calculated the ratio of the "characteristic temperatures" for a number of metals, and came to the conclusion that the ratio is approximately constant. The values have been recalculated by the corrected formula, and it is found that they are far from constant. The ratio calculated for mercury by an independent method does not agree with the conclusion of Ratnowsky.

Some Experiments on the

Thermoelectric Properties of Fused Metals

were shown by Chas. R. Darling, A.R.C.S.

The experiments shown related to observations made during the progress of a research, having for its object the production of a thermoelectric pyrometer with a liquid element. If such a pyrometer could be made of suitable materials—such as graphite and molten copper—it might be possible to extend the useful range of base-metal pyrometers up to or beyond the melting point of platinum, as the boiling point of copper is 2,310°C.

In seeking a satisfactory couple, experiments were first made with molten tin in the following manner : An iron crucible was inserted in a hole in a sheet of uralite, so that its rim was flush with the upper surface of the sheet. A groove was made in the uralite, commencing at the crucible, and the molten metal was then poured into the crucible until it overflowed, and then along the groove, at the end of which a cold junction was formed with the second metal. A wire dipping into the crucible formed the hot junction ; and by this arrangement a continuous circuit was maintained between the liquid in the crucible and the solid in the groove. Advantage was taken of this arrangement to observe the effect of fusion on the E.M.F. developed, about which little information appears to exist.* It was noted that when tin was partnered by iron, nickel, copper, constantan or graphite, no abrupt change occurred at fusion, the E.M.F.-temperature curves showing no break. Using iron and tin in this manner forms an instructive lecture experiment. Starting from the cold, the E.M.F. rises steadily ; remains constant during fusion at 232 deg., and then rises to a maximum at 340 deg., after which inversion takes place—the whole change occupying only two or three minutes, when a small crucible is used.

On substituting lead, zinc and bismuth in turn for tin, and using a variety of wires, it was again found that the change of state caused no alteration in thermoelectric properties. In the case of bismuth, however, three instances of thermoelectric "halt" were noticed, the E.M.F. attaining a maximum and then remaining unchanged over a considerable range of temperature. An iron-bismuth couple reaches a maximum of about 18 millivolts at about 250 C. (M. Pt. of Bi 269), which remains constant to within 3 per cent. up to 550 deg., beyond which it has not been investigated. Copper and bismuth behave in the same manner, the E.M.F. being practically the same as in the former case ; whilst aluminium and bismuth furnish a third example, the E.M.F. (about 15 millivolts) being remarkably constant over a range of 300 deg. A previous instance of this kind was observed by Barrett with a couple of pure iron and an Fe-Ni-Mn alloy.

A suggested form of liquid-element pyrometer was described, and it was suggested that the experimental methods shown might prove useful in the thermal investigation of alloys, as the formation of definite compounds would probably be accompanied by a notable change in E.M.F. The steady E.M.F. furnished by the Bi-Al couple might also be used in work in which a constant, low E.M.F. was required.

Dr. S. W. J. Smith asked if there was any possibility of a chemical action occurring between the elements as the temperature increased, and so modifying the properties of the junction as to bring about the thermoelectric halt observed in some of the couples ?

Prof. C. V. Boys thought that the property must be peculiar to the bismuth, otherwise the same class of phenomenon should be obtainable with combinations of the other elements, iron, copper and aluminium. This, of course, is not the case.

Dr. Shaw asked if Mr. Darling had used the same quantity of bismuth over and over again to see whether the results were affected by contamination ?

Dr. Boys asked if the results were repeated exactly on every occasion.

Mr. Whipple thought these bismuth junctions might prove very useful sources of small constant E.M.F. for calibration purposes in works, &c.

Mr. Darling did not think the thermoelectric halt was due to chemical action. He would like to do much more work on the subject before attempting an explanation.

* See Paper by Porter & Simeon, "Proceedings," June, 1915.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

COMMERCIAL TOPICS	645	Interesting Manufacturing Operations. Illustrated	132
Imports and Exports of Electrical Manufactures	646	Organising British Industries. The Works of C. A. Vandervell & Co. Illustrated	133
LEGAL INTELLIGENCE	646	"Re-Set" Signs. Illustrated	140
PARLIAMENTARY INTELLIGENCE	646		
Educational	646	Empire Notes	649
Business Notices	647	Foreign Notes	649
Liquidations, &c.	647	Miscellaneous Notes	649
Electricity Supply	647	Tenders Invited	650
Traction Notes	648	Tenders Received & Accepted	650
Telegraph and Telephone Notes	648	Municipal Accounts	651
Lighting and Power Notes	648	Companies' Meetings and Reports	651
		New Companies, &c.	651
The Round Table	129	City Notes	652
Magnetic Couplings, Clutches and Brakes. Illustrated	130	Electrical Companies' Share List	652

COMMERCIAL TOPICS.

Engineering after the War.

An important conference of engineers and manufacturers was held in the City Hall, Glasgow, on Friday last in order to consider the position of the engineering industry after the war.

It is stated that over 250 firms connected with engineering in different parts of Scotland have accepted the invitation to attend the conference over which the Lord Provost of Glasgow will preside. It is anticipated that the meeting will be thoroughly representative of every branch of the industry. Committees charged with the mobilisation of British manufacturing engineers have been formed or are in process of formation in Edinburgh, Manchester, Sheffield, Leeds and other important engineering centres, but the meeting on Friday next is the first one on a large scale.

Among those present were Mr. Wilfrid Stokes, Mr. John Thornycroft, Sir John Cowan, Messrs. Hugh Reid, W. Rowan Thomson, Noel E. Peek, James Steven, John Leckie, Archibald Colville, Alex. Fraser, Sam. Mavor (chairman, British Electrical & Allied Manufacturers' Association), &c.

The LORD PROVOST, who explained the objects of the meeting, said the present great war was not being settled in the trenches alone, or in the North Sea alone; the heroism and the blood of our soldiers and our sailors would have been spent in vain if the German, after the war, were to be allowed to resume the place he lately held in the commerce of the British Empire. There were some people who said that organisation was a German virtue. He did not believe it. What the Germans had learnt they had taught them. It seemed clear to him that the natural way to organise their national industry was trade by trade. In the past there had been an unhappy state of things: trades had divided themselves into two halves, each half with the idea of fighting the other half—that was to say, the men had organised to fight the masters and the masters to fight the men. That suited the German very well, for when they were fighting together the Germans were pushing their way in unobserved and unopposed. Now it seemed to many of them in the light of this war that there should be a defensive organisation for each trade as a whole. They must make a beginning somewhere, and where could they make a better beginning than with the engineers? This was an engineer's war, and it was upon their skill, ingenuity, science and enterprise that our victory, under the providence of God, most depended. The engineers of Scotland, in war as in peace, had no cause to be ashamed of themselves and their work; they had done great things. But latterly they had felt the great and organised force of the German engineering trade with the whole strength of the German political and industrial system behind it. When the Germans gave a loan they were thinking of the German engineer; when the German Government inflicted upon Turkey the great misfortune of taking it under the wing of the German eagle the German engineer was not forgotten. The Turkish railway and tramway systems had all to be built by German engineers and supplied with German plant. The tramway system of Buenos Ayres was built and owned by a British company. When it came to be electrified, German agents offered to guarantee the British company good interest on their money in perpetuity upon two conditions only, that the tramway system should be electrified by the Allgemeine Elektricitats Gessellschaft, and should for ever after be supplied with German material. The British engineer and British material were driven out of that great system at one stroke. If they remained disorganised it might be to the benefit of the politician, it was certainly to the benefit of the German, but he was sure it was not to the benefit of the country.

Mr. W. R. THOMSON said it was their imperative duty so to organise their industries as to develop still further their existing and potential sources of wealth as rapidly as possible. They could only achieve that object by eliminating internal rivalry and jealousy, personal dislikes, and what was called class war. They were threatened with a Ministry of Labour and a Ministry of Industry. Personally he viewed that with alarm and distrust, and profoundly hoped that they would take such steps as would prevent these threats being fulfilled. What they wanted to do was to organise themselves to assist the existing Government departments in leaving them alone to manage their business, which they naturally understood better than any politician or any permanent official. The producers of this country were far too much under the heel of the permanent official and the politician, and unless they saw to it at once they would be still more so in the near future. Why should all these Departmental Committees, chosen quite at haphazard, and very often unrepresentative, be sitting to decide their fate? The function of a Government department in dealing with business should be paternal and reasonable obstruction, yielding in the end when the course proposed was proved to be obviously sound. The process of mobilisation should automatically produce a practical working plan—not pious resolutions and vague aspirations—of what the industry wanted from a national point of view. Their patriotism had been exploited by the politician—thinking only of his own commodity, votes—in a way which had hindered rather than helped output, and which had benefited nobody except perhaps the Germans and neutrals. He proposed the following resolution:—

That, in view of the unprecedented situation created by the war and the uncertainty of the future, this meeting is of opinion that all iron, steel, engineering, shipbuilding and allied industries in this country should endeavour to come together in some strong central organisation capable of dealing in a comprehensive and imperial manner with all important questions affecting these and allied industries which will certainly arise in the near future.

The resolution was seconded by Sir John Cowan and adopted.

A preliminary committee was then appointed, with instructions to report at an early date as to the nature, scope and object of an organisation which could deal with the conditions governing the industries represented at the meeting and with the Government regarding any measure (old or new) which might affect those industries after the war. The following names were submitted as the nucleus of the committee, with power to add to their number: Messrs. Archibald Colville (David Colville & Sons), W. Rowan Thomson (David Rowan & Co.), Noel E. Peck (Barclay, Curle & Co.), Sir John Cowan, Hugh Reid (North British Locomotive Co.), A. W. Anderson (Urquhart, Lindsay & Co.), Alex. Gracie (Fairfield Shipbuilding & Engineering Co.), — M'Kinnon, J. R. Richmond (G. & J. Weir), Alex. Lamberton, J. H. Matheson (H. Matheson & Sons), T. F. Cuthbert (Stewarts & Lloyds), J. K. M'Cosh (Messrs. Wm. Baird & Co.), Andrew S. Biggart (Sir Wm. Arrol & Co.), Prof. Barr (Barr & Stroud), and Councillor Thomas Young.

* * * *

New Australian Enterprise.

The Sydney office of H.M. Trade Commissioner in Australia reports under date June 9 that a company has been registered in the Commonwealth with a capital of £1,000,000 for the production of zinc by the electrolytic process and for the manufacture of high-grade spelter. The company proposes to erect works in Tasmania, and negotiations are in hand for the supply of power from the Tasmanian Government's lately completed hydro-electric plant at Great Lake. The articles of association of this company provide for its remaining entirely under British control. British firms interested may obtain the name of the above-mentioned company on application to the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

* * * *

U.S.A. Exports to South America.

The value of the electrical exports from the Port of New York to the principal countries of South America was higher in June than in any month since December, 1915.

The total value of electrical goods and machinery exported from New York in that month was $341,139, the figures for Brazil, Argentina, Colombia and Venezuela showing healthy increases. The exports from New York represent over 80 per cent. of the total for the whole of the United States.

* * * * *

Domestic Electric Appliances in Norway.

In a recent report the United States Consul at Christiania (General E. H. Dennison) states that, owing to the large increase in the price of coal in Norway the demand for electrical appliances is heavy, and American manufacturers are notified that they have an opportunity to develop there an extensive trade.

Coal which formerly cost $7.50 per ton now sells for $23.50, and the people are turning to electricity for domestic purposes, and the sales of

electric cooking and heating stoves, ranges, washing machines, irons, rings, &c., have never been so large as at present. The demand for these articles is said to be unprecedented, and American manufacturers could with little effort improve their position in that market. It is thought that coal will be expensive for a long time to come, and perhaps never return to its original price, for Norway depends entirely on outside sources for its supplies. In any event, the sale of electrical appliances is bound to expand, and, when once installed and their many advantages recognised, it is thought that few will care to return to the use of coal.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From July 29, 1916, *to* Aug. 4, 1916.

IMPORTS.

LIVERPOOL. *Spain:* Elec. carbons, 27 pkgs. *Buenos Ayres:* Elec. lamps and parts, 14 pkgs.

LONDON. *U.S.A.:* Carbon candles, £23; wire and cable, £131; unenumerated, £16,470 7,379 cases. *Holland:* Elec. lamps, 677 pkgs.; glow lamps, £1,846 904 pkgs.; wire and cable, £29; unenumerated, £988. *Japan:* Unenumerated, £1,370 30 cases. *France:* Unenumerated, £172. *Switzerland:* Unenumerated, £233. *Denmark:* Unenumerated, £204. *Italy:* Unenumerated, £500.

MANCHESTER. *U.S.A.:* Elec. fittings, 69 cases.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Wire and cable, £464; unenumerated, £583. *Melbourne:* Wire and cable, £1,646; elec. machinery, £4,754; elec. glow lamps, £420; unenumerated, £2,371. *Sydney:* Elec. machinery, £962; wire and cable, £844; elec. lamps, 27,200 n.o.; glow lamps, 19,802 n.o.; unenumerated, £3,251. *Wellington:* Elec. machinery, £598; wire and cable, £30; glow lamps, 3,600 n.o.; unenumerated, £1,646. *Lyttelton:* Elec. machinery, £121; unenumerated, £67. *Lumsden:* Unenumerated, £48. *Adelaide:* Wire and cable, £5,974; unenumerated, £476. *Brisbane:* Wire and cable, £386; unenumerated, £463. *Christchurch:* Unenumerated, £223. *Hobart:* Wire and cable, £1,739; unenumerated, £20. *Fremantle:* Elec. machinery, £164. *Nelson:* Unenumerated, £32. *Greymouth:* Elec. machinery, £70. *Launceston:* Unenumerated, £28.

AFRICA. *Durban:* Elec. machinery, £160; telegraph material, £275; unenumerated, £595. *Cape Town:* Unenumerated, £1,028. *Port Elizabeth:* Elec. machinery, £607; wire and cable, £240; unenumerated, £199. *East London:* Elec. wire and cable, £84; unenumerated, £227. *Napier:* Unenumerated, £10.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Elec. machinery, £554; unenumerated, £1,581. *Penang:* Elec. machinery, £90; wire and cable, £69; telegraph material, £20. *Singapore:* Wire and cable, £218; unenumerated, £301. *Calcutta:* Elec. machinery, £279; wire and cable, £204; unenumerated, £1,633. *Madras:* Unenumerated, £185. *Colombo:* Elec. machinery, £127; unenumerated, £592. *Karachi:* Elec. machinery, £60; unenumerated, £20. *Bankok:* Elec. machinery, £26; unenumerated, £97. *Saigon:* Unenumerated, £41. *Port Swettenham:* Elec. machinery, £346; telegraph material, £249.

CHINA. *Shanghai:* Elec. lamps, 2,600 n.o.; wire and cable, £440; unenumerated, £84. *Hong Kong:* Unenumerated, £246. *Hankow:* Unenumerated, £37.

U.S.A. *New York:* Elec. machinery, £372; unenumerated, £455.

SOUTH AND CENTRAL AMERICA. *Rio Janeiro:* Wire and cable £232.; unenumerated, £682. *Santos:* Elec. machinery, £495. *Valparaiso:* Unenumerated, £428. *Pelotas:* Unenumerated, £77. *Rosario:* Unenumerated, £23. *Bahia:* Unenumerated, £20.

WEST INDIES. *Barbadoes:* Unenumerated, £109.

HOLLAND. *Amsterdam:* Wire and cable, £120; unenumerated, £95. *Rotterdam:* Wire and cable, £41.

FRANCE. *Dieppe:* Telegraph material, £110; unenumerated, £259. *Paris:* Wire and cable, £295; unenumerated, £265. *Boulogne:* Unenumerated, £787. *St. Nazaire:* Elec. machinery, £495.

MALTA. Elec. machinery, £49; wire and cable £55; unenumerated, £27

RUSSIA. *Vladivostok:* Elec. machinery, £307.

DENMARK. *Copenhagen:* Wire and cable, £411; unenumerated, £10.

SPAIN. *Barcelona:* Elec. machinery, £43; unenumerated, £619. *Carthagena:* Elec. machinery, £230; unenumerated, £40.

PORTUGAL. *Lisbon:* Elec. machinery, £312; wire and cable, £827; unenumerated, £550.

JAPAN. *Kobe:* Telegraph material, £102. *Yokohama:* Unenumerated, £519

FOREIGN GOODS (duty paid and free).

Amsterdam: Unenumerated, £684. *Adelaide:* Unenumerated, £75. *Archangel:* Unenumerated, £482. *Bombay:* Unenumerated, £101. *New York:* Unenumerated, £80. *Sydney:* Elec. lamps, 2,200 n.o., glow lamps, 430 n.o., unenumerated, £41. *Barcelona:* Unenumerated, £248. *Bankok:* Unenumerated, £50. *Boulogne:* Unenumerated, £16. *Dieppe:* Unenumerated, £45. *Havre:* Unenumerated, £41. *Ceylon:* Elec. machinery, £1,114, unenumerated, £28. *Smyrna:* Unenumerated, £35. *Copenhagen:* Unenumerated £28. *Calcutta:* Unenumerated, £24

IN TRANSIT.

Melbourne: Elec. lamps, £1,244

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

LEGAL INTELLIGENCE.

Workmen's Compensation.

At Lambeth (London) County Court on Friday Mrs. Ethel M. Jewell, widow of the late Frederick Seymour Jewell, sought to recover damages for the loss of her husband, the case being heard before Arbitrator (1901) (Ltd.).

Mr. Jewell was employed by the company as a traveller, and on May 15 he was travelling by an omnibus, and he was seen by a witness (who was standing on the pavement at the junction of Pentonville and Kings Cross roads) on the footboard of the omnibus, with his right hand held up to the bell-cord, while under his left arm he had a case containing the firm's catalogues, when suddenly he fell off the 'bus into the road. He died soon afterwards from concussion of the brain. Jewell had also with him some heavy brass fittings wrapped in paper.

Mr. SCANLAN (for respondents) said the defence was that the accident did not occur in the course of his business, though they acknowledged that it arose out of his employment. The car was in motion at the time of the accident, and therefore he had not exercised sufficient care in getting off.

Evidence was given by an inside passenger that Mr. Jewell stepped on the platform and did not attempt to pull the bell, but appeared to step straight off it to the road, where he stumbled and fell.

Judge Parry found that the omnibus was going at a fast rate down the incline and that deceased attempted to pull the bell. No evidence would convince him that he was jumping off the omnibus in order to commit what was suicide. He might have been giddy and fell off. He found that the accident arose out of and in the course of his employment, and awarded applicant £300 and costs on the C scale.

PARLIAMENTARY INTELLIGENCE.

TELEGRAPH (CONSTRUCTION) BILL.

The House of Commons concluded the committee stage of this bill on Monday. The bill amends the Telegraph Acts, 1863 to 1915, with respect to the construction and maintenance of telegraphic lines.

On clause 1 (User of Land and Buildings for Telegraph Lines), an amendment was moved to substitute three months for one month as the period within which consent should be signified by the owner, lessee or occupier of any land or building affected by the placing of a telegraphic line.

The Postmaster General (Mr. J. A. PEASE) agreed to the period being two months, and this compromise was accepted.

The Solicitor-General (Sir G. CAVE) proposed the addition of a provision that the tribunal to which a difference is referred under the section shall not give its consent to the placing of a telegraph line unless satisfied that the refusal or failure of the owner, lessee, or occupier to consent is contrary to the public interest. This was agreed to, as was also another amendment, moved by Mr. J. Pease, ensuring to owners, lessees and occupiers the benefits of the provisions of the Telegraph Act, 1863.

The bill was then read a third time.

AGENTS FOR PURCHASE OF INDIAN MICA.

In the House of Commons on Monday, Mr. A. CHAMBERLAIN stated, in reply to a question, that the export of mica from India to countries other than the United Kingdom and British Possessions, was prohibited save under special licence. At the request of the Minister of Munitions, Messrs. Christien & Co. had been appointed Government agents for the purchase in India of such grades as were specially required for the manufacture of munitions. So far as he was aware, there was no German element in the firm.

Trading With the Enemy (Copyright) (No. 2.) Bill also passed through Committee without amendment, and was read a third time in the House of Commons on Monday.

Royal Assent. On Aug. 3 the Royal Assent to the following Acts of Parliament was read: Gas (Standard of Calorific Power) Act, Public Works Loans Act, Expiring Laws Continuance Act.

EDUCATIONAL.

Armstrong College (University of Durham) Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

University of Edinburgh.—The next session of the engineering department commences on Oct. 10th. The preliminary or entrance examination is held in September. Complete courses of instruction in civil, mechanical and electrical engineering are provided; they qualify for the degree of B.Sc. in engineering and extend over a period of three years. Particulars of entrance examinations, scholarships, &c., may be obtained from the Matriculation Offices, the University of Edinburgh.

University of Birmingham.—At this University there are courses in mechanical, civil and electrical engineering. The full courses extend over four years, and students who enter after matriculation and pass the examinations at the end of each year will be entitled to the degree of Bachelor of Science in Engineering. The next session commences on Tuesday, Oct. 3. Syllabus, with particulars of courses, fees, &c., can be obtained from the Secretary.

University of Manchester.—In the physics department the lecture and laboratory courses prepare for both the ordinary and honours degrees of the university. Particulars can be obtained on application to the Registrar, and Prof. Sir E. Rutherford will meet intending students on Tuesday, Oct. 3.

In the electrical engineering department complete theoretical and practical training is given to students preparing for the higher positions in the electrical engineering profession, and at the end of 3 three years' course students may obtain either the ordinary or honours degree of B.Sc.

in electrical engineering. There is a special course extending over three years which prepares for the certificate in electrical engineering. The John Hopkinson Laboratories have been recently extended and they are equipped with modern electrical machinery and testing appliances, while good facilities are given for research work, &c. The next session commences on Oct. 5. Further particulars may be obtained from the Registrar.

City and Guilds Technical College, Finsbury.—The training at this College is adapted to the needs of various students, including pupils above 15 from secondary schools, who desire a practical and scientific training bearing upon their future industry or profession, and young men who, having previously served a pupilage or apprenticeship in works, desire a more systematic training in engineering and applied chemistry. The College has well-equipped laboratories and workshops for practical work. The entrance examination will be held on Sept. 19. The programme of the College has just been issued, and gives full particulars of the courses of instruction, fees, time-tables, &c. Further particulars may be obtained from the Registrar of the College, Leonard-street, Finsbury, London, E.C.

Northampton Polytechnic, London.—In the day engineering college full-day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

BUSINESS NOTICES.

H.M. Office of Works has removed to the new Government buildings in Great George-street, Westminster.

The Statistical Section of the Labour Department of the Board of Trade is to be removed from Gwydyr House, Whitehall, to Albemarle-street, where offices have been vacated by the Army Aircraft Department.

Sale by Tender.—Messrs. Wheatley Kirk, Price & Co. have also been instructed to sell by public tender, in lots to suit purchasers, the entire stock of electric lamps, cable, sheds, electric fans, electric cooking utensils and accessories, office furniture, &c., upon the premises (39, Victoria-street, London, S.W.) of Krupka & Jacoby (Ltd.), which is being wound up under the Trading with the Enemy Act, 1916. Catalogues may be obtained gratis on application to the Agents for the Controller, Messrs. Wheatley Kirk, Price & Co., 46, Watling-street, London, E.C., and at Manchester and Newcastle-on-Tyne. On view Aug. 23, 24, 25 and 26, and tenders must reach Messrs. Wheatley Kirk, Price & Co., 46, Watling-street, London, E.C., by Aug. 28. *See also an advertisement.*

Sale by Auction.—By order of the Controller (Mr. G. S. Pitt, F.S.A.A.) to conduct the winding up of Isaria (Ltd.), Mr. Ernest Owers will sell by auction the whole of the stock-in-trade of the company, including about 1,200 electricity meters, 100 prepayment meters, 750 electric fans, some starters, rheostats, 90 motors and d.c. dynamos, &c.; also the office furniture. On view Aug. 28 and 29, and catalogues of Messrs. Bolton, Pitt & Breden, Incorporated Accountants, 200, Finchley-road, N.W., and at West Hampstead and Golder's Green. *See also an advertisement.*

Plant for Sale.—Messrs. Wheatley Kirk, Price & Co. will sell by auction at the Mart, Tokenhouse Yard, London, E.C., at noon on Aug. 22, the central station electric lighting plant at 5 & 6, Bovay-street, Holloway, London, N., comprising two 46 kw. Willans-Crompton d.c. sets, two 115 kw. and one 145 kw. Willans-Siemens sets, two Babcock-Willcox boilers, one Davey-Paxman multi-tubular boiler and 40 H.P. Crossley gas engine, switchboards, cables, meters, shop plant and tools. The premises are also for sale by private treaty. On view on 17th and 18th inst., or earlier by appointment. Full particulars and catalogue may be obtained from Messrs. Guscotte & Fowler, solicitors, 1, York-place, Adelphi, London, W.C. or of the auctioneers, 46, Watling-street, London, E.C., and at Manchester and Newcastle-on-Tyne. *See also an advertisement.*

Plant Wanted. Messrs. H. K. Foster & Grace, land agents, Hereford, advertise for a 5 H.P. enclosed motor with starting rheostat for 250 volts.

Catalogues Wanted.—Advertisers who have a large open order for electrical goods for export notify that they desire catalogues from manufacturers of domestic and industrial electrical appliances.

LIQUIDATIONS, &c.

The Bachelet Levitated Railway Synd. (Ltd.) and the Bachelet Flying Train Synd. (Ltd.) are being wound up voluntarily, and Sir W. B. Peat, 11, Ironmonger-lane, London, E.C., has been appointed liquidator.

The Institute of Industry (of Great Britain and Ireland) (Ltd.) is being wound up voluntarily, and Mr. L. W. Hawkins, Basildon House, London, E.C., has been appointed liquidator.

A meeting to receive an account of the winding up of the Biddle Automatic Signal (Ltd.) will be held on Sept. 8 at 25, Victoria-street, London, S.W.

A first dividend of 3s. 4d. will be payable on Aug. 23, at the offices of Messrs. Corfield & Cripwell, 119, Finsbury-pavement, London, E.C., to creditors of Russell Ernest Connold, formerly electrician of 6A, The Parade, Canterbury.

ELECTRICITY SUPPLY.

EXTENSIONS.

Barrow. It has been decided to give a supply of electrical energy to 90 new workmen's houses at Walney.

Burton-on-Trent.—A main is to be laid at an estimated cost of £1,000 to supply energy for power and lighting to the India Rubber & Gutta Percha Co.'s new factory at Horninglow.

Derby.—At the meeting of the Council last week Ald. Wilkins moved that application be made to the L.G. Board for sanction to borrow £9,000 for mains and motors for power purposes.

Ald. WILKINS said the sum included £5,000 which it had been suggested would be required, and had been passed by that Council in committee for the new company which was expected shortly to erect works in Derby. They were having still a great demand for mains and motors from works and factories, and it was necessary for them to spend £4,000 during the next eight months. Their net profit for the past year had been £2,472 and for the previous year it was £2,982, a decrease of £510. The increased cost of coal had been £5,766, the increase in insurance and the allowance to dependents and others had been £725, and their standing charges for interest and sinking fund had increased by £2,128, making £8,619. On the other hand they had decreased the expenditure by £670, although they had turned out 17 per cent. more electricity than in the previous year. The committee had to find, in order to make up the loss, the sum of £7,549. The Council granted them 10 per cent. increase, and that had resulted in the consumer paying £987 more, the tramways, hire of motors, £852, and power increase represented £6,405, a total increase of £9,031. Against that there had been the curtailment, almost discontinuance, of public lighting (£1,592), so that they had had a net increase in their income of £7,439, and an increase in their expenditure of £7,949.

The report and recommendation were adopted.

Sheffield.—Mains are to be extended at a total estimated cost of £1,019 to supply current to new consumers.

The contract with the British Electric Transformer Co. for the supply and delivery of transformers and service gear is to be extended for a further period of two years in accordance with a revised schedule of prices.

GENERAL.

Bermondsey (London).—The Council have decided to take a bulk supply of electricity from the London Electric Supply Corpn.

Increased Charges for Current.—The following increases are announced:—

Dawlish Council has assented to the Dawlish Electric Light & Power Co.'s proposal to increase its charges to private consumers by 10 per cent.

Bexhill Council has made a further increase of 5 per cent. in its charges for current, in addition to the increase of 10 per cent. made in Sept. last.

Luton. Last week the Council applied for sanction to borrow £900, being balance of amount expended for electrical machinery in excess of sum sanctioned in August, 1913.

Malvern. The Urban Council has increased the salary of the gas and electrical engineer (Mr. S. Trow Smith) by £50 per annum.

Municipal Contract with Austro-German Controlled Company.—At last week's meeting of Manchester Corporation the chairman of the Electricity Committee (Mr. Dagnall) referred to the awkward dilemma in which the Committee was placed.

Its minutes contained a recommendation that a tender for the supply of boiler tubes be accepted from a certain firm, 99 per cent. and over of whose capital was German. The difficulty was that the firm in question were the only manufacturers of those tubes, which were essential to the carrying on of the electricity department. The Committee, therefore, wanted the Council to say what was to be done in the matter. The English works of the company were a controlled establishment under the Munitions of War Act.

Ald. KAY (chairman of the Gas Committee) said the Gas Committee

was in exactly the same difficulty, all due to the lack of backbone of the Government in not taking the works over, lock, stock and barrel.

The Council in the exceptional circumstances suspended the Standing Orders and agreed to accept the tender.

Oldham.—It was reported to the Council last week that, in spite of the "Daylight" Savings Act, there was an increase in the number of units consumed of over 21,000, which was very satisfactory.

Mr. DIXON said he had been asked several times why the Electricity Committee was not carrying out the Act. He thought it was a bit of a joke at first, because he did not think such an intelligent committee such as the Electricity Committee, and a chairman such as Councillor Hardman, would not carry out the Act; but he found that the Electricity Committee had failed to put their clocks forward. He had some sympathy with them, seeing that they had over 2,000 clocks, but there was a great deal of dissatisfaction among the consumers who were on the two-rate system, as they were charged two different scales, and they complained that they were "done" out of an hour at the lower rate. The people could not understand why the clocks had not been put forward, and thought that if it was impossible to put them forward they should have some rebate. He did not know if there was any penalty for not observing the Act, but if there was he hoped the Mayor would see it was inflicted on the Electricity Committee.

Councillor HARDMAN, chairman of the Committee, said the question was discussed, and it was felt that, having over 2,000 clocks, they could not possibly in the limited time allowed alter the clocks. If it was a permanency something would have to be done, but it would not have to be a changing of the clocks. Some other means would have to be arranged. Although there was an increase of units consumed, they had a decrease of 10 per cent. in the units for lighting; the increase was in alternating current for power. He thought the dissatisfaction was more apparent than real. They had not had a single application to change from the two-rate meter to the flat meter, and they would be pleased if those not satisfied with the two-rate meters would have a flat meter.

Stockton-on-Tees.—The electricity works staff is to be re-organised owing to the partial shutting down of the steam plant until November consequent upon an agreement with the power company.

The electrical engineer (Mr. J. J. Smith) reports that by the terms of the bulk supply agreement, the Corporation is bound to pay for a minimum of 1,000,000 units per annum, with a reduced charge on all units taken over this 1,000,000, and a further reduced charge on all units taken over a total of 1,750,000, providing that the maximum demand of 1,000kw. is not exceeded during the year, or 500 kw. is not exceeded during the restricted hours during the year. To make a success of this arrangement, it is essential that the Corporation steam plant be run only during the restricted hours, to prevent the demand of 500 kw. being exceeded. Under the proposed new method of running, the engines and boiler will be under steam for 782 hours per year, against approximately 7,500 hours before introducing the bulk supply. Therefore, the labour required for operation and repair of the steam plant can be much reduced, whereas, on the other hand, the work and responsibility of the electrical staff has been considerably increased owing to the fact that the works now contain rotary converters of a capacity equal to the steam plant and that it is intended to run these for long hours together independent of any engines and boilers. The new machinery is of an intricate character, using three-phase a.c. at 11,000 volts and transforming same to d.c. at 460 volts. For the operation and repair of the plant only three shift engineers, two driver-stokers and one coal trimmer (employed for four months in the year) will be retained, thus the services of one fitter-driver and one stoker will be dispensed with. As the running hours are short, repairs to the steam plant can be more cheaply done by obtaining outside assistance when such repairs are greater than can be coped with by the proposed staff.

The Corporation has approved the suggested arrangement.

Sheffield.—The Electricity Committee again recommend the Council to increase the charges for the supply of electrical energy. The recommendation was submitted to the Council on Wednesday.

Torquay.—Last week the Council were informed by the Deputy Electrical Engineer that since the "Daylight" Saving Act came into force the daily kilowatt demand decreased from 350 to 275, with a decreased daily output from 2,820 units to 2,010.

The units generated for the past six months showed an increase of 13·24 per cent. against an increase of 3·7 for the corresponding period in 1914-15. The figures were satisfactory and tended to show that the number of private connections (95) that had been made were making good the losses due to the Act and public lamp extinctions.

TRACTION NOTES.

Dover.—The Council have adopted a report of the deputy borough engineer (Mr. R. H. Crummalk) recommending that the five Edison electric vehicles be used for other work besides house refuse collection.

If house collection work were commenced at midnight, by 6 o'clock in the morning three vehicles could be got ready for other work, and by 10 o'clock the refuse collection would be finished and the remaining vehicles released. Where necessary, one or more could be utilised as street watering carts, and as each vehicle equalled in carrying capacity two horse-drawn water carts, a vehicle would save at least 10s. for every two horse-drawn water cart. With regard to a proposal that one vehicle should be fitted with a machine broom, he stated that from an experiment he had found that the cost of current was just over 3d. per mile of street, and he believed that from four to six sweepers could be dispensed with. Although during the last 18 years only four extra street orderlies had been engaged, from 30 to 40 extra streets had been taken over, the result being that many streets were only swept once per week, which was quite insufficient for keeping them thoroughly cleansed. The question of making a saving in the emptying of the catchpits was somewhat difficult to estimate, but one vehicle would displace two or three horse-drawn vehicles, which at present cost 23s. 4d. or 35s. per day, according to the number hired. In order to carry out the suggested alterations, it would be necessary to have a night foreman, experienced in the upkeep of electric vehicles, to train the necessary extra drivers. There would also be greater consumption of current and more wear and tear, but, taking into consideration the sums previously spent, he thought the adoption of his suggestions would save from £500 to £700 a year.

Manchester.—The Tramways Committee has relaxed the rules against fare-collecting on the platforms of tramcars and the provision of seats.

A notice has been affixed to the cars directing intending outside passengers to hand the exact amount of the fare to the guard on the platform before proceeding upstairs. This method of payment is, however, not to be resorted to at busy loading places.

Middlesbrough.—The Council has appointed a sub-committee to consider the question of taking over the local electric tramways. The Council will have the right to take over the system in its district after six months' notice, in 1918.

Norway.—It is stated that the Railway Committee of the Norwegian Storthing has approved a proposal for the electrification of the Drammen railway at a cost estimated at 21,369,500 kroner.

Rotherham.—Last week the Corporation decided, on the recommendation of the Tramways Committee, to proceed with certain "linking-up" work, but the portion from Frederick-street to Effingham-street has been postponed.

The engineer (Mr. E. Cross) reported that he was not prepared to advise the employment of women tramcar drivers in a town like Rotherham, as it was not likely to conduce to the safety of the public.

TELEGRAPH & TELEPHONE NOTES.

Radiotelegraph Notes.—A telegram from Malmö states that wireless traffic between the United States and Germany, which has been interrupted during the past month owing to atmospheric disturbances, has been reopened.

The Indian Government Telegraph Department is making good progress with the erection of the wireless station at Maymyo, and it is expected to be ready for traffic soon.

The Australian Commonwealth Minister for the Navy (Mr. Jenson) has announced that the Commonwealth Government will meet all wireless requirements in Australia, and that it is now negotiating for the purchase of the Shaw Wireless Works in Sydney.

LIGHTING & POWER NOTES.

Electric Cranes on the Clyde.—The Clyde Navigation Trust have decided to purchase three electric cranes with the necessary grabs at a total cost of £12,000. These cranes will be erected at the Rothesay Dock, Glasgow, and will be mainly used for handling cargoes of iron ore.

Electricity in Petroleum Oilfields.—Mr. J. Annan Bryce, M.P., who presided at the recent meeting of the Spies Petroleum Co. (Ltd.), stated that the item "Electric power station" showed a considerable increase owing to the additional expenditure as it approaches completion. There had been delays in the delivery of motors owing to their having been commandeered by the Russian Government, but they were now coming forward, and it was expected that they would shortly be working entirely with electricity as regarded baling, and soon be able to make a start in its use for drilling.

Until the electric power had been in full working order for all purposes it would, of course, not be possible to judge of the savings from its use. But even with its present comparatively limited use the saving in fuel alone had amounted to about 12½ per cent. on the capital expenditure, without reckoning the saving in labour, and, moreover, as there was a considerably diminished supply of gas in 1915 the actual saving in fuel was a good deal larger than appears from the figures of reduction in consumption of oil.

London Dock Improvements.—Among the recent works of extension and improvements at the London docks is the provision at the Albert Dock of 43 electric cranes, each capable of lifting 3 tons at 60 ft. radius.

Nearly all the cranes have now been delivered by the contractors. The dry dock, which is nearing completion, will add considerably to the facilities of the port for repairing the largest type of vessel. The existing graving docks are being utilised for repairing and fitting out ships.

EMPIRE NOTES.

Australasia.—Dunedin (N.Z.) City Council has received tenders for the supply of six electric tramcars and sections of cars, but in view of the present unsatisfactory conditions as regards prices and shipment of material, none of the tenders has been accepted.

The Electric Light & Power Supply Corpn. (Ltd.), of Sydney, earned a net profit of £8,822 in the half-year ended April 30, compared with £8,826 for the corresponding term of 1915. A dividend at rate of 8 per cent. per annum (the same as that for the previous term) has been paid, absorbing £6,177. £1,800 has been allocated to reserve, and £4,000 for depreciation of assets, leaving £67 to be carried forward, against £3,222 forward from previous year. The revenue for the half-year showed an increase of £1,737 over that of the corresponding half-year in 1915.

Canada.—It is reported that the Ontario Government has found an economical process of refining nickel within the province through the medium of the Nickel Commission. The process is said to be an electrical one and it is claimed to be a much cheaper method than that at present in use. The use of hydro-electric power will prove one of the big factors in reducing the cost.

India.—At a recent meeting of Madura Council Mr. K. T. B. Tressler, Director of Industries of Madras, addressed the Council, and said that at present it would not be possible for the Government to take up the Periyar Electric Supply scheme. It was, therefore, necessary that the Madura Council should have its own scheme. The suggestion that a private company might be asked to work out a scheme would not find favour with Government. The total cost would be nearly R.1,00,000. The chairman said the Municipality had 2,500 lights costing about Rs. 26,000 and the lighting was insufficient. Mr. Tressler said that the scheme would provide for 2,500 lights of 25 c.p. and 200 fans. They could not know exactly what the demand would be from private individuals, but "a small scheme would always be the best at the beginning," and the Government would view with favour only a modest scheme. It would be possible to supply the town with electric light within six months.

The "Financier" states that in addition to the existing hydro-electric company (the Tata Hydro-Electric Power Co.), which undertook to supply 40,000 H.P. in Bombay, and is already supplying 30,000 H.P., there is to be another Tata undertaking started which is also intended to supply 40,000 H.P. in Bombay. It is estimated that if all the mills were electrified Bombay could employ 100,000 H.P., and the electrification of the local lines of the Great Indian Peninsula & Bombay, Baroda and Central India Railways is contemplated. The new hydro-electric concern will, like the one now working, employ running water of the Ghats for its power, and the head works will be 10 miles from those of the existing system, the current being transmitted 59 miles to Bombay.

FOREIGN NOTES.

Russia.—The British Vice-consul at Ekaterinburg states that the outlook for platinum mining in the Urals seems to foreshadow an even smaller production this year than in 1915.

Recent mobilisations in the district have greatly curtailed the output from hand washings, and the production from the larger companies by means of dredging is likely to be similarly affected by the scarcity of labour. The price ruling (at June 22) was 67,500 roubles (£7,125) per poud (36 lb.) for quantities up to 10 lb., and from 68,000 roubles (£7,178) to 68,500 roubles (£7,230) per poud for larger quantities. The future prices will depend largely on the quantity allowed to be exported.

United States.—*Bauxite and Aluminium.*—According to a statement issued by the United States Geological Survey, the bauxite and aluminium industries had a flourishing year in 1915.

The production of bauxite was 297,041 tons, valued at $1,514,834 (increase 77,723 tons and $445,640). This large increase was due to greatly increased activity in the aluminium industry. The foreign bauxite used was only slightly over 1 per cent. of the total consumption of more than 300,000 tons. Arkansas produced more than 90 per cent. of the domestic production, and Georgia, Alabama and Tennessee the remainder. In spite of the fact that 99,806,000 lb. of metallic aluminium were consumed in the United States in 1915, there was a great scarcity of the metal in the country, especially during the later part of the year, the chief causes being the greatly increased demand and the curtailment of imports.

MISCELLANEOUS NOTES.

Appliances for the Wounded.—We have received the following communication from Mr. H. F. Simon, managing director of Electrical Installations (Ltd.), 27 and 28, Martins-lane, London, E.C.

May I ask you through the medium of your valuable journal to appeal to all electrical manufacturers and contractors who have any form of workshop, whether large or small, to help me in the following excellent cause. A very large number of metal leg and arm rests are required for those of our wounded heroes returned from the front with fractured limbs. I have taken it upon myself, on behalf of a branch of the Red Cross Society, to offer to supply a certain number of the necessary parts required in making up the above frames. This form of apparatus relieves the wounded of much suffering and helps to hasten the mending of the fractures. Anybody with an ordinary lathe can bend and drill certain simple parts of the apparatus made up of ordinary pieces of flat iron strip and galvanised rod, and if contractors would kindly help to supply even a small number of these parts per week I should then be in the position to keep this branch of the Red Cross equipped with sufficient material per week to enable the amateur workers who put the frames together to complete a considerable number per week. At the present time thousands of these frames are required, and as the putting together is all done voluntarily every small help is of valuable assistance. Therefore, again I appeal to all manufacturers and contractors to give me their support in this matter. The raw material will be supplied by me, and patterns of the parts required can either be seen in my office or would be sent on application.

Electrolytic Disinfecting Fluid at Poplar.—In the annual report of the medical officer of health (Dr. W. F. Alexander) on the sanitary condition of the borough, particulars are given of the output, cost, &c., of the electrolytic disinfecting fluid made and supplied by the Borough Council in the year 1915.

The fluid distributed to the seven depots, where it is still in great demand, and to baths, schools, libraries, public buildings, &c., amounted to 73,970 gallons. The cost of material for 36,985 gallons (afterwards broken down to 73,970 gallons) was £84. 11s. 3d., including 7,776 units of electrical energy (£48. 12s.), 3 tons 15 cwt. 2 lb. of chloride of magnesium (£19. 3s. 9d.), 55 tons 8 cwt. of salt (£9. 3s. 7d.), caustic soda (£5. 8s.) and water (£1. 13s. 11d.). To this may be added electric motor for stirring (210 units), £1. 6s. 3d.; bottles, £16. 19s.; and corks, £9. The total quantity manufactured in the 10 years the plant has been in operation is 418,779 gallons, at a cost of under ½d. per gallon. For supplies to manufacturers and trading concerns a charge of 8d. per gallon has been made since October, 1915, out of which 10 per cent. is allowed to the electricity department for establishment charges. It is stated that the process has been a success for 10 years.

The cost has been much reduced since August, 1914, by manufacturing the fluid at greater strength and afterwards breaking it down to half strength, the cost of 73,970 gallons in 1915, as stated above, being £84. 11s. 3d., whereas the cost of 66,740 gallons in 1913 was £133. 8s. 1½d.

Enemy Firms Wound Up.—The Board of Trade has ordered the winding up of 296 businesses controlled by alien enemies.

The latest lists include R. Dolberg, 119-125, Finsbury-pavement, London, E.C., portable railways. (Controller: Wm. Hancock, 90 and 91, Queen-street, Cheapside, E.C.) F. Prager, 21, Mincing-lane, London E.C., rubber merchant. (Controller: R. J. Knight, 3, Raymond-buildings, Gray's Inn, W.C.) Simon Menzel, 15, Seething-lane, London, E.C., iron merchant. (Controller: G. Bostock, 21, Ironmonger-lane, E.C.) Levy & Soicher, 15, Seething-lane, London E.C., iron merchants. (Controller: G. Bostock, 21, Ironmonger-lane, E.C.) Duron Co. (Ltd.), Bank-buildings, 1, Manchester-road, Bradford, manufacturers and dealers in oils, fats and chemicals. (Controller: W. E. Harding, Central Bank-chambers, Leeds.) C. P. Goerz Optical Works (Ltd.), 4 and 5, Holborn-circus, London, E.C., opticians, &c. (Controller: C. Field, Broad Street-avenue, E.C.) Grimme Natalis & Co. (Ltd.), 46, Cannon-street, London, E.C., agents for sale of calculating machines. (Controller: L. L. Samuels, 7, Norfolk-street, Manchester.)

Claims against C. A. Muller, 10, Arcade, Westgate, Bradford, electrical accessories merchant, are to be sent to Mr. W. Durrance, 12, Duke-street, Bradford.

Engineers' Wages.—The engineering trades on the north-east coast have been awarded an advance of 3s. a week, Clyde engineers 3s. 4d. a week and Welsh steelworkers 10½ per cent.

The G.E.C. Cadet Corps.—On Saturday, Aug. 5, an inspection of this corps, which is formally known as the 1st Cadet Battalion Sussex Yeomanry "G" London Company, was held on Hampstead Heath. The corps was under the command of Capt. E. A. Joyce, and gave an excellent display of company drill and field manœuvres, culminating in an enveloping movement which was carried out with a high degree of skill and intelligence.

After the manœuvres the corps marched to "Springmead," the residence of the chairman of the General Electric Co. (Ltd.), where they were entertained to lunch and tea. The afternoon was spent in a variety of sports, including several boxing matches which were keenly enjoyed by a number of wounded soldiers who had also been invited. The band of the 19th Batt. King's Royal Rifles was in attendance.

Trading with the Enemy.—Further lists of persons and firms with whom trading by persons and firms in the United Kingdom is prohibited have been published :—

These include : *Brazil :* Companhia Sul-Americana de Electricidade A.E.G. (Rio de Janeiro) ; *Ecuador :* Orenstein & Koppel : *Liberia :* Deutsche Sudamericanische Telegraphegesellschaft, A.G. : *Netherlands East Indies :* Technische Bureau Behn Meyer & Co. (Soerabaya) ; *Spain :* Campania Sevillana de Electricidad (Seville).

It is announced that it is an offence to trade with any persons or firms of enemy nationality in Persia, Morocco or Portuguese East Africa, even if such persons or firms have not been included by name in the statutory list.

Imports.—The following are official values of electrical machinery material and apparatus imported into this country (*a*) during July, 1916, and (*b*) the aggregate figures from Jan. 1 to July 31, with increase or decrease compared with corresponding periods of 1915 :

Electrical machinery, (*a*) £81,746 (decrease £26,511), (*b*) £735,352 (decrease £287,109) ; including generators and motors other than for aeroplanes, motor cars and cycles, (*a*) £16,793 (decrease £7,579), (*b*), £119,142 (decrease £16,877) ; and electrical machinery unenumerated (*a*) £67,953 (decrease £18,965) (*b*) £616,210 (decrease £240,223) ; telegraph and telephone cables other than submarine, (*a*) £1,148 (decrease £815), (*b*) £53,334 (increase £36,433) ; telegraph and telephone apparatus, (*a*) £4,510 (decrease £3,068), (*b*) £199,229 (increase £156,476) ; other electrical wires and cables, rubber insulated, (*a*) £12,546 (decrease £2,083), (*b*) £77,396 (increase £20,531) ; with other insulations, (*a*) £1,596 (decrease £2,822), (*b*) £5,217 (decrease £15,651) ; carbons, (*a*) £6,216 (decrease £7,419), (*b*) £54,749 (decrease £17,477) ; glow lamps (*a*) £27,428 (increase £15,775), (*b*) £161,701 (increase £81,769) ; arc lamps and electric searchlights, (*a*) nil, (*b*) nil (decrease £1,586) ; parts of arc lamps and searchlights (other than carbons), (*a*) £9,465 (decrease £2,462), (*b*) £57,631 (increase £3,892) ; primary and secondary batteries, (*a*) £14,429 (increase £7,671), (*b*) £115,337 (increase £17,450) ; meters and measuring instruments, (*a*) £6,896 (increase £2,931), (*b*) £54,798 (increase £6,593) ; switchboards, (*a*) nil (decrease £559), (*b*) £257 (decrease £3,758) ; electrical goods and apparatus unenumerated, (*a*) £44,534 (increase £23,521), (*b*) £198,997 (increase £86,691). Total of electrical goods and apparatus other than machinery and uninsulated wire, (*a*) £128,978 (increase £39,739), (*b*) £943,759 (increase £393,303).

Exports.—The exports of electrical machinery, material, &c., (*a*) during July, 1916, and (*b*) from Jan. 1 to July 31, with increase or decrease compared with corresponding periods of 1915, were as follows :—

Electrical machinery, (*a*) £137,831 (increase £27,624), (*b*) £785,758 (decrease £41,715) ; including railway and tramway motors, (*a*) £3,598 (decrease £835), (*b*) £29,425 (decrease £65,809) ; other generators and motors except for aeroplanes, motor cars and cycles, (*a*) £86,294 (increase £12,298) (*b*) £450,218 (decrease £38,586) ; and electrical machinery unenumerated, (*a*) £47,939 (increase £16,163), (*b*) £334,915 (decrease £14,082) ; telegraph and telephone cables, submarine, (*a*) £31,737 (decrease £10,836), (*b*) £274,214 (increase £26,262) ; other than submarine, (*a*) £39,465 (increase £3,469), (*b*) £272,155 (increase £58,903) ; telegraph and telephone apparatus, (*a*) £20,518 (increase £3,767), (*b*) £152,739 (increase £36,581) ; other electrical wires and cables, rubber insulated, (*a*) £37,555 (increase £9,855), (*b*) £291,308 (increase £122,019) ; with other insulation, (*a*) £67,155 (increase £20,662), (*b*) £295,465 (increase £249,272) ; carbons, (*a*) £1,454 (decrease £103), (*b*) £6,195 (increase £1,266) ; glow lamps, (*a*) £15,273 (decrease £1,967), (*b*) £103,253 (increase £21,532) ; arc lamps and searchlights, (*a*) £173 (decrease £124), (*b*) £5,832 (increase £3,494) ; parts of arc lamps and searchlights (other than carbons), (*a*) £1,215 (decrease £1,165), (*b*) £14,396 (increase £604) ; primary and secondary batteries, (*a*) £28,225 (increase £15,018), (*b*) £157,867 (increase £41,729) ; meters and measuring instruments, (*a*) £24,536 (increase £11,078) (*b*) £121,205 (increase £24,601) ; transformers, (*a*) £9,369 (increase £5,386), (*b*) £57,582 (increase £13,811) ; switchboards, (*a*) £5,494 (decrease £517), (*b*) £58,841 (decrease £58) ; electrical goods and apparatus unenumerated, (*a*) £67,828 (increase £21,279), (*b*) £372,496 (increase £32,776). Total of electrical goods and apparatus, other than machinery and uninsulated wire, (*a*) £349,967 (increase £87,916), (*b*) £2,588,099 (increase £639,011).

TENDERS INVITED.

Cables, Switchgear, &c.

BARKING Council requires tenders by 7 p.m. Aug. 15 for e.h.t. Cables, Main and Substation Switchgear and Transformers. Specification from the Acting Engineer and Manager, Electricity Works, Barking.

Ash-handling Plant.

MANCHESTER Electricity Committee requires tenders by 10 a.m. Aug. 15 for Hoist Gear, Motor, Cage and Hoist Well for ash-handling plant for electricity works. Specifications and forms from Mr. F. E. Hughes, Town Hall, Manchester.

Accumulators.

ST. ASAPH Guardians want tenders by Aug. 15 for renewal of Accumulators at the workhouse. Specifications from Mr. E. H. Wright, Electricity Works, Rhyl.

Tramcar Tyres.

LONDON County Council requires tenders by 1 p.m. Aug. 22 for Supply of 1,000 Forged Steel Driving Wheel Tyres, and 500 Forged Steel Trailing Wheel Tyres. Forms of tender from the Chief Officer of Tramways, 62, Finsbury pavement, E.C.

Telegraph and Telephone Material.

The Deputy Postmaster-General, Perth (W. Australia), require tenders by 3 p.m. Aug. 16 for the supply of Resistance Boxes, Morse Sounders, Switches, &c., for the AUSTRALIAN COMMONWEALTH Postmaster-General's department. Specifications from the Deputy Postmaster-General, Perth (W.A.).

Tenders are invited up to Aug. 16 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster General's Dept. (State of Western Australia) of (*a*) Distilling Apparatus (schedule 502), (*b*) Instruments (Telegraph and Measuring), various and parts (schedule 498). Tender forms and specifications can be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster General, Perth, requires tenders by 3 p.m. Oct. 1 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster General, Perth, W.A.

Turbo-Alternator, Condenser, &c.

The Town Clerk, INVERCARGILL (N.Z.) will receive tenders until 1 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 10). Specification, &c., from the Town Clerk.

Electric Crane, Air Compressor, Crane Motors, &c.

The VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

The NEW SOUTH WALES GOVERNMENT RAILWAYS & TRAMWAYS DEPARTMENT require tenders by noon Sept. 20 for the supply and erection of an Electric Overhead Travelling 50-ton Crane (specification 471) : and by noon Oct. 11 for a motor-driven Air Compressor (specification 480) for Zarra-street power house. Specifications, &c., from the Electrical Engineer, 61, Hunter-street, Sydney.

TENDERS RECEIVED AND ACCEPTED.

Southport.—The Tramways Committee has accepted the tender of the Dodman Lock & Engineering Co. for the supply of 15 Peckham trolley [illegible].

Barrow.—The Council have placed an order with the British Westinghouse Co. for a [illegible] set at £735.

Grantham.—The Electricity Committee have accepted the tender of C. A. Parsons & Co. for the supply of a turbo-generator set at £18,650.

Tenders were also handed in by Messrs. Dorman Adamson & Co., Belliss & [illegible], British Westinghouse Co., British Westinghouse Co., C. A. Parsons & Co., P. & J. Rose & Co., Luther, Wyse & Co., [illegible], Siemens Brothers, & Co., Metropolitan Vickers, Crompton & Co., Willans & Robinson.

Southampton.—The Council has accepted the tender of F. [illegible] for [illegible] conductors at the refuse destructor.

Southampton.—The Council has placed a contract with J. L. Udall & Co. for the [illegible] at the Town Quay.

Cawston (Norfolk).—The Electric Utility Co. has secured a contract for [illegible] wiring for electric light, telephones, &c., for Mr. A. L. Chipperfield's [illegible].

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Brighton.—The accounts of the electricity department show total capital expenditure £842,867 (an increase of £2,569 for the year ended March 31), and the total amount provided for redemption of loans is £396,195.

Revenue was £96,649 (compared with £93,869 in previous year), working and special expenses were £56,203 (£50,576), and gross profit was £40,345 (£42,966). Interest required £17,760 (£17,898), sinking fund contribution £24,907 (£26,448) and income tax £1,667 (£326), the net result being a deficit of £3,990 (£1,354). Fuel cost 0·65d. (0·44d.) per unit sold, total costs were 1·36d. (1·06d.) exclusive and 2·46d. (2·10d.) inclusive of loan charges. Units generated were 11,369,064 (12,342,172) and sold 9,336,639 (10,214,436). Maximum load was 4,280 kw. (4,960 kw.), and load factor 24·9 (23·5) per cent.

Croydon.—The tramway accounts for the year ended March 31 show gross capital expenditure £286,764, and £116,376 has been applied to reduction of debt, while the reserve and renewals fund amounts to £43,824.

Revenue was £94,416 (compared with £88,614 in previous year), working expenses were £72,509 (against £70,307), allowances to staff in H.M. Forces absorbed £4,982 and war bonus £925, the net balance after payment of interest and income tax (£9,978) and sinking fund and instalment of loan (£7,455) being £811, which has been placed to renewals fund. Total revenue per car-mile was 8·632d., and working expenses, including power, were 6·535d. Passengers carried were 21,030,075, car-miles run 2,663,195, and units used 2,925,807 (1·099 per car mile).

Dundee.—The accounts of the electricity department for the year ended May 15 show total capital expenditure £262,013 (increase £16,958), of which £369,422 is outstanding.

Revenue was £78,295 (compared with £65,529 in previous year) and working and general expenses were £48,656 (£38,617), leaving gross profit £29,638 (£26,912), to which is added £2,835 balance from previous year. Interest required £13,635 (£12,060), sinking fund £12,971 (£10,385), military service allowances £1,065 (£788), and war bonus £784 (£71), the balance carried to next year's account being £3,244 (£2,835). Units generated were 21,687,392 and sold 18,356,957. Max. load 7,793 kw.

The tramway accounts for the year ended May 15, 1916, show total capital expenditure £383,486, of which £103,642 has been redeemed. The year's revenue was £71,949 (compared with £68,273), working expenses were £48,431 (£43,358), interest required £9,852 and sinking fund £6,889, leaving net profit £6,777 (£8,902), of which £3,650 has been placed to renewals fund, £2,095 to depreciation, £1,000 to common good fund, and £32 to reserve. Average traffic revenue per car-mile was 11·942d., and working expenses, including power, were 8·209d. Passengers carried were 19,626,640, car-miles run 1,415,887 and units used 2,707,958.

Gloucester.—Accounts of the electricity department for year ended March 31 show total capital expenditure £106,947 (increase £2,417), and £40,419 has been repaid or contributed to sinking fund.

Revenue was £15,879 (compared with £15,561 in previous year). Working and general expenses were £10,649 (£7,539), and gross profit was £5,229 (£8,021). Capital charges were £7,285 (£7 118), the net result being a deficit of £2,056 (against a net profit of £904). Units sold were 1,916,205 (1,993,516). Maximum load was 975 kw. (995 kw.) for lighting and power and 310 kw. (342 kw.) for traction.

Mr. F. H. Corson (city electrical engineer), in his report, attributes the deficit to enforced restriction of lighting and the further reduction of lighting in consequence of the altered summer time, the increase of 70 per cent. in the price of coal, the payment of war bonuses and allowances, and the increase of £757 in rates, and he advocates an increase of 20 per cent. in the charges for current for all purposes.

Lowestoft.—At the Council meeting recently the Tramways Committee reported traffic receipts from Oct. 1, 1915, to July 1, 1916, £5,084, against £6,561 in the corresponding period, 1914-15.

Mr. F. Spashett, Chairman of the Committee, said the decrease from Oct. 1 to date was £1,435, but there had been a decrease in working expenses of £935. There were several reasons why the trams should not cease running during the war; one was that to the end of June the gross income was £5,230, the working expenses £4,650, which left a credit balance of £580 to go towards payment of interest and sinking fund. That proved what a serious loss to the ratepayers they would incur by stopping the service.

Marylebone (London).—The accounts of the electricity department for the year ended March 31 show total capital expenditure £2,141,917 (increase £5,295), of which £1,755,004 is outstanding.

Revenue was £202,640 (compared with £185,330 in previous year), working expenses were £76,081 (£69,598), leaving gross profit £122,192 (£111,719). Capital and special charges were £119,821 (£118,777), and net profit was £2,371 (compared with a deficit of £7,057). Total working costs were 1·136d. (1·049d.) per unit sold, and capital and special charges 1·789d. (1·790d.). Units generated were 22,251,773 (22,547,171) and sold 16,039,870 (15,926,167). Plant capacity was 19,060 kw. (as in previous year), maximum load on feeders was 8,986 kw. (8,514 kw.), and load factor 21·3 (21·4) per cent.

The Electric Supply Committee state in their report that a new source of income, which will be of importance to the department in the near future, is the sale of energy for electric vehicles. Of income collectable within the year, 99·54 per cent. has been collected. Special (war) expenses were £1,297 (£2,301). Fuel cost 0·465d. per unit sold (against 0·318d.), representing £9,840 increase, which would have been much greater but for the new plant. The higher rate of income tax accounted for £1,456. In all, the extra costs arising from the war amount to £18,450. The sales and publicity department shows a credit balance of £479 (against a debit balance of £2,339). Adding the net profit (£2,371) to the appropriation account brought the latter to £17,968; of which £13,916 is left after providing £4,051 for service lines, mains, machinery and depreciation of apparatus on hire.

COMPANIES' MEETINGS AND REPORTS.

ELECTRIC LIGHT & POWER SUPPLY CORPN. (OF SYDNEY) (LTD.)—The directors' report for the six months ending April 30, 1916, stated that the number of new consumers connected during the half-year constituted a record. The total consumers on April 30 was 3,648, an increase of 380. The coal conveyor had been delayed awaiting delivery of the mechanical portions from America, but the contractors expected to complete the erection in June, when a substantial reduction was anticipated in the cost of fuel. The lighting of Parramatta-road between the municipalities of Annandale and Petersham had been completed, and had given general satisfaction. The increased cost of fuel, stores and other material, together with the increases in wages granted to the employés by the State Wages Board, had considerably increased the total working expenses. The total revenue was £23,185, against £21,448 in 1915, an increase of £1,737, which was considered very satisfactory. The profit for the six months was £11,196, and, with £3,222. 13s. 11d. brought forward from last October, and after deducting £2,344. 16s. 8d. for debenture interest, the credit balance was £12,044. 13s. 3d. A sum of £4,000 was placed to reserve for depreciation of assets, and £1,800 to reserve fund. A dividend for the half-year at rate of 8 per cent. per annum (£6,176. 19s. 2d.) was paid and £67. 14s. 1d. carried forward. During the half-year one new sub-station was erected and completed. In obtaining supplies difficulty is being experienced especially copper wire and meters and if the cost of these increase much more, it is possible that extensions of the recticulation system and the supply to new consumers may have to be withheld until conditions become normal again. The capital expended during the half-year on land, sub-station, services and extensions of mains, &c., was £11,740. The number of units generated was 6,068,539.

NORTH MELBOURNE ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The net revenue for the year ended Sept 28 was £11,732, compared with £10,717 for the previous year. The amounts written off in exchange for income certificates were £37,575 in respect of arrears of debenture interest and £16,525 in respect of bills payable, and a further £5,433 has been written off for interest waived by the holders of the bills. The total amount written off is £59,534, out of which the directors have applied £23,000 for depreciation and the balance in extinguishing the debit to profit and loss; a credit balance of £3,220 is now shown in the latter account.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

GRINYER & CO. (LTD.) (144,531.)—Reg. Aug. 4, capital £5,000 in £1 shares, to take over the business of electrical and mechanical engineers formerly carried on as Grinyer & Co. Private company. First directors are J. McLaren (permanent chairman) and W. R. Germain. Reg. office, 146, Bishopsgate, E.C.

LAMBLOUGH RADIATOR & ENGINEERING CO. (LTD.) (144,434.)—Reg. July 24, capital £10,000 in £1 shares, to carry on the business of mechanical, electrical, hydraulic and general engineers, machinists, tube makers, manufacturers of and dealers in engines, motor cars, airships, steam generators, dynamos and motors, &c. Private company.

MORTGAGES AND CHARGES.

COMPANIA DE ELECTRICIDAD DE LA PROVINCIA DE BUENOS AIRES (LTD.)—A trust deed dated July 19, 1916, supplemental to a trust deed dated Nov. 24, 1911, to secure an increased rate of interest payable on amount secured by the principal deed (£900,000), charged on the power distributing and transforming stations in the Argentine Republic and the company's undertaking and property, including uncalled capital and all existing and future concessions and contracts, has been registered. Trustees, City Safe Deposit & Agency Co.

MANDER & CO. (LTD.)—A first mortgage debenture dated July 24 1916, to secure not more than £300, charged on company's undertaking and property, present and future, has been registered. Holder, J. E. Bendell.

SMALL ELECTRIC MOTORS (LTD.)—Particulars of £3,000 debentures, created July 19, 1916, have been filed, whole amount being now issued. Property charged, company's undertaking and property, present and future. No trustees.

CITY NOTES.

MEMORANDA (Aug. 9).—Bank rate 6 per cent. (since July 13, 1916). Consols 58¾. Consols Pay Day, Sept. 1. Stocks and Shares Ticket Days, Aug. 15 and 30. Pay Days, Aug. 16 and 31. Price of silver, 31 1/16d.

ELMORE'S GERMAN & AUSTRO-HUNGARIAN METAL CO. (LTD.)—The accounts for 1915, after providing for debenture interest, &c., show a loss of £4,815 increasing an adverse balance of £21,517 to £26,332.

KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares for the half-year ended June 30 at the rate of 5 per cent. per annum.

OLDHAM, ASHTON & HYDE ELECTRIC TRAMWAY (LTD.)—An interim dividend at rate of 5 per cent. per annum (6d. per share) has been declared on the ordinary shares for the past half-year.

PAISLEY DISTRICT TRAMWAYS CO.—The directors have declared an interim dividend at rate of 5 per cent. per annum on the preference shares for the half-year to June 30.

WESTERN CANADA POWER CO.—The First Mortgage Bondholders' Committee has approved the scheme of reorganisation formulated by the protective committee for noteholders of Western Canada Public Utilities (Ltd.).

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date Aug. 8, the following as the present basis prices of:

New Metals.	per lb.		Per ton.
Solid Drawn Brass Tubes	14½d.	English Lead	£29 10 0
Solid Drawn Copper Tubes	17½d.	Antimony	Nominal.
Brazed Copper Tubes	17½d.	**Old Metals.**	Per ton.
Brazed Brass Tubes	16½d.	Clean Copper Scrap	£92 0 0
Brass Wire	14½d.	Clean Brass Scrap	59 0 0
Copper Wire	18d.	Brazicry Copper Scrap	80 0 0
Rolled Brass	14½d.	Old Lead	25 0 0
Brass Sheets	15½d.	Old Zinc	30 0 0
	Per ton.	Hollow Pewter	115 0 0
Copper Sheets	£146 0 0	Black Pewter	70 0 0
Spelter	44 0 0	Gun Metal	72 0 0

Mr. A. Joseph, Earl-street, Lonon-road, Southwark, London, S.E., quotes under date Aug. 8, the following approximate prices of Scrap Metals:—

	Per ton.		Per ton.
Aluminium Cuttings	£110 0 0	Old Lead	£3. 15s. under English lead price
Clean Mixed Brass	61 0 0		
Clean Copper	92 0 0	Old Zinc	40 0 0
Brazicry Copper	78 0 0	Hollow Pewter	120 0 0
Gun Metal	80 0 0	Shaped Black Pewter	85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80, Commercial Tinman's Solder, £97, Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, Aug. 8. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., Aug. 8	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord	8⅛	6 19 2	Mar., Sept.
10	4½%	Do. 4½% Cum. Pref.	8⅛	5 11 8	Feb. Aug.
10	6%	Do. 6% Cum. 2nd Pref.	10⅛	5 19 3	Feb. Aug.
5	10%	Brompton & Kensington Ord	6⅝	7 12 5	Mar. Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar. Aug
St.	4%	Central Elec. Supp. C. Deb. St.	80	5 0 0	..
St.	4%	Charing Cross West End & City Deb.	79½	5 0 8	Jan. July
5	2 3	Do. 4½ Pref.	3⅞	6 7 5	..
5	5%	Do. Ord.	3½	6 13 4	Aug. Feb.
5	4½%	Do. City Pref.	2⅛	7 13 2	Jun. Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3½	6 8 0	Mar. Sept
St.	4½%	Do. do. Deb.	84½	5 6 4	Jan. July
10	8%	City of London Elec. Lt. Ord.	1⅛	5 6 9	Feb. Aug
10	6 0	Do. 6% Pref.	101	5 14 3	Mar. July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun. Dec
St.	4½%	Do. 4½ Deb.	80	5 2 6	Jun. Dec
10	7%	County of London Ord.	10½	6 8 0	Mar. Sept
10	6%	Do. 6% Pref.	101	5 14 3	Feb. Aug.
St.	4½%	Do. 1st Deb.	85½	5 1 1	Jan. July
St.	4½%	Do. 2nd Deb.	93½	5 7 9	May, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Deb.	91	5 18 10	July
5	7%	Kensington & Knightsbridge Ord.	11	6 11 4	Feb. Aug
St.	4%	Do. Deb. St.	94	5 1 0	Jan. July
5	6%	London Elec. Supply 6% Pref.	1⅛	6 11 6	..
St.	4%	Do. 4% Mort. Deb.	85½	4 17 0	Jan. July
5	3%	Metropolitan E. Supp. Ord.	2½	6 13 4	Mar. Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan. July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St.	99	5 1 0	Jan. July
..	6%	Newcastle & Dist. E.L. 6% 2nd Debs.	99½	6 0 6	Mar. Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt Db St.	92	5 8 8	Mar. Sept
1	6%	North Metropolitan E.P. Supp. 6% Pref.	1	6 0 0	Apl. Oct
4	5%	South London E.S. Ord.	2⅝	6 16 2	Mar. Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price, Tues., Aug. 8	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	6 7/16†	6 9 4	Feb. Aug
5	7%	Do. do. Pref.	5¼†	5 19 2	Feb. Aug
St.	3½%	Do. do. Debs	74	4 14 8	Jan. Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	73	6 3 3	Apl. Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations	1 3/32	6 11 3	Mar. Aug
5	7%	Westminster E.S. Corp. Ord.	6½	5 12 0	Mar. Sept
5	4½%	Do. 4½ Cum. Pref.	4½	5 4 1	Jan. July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	85	5 17 8	Apl. Oct
St.	6%	Do. 6% Cum. Pref.	80½	7 12 2	Feb. Aug
St.	4%	Central London Guar. Assented Ord.	75½	5 6 4	..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	..
St.	4½%	Do. 4½% Pref.	81½	5 10 5	Jan. July
St.	4%	Do. 4% Deb. St.	77½	5 3 3	Jan. July
St.	4%	City & S. London Deb.	74½	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70¾†	7 1 4	Feb. Aug
10	11%	London Electric Ry. Ord.	2½†	5 11 1	Jan. July
St.	4%	Do. 4% Pref.	67†	5 19 5	Mar. Sept
St.	4%	Do. 4% Debs.	76½	5 4 11	Jan. July
St.	1%	Metropolitan Ry. Con. Ord.	24¾†	4 0 9	Feb. Aug
St.	3½%	Do. 3½% Pref.	63¾†	5 9 7	Feb. Aug
St.	3½%	Do. 3½% Convertible Pref.	58	6 0 8	Feb. Aug
St.	3½%	Do. 3½% A Debs.	69½	5 1 3	Jan. July
St.	3½%	Do. 3½% Debs.	70	5 0 0	Jan. July
St.	..	Metropolitan Dist. Ry. Ord.	18¾	..	Feb. Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 4	May, Nov
St.	4½%	Do. 4½ First Pref.	72½†	6 4 2	Feb. Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 7	Jan. July
St.	4%	Do. 4% Debs.	77	5 3 11	Jan. July
St.	4%	Do. 4% Debs. (1903-5)	78	5 2 7	Jan. July
St.	4%	Do. 4% Guar. Stock	70†	5 14 4	Mar. Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2⅞	5 4 4	Apl. Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl. Oct
1	7%	Brit. Aluminium Ord.	1⅜	5 9 3	Mar
100	5%	Do. Prior Lien Debs.	93	5 7 6	Jan. July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan. July
5	17½%	Brit. Insulated & Helsby Ord.	12⅜	7 3 6	Aug. Feb
5	3 0	Do. 6% Cum. Pref.	5⅜†	5 15 8	Jan. July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	⅛	6 8 0	Mar. Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb. Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	5 17 1	April
100	6%	Do. 6% Prior Lien Debs.	102	5 17 8	Apl. Oct
St.	4%	Do. 4% Mort. Deb. St.	66¼	6 0 4	Jan. July
5	20%	Callender's Cable, &c., Co. Ord.	12⅜	8 1 7	Jan. July
5	5%	Do. 5% Pref.	4¼	5 17 8	Feb. Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	June Dec
1	6%	Dick, Kerr & Co. 6% Pref.	2⅞	7 2 3	Sept
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	⅝	..	Feb. Aug
St.	4%	Do. 4% Deb.	60½	6 12 3	June Dec
1	7½%	Elec. Construction Ord.	⅛	9 4 7	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan. July
St.	4%	Do. 4% Debs.	66	6 1 3	Jan. July
10	10%	General Electric Ord.	13⅜†	7 13 6	July
10	6%	Do. 6% Pref.	9⅞	6 2 6	June. Dec
5	20%	W. T. Henley's Teleph. Wks. Co. Ord.	16	6 5 0	Feb. Aug
5	2/3	Do. 4½% Cum. Pref.	4	5 12 6	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun. Dec
10	10%	India Rubber, G.P. &c., Ord.	12	8 6 8	Feb. Aug
10	5%	Do. Pref.	8	6 3 0	Apl. Oct
12	20%	Telegh. Con. & Main. Co.	39	6 3 1	Mar. July
100	4%	Do. 4% Debs.	95¼	4 4 1	Jan. July
1	7½%	Vickers Ord.	1⅜	4 1 4	May Aug
1	6d.	Do. 5% Pref.	⅞	5 3 3	May. Aug
St.	4%	Do. 1st Debs.	79½	5 0 4	June Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	June. Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40½	10 3 8	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30 0	Anglo American 6% Pref. Ord.	103	5 16 6	Ft My Aug N
St.	1½%	Do. Def. Ord.	23¼	6 16 0	Ft My. Aug. N
St.	4%	Commercial Cable 4% Debs.	70⅜	5 12 10	Ja Ap Jly. O
10	5%	Cuba Submarine Ord.	8½	5 17 8	May. Nov
10	10%	Do. 10% Pref.	13¾	7 5 5	..
5	5 0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅝	6 6 9	Ja Ap Jly. O
St.	8%	Eastern Tel. Co. Ord.	147½	5 7 9	Ja. My. Jly. O
St	3½%	Do. 3½% Pref.	68	5 2 11	Ja My Jly O
St	4%	Do. 4% Deb.	79	5 1 3	Mar. Nov
St	4%	Eastern Extension Tel Co. 4% Debs.	77	5 3 11	Feb. Aug
10	8%	Do. Ord.	14⅜	5 5 7	Ja Ap Jly. O
10	22%	Gt Northern Tel Co. Will Coup. 11	38½	5 15 5	Ja My. Jly
25	13%	India-European	48½	6 14 8	May. Nov
1	10%	Marconi's Wireless Tel. Co.	3⅜	3 2 9	April
1	7%	Do. 7% Pref.	2⅛	2 13 4	July
10	1%	West India & Panama Ord.	1⅛	9 4 8	May. Nov
10	6%	Do. 1st Pref.	7⅝	7 12 5	May. Nov
10	8%	Western Telegh Co.	14⅛	5 8 11	Mr. Jly. O. Dec
St	4%	Do. 4% Deb. St.	77	5 3 11	June Dec
..	4½%	Western Union 50-yr. Bd.	99¼	4 10 10	May. Nov
		Telephones.			
1	7½	Marconi Wireless Teleph. Ord.	2⅜	7 13 7	Nov
1	10%	Oriental Telephone Ord.	2⅞	4 18 6	Apl. Oct
St	4%	Do. Deb. St.	79½	5 0 11	Jan. July
St	4½%	Telephone Co. of Egypt Deb. St.	83	5 8 5	Jan. July
5	6%	United Kingdom Tele. Ord.	6⅜	5 19 1	Apl. Oct
5	5%	Do. 5% Cum. Pref.	4½	5 6 8	Jan. July
St	4½%	Do. Deb. St.	85½	5 5 3	Jan July
		Financial and Investment.			
10	6%	Globe Telegh & Trust	12½	4 14 1	Sp De Mr. Jn
10	6%	Do. 6% 1st	10½	5 11 6	Sp. De. Mr. Jn
100	5%	Marconi Company Common	85½	5 17 6	Ja. Apl. Jly. O
..	4%	Do. $100 Pref.	70½	5 13 6	Ja Apl. Jly. O
100	6%	Submarine Cable Trust Cert.	1 5	4 16 0	Apl. Oct
		Colonial and Foreign Electric Supply, &c.			
5	3 0	Adelaide Elec. Supply 6% Pref.	5	6 0 0	Mar. Sept
St	5%	Do. 5% Debs.	94½	5 5 10	Jun. Dec
10	6 0	Bombay E.S. & T. 6% Pref.	10½	5 14 3	..
St	4½%	Do. 4½% Debs.	83	5 8 5	Jan. July
5	9%	Calcutta E.S. Corp. Ord.	6½	7 0 1	May. Nov
5	5%	Do. 5% Pref.	4½	5 11 1	Mar. Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,996. [No. 20. Vol. LXXVII.] **FRIDAY, AUGUST 18, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 653
Arrangements for the Week.. 656
Adapting Direct-Current Motors to Changed Conditions. By H. L. Smith. Illustrated 657
Iron Losses in Direct Current Machines. By B. G. Lamme. Illustrated.—*Concluded*.... 659
Long-Distance and Cable Telephony (Underground and Submarine). By B. S. Cohen and J. G. Hill. Illustrated.—*Continued*..... 660
The Air-Gap Field of the Polyphase Induction Motor. By F. T. Chapman, D.Sc. Illustrated 663
Illumination in the Navy (U.S.A.). By Lieut. C. S. McDowell. Illustrated.... 667
Electricity Supply in Greater London..... 669
REFORM OF OUR PATENT LAWS..... 670
REVIEWS..... 671
The Engineers' Year Book of Formulæ, Rules, Tables, Data and Memoranda for 1916 [Kempe].
Continuous-Current Engineering [Hay].
Mechanical Engineers' Pocket-Book [Kent].
Earth Connections for Telephone Exchanges. By W. H. Grinsted, A.C.G.I. Illus. 672
CORRESPONDENCE..... 674
German Bounty-Fed Steel (H. Gurney Wood).
The Metallurgy of the Rarer Metals. By Joseph W. Richards 675
Ball Bearings for Motor Generator Sets. Illustrated .. 677
Efficiency of Labour 677
LEGAL INTELLIGENCE 677
PARLIAMENTARY INTELLIGENCE 677
The "Electrician" Commercial and Industrial Section .. 679–686

NOTES.

Chemical Engineers.

WE fear that the chemical engineer, probably so called, is very deficient in numbers in this country at the present time, and that there is not such a close co-operation between engineering and chemistry as there should be. In our technical colleges there is a tendency for the engineering student to wash his hands of chemical mess and "stinks." On the other hand, the chemical student probably feels that he is superior to the purely engineering student in theoretical knowledge. Consequently there is not much sympathy between these two sections of study. In practice, however, this combination is essential. An engineer in a chemical works should know what is going on in all the chemical operations from the chemical point of view, and equally the chemist should know what makes for efficiency in working in all the various items of plant, otherwise the best results cannot be obtained. In the current issue of "The Times Engineering Supplement," Prof. F. G. DONNAN, F.R.S., deals with this subject at some length, and expresses the view that our lack of chemical engineers is largely due to the fact that we merely train chemists who are expert "molecule-jugglers." There is a good deal of truth in this. A molecule-juggler is very useful for purely scientific investigations, and we cannot dispense with him, but that is no reason why we should not turn out chemists and engineers who are capable of taking a broad and practical view of industrial chemical problems. For this purpose a different type of college laboratory is required, one in which the efficiency of chemical operations can be tested, apart altogether from the purely chemical view of the various processes concerned. This is a class of work which may not appeal to those responsible for our examination systems which do so much to efface the desirable qualities of the student, but such systems must be modified so that the required product is obtained; for there is little doubt that if we are to hold our own with Germany in the future in chemical manufactures we must evolve chemical engineers capable of understanding and appreciating the various problems of industrial chemistry in all its aspects.

Truth is Stranger than Fiction.

RIGHTLY or wrongly, by many the view is held that this is an engineers' war. Mr. HARD WORKER, a student in the electrical engineering department at one of the smaller technical colleges, recently took a First Honours in the B.Sc.Eng. (Lond.) examination, as well as one of the much-coveted medals and prizes in electrical engineering, awarded by the City and Guilds of London Institute. Being of military age, he is now Private HARD WORKER in the Army. Much of his time is now spent in listening to elementary lectures on Ohm's law, and the war, "like a wounded snake, drags its slow length along." Later, we have no doubt, this same honours graduate in engineering will be helping to win the war by scrubbing barrack-room floors. If those who attach more importance to performance than to pedigree, if there be such, will communicate with us direct we shall have pleasure in forwarding full particulars on receiving written assurance that there shall be no reprisals. The man referred to has neither written to us nor have we seen him since he joined the Army.

WE offer no comment on the above, beyond stating that it is not an isolated case. Wireless telegraph experts—not mere operators—are said to be urgently required. Another graduate of our acquaintance, *au fait* with wireless and a good engineer in addition, as well as a public school man, with a pedigree as long as or longer than that of his colonel, is and has been for two years, a "Tommy" in an infantry regiment. He is now a round peg in a square hole "somewhere in France." Every attempt to move the authorities has been unsuccessful. For such reasons are wireless experts urgently required in the Army.

THE men whose privilege it was to train such students are now doing anything and everything except this work of national importance. Neither they nor their students—who should be the leaders to-morrow in engineering—will be in a condition to resume their normal work for some time after peace is proclaimed. When everything has settled down our people will be rudely awakened to the fact that there is another side to warfare beyond the carrying of a rifle. And in the days to come our masters will declare that we are again "too late."

Illumination of Warships.

SPECIALISTS will read with interest the abstract, given elsewhere, of a Paper on "Illumination in the Navy" which was

presented to the New York Section of the Illuminating Engineering Society by Lieut. C. S. McDowell. As an Appendix is given a useful table showing the intensities of illumination adopted as the result of an investigation carried out by the U.S. Navy Department in 1912. The section of the Paper devoted to searchlights serves to give some idea of the enormous amount of work that has recently been carried out with the object of improving the efficiency and increasing the utility of the projector. Such improvement has demanded a close study of the properties of the arc, and the endeavour to approximate to a point of light has necessitated the practical solution of a number of difficult problems. Reference is made to the work of Mr. H. Beck, to whom is said to belong the principal credit for the development of the modern projector. To enable those interested in the subject to study the improvements made by Mr. Beck we give, in the form of a note at the end of the article, extracts from one of his recent patent specifications, as well as references to patents applied for in the United Kingdom by Mr. E. G. Sperry, another active worker on the projector.

Liability for Incomplete Tramcar Journey.

An action of some importance to owners of tramways and to persons who use the tramcar as a means of conveyance, is reported in our columns this week. As frequently happens, the amount in dispute was small, but the principle involved is of wide application. It appears that the Edinburgh cable system of tramways is in a bad state of repair, and breakdowns have been somewhat frequent, resulting in passengers being unable to complete journeys for which they had paid. We can imagine nothing more exasperating to business people than frequent failures of a means of public conveyance such as a tramway, and we are not surprised that a passenger invoked the aid of the law, and sued the company for the recovery of 2s., the cost of two cab fares expended by him on two separate occasions, when, being the holder of a three-halfpenny transfer ticket, the car on the second portion of the journey had broken down. After taking time to consider his judgment, the Sheriff found that the passenger did not act unreasonably in taking a cab to complete his journey, and that no easier or more reasonable way of doing so had been suggested. On the facts we think that this decision is not inequitable, though there is little analogy between the railway decisions cited in the course of argument and the present case. Railway travelling involves long distances, and there is usually no alternative cheap method of transit available. On the other hand, tramway traffic is purely local; it involves only short-distance travelling, and in most cases there are alternative modes of cheap locomotion. Breakdowns occur sometimes on the London and other tramway systems, and, on the principle of the Edinburgh case, we form visions of disappointed tramcar passengers demanding payment of their taxicab fares. However, the position in London is unique; usually there is an alternative mode of conveyance cheaper than a taxicab, and we think it is seldom that such a claim would be successful.

Power-line Poles in South Africa.—In reference to the electrical plant on a Swaziland tin mine, Mr. W. Elsdon-Dew (past president), speaking before the South African Institute of Electrical Engineers, said that no trouble had been experienced from attacks by white ants on the power-line poles when these had been creosoted, and if paraffin were periodically introduced into a hole bored into the wood near the base of the pole. But blue-gum poles cut from trees that have been growing less than five years have a very short life through dry rot setting in. Black wattle of more than five years' growth would now be used, and much better results were expected.

Wireless on Aeroplanes.—In the recently published report of the Advisory Committee for Aeronautics, over which Lord Rayleigh presides, and in reference to the Royal Aircraft Factory, it is stated that two wireless telegraphy sets of very light weight have been designed and tested.

Forced Ventilation.—In a discussion on "Modern Electric Mine Locomotives," at San Francisco, Mr. W. M. Hoen, after referring to the high temperatures sometimes attained in motor armatures, states: "The addition of a blower giving forced ventilation increases the radiating capacity of the motors, giving much lower temperatures for the same service." The increased capacity greatly overbalances the disadvantages, especially on the larger engines.

Clamp Joints on Aluminium Power Lines.—Mr. W. Elsdon-Dew exhibited at a recent meeting of the South African Institute of Electrical Engineers some samples of stranded aluminium air line with attached aluminium clamp and cut from a conductor at a tapping-off point. Although apparently still tight, the joint had proved so imperfect electrically as to cause arcing and fusing, necessitating its replacement. Mr. Dew mentioned that both wire and clamp came from the same firm, and that in his opinion clamped joints on aluminium cables of stranded formation should have a very large area.

Electric Railway Progress in U.S.A.—The conversion to electric traction of the Rocky Mountain section of the Chicago, Milwaukee and St. Paul Railway has just been completed. The equipment of 440 miles of line has been finished, but only 115 miles are in operation. The electrical line runs across the three principal mountain ranges. Under normal conditions 42 electrical locomotives are required to operate over the electrified portion of the railway. Each of these cost nearly £25,000, and each will haul an 800-ton passenger train on a level stretch at 60 miles an hour. The electrical energy required is obtained by water-power from mountain waterfalls. The work of electrification cost nearly £2,500,000, and occupied three years.

Canadian Radio Service.—We are informed that Mr. Philip E. Edelman, of St. Paul (Minn., U.S.A.), has been engaged by the Canadian Government as electrical engineer to prepare plans for wireless telephony and telegraphy installations in the 7,000 sq. miles embraced by the Dominion parks of Western Canada. The installation will be of a new design, specially adapted to the difficult mountain service. The installation will be the first of its kind, and a new application of radio-communication. The object of the installation is to prevent forest fires and game trespassing by affording an instant means of communication for reporting and calling for aid in territory where ordinary means of communication are out of the question.

Osmotic Pressure.—A Paper on "Determinations of Direct Osmotic Pressures," was read recently by the Earl of Berkeley, F.R.S., and Mr. E. G. J. Hartley before the Royal Society.

The osmotic pressures of the following substances were measured directly: Cane-sugar and methyl glucoside, a number of ferro- and ferri-cyanides, and one or two other salts. The cane-sugar determinations were made on a somewhat purer sugar than was the case in the authors' previous work; the results extend over the range already covered by Prof. Morse and his co-workers, and the two sets of numbers are found to differ slightly at the lower concentrations. For the ionised substances examined it may be stated that, with the exception of one salt, all those having a molecule made up of a dyad base combined with a dyad acid radicle are associated in aqueous solution. The "dynamic" method of measuring osmotic pressures is developed so as to afford a means of rapidly estimating molecular weights to a considerable degree of accuracy even in very dilute solutions.

Lifting Magnets.—According to the "Mechanical Engineer," Messrs. Steel, Peech and Tozer, Sheffield, have designed a lifting magnet, in which the whole of the magnetic flux is utilised for lifting effect, there being no diversion of the lines through the chains or suspension gear. There are two rectangular soft-iron pole-pieces with a cylindrical core between them: two annular coils are wound on the core and connected to a convenient source of supply. Between the coils and equidistant from the pole-pieces is a central rectangular plate, to the top corners of which are attached two shackle

chains united by a common ring through which the chain hook passes. This central plate does not become magnetised when the current is turned on, consequently the attachment to it of the lifting chains does not divert the magnetic flux from the main work of lifting the load.

Damping Factor in Moving Coil Ballistic Galvanometer.—Mr. Paul E. Klopsteg has a note in the "Physical Review" on "The Damping Factor Used in Ballistic Constants of Moving Coil Galvanometers." After referring to the solution of the well-known differential equation, it is pointed out that for small values of damping

$$K=i/\varphi\ \tau/2\pi\ \sqrt{\rho}$$

the degree of approximation being 0·3 per cent. when the logarithmic decrement is as high as 0·184. As is well known i/φ is the current constant of the instrument, and ρ is the ratio of two consecutive swings. For higher values of the logarithmic decrement the correct value of the damping factor should be used, and it is pointed out that it is preferable to use tables rather than a curve to obtain the value of θ_1/θ_2. The author refers to an article by Mr. Lindley Pile in the same Paper, which was dealt with in our issue of January 28 last, page 587.

Portable Transformers in Film Productions.—In Southern California an important industry has arisen in the manufacture of films, and this work calls for special lamps and illumination at different points in the open country. The local power companies are often called upon to supply energy at short notice, and in considerable quantities for perhaps only a few minutes or hours service. To meet this class of demand a transformer wagon was fitted up and equipped with two 25 kw. 1,100/2,200, 110/220-volt transformers, coupled up with a three-wire secondary. Under the wagon seat are two 2,200 volt fuses, and a 6 in. diameter pine pole 20 ft. long is used for the support of the incoming primary leads. All metal parts of the wagon are earthed when the equipment is in service. At the rear of the wagon is a wooden reel carrying 200 ft. of three-wire secondary cable, for connecting up to the lights of the cinema company. The wagon has been moved a distance of 2 miles and completely connected up in an hour's time, an operation for which, under former conditions, 12 hours would have been needed.

Crystal Detectors.—To the "Physical Review," Messrs. V. A. Hume and L. E. Whittemore contribute an illustrated account of tests of various crystal detectors used in radio-telegraphy when subjected to varying conditions of temperature, pressure and humidity. From tests on galena, perikon, silicon and carborundum detectors it appears that change in air pressure has no effect upon rectifiers, and the effect of temperature is shown in a number of diagrams. One of the peculiarities noticed was that certain crystals do not always rectify the oscillating current in the same direction. With one adjustment the rectified current would flow from crystal to point, and another would flow in the opposite direction. Once during a test on the effect of change of temperature upon carborundum, the rectification actually reversed although no change had occurred in the adjustment. The most common direction of rectification for silicon and for galena, was from the crystal to the brass point which was used. In the case of carborundum the ordinary course of rectification was from needle to crystal. The perikon detector was the only one of the four which showed no reversal, always rectifying from chalcopyrite to zincite.

Mica in Intense Fields.—Mr. H. H. Poole, in a Paper in the "Philosophical Magazine" on "The Dielectric Constant and Electrical Conductivity of Mica in Intense Fields," considers that, in view of the analogy between electric polarisation and magnetisation, it is not unreasonable to suppose that some variation in the dielectric constant might be observed as the potential gradient approaches the sparking value. The method used consisted in charging a small mica condenser to a known voltage by means of a Wimshurst machine, and then discharging it through a ballistic galvanometer, suitable precautions being taken to avoid piercing the insulation of the latter. Simultaneously another condenser of nearly equal capacity, and charged to the same potential, was discharged through a second galvanometer. It was found that the ratio of the throws of the two galvanometers was almost independent of the time of charge if this was not less than 20 seconds. The results obtained showed that there was no variation in the dielectric constant up to gradients of 3×10^6 volts per centimetre. The conduction current increases very rapidly when the gradient is large. The formula

$$C=A+Bx+\log x$$

represents the current over a wide range, where x is the potential gradient, A and B being constants.

Contact Potentials and Electrochemical Action.—Before the American Electrochemical Society recently, Dr. Langmuir read a Paper on this subject. The progress of electrochemistry has been marked by a century-long conflict between the contact theory and the chemical theory of electrochemical action. The modern electrochemist usually considers that this conflict has long been brought to a close by the victory of the chemical theory. He believes that contact potentials between metals are entirely unappreciable. No such uniformity of opinion has existed among physicists. Within the last few years very remarkable work in physics has demonstrated that the contact potentials of large magnitude do exist even between pure metals in a practically perfect vacuum.

This evidence, which is reviewed by Dr. Langmuir in some detail, has been obtained by a study of (*a*) electron emission from heated metals, (*b*) photo-electric phenomena, (*c*) contact potentials. Several independent methods lead to values of contact potentials which are in substantial agreement. Much of the difficulty which the electrochemist has had in reconciling the contact theory with the known intimate relation between chemical action and electrochemical phenomena has been due to failure properly to define "potential difference" and "electromagnetic force." Definitions of these are given, and a theory that the mechanism of the effect is developed. It is not necessary to take into account contact potentials when only the E.M.F.s of reversible cells are considered; but in dealing with the kinetic phenomena, such as over voltage and passivity, or with effects due to single potential differences, the contact potential must be an essential factor.

Volume Effect in a Silver Voltameter.—Scientific Paper No. 283 of the Bureau of Standards on "The Volume Effect in the Silver Voltameter," by Messrs. E. B. Rosa and G. W. Vinal, has just been published. Some years ago the Bureau of Standards discovered that the silver deposits in large size voltameters were heavier than the deposits in small voltameters connected in series with them. The cause of this effect was attributed to impurities in the solution, but this explanation was not accepted by all the observers who worked with the voltameter. Jaeger and von Steinwehr thought that because the evidence rested principally upon the results with the porous-cup form of voltameter the effect was due to the porous-cup, but Richards, on the contrary, thought that the greater surface of the large cathodes permitted greater inclusions and, therefore, the deposit appeared heavier. The recent experiments of Vinal and Bovard have shown that Richards's theory is not correct, but further experiments were necessary in order to answer Jaeger and von Steinwehr's contention. The authors have analysed all their former observations with reference to the volume of the electrolyte, the weight of the deposit and the purity of the solution. They have also made some further experiments with specially impure solutions, and with other forms of voltameter than the porous-cup form. All these observations have been treated by statistical methods, and the authors show, first, that the volume effect is not confined to the porous-cup form of voltameter, but that it is common to all forms of voltameter; and, second, that it is caused by impurities in the electrolyte. The authors give a theory for the mechanism of the effect, and they believe that the evidence proves conclusively that it is a valuable criterion for the purity of the silver nitrate.

Ernolith: A New Celluloid Substitute.—According to the "Scientific American" it is only in recent years that the very remarkable properties of yeast have been realised. Not only can valuable extracts be obtained from it, but it contains a relatively large percentage of albuminous matter. Finally

the mass of cellulose, its remaining constituent, is capable of various reactions with other substances. This latter property has been taken advantage of for the formation of plastic masses by combination with aldehydes. When these masses are subjected to heat under pressure, a hard solid, known as "Ernolith," is obtained. This makes an excellent substitute for celluloid, ebonite, galalith, bakelite and resinite. Two chemists, Messrs. H. B. Blücher and E. Krause, have been able to vary the hardness and elasticity of this product within certain limits. The colour, which is originally black, can also be varied by the incorporation of mineral or vegetable dyes, so that many shades of colour, as well as marble or veined effects, can be obtained. To the fundamental components of Ernolith, yeast and aldehyde (particularly formaldehyde) are added, which cause a modification of the chemical and mechanical properties. It appears that the process of manufacture consists of two phases: First, the union of the yeast and aldehyde (with various "fillers" and subsidiary reactions). The mass thus obtained is dried and ground, and in this form is indefinitely durable. The next step is its compression in heated hydraulic presses, and the articles reproduce on their surface the most delicate details of form. In addition to this, Ernolith machines well. It has an exceedingly close, dense structure, and a conchoidal fracture. As remarked, the process may be so varied as to make the product very hard and brittle, or softer and more elastic as may be required. It possesses a very decided advantage over celluloid in being practically non-inflammable. Another valuable property lies in the economy of production. Its specific gravity when pure, *i.e.*, without "fillers," is about 1·33. Ernolith has also the quality of adhering very tightly to metal parts pressed into it. This property makes the material suitable for the manufacture of articles with a metal surface or core. As primary material it is possible to employ not only the ordinary waste yeast of brewers, but also the "air-made" yeast of the Delbrück process.

OBITUARY.

Killed in Action.—Second-Lieut. Joseph R. Holden, of the West Lancashire Field Company, Royal Engineers, was educated at Stonyhurst College, and subsequently worked at the Anchor Cable Works, Leigh. Later he obtained an appointment with the Hornsey electricity works, and at the outbreak of the war joined the Royal Engineers. Last October he obtained his commission and went to the front at the end of March.

Second-Lieut. Dennis was 31 years of age, and for 17 years he had been on the engineering staff of the Nottingham Corporation Electricity Department. In December, 1914, he joined the University O.T.C., and he secured his commission in April, 1915. He went to France in May.

Private George A. Swain, of the Royal Warwickshire Regiment, who has been killed in action, was in the employment of the General Electric Co., of Witton, before he joined the Army in September, 1914.

Capt. Carlton Collingwood, of the South Lancashire Regiment, was an engineer, and before the war he was engaged at Newton-le-Willows.

Second-Lieut. C. De Freee, who was recently killed as the result of an aviation accident, was 19 years of age, and had been an electrical engineering pupil at the Finsbury Technical College.

Private Roland Clayton, formerly employed in the Burnley electricity department, has died of wounds.

Second-Lieut. Geoffrey Clogstoun Martin, Royal Dublin Fusiliers, entered the Eastern Telegraph Co.'s training school for submarine telegraphy, but afterwards joined the Army. He was 24 years of age.

PERSONAL.

Capt. James Hendry, Royal Scots, who has been dangerously wounded, was trained in Glasgow as an electrical engineer, and at the outbreak of the war he was engaged in Liverpool.

APPOINTMENTS VACANT.

An advertiser requires a wireless telegraph engineer for the East.

An advertiser requires a capable electrical engineer for works abroad, capable of running three-phase a.c. generators, transformers and motors.

An assistant telegraph engineer is required for Government Posts and Telegraphs Dept., Gold Coast. Salary £350, rising by £10 increments to £400, with free quarters and first-class passages. Applications to Messrs. Preece, Cardew, Snell & Rider, 8, Queen Anne's-gate, London, S.W. *See an advertisement.*

An electrician accustomed to a.c. plant is wanted for abroad. *See an advertisement.*

West Ham Council require a manager of their electric tramways system. Salary £600, rising by annual increments of £50 to £750 per annum. Applications to the Town Clerk by Aug. 31.

A lecturer in engineering is required at Rutherford Municipal Technical College. Salary £250 per annum. Applications (on forms to be obtained from the Director of Education, Northumberland-road, Newcastle-on-Tyne) by Aug. 25.

The local education authority invite applications for the position of principal of the Barrow Technical School. Salary £400. Particulars from the Director of Education, Town Hall, Barrow-in-Furness, to whom applications by Sept. 2.

Portsmouth Education Committee invite applications for the position of head of the mechanical and civil engineering department at the Municipal College. Salary £225, rising to £250. Applications to the Secretary by Aug. 23.

An electrician is required for the Gold Coast Government Waterworks. Salary £300, rising to £350, per annum, with free quarters. Applications to the Crown Agents for the Colonies, 4, Millbank, London, S.W.

INSTITUTIONS AND SOCIETIES.

Board of Scientific Societies.—On the initiative of the Royal Society a Board of Scientific Societies has now been established for the furtherance of the following objects: Promoting the co-operation of those interested in pure or applied science: supplying a means by which the scientific opinion of the country may, on matters relating to science, industry and education, find effective expression: taking such action as may be necessary to promote the application of science to our industries and to the service of the nation: and discussing scientific questions in which international co-operation seems advisable.

The board at present consists of representatives of 27 scientific, including technical, societies. The regulations give power to add to this number and to appoint as members of sub-committees individuals who are not necessarily connected with any of the constituent societies. An Executive Committee has been appointed consisting of the following members: Sir Joseph Thomson, O.M., P.R.S. (*Chairman*), Dr. Dugald Clerk, F.R.S., Sir Robert Hadfield, F.R.S., Mr. A. D. Hall, F.R.S., Prof. Herbert Jackson (*Hon. Secretary*), Sir Alfred Keogh, K.C.B., Sir Ray Lankester, K.C.B., F.R.S., Prof. A. Schuster, Sec. R.S., Sir John Snell, Prof. E. H. Starling, F.R.S., Lord Sydenham, G.C.S.I., F.R.S., Mr. R. Threlfall, F.R.S. The first meeting of the board was held on July 20, when important questions relating to scientific, educational and industrial matters were under consideration, with a view to taking effective steps for co-ordinating the work carried out at present by a number of independent bodies, or initiating action in the case of other matters of national importance.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for August.

Headquarters and Range.—The headquarters will be closed during August, except on Tuesday evenings. The range will be open on Thursday evenings only. On these evenings the Sergeant-Major will take charge and be responsible for the maintenance of order and discipline. Recruits are urged to take advantage of this arrangement for drill and shooting.

Instruction Classes.—Instruction classes at Regency-street will be held as usual for Platoons Nos. 9 and 10.

Camp.—The camp at Otford will be available until Aug. 31. Members wishing to attend should enter their names at headquarters on the sheet provided for the purpose. The cost will be about 3s. per day. Members should provide themselves with two blankets, knife, fork spoon, plate, mug and a spare pair of boots.

Entrenching.—As many members as possible should endeavour to attend the Sunday entrenching parades, in order that the work to be done may be completed as expeditiously as possible. Parade in uniform as usual at Victoria Station (S.E. & C. Railway) Booking Office, 8.45 a.m. Members are reminded that this work is of national importance, and therefore all who are able to put in Saturdays or occasional week days are urged to do so. They are reminded that they can obtain railway vouchers from the booking clerk by showing their cap badges.

ADAPTING DIRECT-CURRENT MOTORS TO CHANGED CONDITIONS.*

BY H. L. SMITH.

Summary.—The author briefly considers the theory of continuous-current motors, and points out how motors constructed for working under one set of conditions may be altered so as to give satisfactory performance under other conditions. These are: Operation at various speeds, adjustment of regulation, change of voltage, speed reduction by resistance in the armature-circuit, reconnecting the armature, and operation of the motor as a generator.

It is frequently desirable to change a direct-current motor so that it may be operated under different conditions, and many of the changes may be made with little trouble and expense.

The theory encountered is relatively simple. First consider some fundamental principles in the operation of a direct-current generator. The field poles supply a stationary magnetic field, cut by the conductors on the revolving armature and having E.M.F. generated in them directly proportional to the magnetic flux and the rate of cutting, and which may cause a current to flow through the armature and external circuit. Whenever a current flows through a conductor in a magnetic field, a force is exerted tending to move it to one side or the other, depending upon the direction in which the current is flowing, relative to the flux and directly proportional to the flux and the current flowing. When conductors in the slots of an armature are acted upon by such a force, a turning moment or torque is produced. In a generator the current flows in the same direction as the E.M.F. generated by the armature and due to this a torque is produced which opposes rotation; thus external power is required to drive the armature and overcome this force. Since the current flows in the same direction as the generator E.M.F., the internal resistance drop opposes the flow, thus the terminal E.M.F. is equal to the generated E.M.F. minus the resistance drop. In the case of a motor the line E.M.F. drives the current through the armature, and a torque is produced causing rotation, and E.M.F. is generated in the same way as that produced in a generator. In this case the E.M.F. opposes the flow of current. Stability is reached when the difference between the generated voltage or counter E.M.F. and the applied E.M.F. is just sufficient to allow a current which will produce the required torque to flow through the internal resistance, *i.e.*, internal resistance drop plus the counter E.M.F. always equals the applied E.M.F. The following equations show this:—

$$\text{In a generator. } E=\frac{W_s.p.\varphi.R_m}{60\times10^8}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\text{In a motor, } R_m=\frac{(E-IR_1)10^8\times60}{W_s.p.\varphi}. \quad . \quad . \quad . \quad . \quad (2)$$

Where E= terminal E.M.F., I=armature current, R_1=resistance of armature, commutating and series coils, W_s=series conductors on the armature, p=number of poles, φ=magnetic flux issuing from one pole, and R_m=revs. per min.

The function of the field coils, both shunt and series, is to supply the magnetising force necessary to produce the required flux. The magnetising force is made up of two parts, by far the larger being that required to drive the flux across the air-gap and which varies directly as the flux and the equivalent air-gap length, and is plotted for two lengths of air-gap in Fig. 1. The magnetising force for the iron part of the circuit follows no direct law, but depends on the magnetic density and material and is represented in Fig. 1 as added to the air-gap line, giving the solid curved line, or the no-load saturation curve. When operating under load, the armature teeth and pole tips become more or less saturated, due to armature reaction, and the flux is slightly reduced. To get an idea of the effect of changing the air-gap on the flux and excitation consider the relation expressed in Fig. 1. With a 0·25 in. air-gap a magnetising force of *oa* ampere-turns will be required to produce the flux φ_1, while with a 0·125 in. gap, only *ob* ampere-turns will be needed to produce the same flux. Again, keeping the excitation constant and equal to *oa* ampere-turns, a 0·125 in. air-gap will give a flux equal to φ_2.

It is obvious that for a given motor operating at any given load, equation (2) reduces to

$$R_m=\left\{\frac{(E-IR_1)\,10^8\times60}{W_s.\varphi}\right\}\times\frac{1}{\varphi}=\frac{K}{\varphi}$$

By this equation the flux for any given field excitation can be reduced to speed, and plotted as such against field ampere-turns. This gives the curves in Fig. 2, better adapted for showing the relations of speed and regulation, readily taken by test, and known as the shunt regulation curves. From the equation one would expect the full-load curve to fall below the no-load. It may or may not, depending upon the relation between the resistance drop in the motor and the reduction in the flux due to armature reaction. Usually the full-load curve is the higher, as in Fig. 2, except in high voltage, or small size machines, where it may coincide or fall lower. It will be obvious the speed can be changed by varying the field excitation, the air-gap length, or both. In practice the field excitation may be reduced by adding resistance in the shunt field circuit, but can only be increased by using new shunt coils, or by increasing the E.M.F. impressed upon them. In modern machines, built with the poles bolted to the frame, a considerable adjustment in the air-gap is possible. The poles are made short so that by inserting steel liners next to the frame, different air-gap lengths can be obtained. According to Fig. 2, one might think the speed could be increased to the desired point by shunt resistance alone and the desired speed certainly could be obtained, but speed regulation would probably be bad. Speed ratios as high as 4:1 are obtained by shunt field control, but in the design of these motors special attention is given to the regulation at high speeds. A constant-speed motor having practically a flat speed curve at its rated speed may have a decidedly rising characteristic on weak field, thus it is unsafe to depend on this method.

It is not always possible to distinguish a compound from a shunt motor by its series coils, for it is the practice of some manufacturers to supply series coils on the shunt machines also, except in the case of small sizes and high-voltage machines. The function of the series coil on a shunt motor is to ensure stability and give a more nearly flat speed curve. In Fig. 2 *oa* represents the ampere-turns supplied by the shunt coil. At no-load the speed will be *x*. If there is no series coil, the full-load speed will be equal to *z*. Plotting these values as speed curves, as in Fig. 3, it is found that the speed actually rises with the load and tends to produce an unstable condition. Now, if a series coil be added which will supply *ab* ampere-turns, there is a total of *ob* ampere-turns acting on the pole, which will give

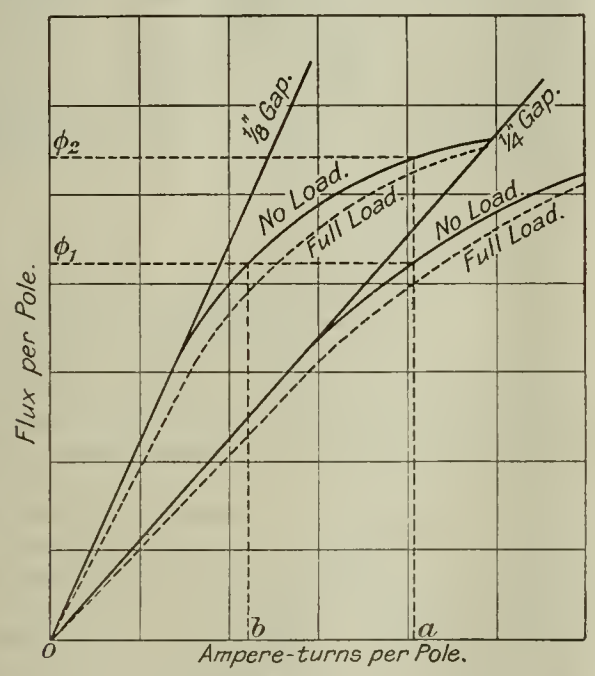


Fig. 1.—Typical Magnetisation Curves.

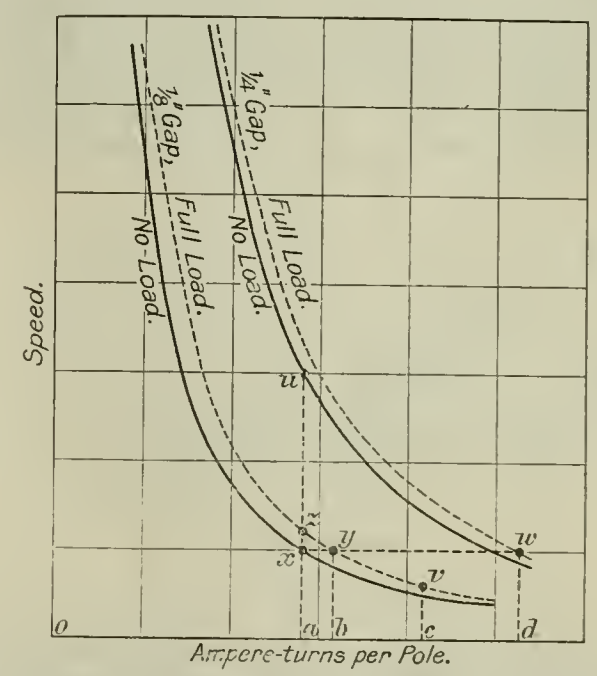


Fig. 2.—Typical Shunt Regulation Curves.

* From the "Electric Journal," slightly abbreviated.

a speed at full-load equal to y, which is also equal to x; thus we have a flat speed curve xy in Fig. 3, which is desirable for a shunt motor. By using a series coil which will supply ac ampere-turns, a full-load speed equal to v is obtained. This gives a drooping characteristic (xv in Fig. 2) desirable in a compound motor.

Operation at Various Speeds.—Next to be considered is the range over which the speed may be changed, and the way to effect this. Roughly, the change in the air-gap should be from three to four times the percentage of the change in speed. It is usually possible to change a speed from 10 to 15 per cent. by manipulation of the air-gap alone where the iron is not highly saturated. When a higher speed than can be obtained by increasing the gap alone is desired, it may be permissible to add such a resistance to the shunt circuit as will give the right speed. In this case the regulation should be checked carefully and adjusted, if necessary, as explained below.

Adjustment of Regulation.—For line-shaft driving, practically constant speed is required and a shunt motor should be used. Other classes of work require drooping speed characteristics, varying from the standard 20 per cent. regulation to the heavily compounded bending roll motors, which have only enough shunt ampere-turns to keep them from running away at no-load.

Referring again to Fig. 2, it is obvious that if there are oa ampere-turns at no-load, and ob ampere-turns at full-load and a 0·125 in. air-gap, the speed curve will be flat, as xy in Fig. 3. Changing the air-gap to 0·25 in. gives a no-load speed equal to u. By adding series turns until the full-load ampere-turns equal od, a speed w will be obtained, which is the same as that obtained at full-load with the smaller gap. This condition gives speed curve uy in Fig. 3, a compound characteristic.

From the above it is obvious that to obtain a compound characteristic from a shunt motor the air-gap should be increased, then series turns added until the full-load speed is the same as it was before. Flexible copper cable wound over the shunt coil, and tied in place, makes a very good series coil. It is easily wound, and requires no extra insulation. The copper section should be about the same as

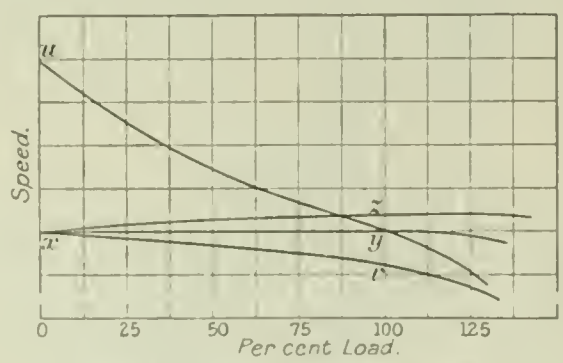


Fig. 3.—Typical Speed Curves.

that of the old coils, so as to ensure no overheating. When changing from a compound to a shunt characteristic, a smaller gap should be used, and then current shunted out of the series coil until flat speed curves are obtained.

Operation at Other Voltages.—Usually a motor is guaranteed to operate successfully on voltages 10 per cent. over that for which it is rated. It has been shown that the speed varies directly as the impressed voltage and inversely as the flux; but the flux also changes with the voltage, although it is not a direct relation. The shunt ampere-turns do vary directly with the voltage, but the flux does not follow the excitation on account of the saturation in the iron. It is obvious that if the flux should follow a direct relation, as in the case when operating on a weak field, where practically all the magnetising force is required for the air-gap (*see* air-gap line in Fig. 1), the speed should remain practically constant over a considerable range. However, motors are usually operated well up on the curve for reasons of stability and economy, so this direct relation of exciting voltage to flux does not hold. In most cases the flux lags considerably, thus the speed will follow the applied voltage more or less. When the voltage is not to exceed 20 to 25 per cent. over or under the rated value, it is usually possible to change the air-gap and obtain the correct speed. Care should be exercised when operating at an over-voltage to note the temperature of the shunt coil: it will vary approximately as the square of the voltage so it may not be possible to operate on full voltage without prohibitive heating. By making a full-load heat run one can determine the amount of resistance necessary to keep the temperature down to a safe point. Take 50° C. temperature rise as an upper limit. When a machine has the minimum air-gap, and the shunt coils are worked up to the maximum allowable temperature, nothing can be done to reduce the speed except to use new coils. In case of operating at a voltage lower than the rated, the maximum air-gap should be used and shunt field resistance inserted until the rated speed is obtained. In either case it may be necessary to re-adjust the series coil.

The question may arise how to change a motor built for one voltage so as to operate on either one of the others. A 230-volt motor may have its shunt coils connected in two groups and paralleled, then connected across a 115-volt circuit. In this case the voltage per coil has not been changed, thus the flux will remain constant, but the speed will only be half what it was before. This can be brought up to the normal again by using the maximum air-gap and reducing the shunt field by resistance. When operating a 115-volt motor on a 230-volt circuit the minimum gap should be used and the shunt coil worked at the maximum temperature. This probably will not bring the speed down to the rated one, but it is the best that can be done without new coils. The same procedure follows when changing from one circuit to another. When going to a higher voltage use the minimum air-gap and shunt field resistance, but working the coils as hard as possible. When going to a lower voltage use the maximum gap and parallel the coils.

Armature Conditions.—At low speeds the ventilation is not so good, and the current may have to be reduced. If a 115-volt motor be operated on a 230-volt circuit the horse-power will be doubled, although the speed has been kept nearly the same. The reverse is true of a 230-volt motor on a 115-volt circuit.

Speed Reduction by Means of Resistance in the Armature Circuit.—Equation (2) shows that the speed still depends on three terms: $(E-IR_1)$, W_x and p. The number of poles cannot be changed, and W_x is a function of the armature winding and not very readily changed. The line voltage is also a constant. From the equation it is obvious that by increasing R_1 the speed at any load will be decreased, but that the no-load speed will remain the same. Since R_1 is internal resistance, or the resistance of the armature, commutating and series coils, it cannot be increased; but an external resistance R_2 can be connected in series, which has the same effect; thus the term becomes $E-I(R_1+R_2)$. Since the speed varies as $(E-IR)$ or the counter E.M.F., the ratio can be obtained as in equation (3)—

$$\frac{R_{m1}}{R_{m2}}=\frac{E-I_1R_1}{E-I_2(R_1+R_2)}, \quad \ldots \quad (3)$$

whence

$$R_2=\frac{(R_{m1}-R_{m2})E+R_1(I_1R_{m2}-I_2R_{m1})}{I_2R_{m1}} \quad \ldots \quad (4)$$

Where R_{m1} = present full-load speed, R_{m2} = desired full-load speed, R_2 = necessary resistance to be put in the armature circuit. I_2 = armature amperes at full load, and I_2 = armature amperes at desired load.

Equation (4) gives an expression for determining the amount of external resistance, to be added to the armature circuit to give a desired speed reduction. Besides poor regulation, there is a considerable loss in the external resistance, which lowers the efficiency. In spite of these drawbacks it is often profitable to use this method of speed reduction where the load is practically constant and the low speed is only needed at intervals. About the only requirement for this external resistance is to be able to radiate the heat generated without excessive rise of temperature.

Reconnecting the Armature.—To get the best economy of material and the most efficient operation, the flux should be kept constant and the series conductors on the armature changed, so as to meet the various requirements [*see* equation (2)]. For example, take the question of operating a 115-volt motor on a 230-volt circuit. If the armature conductors be doubled and the copper section made half that used before, the speed and horse-power output will remain the same. The conductors will only carry half as much current as before, but the impressed voltage is doubled, so the watts input will remain constant.

Although changing the number of conductors on an armature is the ideal method, it is also the most difficult to accomplish. It is only in a few very special cases that an armature can be reconnected. Sometimes it is possible to obtain new coils from the manufacturer, but it is more often the case that the desired number of conductors can only be obtained with a different number of slots and commutator bars. With the use of commutating poles another complication enters.* For any change in a number of armature conductors there must be a corresponding change in the commutating pole coil. This usually means new coils. There are a number of other considerations that also enter, such as brush density, maximum voltage per commutator bar, &c. For instance, to maintain the same brush density in changing a machine from 230 to 115 volts, twice as many brushes must be used, which means twice as long a commutator; whereas changing from 115 to 230 volts with the same maximum voltage

* See "Theory of Commutation and Its Application to Interpole Machines," by Mr. B. G. Lamme, in "Transactions," Am. Inst. E.E., 1911.

between bars requires twice as many commutator bars. It is best to refer to the manufacturer when any change to the armature is contemplated.

Operation of the Motor as a Generator.—When the attempt is made to operate a motor as a generator trouble is encountered in obtaining the required voltage at full load. This is not a fault of the machine, but is an inherent quality in the design. In the case of a generator the line E.M.F. is equal to the E.M.F. generated by the armature minus the resistance drop, while in a motor the line E.M.F. equals the armature E.M.F. plus the resistance drop. According to this, one would expect the terminal voltage at full load, of the motor operating as a generator, to be lower than the rated motor voltage by twice the resistance drop, assuming the speed, armature current and flux as remaining the same. The flux will not remain constant on account of the reduction of the voltage over the shunt coil, so that the terminal E.M.F. will fall still lower. In order to raise this voltage the first thing to do is to obtain the minimum air-gap ; the speed at full load should then be noted running as a motor with the series coils cut out. The following equation will then determine the speed at which it will be necessary to operate, so as to obtain the desired voltage at full load, running as a shunt generator. It is well to increase this speed slightly so as to have some latitude for overloads.

$$R_{m_3}=R_{m_1}\frac{(E_3+IR_1)}{(E_1-IR_1)}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Where R_{m_3}=speed when operating as a generator, R_{m_1}=speed when operating as a motor with the series field cut out, E_3=terminal voltage at full load, operating as a generator, E_1=line voltage as a motor, I=armature current, and R_1=internal resistance.

When operating as a compound generator the series coils should be adjusted so as to give the required compounding.

The changes as just considered apply to cases where the generator voltage is to be equal to or higher than the voltage as a motor. For instance, a 115-volt motor operating as a 125-volt generator, or a 230-volt motor as a 250-volt generator. Equation (5) is based on the assumption that the shunt excitation remains the same. This will only be true when a shunt field rheostat is used. Since it is not necessary that the shunt excitation be increased beyond what it was as a motor, the temperatures should not change. When it is wished to operate a 230-volt motor as a 125-volt generator it is usually sufficient to keep the same speed and air-gap, for the flux will not decrease as fast as the shunt excitation, on account of saturation. The output as a generator will be equal to the ampere rating as a motor multiplied by the voltage rating as a generator.

It may thus be taken as a general rule that for successful operation of a motor as a generator the speed must be increased. In certain cases this may not be necessary, for the decrease in the air-gap may compensate for the difference. This should be no very great drawback, however, for with belted machines the speed can be easily varied by use of different pulley ratios.

Mechanical Limitations.—When increasing the speed of any motor or generator great care should be exercised not to allow the speed to exceed the limit of safe operation. It is not merely a question of the band wires or wedges withstanding the stresses due to centrifugal force, but also the rigidity of the coils. The insulation is more or less plastic, and when under stress the coils will shift slightly, which will throw the armature out of balance. An armature designed for high speed will not only have heavier banding, but the coils will be braced by coil supports. At high overspeeds it is also found that the commutator bars will deflect a certain amount. This distortion will reduce the brush contact and cause bad commutation. Usually the factor-of-safety is so large that a 25 per cent. increase in speed will be perfectly safe. Any greater increase should be discussed with the manufacturer.

IRON LOSSES IN DIRECT CURRENT MACHINES.*

BY B. G. LAMME.

(*Concluded from page* 635.)

Summary.—The Paper discusses the various losses taking place in the rotating parts and magnets of a generator. It is shown that it is practically impossible to calculate the loss even at no-load with any degree of accuracy.

Pole-face Losses at No Load.—It is well known that with open-slot armatures there are considerable losses in the field pole-faces, due to the bunching of the magnetic flux from the armature teeth to the pole face, the action of the armature teeth thus resembling the small poles of an inductor-type alternator in which the pole-face to a small depth serves the function of the armature core. The amount of this loss has often been under-estimated, especially in machines with relatively small air-gaps compared with the width of the armature slots. In Fig. 4, a represents the width of one armature tooth, b represents the width of one armature slot, g represents the single air-gap iron to iron. In the lower diagram, which represents the flux distribution in the air-gap, B_a represents the flux density in the armature teeth, and B_b the minimum flux density opposite the centre of the slot.

Then $a\times b_a$=the total flux under one tooth per unit width of core, and $b(B_a-B_b)c$=the total decrease in flux over the space covered by one slot, c represents the average height of the curve *def* in Fig. 4. If the curve was sine-shaped the value of this would be 0·636, and in practice this does not differ greatly from the figures obtained. For instance, in a V-shaped curve this would be equal to 0·5, and a circular shape would give at the other extreme c=0·784, consequently the value would lie somewhere between these two. In calculating the effective gap from the above diagram and assumptions the following equation would be obtained:

$$\text{Increased gap } g'=g+1/\{1-bc(B_a-B_b)/(a+b)B_a\}.$$

Carter's equation is $g'=g\times 1/\{1-bk/(a+b)\}$.

Comparing these two formulæ, it is evident that

$$k=(B_a-B_b)c/B_a.$$

An extremely close approximation to k can be obtained from the empirical formula,

$$k=b/g/5+b/g.$$

This agrees closely with Carter's equation over almost the entire range. Consequently we obtain the equation,

$$B_b/B_a=1-b/c(5g+b).$$

This gives a ratio of the flux density at the middle of the slot to the flux density under the tooth. As an example of what this value may be, assume that $a=b$, and that g is equal to 0·25 times b (which is not unusual for induction motors), let c=0·635, then the ratio of b to b_a =0·3 of the density in the middle of the slot is only 0·3 of that under

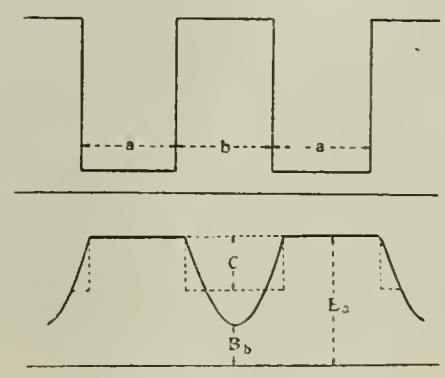


Fig. 4.

the tooth. This analysis is only given to furnish a means for determining the possible variations in the flux density which may be obtained with open slots, but the difficulty in determining a workable formula is very considerable. For instance, the thickness of the lamination or material of the pole-face may have an influence. One formula for this loss given by Prof. C. A. Adams is very complex, but a simple formula for laminated pole-faces is as follows —

$$\text{Watts loss}=(75bE^2/C_fW_s^2gL)\times\sqrt{S_c/R_sg},$$

E the generating voltage, b width of slot, g single air gap, W_s armature wires in series, L the width of pole-face, C_f field form of constant and S_c total slots space equal to the width of slot by number of slots. This formula is necessarily approximate and applies only to laminated pole-pieces where the laminations are 0·031 in. In the following table are given some losses in various machines, and although some of the calculated values appear to agree fairly closely with the test totals these are purely accidental and must not be taken as proof of any great accuracy in the methods. It is obvious from the table that the pole-face loss may be comparatively high in some cases. If this loss could be calculated with any great accuracy the design of the machine might be considerably modified, compared with more recent practice, with advantageous results. They are greatly increased with load, and eddy currents in the copper are also affected by field distortion, corrected methods of calculation for this loss would mean a considerable modification in the proportioning of direct-current machines in general.

Kw.	E.M.F.	Revs. per min.	No. of poles.	No. of slots.	Calculated total losses	Test total losses.
200	250	1,150	6	64	9,420	8,500
750	550	514	10	200	14,290	14,000
1,000	600	514	10	140	32,930	30,800
	700				61,300	62,500

* Abstract of a Paper read before the American Institute of Electrical Engineers.

Stray Losses.—These may include secondary losses in the armature windings due to unsymmetrical cross-connections or unbalanced voltages in parts of the winding which are connected. It is always advisable to use windings which are as symmetrical as possible. Another source of loss is short-circuiting of the coils and the armature winding under an active field. The third condition which may occur is when there are considerable pulsations in the reluctance in the air-gap under the main poles as the armature teeth move under the poles. Armature coils short-circuited by the brushes will act as secondaries to these pulsating fluxes. In consequence there may be some loss in the short-circuited coils due to this cause. Any solid parts of the yoke or poles may also have losses due to this cause. The fourth source of loss may rise from stray flux from the main fields to the armature which do not pass from well-laminated parts of the armature core. For instance, ventilating spacers may be so dimensioned and shaped that eddies can be set up in them. The finger

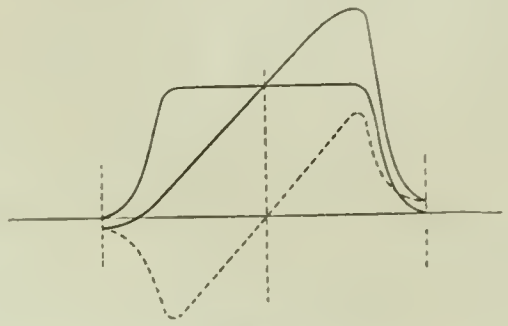


Fig. 5.

plates at each end of the core and end-plates may produce some loss. Bands on the armature or at the ends may also be the seat of E.M.F. and will have some loss in them.

Full Load Losses.—The effects of flux distortion by the armature magnetomotive-force exaggerate the pole-face losses as well as those in the armature copper. These are the two relatively large losses most difficult to calculate at no load. Also commutation and brush losses due to load now enter into the problem.

Armature Ring Loss With Load.—It is evident from Fig. 5 that the flux is crowded towards one pole edge, and therefore, for the most part concentrated in a narrow space. The average length of the flux path may be greater than at no load, but in some cases this tends to distribute the flux more uniformly through the depth of the ring where the flux enters the core at the base of the tooth. There will be slightly more crowding and, therefore, somewhat increased loss. Taking everything into consideration, it would appear that the armature-ring loss is practically independent of variation in load, but in variable-speed machines it is difficult to calculate the loss with any degree of accuracy.

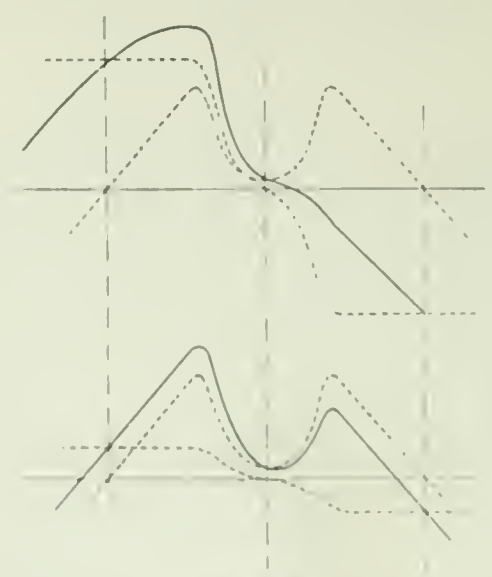


Fig. 6.

Armature Tooth Losses With Load.—The increased density in the armature tooth means increased iron loss, and if the distortion is very great the increase in tooth loss may be very large, sometimes being three times as great as the no-load tooth loss. No direct rule can be given for the calculation of this loss except that it may be determined approximately by calculating the flux distribution with load and thus determining the flux densities in the tooth. In variable-speed machines the tooth loss with load will be affected very considerably by changes in both speed and total fluxes. With low field magnetomotive-force the distortion may be so great as to give a double peak as indicated in Fig. 6. This double peak gives the effect of a double frequency and thus further increases the loss.

Eddy Losses in Copper.—The amount of loss may be calculated approximately by using the formula already given for no-load conditions, but with the ampere-turns in the teeth based on the new conditions. The results are startling when applied to some of the old type machines. Calculations show that in some cases the eddy current loss on heavy load was several times greater than at no load. This is true, but to a less extent, in more modern types of machines. The practice of cutting off pole corners without regard to field form on load was largely for the purpose of correcting commutation and not to obtain best field form, but the best result would be obtained by reducing distortions as much as possible.

Pole Face Losses With Load.—A rough approximation for the increased iron loss can be obtained by comparing the squares of the densities at several points along the distorted field form, with the squares of the densities of the no-load field form corresponding to the total induction.

Stray Losses.—The losses at no load may be much exaggerated by load. Also other losses may appear which are not found at no load. Copper loss due to short-circuiting would be more pronounced, particularly in non-commutating pole machines. Also the effect of variable reluctance in the air-gap is greater than at no load and consequently pulsations of the main field flux may cause more loss in the short-circuited armature coils. Stray fluxes from the main poles will be distributed adversely from the no-load condition, and the densities of these stray fields may be considerably higher and thus give increased losses. Bands or supporting parts or other solid metal rotating with the end winding may cut these stationary fields of flux and thus losses may be set up which are a function of the load. Another source of loss may be found in the operation of commutation itself. At the point of commutation the flux is reversed in direction with respect to the armature conductors, and, therefore, there will be local currents set up in the armature copper itself due to this action.

The above dissertation has somewhat complex conditions, such as the effect of pulsations in flux superposed on high densities, displaced minor hysteresis loops, &c., which mean additional losses.

LONG-DISTANCE AND CABLE TELEPHONY (UNDERGROUND AND SUBMARINE).*

BY B. S. COHEN AND J. G. HILL.

(*Continued from p.* 629.)

Long-Distance Underground Telephony.

27. It may be remarked at once that unloaded conductors in air-space paper cables are in the present state of our knowledge quite unsuitable for long-distance telephony. The comparative speaking range of such cables is only of the order of a quarter of that of wires of equal gauge in aerial lines, so that they may be left out of consideration for this purpose.

28. In recent years, however, the efficiency and reliability of loading coils have been so much improved that it becomes a question of interest and utility to compare the advantages and disadvantages of underground cables and aerial lines from the point of view of long-distance telephone communication. The question can with advantage be viewed from the following points:—

(*a*) A comparison of the transmission efficiency of conductors of the same gauge in aerial lines and underground cables; (*b*) the possibility of obtaining reliable superposed or phantom circuits in the two cases; (*c*) a comparison of the reliability of service, and degree of freedom from extraneous sources of inductive disturbance.

29. As regards (*a*) the minimum attenuation constant which can be obtained in the case of both underground and overhead circuits is very nearly $\sqrt{CR\left(\frac{R_1}{L_1}+\frac{G}{C}\right)}$ per unit length.

Where C is the Capacity of the circuit per unit length.
" R " Resistance " " "
" G " Leakance " " "
" L_1 " Inductance of loading coil.
" R_1 " Effective resistance of loading coil at a frequency of 800 periods per second.

30. The natural inductance of the circuit is neglected to make the comparison simple, and this involves only a small error. The

* A Paper prepared for presentation at the International Telegraph and Telephone Engineers' Conference, Berne, Sept., 1914, abandoned owing to the outbreak of war. Reproduced, with permission, from the Post Office Electrical Engineers' "Journal."

capacity in an overhead heavy gauge line is approximately 0·01 mfd. per mile. In an underground air-space cable it may be taken as 0·065 mfd. per mile.

31. For underground work a coil having a resistance of 35 ohms per henry, or $R_1/L_1=35$ is available and a value of $C/G=20$ can be obtained. The best value for an aerial coil in England is $R_1/L_1=25$. Adopting these values as practical figures and comparing the formulæ for the minimum attenuation constants we have

$$\frac{\text{Underground}\sqrt{R\times 0{\cdot}065\times 10^{-6}\ 35+20}}{\text{Open (approx.)}\sqrt{R\times 0{\cdot}01\times 10^{-6}\left(25+\frac{G}{C}\right)}}$$

$$=\sqrt{\frac{6{\cdot}5\times 55}{25+\frac{G}{C}}}=\sqrt{\frac{357{\cdot}5}{25+\frac{G}{C}}}$$

32. From this it will be seen that if the value of G/C in the aerial line becomes 332·5 (0·3 megohm per mile, or 0·48 megohm per kilometre) the underground line is theoretically as efficient as the overhead line, even when the latter is loaded, if coils of the type supposed are used.

33. These figures have, however, merely been given as an approximate illustration, as the figures given for the coils are purely arbitrary. In many cases overhead lines having a much higher insulation than half a megohm per kilometre are available, but other factors require to be taken into account in favour of underground lines. It should here be emphasised that the winter insulation of an open line should be selected for comparison.

34. Superposed circuits on long overhead lines are not found to be satisfactory in England owing to difficulties in maintaining an electric balance of the four wires making up the superposed group, especially in winter weather. Extraneous sources of disturbance on such circuits are also much more difficult to eliminate than on ordinary direct telephone loops.

35. In underground circuits the position is quite different. If the four wires making up the superposed or phantom group can be electrically balanced in the first instance, there is a favourable prospect of satisfactorily maintaining the balance, and also of excluding extraneous sources of disturbance. Moreover, although superposing involves an increase of resistance in the direct or "side" circuits, owing to the introduction of the additional coils required to load the superposed circuit, this may be more than counterbalanced by the fact that the capacity of the superposed circuit is materially less than that of the side circuits.

36. Experiments made on underground air-space paper cables laid and jointed without special precautions being taken, have shown that loaded superposed circuits provided in this way are subject to marked overhearing, and are not commercially workable.

37. In view of the importance of this subject, an exhaustive investigation has been made by the British Post Office into the conditions necessary to ensure satisfactory phantom working in such cables. (*See* article by Mr. S. A. Pollock in the Post Office Electrical Engineers' "Journal" for April, 1914, entitled "Balancing of Telephone Cables which Requireto be Loaded for Superimposed Working.")

38. It is necessary that the insulation of such cables shall be of a high order, and that the resistance of the conductors in a given loading combination of four wires shall be well balanced. The inductance of the loading coils must also be carefully balanced in all the combinations in which they are to be used, and they must be practically free from cross-talk. These matters can be attended to in the process of manufacture by reliable contractors, but it has not been found possible to obtain during manufacture a sufficiently close capacity balance among the four wires forming the superposed group to permit of superposed loaded circuits being provided. Special capacity tests are, therefore, made before the jointing of the different lengths of cable to each other after they are laid.

39. The method adopted in England is to measure the effective capacity of the wires to each other in all the combinations in which they can be connected, and in every length laid (one-tenth of a mile). Afterwards, by inspection of the measured capacities, those wires are selected for jointing which will give the best balance among the three circuits in the superposed group, on a section half a mile in length. These sections are then similarly retested, and ultimately the necessary number are jointed together to form a loading coil section, *i.e.*, the length of cable between two consecutive loading coils. The testing apparatus used must be of high accuracy, and as it is used in the open air the question of insulating the apparatus necessitates special precautions.

40. Finally, speech tests are made to verify that the required absence of cross-talk has been attained.

41. The capacity tests can be made much more quickly than would appear at first sight, indeed almost as quickly as they can be written down.

42. The result of these precautions is that phantom working on loaded circuits is now practicable.

43. From the point of view of reliability and continuity of service, and also freedom from external sources of disturbance, underground conductors are enormously superior to overhead lines, and indeed this aspect of the question may be a powerful factor in deciding administrations to place telephone circuits underground in the future as far as possible.

44. In England a loaded and superposed cable is, at the time of writing, being laid between London and Birmingham, a distance of 113 miles (181 km.), and thence to Liverpool, a further distance of 90 miles (144 km.), the circuits are for the most part provided for service between the cities of London, Birmingham and Liverpool, but the cable between London and Liverpool contains two pairs of 300 lb. conductors (3·49 mm. diameter). These circuits will, it is confidently expected, be quite as efficient as 300 lb. aerial conductors*

45. There can be no doubt that a large part of the trunk telephone traffic over moderate distances will in the future be conducted on loaded underground conductors.

Long-Distance and Cable Telephony.

46. *Submarine Telephone Cables.*—Unloaded telephone circuits in submarine cables are much less efficient than such circuits in underground air-space paper cables; and are, of course, inferior in a much greater degree to unloaded aerial circuits. The reason is at once apparent if the four constants of the cable are examined and compared with those of underground and aerial lines. The resistance is the same in all cases. The inductances of the submarine cable and underground cable are similar, but both are materially less than that of open lines. This point is not, however, very important, as will appear later. The value G/C in pure gutta-percha cables is, however, of the order of 120 at a frequency such that $2\pi f=5{,}000$, whereas in paper cables it can be reduced to $G/C=20$ or less. The inferiority of gutta-percha in this important respect has led expert manufacturers to make researches with the view of finding a material having a lower value of G/C. Messrs. Siemens Brothers & Co., London, have succeeded in producing a dielectric consisting of a variety of gutta-percha which has a value of G/C not exceeding 20, and the British Post Office has at the present time three submarine cables insulated by means of this dielectric, and a fourth in process of construction. The capacity of a submarine cable is, however, much greater than that of air-space paper cables, and very much greater than that of open lines. In this fact its relative inefficiency lies. Moreover, owing to the fact that gutta-percha is the most expensive material in the cable, the greatest transmission efficiency for a given sum of money is obtained by making the gutta-percha insulation of a given copper conductor as thin as practicable, compensating for any increase in capacity by increase in copper so far as this can be safely done. Cables manufactured on these lines have not a uniform capacity, however, *i.e.*, the capacity of the conductors increases somewhat rapidly as their gauge is increased, at any rate much more so than is the case in underground cables, so that a simple ratio between the capacity of a submarine and an underground cable does not exist. For a heavy gauge submarine cable, however, the capacity would approximate to 0·2 mfd. per naut or 0·173 mfd. per mile (0·106 per kilometre), against, say, 0·065 mfd. (0·04 per kilometre) in the case of air-space underground cables and 0·01 (0·0062 per kilometre) in the case of aerial lines.

47. Submarine cables can with great advantage be loaded, and it is of interest to compare the efficiency of a loaded submarine cable with a loaded underground cable.

Let the capacity of the submarine cable be taken at 0·17 mfd. per mile, and that of the underground cable at 0·065 mfd. It is known that a value of $G/C=20$ can be obtained in each case. The values R_1/L_1 are somewhat arbitrary. The value to be used in the submarine cable is limited by the fact that the coil must not be too large for insertion in the cable. As a matter of fact a value of $R_1\ L_1=40$ can actually be done at the time of writing. For underground work the best coil used up to the present in England has a value $R_1\ L_1=35$, and for the purposes of comparison this value will be taken, although obviously the value is not a final one. In comparing the two types of cable we then have

$$\text{Submarine cable} = \sqrt{CR\left(\frac{R_1}{L_1}+\frac{G}{C}\right)}$$

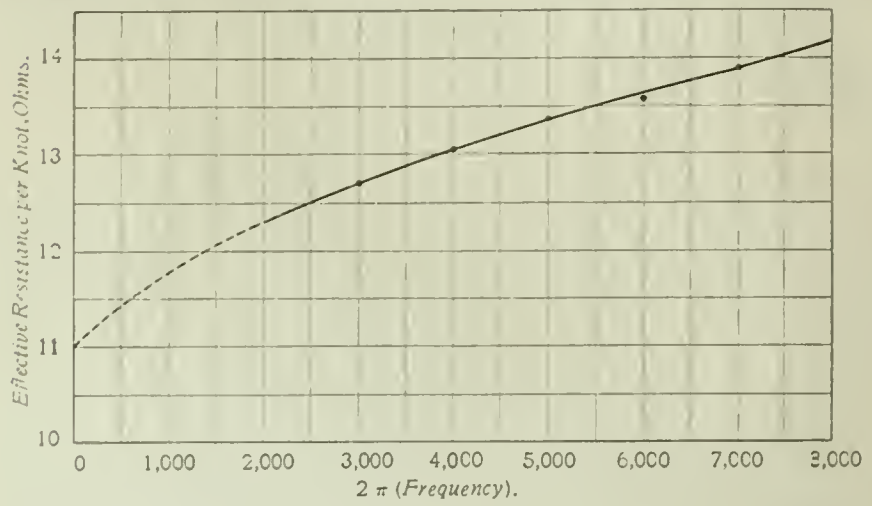
$$\text{Underground cable} = \sqrt{CR\left(\frac{R_1}{L_1}+\frac{G}{C}\right)} = \frac{\sqrt{0{\cdot}17\times(40+20)}}{\sqrt{0{\cdot}65\times(35+20)}}$$

$$=1{\cdot}7 \text{ nearly.}$$

So that the range of speech in an underground loaded cable is approximately 1·7 times as great as that in a submarine cable with the type of loading coil supposed.

* These circuits are now completed and working, and the expectation is more than realised.

48. The submarine cable, by comparison with the underground cable, has the disadvantage that, if superposed, the capacity of the phantom or superposed circuit is double that of the direct or side circuit, whereas in multiple twin underground cables such is not the case. In very heavy gauge submarine cables the addition of coils for superimposing would materially increase the attenuation of the cables. A submarine cable having an attentuation constant of 0·0064 per naut (0·0396 per kilometre) can now be obtained, so that with an attenuation length of 3 nearly 400 nauts (750 km.) of cable could be spoken through. This represents a great advance in recent years. In considering the question of long-distance submarine cable telephony, the claims of continuously loaded cables call for examination (for the theory of this cable *see* Prof. Breisig's "Theoretische Telegraphie"). The requirements in the case of this type of loading and of coil-loading are fundamentally the same, *i.e.*, to add the



NOTE.—*Direct-current Resistance* = 11 *ohms per knot. Full Line shows observed Results.*

FIG. 4.—EXPERIMENTS ON LUNDY ISLAND CABLE (SINGLE WIRE). VARIATION OF EFFECTIVE RESISTANCE WITH FREQUENCY.

required amount of inductance to the cable to give any desired degree of loading with the minimum addition of resistance, or of addition to any other electrical constant (*i.e.*, G and C) at the lowest cost, it being understood that the construction of the cable must be mechanically sound and such as can be satisfactorily maintained. Loaded submarine cables can be made of any weight up to, say, 800 lb. per naut (5·28 mm.) at present. The amount of inductance required to fully load a cable, as is well known, is determined by the formula $L=\frac{R}{R_1 L_1 - G C}$, where L is the amount of inductance required for maximum loading. If cables varying between 3Ω per naut and 20Ω per naut be taken as within the practicable range, then the amount of inductance required by the above formula varies from 50 to 330 millihenrys per naut. In practice so high a value as 330 millihenrys would not be inserted, but any required amount of inductance can be obtained on the coil-loading method. In the case of the continuously loaded cable, however, a very good result would be 20 to 25 millihenrys per naut as a practical maximum. The percentage by which any given amount of loading falls short of producing the minimum attenuation constant is given by the formula,

$$Pr = 50\left(\sqrt{\frac{L}{L_1}} + \sqrt{\frac{L_1}{L}} - 2\right),$$

Where Pr is the required percentage, L is the inductance required to produce the minimum attenuation constant, and L_1 any inductance selected for loading purposes. This formula holds good so long as the following formula is valid :

$$\text{Attenuation constant} = \frac{R-(R_1 L_1 + G C)L}{2}\sqrt{C L}.$$

49. From this it may be seen that continuous loading never attains the minimum attenuation constant, and only approaches it in the case of very heavy cables. A further important consideration is the amount of effective resistance added to the cable by loading. At the present time a loading coil having a value such that $R_1/L_1 = 40$ can be obtained as already shown. No continuously loaded cable appears to have given so favourable a figure up to the present ; probably a very good result would be $R_1/L_1 = 60$ at a frequency $2\pi f = 5{,}000$. If, however, the coil-loaded cable be superimposed, the advantage under this head is materially reduced (but not neutralised), owing to the necessity of introducing additional coils in the cable for this purpose. It must not be overlooked that the iron winding in a continuously loaded cable increases the capacity, assuming equal thicknesses of gutta-percha in the coil and the continuously loaded cables, as well as adding to the quantity of gutta-percha used. In practice, moreover, the thickness of gutta-percha should be increased as the diameter of the copper strand or copper—iron wire thickness. Data have been obtained showing the necessary thickness of gutta-percha to ensure sound mechanical construction. From these data the Post Office has recently developed the empirical equation :

$$T = A \cdot \sqrt{d - 2t}.$$

Where T is the thickness of the dielectric,
d .. overall diameter of the copper conductor strand,
t .. total thickness of the iron winding (if any),
A is a constant at present taken as 8.

From this it appears that some increase in the thickness of the dielectric is necessitated by the iron winding. It may be shown that the relation of weight of gutta-percha for equal capacities in the two types of cable is as given in the following equation :

$$W_1 = \left(1 + \frac{2t}{d}\right)^2 W.$$

Where W_1 is the weight of gutta-percha required to give the same capacity in a continuously loaded cable as the weight of gutta-percha W gives in a coil-loaded cable (the assumption being that circuits of equal ohmic resistance are being dealt with).

50. From the foregoing considerations it appears that from the electrical and first-cost points of view, coil-loaded cables are at present superior to continuously loaded cables. The question of maintenance remains, but sufficient time has not yet elapsed since the first submarine coil-loaded cable (the Anglo-French, 1910) was laid to put the matter to a practical test. It has not yet been interrupted, however.

51. For very short lengths continuously loaded cables possess decided advantages, and those who prefer them for longer cables

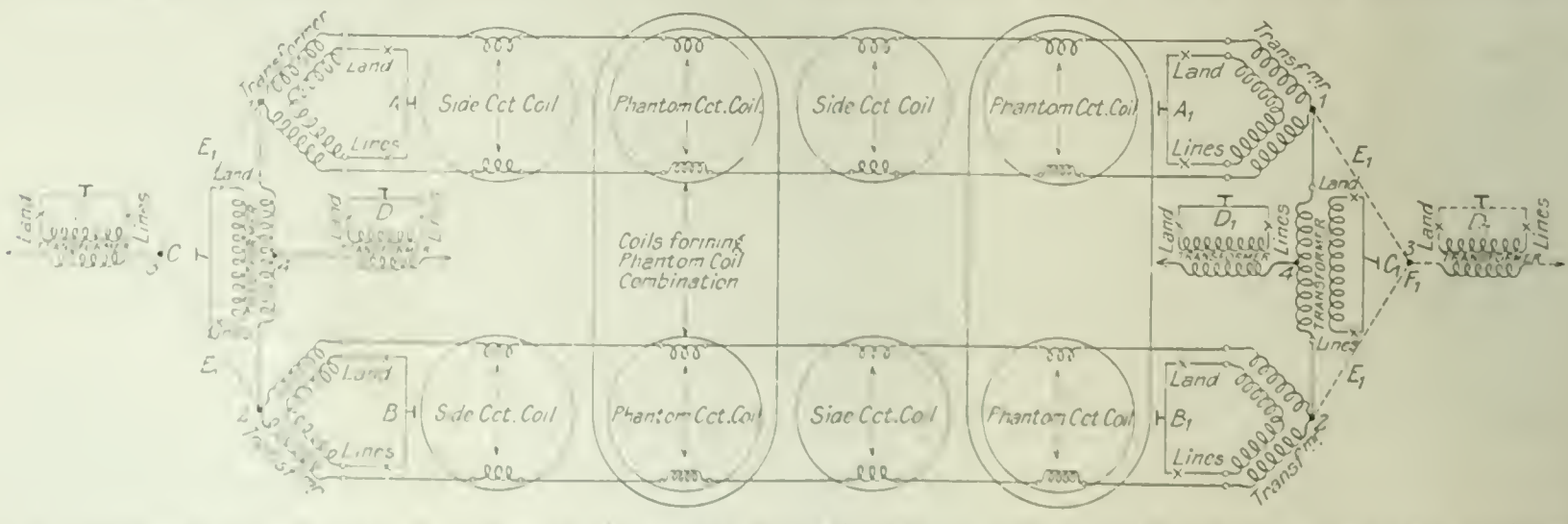


FIG. 5.—SCHEME FOR WORKING FOUR LOADED SUBMARINE CABLE CIRCUITS IN A FOUR-WIRE CABLE FROM TWO PAIRS OF WIRES.

believe their construction to be more reliable. The English administration has not, up to the time of writing, seen any reason to think that the coil-loaded cables are not satisfactory in the waters in which they are used.

52. It may be mentioned that some difficulty has been experienced in obtaining the desired degree of freedom from overhearing in superimposed circuits in coil-loaded submarine cables, although such circuits are at present working satisfactorily in practice. The difficulty is believed to be partly due to the fact that some time is required after laying for sea-water to perfectly surround the conductors. To overcome this difficulty the cores are now being covered

with brass tapes. Experiment has shown that the increase in effective resistance is very small.

53. Experiments on single wire submarine cables have recently been made in England, to ascertain whether the effective resistance and other constants of such circuits are the same as those of loop circuits, and, secondly, whether such circuits are sufficiently silent for commercial service. The results of tests on a single wire cable 16 nauts in length, connecting the mainland of England with Lundy Island, are shown in 4. It will be seen that the effective resistance increases with frequency. At a frequency $2\pi f=5{,}000$ the increase was a little over 20 per cent. A loop circuit of exactly similar cable was found not to vary in resistance over the same range of frequency to an appreciable extent. The increase of resistance in the case of the single wire is probably due in large part to the effect of the iron sheath. The other constants varied slightly, but do not call for any special comment. Some inductive disturbance on single-wire telephone circuits in cable huts into which telegraph cables are also led was found to exist. The amount observed was not serious, and it apparently arose from the fact that the telegraph and telephone cables are run in the same trench down to the sea. Special experimental earth wires, run out half a naut to sea, have been provided in the new Anglo-Irish loaded telephone cable for experimental purposes, and these are quite successful in eliminating inductive disturbance.

54. A practical application of the use of single wires in submarine cables has recently been proposed, which has the effect of enabling a fourth *loaded* telephone circuit to be obtained in a four-wire loaded cable as shown in 5. Circuits AA_1, BB_1, and CC_1 are worked on the usual phantom scheme, and are all loaded in the regular manner, Circuit DD_1 is obtained by working in parallel through all the four wires. In that case the currents split through the transformers AA_1, BB_1 and CC_1 without affecting them, but transformer D is operative. (This principle is well known.) As the phantom coil combination at each loading point consists of two separate loading coils in Messrs. Siemens Brothers' construction (which is the one used)—one coil being in each pair of wires and two windings on each coil—it follows that all the phantom coil windings in circuit DD_1 will be inductive, and, therefore, the fourth circuit will be loaded. The scheme also applies to a continuously loaded cable. Some experiments with this system are now being made.

(To be continued.)

THE AIR-GAP FIELD OF THE POLYPHASE INDUCTION MOTOR.

BY F. T. CHAPMAN, D.SC.

SUMMARY OF CONTENTS.

I.—Introduction.
II.—The Field Produced by Stator or Rotor Windings Acting Alone, the Permeability being Constant.
Sections 1 to 6.—Analysis of magnetic field due to polyphase currents in stationary windings.
Section 7.—The E.M.F. induced by any component field in a stationary winding.
Section 8.—The E.M.F. induced by any component field in a moving winding.
Sections 9 to 13.—The E.M.F. in a stationary winding due to all the fields acting collectively. The inductance of any winding due to the air-gap fluxes.
Section 14.—Analysis of field due to sine-distributed currents in a squirrel-cage winding.
Section 15.—The inductance of a squirrel-cage winding.
III.—The Reaction of Rotor Currents on Stator Field (Permeability Constant).
Sections 16 to 18.—Analysis of field due to rotor currents. E.M.F.s induced by these fields in stator windings.
Sections 19 and 20.—The circle diagram, circle coefficient and air-gap dispersion.
Sections 21 and 22.—Superposition of rotor multiple fields on those of stator. The effects in the case of two- or three-phase rotors and of squirrel-cage rotors.
Sections 23 and 24.—"Crawling." Effects of skewed slots.
IV.—The Effects of Magnetic Saturation.
Section 25.—The saturation curve. Fundamental and third harmonic of time-flux wave.
Sections 26 to 28.—Effect of saturation on multiple fields.
Section 29.—Effect of saturation on air-gap dispersion.
Section 30.—Calculation of no-load current.
Section 31.—The actual form of the current locus.
V.—Oscillograms Illustrating Parts II., III. and IV.
VI.—Conclusion and Table of Air-gap Dispersion Coefficients.

I. Introduction.

The purpose of this Paper is to investigate the effects of the reaction of the rotor currents, and of the saturation of the magnetic circuit, on the distribution of the field in the air-gap of the induction motor. From the data obtained, formulæ are developed for the calculation of the air-gap dispersion and of the no-load current.

In studying the theory of the motor we shall employ the circle coefficient, a quantity which is much used by designers in estimating the results to be expected from a machine, and is in itself an indication of the quality of a design. Its accurate calculation is a matter of importance, and, to make this possible, formulæ for the determination of the air-gap dispersion, the slot leakage and the end-winding or flank leakage are necessary. For the last two quantities rigorous mathematical expressions cannot be given, and empirical formulæ must be used. These are computed from data derived from machines of different sizes and proportions,* but the interpretation of such data will be erroneous unless correct allowances are made in the first place for air-gap dispersion.

We shall endeavour to place the calculation of the air-gap dispersion on a sound basis, and shall deal especially with the difficulties introduced by the rotor reactions and by the variable permeability of the iron. Most of the formulæ and tables are believed to be novel, but the author has employed them (or others closely related to them) in the interpretation of data obtained in the ordinary course of commercial practice, and their application to widely different designs has given complete satisfaction. It is hoped they may be similarly useful to other designers.

In the first part of the Paper we study the nature of the air-gap produced by a single winding, and formulæ are developed for the inductance of various kinds of windings, on the assumptions that the permeability of the iron is constant and that the path of every line of force which crosses the air-gap has the same permeance. The resolution of the complete field into fundamental and multiple fields has been given already by several writers,† and it is, therefore, only reproduced fully in the case of squirrel-cage windings. An attempt has been made to simplify the expression of the results of this analysis by the introduction of the idea of positive and negative fields. This method of studying the field is adopted because of its special suitability when dealing with the reaction of the rotor currents.

This reaction is next examined on the same assumptions as before, the circle diagram is derived by means of the functions developed in the first part of the Paper and a new analysis of the expression for the circle coefficient is given. We shall find that the reaction of the rotor currents on the multiple fields is negligible, except in the squirrel-cage machine, and that the only link between the stator and rotor windings by which useful work is transferred from one to the other is the fundamental air-gap field. The multiple fields themselves combine to produce the air-gap dispersion, which is here taken to include those leakage fluxes sometimes referred to as "zigzag" and "differential" respectively.

Saturation of the magnetic circuit modifies profoundly the distribution of the air-gap field, introducing a fresh group of multiple fields and changing the relative importance of the original fields. The treatment given in part IV. is based on the assumption that the time-flux wave, produced in a magnetic circuit containing iron by a sine-shaped time M.M.F. wave, consists of a fundamental and a third harmonic, together with other small terms which are negligible. The presence of other terms of importance, however, would not affect the conclusions drawn by means of this assumption.

Oscillograms illustrating these points are reproduced, and the main conclusions drawn from the arguments of the Paper are embodied in the numerical tables with which it closes.

II. The Field Produced by a Single Winding.

1. We shall first make the assumption that the permeance of the path of every group of the magnetic fluxes is constant

* Behn-Eschenberg, "Journal" I.E.E., Vol. XXXIII., p. 239, 1904; Goldschmidt, The Electrician, Vol. LX., p. 236, 1907.

† *See*, for instance, O. S. Bragstad, "Mehrphasigen Asynchronmotoren," Stuttgart, 1902; A. Russell, "Alternating Currents," Vol. II., Ch. xiv., 1906; and M. B. Field, "On Oscillatory and Rotatory Magnetic Fields, &c.," *Electrical Review* Vol. XLIV., p. 194, 1899.

at every instant, and that it has the same value for every group. The density at any point in a particular path will then be proportional to the ampere-turns acting on that path. We shall also assume that the stator and rotor cores behind the teeth are at the same magnetic potential, and that P is the permeance of a path connecting one core with the other, which has unit area of cross-section where it lies in the air-gap, P is supposed to include an allowance for the reluctance of the cores. Then if any line of force encloses $\overline{A}$ ampere-conductors the density at the points where it crosses the air-gap will be $\frac{1}{2}\overline{A}/P$, P being measured in suitable units.

With this assumption the field produced by the independent sets of magnetomotive forces acting simultaneously may be regarded as the resultant, obtained by the superposition of the two fields which these magnetomotive forces would have produced separately; in fact, it will be clear that we may go still further, and regard the E.M.F. produced by the actual field as being the resultant of two E.M.F.s, due respectively to the hypothetical component fields.

The currents in the windings of induction motors produce magnetic fluxes which may be divided into the following groups:—

(1.) Fluxes crossing the air-gap.

(2.) Fluxes passing from one tooth to its neighbour across the intervening slot.

(3.) Fluxes linked with the end connections only.

The power is transferred from the primary to the secondary member through the medium of the first group of fluxes, though the fluxes of this group are not all equally effective; indeed, as we shall see on analysis, a considerable proportion of them are quite ineffective, and constitute the so-called "zigzag" and "differential" leakage. This Paper is occupied exclusively with fluxes of group (1).

2. In all the commonest induction motor windings the conductors of any one phase are arranged in p exactly similar groups, p being the number of poles. It is true that windings with dissimilar groups are sometimes employed, but designers only resort to them when compelled to do so by unusual conditions, for the irregular fields which they produce tend to reduce the good qualities of the machine.

List of Symbols.

Suffixes 1 and 2 generally denote stator and rotor quantities respectively.

A_0 = No-load stator current per phase (effective value).
A = Effective current per phase.
a = Fractional reduction in the span of a winding.
$\overline{A}$ = Ampere-turns.
$\overline{A}_{\pi/3}$ = Ampere-turns at points 60 deg. from the zero point of a flux wave.
b = Actual reduction in the span of a winding (stated in terms of slots).
C = Amplitude of the cosine component of a wave.
C_c = Amplitude of the cosine component of the cth harmonic of a wave.
c = Order of a harmonic or of a multiple field.
d, d', d_1, d_2 = Integers.
E_1 = Primary applied E.M.F. per phase (effective value).
E_c = Amplitude of E.M.F. due to a multiple field of the cth order.
e_c = Instantaneous value of the E.M.F. due to the cth multiple field.
F, F_1, F_m = Amplitudes of magnetic density opposite various teeth.
f_1 = Frequency of applied E.M.F.
f_2 = Peripheral speed of rotor divided by 2τ.
f_s = Frequency of rotor currents due to the first field (slip frequency).
f_{sc} = Frequency of rotor currents due to the cth field.
G = Number of slots in a squirrel-cage rotor.
I = Current amplitude.
I_G = Current amplitude in bars of squirrel-cage winding.
I_{2c_1} = Amplitude of rotor current produced by the c_1th rotor field.
i = Instantaneous value of a current.
K_{mc} = A winding coefficient referring to a winding with m slots, per pole, per phase, and to the cth multiple field. When $c=1$, it is sometimes omitted.
m = Number of slots per pole per phase.
n = A numeral.
P = Number of phases.
P, P_1, P_2 = Magnetic permeance (*see* Figs. 2*a* and 2*b*).
p = Number of poles.
Q = A winding coefficient.
q = Number of slots per pole.
r = A ratio.
r_2 = Resistance of rotor winding per phase.
S, S_1 = Amplitude of sine component of a wave.
T = Number of turns in series per phase.
t = Duration of time.
V_1 V_3 = E.M.F.s due to multiple fields of corresponding orders (effective values).
v_c = Linear velocity of the cth multiple field.
v_{cG} = Linear velocity of the cth multiple field due to currents in a squirrel-cage winding.
$W = 2\pi TP/p\pi$.
X = Total reactance of a winding.
X' = Reactance of a winding due to air-gap fluxes only.
x = A variable distance measured along the air-gap from a point fixed on the stator.
x' = A variable distance measured from a point fixed on the rotor.
x_1 = A fixed distance.
Y = Mutual reactance between two windings.
y = Ordinate of magnetic density curve at any point.
y_M = Amplitude of a density curve.
y = Magnetic density at any point due to the cth field.
y_{cP} = Density at any point due to the cth field produced by P phase-windings acting together.
$y_{c_2c_1}$ = Density at any point of the c_2th field produced by currents excited in the rotor by the c_1th stator field.
Z_2 = Impedance of rotor winding per phase.
$\alpha, \alpha_1, \alpha_2$ = Phase angles of fluxes in various teeth.
β = Ratio, width to pitch of depressions in density curve of Fig. 2B.
γ = Angle through which rotor slots are skewed.
λ = The ratio between the linkages with any winding due to the slot and end-winding fluxes and those due to the air-gap fluxes.
λ' = The ratio between the linkages in a winding, due to the higher multiple fields, and those due to the first field.
σ = Circle coefficient.
τ = Pole pitch.
Φ_1 = Flux per pole of first field.
Φ_T = Maximum flux per tooth in squirrel-cage rotors.
φ = An angle of phase displacement.
ψ = An angle.

Fig. 1 represents three such groups of conductors, at (A) for a full-pitch winding with three slots per pole per phase, and at (B) for a similar winding but with fractional pitch. Each conductor is separated by a distance, τ, equal to the pole-pitch, from the corresponding conductor in the next group, and the conductors fall naturally into a number of sets, each comprising p similar conductors. If the number of turns in series per phase be T, the number of such sets in the winding of one phase will be $2T \div p$.

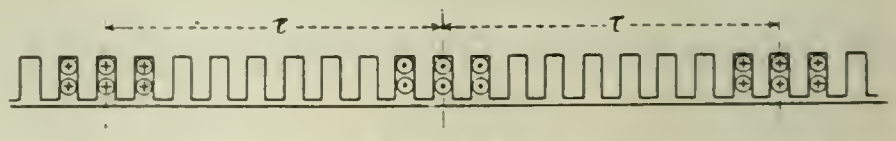


Fig. 1A.—Three-phase, Full Span Winding, Three Slots per Pole per Phase.

The field produced by the winding as a whole, in the case we are now considering, can be built up conveniently from the field produced by a single set of p conductors.

Let the number of slots per pole be q, and the instantaneous value of the current per conductor be i. The field produced by a set of p conductors will have the rectangular form shown in Fig. 2A, the magnetic density at any point being iP. Fig. 2a shows the density curve when the variations in permeance due to the stator slot openings are taken into account, the rotor

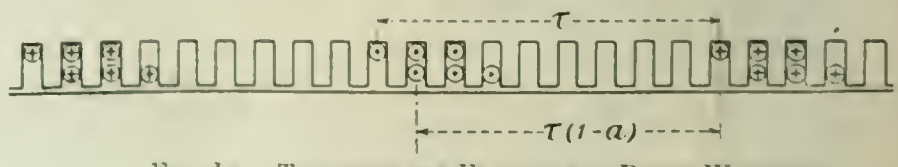


Fig. 1B.—Three-phase Fractional Pitch Winding.

slots being supposed closed or equivalent to closed. The actual variations in density in the latter case will not follow a rectangular law, but a law of this form is adopted for discussion in order to simplify analysis, and the general conclusions as to the effects of the slot apertures are not invalidated thereby.

The density in the case of Fig. 2A can be expressed as a Fourier series, thus:—

$$y = \frac{2iP}{\pi} \sum_{c=1}^{c=\infty} \frac{1}{c} \cdot \sin c\pi \frac{x}{\tau}, \quad \ldots \quad (1)$$

where c is the order of a harmonic, and is always odd. The series corresponding to Fig. 2B is easily shown to be

$$y = \frac{2i}{\pi} \sum_{c=1}^{c=\infty} \frac{1}{c} \left[P_2 + (P_1 - P_2) \frac{\sin c\pi(1-\beta)/2q}{\sin c\pi/2q} \right] \sin c\pi \frac{x}{\tau}, \quad . \quad (2)$$

where P_1 is the greater and P_2 the smaller value of the permeance, and β is the ratio of the width of the depressions in the density curve to the pitch of the teeth (*see* Fig. 2B).

The mean permeance in the last case is $\mathrm{P}=[\mathrm{P}_1(1-\beta)+\mathrm{P}_2\beta]$.

The effect of the slot openings can be illustrated most conveniently by means of a numerical example. A machine with wide open slots on the stator and a continuous surface on the rotor, the width of both slots and teeth being equal to eight times the mechanical clearance would have, roughly, $\beta=0{\cdot}5$, $\mathrm{P}_1=1{\cdot}4\mathrm{P}$, and $\mathrm{P}_2=0{\cdot}6\mathrm{P}$, where P is the mean permeance

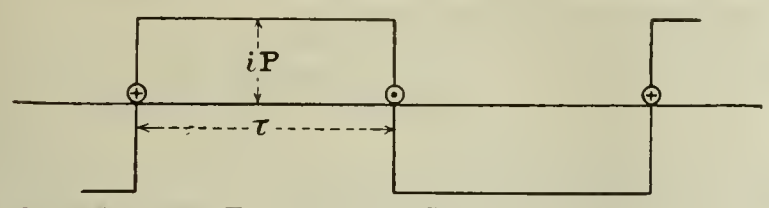


Fig. 2A.—Magnetic Field due to Single-slot Winding. Slot Openings Neglected.

estimated by Carter's formula.* Let us suppose $q=9$. The series for this case would be :—

$$y=\frac{2i\mathrm{P}}{\pi}\sum_{c=1}^{c=\infty}\frac{1}{c}\left[0{\cdot}6+0{\cdot}4\sec\frac{c\pi}{36}\right]\sin c\pi\frac{x}{\tau}.$$

For the fundamental the amplitude is :—

$$\frac{2i\mathrm{P}}{\pi}\times 1{\cdot}0015.$$

Hence, in dealing with the fundamental we may without appreciable error take the mean permeance P and proceed as for closed slots. The greatest differences between the two

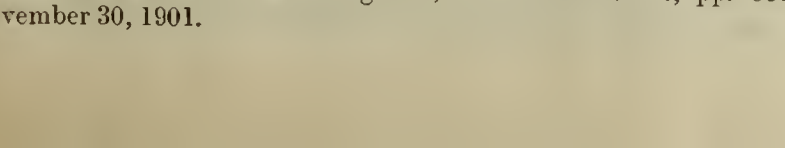


Fig. 2B.—Diagram Showing Effect of Slot Openings on Magnetic Field due to Single-slot Winding.

cases occur when $c\pi/2q$ approximates to π, 3π, &c., particularly when $c=2d'q\pm 1$, where d' is any odd integer. Table I. below gives r the ratio between the amplitude of a given harmonic in case (b) to that of the same harmonic in case (a) :—

Table I.

c	1	3	5	7	9	11	13	15	17	19	...	53	55
r	1·0015	1·018	1·041	1·087	1·166	1·297	1·547	2·145	5·59	−3·99	...	−3·99	+5·59

In practice the most obvious effects of these harmonics are met with in squirrel-cage motors during the starting period, and result in the tendency to "crawl" which such motors exhibit at certain low speeds.

In a three-phase motor, with $q=9$, as in the case just cited, the most important harmonics, as regards the "crawling" effect, are the thirteenth and nineteenth. It is clear from the table that motors with large slot openings will exhibit these effects to a much larger extent than those with practically closed slots. It may be observed here that in this case the sign of the harmonics between the nineteenth and fifty-third, inclusive, is reversed.

This will be referred to later (*see* § 12).

3. We will next investigate the combined effects of the groups of conductors which make up the windings of one phase. Let P_1 be the number of phases, $m=q\div P_1$, the number of slots per pole per phase, and T the number of turns in series per phase. Then $2TP_1/pq$ is the number of conductors per slot and the Fourier series corresponding to the density curve produced by the conductors in p slots separated from one another by the distance τ, is obtained by multiplying equation (1) by $2TP_1/pq$, giving

$$y=\frac{4iTP_1\mathrm{P}}{\pi}\sum_{c=1}^{c=\infty}\frac{1}{c}\cdot\sin c\pi\frac{x}{\tau}.$$

* "Electrical World and Engineer," Vol. XXXVIII., pp. 884-888, November 30, 1901.

The effect of the complete phase-winding is obtained by adding together q/P_1 sets of sine curves, the cth harmonic in one set being displaced from the cth harmonic in the next by $c\pi/q$. Referred to the origin at the centre of a phase group the resultant cth harmonic is

$$y_c=\frac{4iT\mathrm{P}}{p\pi}\cdot\frac{1}{c}\cdot\frac{P_1}{q}\cdot\frac{\sin(c\pi/2P_1)}{\sin(c\pi/2q)}\cdot\sin c\pi\frac{x}{\tau},$$

or, writing $i=I\sin 2\pi ft$ and expanding :—

$$y_c=\frac{2IT\mathrm{P}}{p\pi}\cdot\frac{1}{c}\cdot\frac{P_1}{q}\cdot\frac{\sin(c\pi/2P_1)}{\sin(c\pi/2q)}\left[\cos\left(2\pi ft-c\pi\frac{x}{\tau}\right)-\cos\left(2\pi ft+c\pi\frac{x}{\tau}\right)\right]. \quad . \quad . \quad . \quad (3)$$

For a winding with a pitch equal to $\tau(1-a)$, as in Fig. 1B, the expression requires to be multiplied by $\cos ac\pi$.

4. In a machine with P_1 phases we have P_1 times p groups of conductors. The distance from the centre of one group to that of the next is τ/P_1, and the currents in the several phases are $-i_1=I\sin 2\pi ft$, $i_2=I\sin(2\pi ft-\pi/P_1)$, $i_3=I\sin(2\pi ft-2\pi/P_1)$, &c. For the nth phase $i_n=I\sin(2\pi ft-n\pi/P_1)$ and in equation (3) we must write $x-n\tau/P_1$ for x.

The field intensity due to the nth phase is thus, for any harmonic

$$y_{cn.}=\frac{2IT\mathrm{P}}{p\pi}\cdot\frac{1}{c}\cdot\frac{P_1}{q}\cdot\frac{\sin(c\pi/2P_1)}{\sin(c\pi/2q)}\cdot\cos ac\pi$$

$$\times\left[\cos\left\{2\pi ft-\frac{n\pi}{P}-c\pi\left(\frac{x}{\tau}-\frac{n}{P_1}\right)\right\}-\cos\left\{2\pi ft-\frac{n\pi}{P_1}+c\pi\left(\frac{x}{\tau}-\frac{n}{P_1}\right)\right\}\right]$$

$$=W.K_{m_1c}.\left[\cos\left\{2\pi ft-c\pi\frac{x}{\tau}+(c-1)\frac{n\pi}{P_1}\right\}-\cos\left\{2\pi ft+c\pi\frac{x}{\tau}-(c+1)\frac{n\pi}{P_1}\right\}\right] \quad . \quad . \quad (3A)$$

where $W=\dfrac{2IT\mathrm{P}}{p\pi}$ and $K_{m_1c}=\dfrac{1}{c}\cdot\dfrac{P_1}{q}\cdot\dfrac{\sin(c\pi/2P_1)}{\sin(c\pi/2q)}\cdot\cos ac\pi$.

Adding together the intensities due to P_1 phases we get for the cth harmonic of the resultant field

$$y_cP_1=W.K_{m_1c}\left[\cos\left\{2\pi ft-c\pi\frac{x}{\tau}+(P_1-1)(c-1)\cdot\frac{\pi}{2P_1}\right\}\cdot\frac{\sin\frac{c-1}{2}\pi}{\sin\frac{c-1}{2P_1}\pi}\right.$$

$$\left.-\cos\left\{2\pi ft+c\pi\frac{x}{\tau}-(P_1-1)(c+1)\frac{\pi}{2P_1}\right\}\cdot\frac{\sin\frac{c+1}{2}\pi}{\sin\frac{c+1}{2P_1}\pi}\right]. \quad . \quad (4)$$

The first term in square brackets will be zero, unless $c-1=2P_1d$, where d is an integer, while the second term will be zero, unless $c+1=2P_1d$. The only case in which both expressions exist together is that of a single-phase machine, for which $P_1=1$.

Case 1.— $c-1=2P_1d$, or $c=2P_1d+1$,

$$y_{cP_1}=W.K_{m_1c}\cos\left\{2\pi ft-c\pi\frac{x}{\tau}+(P_1-1)d.\pi\right\}\cdot\frac{\sin P_1d.\pi}{\sin d.\pi}$$

$$=WK_{m_1c}\cos\left\{2\pi ft-c\pi\frac{x}{\tau}\right\}\cdot\frac{\cos(P_1-1)d\pi.\sin P_1d.\pi}{\sin d.\pi}$$

$$=P_1W.K_{m_1c}\cos\left(2\pi ft-c\pi\frac{x}{\tau}\right),$$

If we write $x=x_1+\dfrac{2f\tau t}{c}$ we get

$$y_{cP_1}=P_1WK_{m_1c}\cos c\pi x_{1/\tau} \quad . \quad . \quad . \quad \text{a constant.}$$

We are therefore dealing with a rotating field, gliding along the air-gap with a linear velocity $2f\tau/c$.

Case 2.— $c-1=2P_1d$, or $c=2P_1d-1$,

$$y_{cP_1}=-P_1W\,K_{m_1c}\cos\left(2\pi ft+c\pi\frac{x}{\tau}\right),$$

which represents a field rotating with linear velocity $-2f\tau/c$.

Case 3.—When $P_1=1$ we can consider either that we are dealing with equal fields moving with equal velocities in opposite directions or that we have simple alternating fields. This case is not within the scope of the present Paper.

5. In the last section we have considered c to have only positive values which are given by the series $c=2P_1d\pm1$, where d is any positive integer. It is convenient, however, to merge cases 1 and 2 together by writing $c=2Pd\pm1$ and assigning to d any positive *or* negative value. Case 1 then includes those fields for which c and d are positive, case 2 those for which c and d are negative.

We shall write, then, in general

$$\mathrm{c}=2P_1\mathrm{d}+1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and $$\mathrm{y_{cP_1}}=P_1\mathrm{WK_{m_1c}}\cos\left(2\pi\mathrm{ft}-\mathrm{c}\pi\frac{\mathrm{x}}{\tau}\right)$$

$$=P_1\cdot\frac{2\mathrm{ITP}}{\mathrm{p}\pi}\left[\frac{1}{\mathrm{c}}\cdot\frac{P_1}{\mathrm{q}}\cdot\frac{\sin(\mathrm{c}\pi/2P_1)}{\sin(\mathrm{c}\pi/2\mathrm{q})}\cdot\cos\mathrm{ac}\pi\right]$$

$$\times\cos\left(2\pi\mathrm{ft}-\mathrm{c}\pi\frac{\mathrm{x}}{\tau}\right), \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and also for the velocity of any field

$$=(2\mathrm{f}\tau/\mathrm{c}) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

It will be observed that the sign of K_{m_1c}, and, therefore, that of y_{cP_1} changes with the sign of c. The sign of v_c is affected in the same way.

We shall refer to the field for which $c=1$ as the first or fundamental field, and to the others as multiple rotating fields. For a three-phase machine c will have the following series of values :

1, −5, +7, −11, +13, −17, +19, &c.

For a two-phase machine the possible values for c are :—

1, −3, +5, −7, +9, −11, +13. −15, &c.

6. If we take the slot openings into account we shall find the same relative changes in the amplitudes of the various multiple fields as we found in section 2 for the corresponding harmonics when discussing the field of a single-slot winding.

7. Since the speed of each of these multiple fields is inversely proportional to the number of its poles, each field will induce in any stationary winding E.M.F.s of the same frequency.

The E.M.F. induced in a stationary conductor at a distance x from the centre of the stator phase group in which the current is $I\sin 2\pi ft$ by the cth multiple field is

$$e_c=-\frac{2f\tau}{c}\cdot l\cdot P_1\cdot W\cdot K_{m_1c}\cos\left(2\pi ft-c\pi\frac{x}{\tau}\right)\times10^{-8}\text{ volts} \quad (8)$$

where l = axial length of stampings in stator and rotor.

Let there be a second stationary winding having P_2 phases, T_2 turns in series per phase, q_2 slots per pole and a winding span of $\tau(1-a_2)$, the distance of the centre of a certain group of conductors of one phase from the centre of the above stator group being x. The E.M.F. induced in this phase by the cth multiple field will be

$$e_c=-\frac{4T_2f\tau}{c}lP_1WK_{m_1c}\cos\left(2\pi ft-c\pi\frac{x}{\tau}\right)\cdot\frac{P_2}{q_2}\cdot\frac{\sin(c\pi/2P_2)}{\sin(c\pi/2q_2)}\cdot\cos a_2c\pi\times10^{-8}$$

$$=-\frac{8fl\tau\mathrm{PI}P_1T_1T_2}{p\pi}\cdot K_{m_1c}K_{m_2c}\cos\left(2\pi ft-c\pi\frac{x}{\tau}\right)\times10^{-8}\text{ volts.} \quad (9)$$

If $x=0$, *i.e.*, if the centre of the induced phase-group is opposite to the centre of a stator phase group, the E.M.F.s due to all the multiple fields will be in phase with one another, or will differ by π, and will have the same frequency. If x is not zero the various E.M.F.s will differ in phase, and their resultant will vary both in magnitude and in phase as x changes : the change in the phase of the resultant will not be proportional to the change in x. This explains why, in a motor with phase-wound rotor, the standstill current varies as the rotor is turned slowly round when its circuits are closed. The effect is illustrated by Fig. 3, in which the vectors I_1 I_5, &c., represent the E.M.F.s induced by the multiple fields of a three-phase winding for various values of x.

8. Suppose the second winding is carried by a rotor rotating with a surface velocity of $2f_2\tau$. Let x_1 be the distance of the centre of a certain phase-group of conductors from the origin on the stator at the instant $t=0$, then at any other time the position of the same point is given by

$$x=x_1+2f_2\tau t. \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

The relative velocity of the cth field with respect to the rotor conductor is

$$\frac{2f_1\tau}{c}-2f_2\tau=\frac{2\tau}{c}(f_1-f_2c). \quad . \quad . \quad . \quad . \quad (11)$$

The E.M.F. induced by this field in a rotor phase is

$$e_c=-4T_2(f_1-f_2c)\tau lP_1W\,K_{m_1c}K_{m_2c}\cos\left\{2\pi f_1t-\frac{c\pi}{\tau}(x_1+2f_2\tau t)\right\}\times10^{-8}$$

$$=-\frac{8(f_1-f_2c)l\tau\mathrm{P}IP_1T_1T_2}{p\pi}K_{m_1c}K_{m_2c}\cos\left\{2\pi(f_1-f_2c)t-\frac{c\pi x_1}{\tau}\right\}\times10^{-8}. \quad (12)$$

The frequencies of the E.M.F.s are (f_1-f_2c). If the rotor be running at synchronous speed $f_2=f_1$ and the frequency due to the cth field is $f_1(1-c)$. The following Table (II.) gives some of the rotor frequencies for certain values of c in a three-phase motor :—

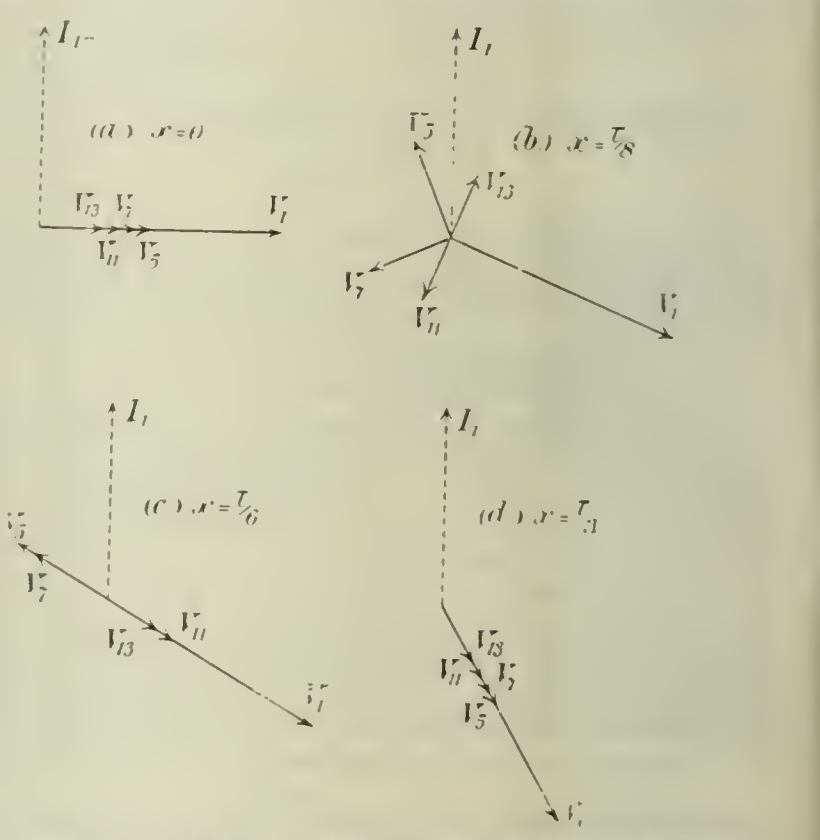


Fig. 3.—Phase Relations of E.M.F.s due to Multiple Fields, for Various Relative Positions of Induced and Inducing Windings.

Table II.

$c=$	1	−5	+7	−11	+13	−17	+19
$f_1(1-c)=$	0	$6f_1$	$-6f_1$	$12f_1$	$-12f_1$	$18f_1$	$-18f_1$

Hence in the rotor winding there will be two sets of E.M.F.s of each frequency arising from different sources. If for one phase of the rotor winding $x_1=0$ then for that phase both the E.M.F.s of any one frequency are in phase with each other or are in opposition, but for another phase winding $c\pi\frac{x_1}{T}$ is different for the two values of c and the resultant E.M.F. has a value different from that obtaining in the first phase. If the rotor of an induction motor be driven synchronously, the form of the resultant E.M.F. wave will be different for all the rotor circuits, and it can be varied by altering the relative positions of the rotor conductors and the fundamental field.*

9. The total E.M.F. per phase in a stator winding is Σe_c, which is equal to

$$-\frac{8f_1l\tau\mathrm{P}IP_1T_1^2}{\pi p}\sum_{c=1}^{c=\infty}\left\{K_{m_1c}^2\cos\left(2\pi ft-c\pi\frac{x}{\tau}\right)\right\}. \quad . \quad (12\text{A})$$

* For oscillograms illustrating this point *see* Simons & Vellmer, "Elektrot. Zeits.," Vol. XXIX., pp. 93-96, 1908.

an expression obtained from equation (12) by writing $f_2=0$, $T_1=T_2$, $K_{m2c}=K_{m1c}$, and $x_1=x$.

We shall see in later sections that when the rotor has squirrel-cage windings certain terms of this series are considerably reduced and their phase relations are disturbed by the reaction of the rotor currents. When the rotor windings have two or three phases only, the effects of rotor currents on the multiple field are practically negligible.

In any case, however, the series given above does not form a convenient basis for the practical calculation of the total back E.M.F. due to the air-gap fluxes. A more useful method, applicable to those cases in which the reaction of the rotor currents is negligible, and by which we can determine the total inductance per phase of the winding, is given in the following section.

Consider first a single-slot winding. The conductors per slot will be $2T/p$, the flux density in the air-gap will be $iT\mathrm{P}/p$, and the total flux per pole $iT\mathrm{P}l\tau/p$. The total number of line-linkages in the whole winding will be

$$\frac{iT^2\mathrm{P}l\tau}{p}.$$

The inductance of the winding will thus be $T^2\mathrm{P}l\tau/p\times10^{-8}$ henry. In the case of a winding which is distributed in $m=q/P$ slots per pole the self-induced linkages will be less than the above, and in single and two-phase windings the inductance will be less in consequence. When the winding has more than two phases a current in one phase will cause linkages in the remaining phases, and if we define the inductance per phase of the winding as the maximum number of line-linkages per phase, divided by 10^8, which are produced when every phase carries a sine-shaped current with a maximum value of 1 ampere, it is evident that mutual inductance between the phases increases this quantity.

In general, we may write for the inductance per phase of any winding, due to the air-gap fluxes,

$$L'=\frac{T^2\mathrm{P}l\tau}{p}.Q\times10^{-8}, \quad . \quad . \quad . \quad . \quad . \quad (13)$$

where Q is a coefficient, the value of which depends on the nature and distribution of the windings. Formulæ for Q will now be developed.

10. When the winding is constructed with a full pitch the conductors of each phase will occupy $m=q/P$ slots per pole. Fractional pitch windings will have coils with a span of $q-b$ slots (where $b=aq$), or something equivalent to it.

(To be continued.)

ILLUMINATION IN THE NAVY (U.S.A.).*

BY LIEUT. C. S. McDOWELL.

Summary.—This Paper concerns the use of incandescent and arc lamps for general illumination on shipboard, for searchlights and for signalling purposes The design of reflectors, size of carbons and colour of light are given as important features in searchlight efficiency. The use of searchlights, illuminated semaphores and flashing lights are considered from the standpoint of visibility for day and night signalling.

The art of illumination in the navy has followed the development and progress of illumination on shore. The conditions existing on board ship, however, are so different from those on shore that special apparatus is required in most cases. Illumination on a naval vessel may be divided in the following classes, some of which are purely military and others not: Illumination of spaces on shipboard; illumination of distant objects by projected light from searchlights; signalling by means of light; special illumination, such as gun sights, compass cards, &c.

Illumination of Spaces includes the lighting of officers' and crews' living spaces, machinery spaces, firerooms, turrets and gun compartments, shell rooms, powder magazines, sick bays, coal bunkers, upper-deck spaces, gangways, &c. The requirements on naval vessels where the numerous compartments have low head-room and are assigned for special uses, liability to damage due to shock from gun fire, and the necessity of maintaining the integrity of the watertight compartments all make it necessary to provide special types of fixtures and methods of installation. In 1912 the Navy Department started a special investigation on this subject which led to the adoption of an ideal table of intensities of illumination which should be obtained in the various compartments and spaces and here given as an appendix. It has, of course, been necessary to vary these figures to a certain extent, but a great improvement has been made in illumination of spaces on shipboard, especially on new ships which have been built since this investigation was made. Standard types of fixtures, globes and shades have been developed to get the desired results. On account of the low ceilings and white wall surfaces the fixtures are mostly of the indirect or semi-indirect type. Incandescent lamps are used entirely in the newer installations; tungsten lamps of 25, 40, 60 and 250 watts are installed in most places except for portables, where, on account of breakage, carbon lamps are used. The 250-watt units are installed in the engine rooms, fire rooms, dynamo rooms, &c., where high head-room is available. The standard voltage until the last two years has been 125. On the newer battleships 240-volt generators are installed with a three-wire system to the distribution boards. The lighting circuits from the distribution boards are 120 volts.

On board battleships there are two regular lighting circuits known as "battle" and "lighting." The battle circuit includes all circuits below the protective deck, circuits to guns, searchlights, signalling apparatus, running lights and in general all the lights which would be absolutely necessary in action. The lighting circuit includes those which may be dispensed with in action.

In addition to the above there is installed an auxiliary (or emergency) lighting circuit which is of 20 volts, supplied by storage batteries, with the minimum number of lights installed at the various necessary locations; this circuit is automatically energised when the main circuit breakers on the regular lighting circuits pull out.

Searchlights have been in use for about 50 years. Until the last couple of years their development has been practically stationary for about 25 years. The great increase in range and reliability of the modern torpedo increased the demand for greater range for the searchlight. As the searchlight is a defensive weapon against night torpedo attack, engineers and scientists have been and are working on this problem and development has been accelerated by the war, for searchlights are used on land for military purposes as well as at sea.

Although a number of others have made certain advancements lately in searchlights it is believed that the principal credit for the modern searchlight, which in some form has been adopted during the past year by most countries, is due to the researches of Mr. Heinrich Beck.

The searchlight considered solely from an illuminating standpoint consists of a source of light and a reflecting mirror. The most efficient reflecting surface is a glass mirror with silver surface and the best source of light is the carbon arc. The military purpose of the searchlight is to throw as intense a beam of light as possible on the target and, therefore, the angle of dispersion of the projected beam should be a minimum so as to decrease the zone of light and increase the zonal candle-power. To accomplish this the mirror is made in a true parabolic form, the source of light is made a minimum and the focal length made a maximum, consistent with obtaining the greater part of the light given off by the source, on the mirror. On shipboard the size of the mirror and searchlight drum is restricted by the necessity that it must not be too cumbersome for handling in a rough sea and in the space available. The focal length depends upon the diameter of the mirror. Therefore, to decrease the angle of dispersion and increase the illumination on the target it becomes necessary to decrease the diameter of the source of light without decreasing the candle-power. In the latest searchlights the diameter of the positive carbon has been decreased to one-half the diameter formerly used, although the amperage has been increased so that with a crater of $\frac{5}{8}$ in. (15·87 mm.) diameter there is obtained a maximum luminous intensity of 90,000 c.p. and a zonal candle-power throughout 70 deg. of very nearly the same amount.

The 36-in. (0·91 meter) diameter mirror is the standard for large ship installations in this country; in the new type of searchlight the maximum candle-power of the arc has been increased from about 50,000 to 90,000, and the area of the beam reduced to one-fourth that formerly obtained, so that the illumination received on the target is more than six times as great as that from the older type. This has been accomplished principally by putting 150 amperes through a positive carbon only $\frac{5}{8}$ in. (15·87 mm.) in diameter and providing means for carrying off the heat. The composition of the positive electrode is very important. It contains a fairly large core of white flaming material. The negative carbon is set at an angle to the

* Abstract of a Paper read before the New York Section of the Illuminating Engineering Society.

positive, as is frequent practice in projector lamps, so that the negative flame impinges on the positive in such a manner as to hold the luminous flame confined within the positive crater. This effect seems to require a certain minimum current which is approximately 90 amperes. If the current goes below this amount the velocity of the negative flame is reduced to such an extent as to allow the positive stream to emerge from the crater and intermingle with the negative flame ; whereupon the arc takes on the characteristics of the ordinary flaming arc.

The size of the negative carbon has also been reduced so that it is now for 150 amperes but $\frac{7}{16}$ in. (11 mm.) in diameter compared with 1 in. in the older type. This reduction in size of the negative carbon had been made by others, however, before Mr. Beck's lamp was produced. The advantages of the small negative electrode are that the shadow cast on the mirror is reduced, which feature is especially important from the fact that the candle-power of the arc crater increases as the angle from the normal decreases. The centralising of the arc by means of the small negative keeps the light much steadier and at the focus of the mirror. The positive carbon is rotated to increase the steadiness of the arc and to keep the crater edges even. In the Beck lamp this rotation also provides for the bathing of the carbon in an indifferent gas to prevent oxidation and increase the cooling of the carbon shell.

Some tests have been carried out by the navy and by others on nitrogen-filled tungsten lamps as a source of light for searchlights. It is evident, however, that these lamps cannot compare in intrinsic brilliancy with the carbon arc, although they contain the desirable features of fixed position of source of light and steadiness, and without the necessity of loss of power in stabilising rheostats. The concentrated tungsten-filament searchlight will probably be developed so as to be satisfactory for such searchlights as are required for navigational purposes where it is not necessary to illuminate objects at great distances.

The gold-backed mirror has been extensively used by certain countries ; but it would seem that for normal conditions it would not be advisable to use it with the later type of arc light which gives off a light strong in blue and violet rays.

The modern searchlight is trained and elevated from a distance by either mechanical or electrical control apparatus so that the person controlling the movement of the light may observe the target without being blinded by the glare of the stray and refracted light. Searchlights are usually fitted with a shutter so that the light may be kept burning ready for use but darkened until such time as it is desired to illuminate the target. The name searchlight is somewhat a misnomer in a military sense, for a searchlight is not as a rule used for searching, but principally for illuminating the target after it has been discovered by pickets or other means. The use of a searchlight in the first instance betrays the position of the ship using it to the enemy before the enemy itself can be discerned.

Metal mirrors of various compositions and colours have been used to a certain extent, principally to prevent breakage due to rifle fire and the shock of gunfire. They have, however, been found to possess a low coefficient of reflection and to tarnish very quickly. They require much care to keep properly polished and are not as true to parabolic form as the glass mirror.

Signalling by Means of Light.—This subject may be divided into two general classes : interior communication signalling on board ship and distant signalling.

Interior communication light signals comprise numerous different circuits and systems for giving definite and fixed indications or messages by illuminating a glass or other translucent dial which contains the message or indication, and thus being similar to many uses of light signals on land.

Distant signalling consists principally of the following systems : Ardois, night semaphore, blinker light, searchlight.

The ardois consists of four lamps mounted in a vertical line, one above the other, as high up as possible in the rigging. Each lamp is double, containing a red and a white light, and these lights are controlled from a keyboard arranged similarly to that of a typewriter. The continental Morse code is used. A red light indicates a dot and a white one a dash. This gives a very simple signal system, as the keys are lettered and numbered so that anyone may transmit a signal with it. This system, however, cannot be used for any considerable distance and it is comparatively slow in operation. Moreover, it is available only at night and is used mostly for tactical signals.

The semaphore system of signals consists of a different position of two arms for each letter and numeral. It was originally used by the British and the French for signalling with a flag in each hand : later it was adopted by this country. While it has been used to a certain extent with hand flags, a machine has been developed containing two swinging arms which were made about 6 ft. (1·7 metre) long and could be seen distinctly at much greater distances than the flags. Furthermore, these swinging arms are equipped with tungsten lamps and a reflector so that they may be used at night.

The flashing signal system uses a pulsating single light, in some cases mechanically occulted. It is controlled by a telegraph key and the continental Morse code is used. Rapid signalling may be effected by its use, but it is available only for night work.

The use of the searchlight for signalling gives a visual means of signalling at great distances. Signals have been sent by this means at least 50 miles, and before the advent of radiotelegraphy this promised important developments. The introduction of radio apparatus on board ships obscured the real field of searchlight signalling for a number of years, and it is only lately that it has again been taken up.

In the present system of searchlight signalling the Morse code is used and the emission of light controlled generally by a quick acting shutter, either hand operated or electrically operated by hand key and relay control. There has been developed more recently, however, a system of controlling the light itself by means of a telegraph key without requiring the mechanical striking of the arc. A number of different means have been developed for accomplishing this. By striking the arc with high-frequency high voltage, the arc once struck may be maintained by low voltage. By shunting the arc with a resistance, the current in the main line may be maintained constant and the current across the arc reduced to about one-tenth of its normal value, the variation in light given out producing the same effect as if the light was actually shut off.

The searchlight can be used equally well in the daytime and is generally so used, acting in this case as a heliograph. It possesses the additional advantage in daytime of selectiveness in that ships at a few degrees from the object on which it is trained cannot see the flashes. In daytime small searchlights have been used successfully for over eight miles. For long-distance night work the searchlight is trained on some dark cloud in the general direction of the receiving ship.

There are a number of special uses of illumination on shipboard. Among such special uses is the illumination of the compass cards. With the use of a dimmer the markings of the compass are distinct, but no glare is produced to dazzle the eyes of the man at the wheel. The illumination of the cross wires of the telescopic gun sights is another example.

APPENDIX.

Table showing Intensities of Illumination adopted by the U.S. Navy Department :—

FOOT-CANDLE INTENSITIES.

Ammunition passages	2·0	General mess pantry	2·0
Armoury, plus metal reflectors at bench	2·0	Galleys	2·0
Battle dressing station	2·0	Handling room	2·5
Battle dressing stores	2·0	Interior com. room	2·0
Bakery	2·0	Ice machine room	2·0
Bath room	2·0	Isolation room	2·0
Barber's shop	2·5	Issuing and store room	2·0
Boiler rooms, plus 250-watt units	1·5	Laundry	1·5
Butcher's shop	1·5	Lamp room	1·5
Band room	1·0	Machine shop (general)	1·0
Blower room (special)	—	Magazine	1·5
Blower space	1·0	Mess room (officers')	2·5
Cabins	3·0	Mess attendants' wash room	2·0
Carpenter's shop	3·0	Offices	4·0
Chart house	5·0	Operating table	15·0 to 25·0
Chief P.O. quarters (berthing)	1·5	Paint room	1·5
Chief P.O quarters (messing)	2·0	Paint-mixing room	1·5
Crew's space	1·5	Pantries	2·0
Country (officers')	1·5	Printing office	4·0
Crew's wash room	2·0	Pump room	1·5
Crew's water closets	2·0	Post office	4·0
Conning tower (special)	—	Prison (special)	—
Chain locker	1·5	Reception room	3·0
Coal bunkers	0·7	Surgeon's examining room	2·0
Coaling ship (special)	—	State rooms	3·0
Dispensary	3·0	Sub	4·0
Desk	4·0	Sub central	4·0
Distribution room	2·0	Shell room	2·0
Dynamo room, plus 250-watt units	1·5	Store rooms (fixed stores)	0·7
Decks, outside (special)	—	Store rooms (stock for issue)	1·0
Engine room, plus 250-watt units (treated as special)	1·5	Sick bay	2·0
Evaporator room	1·5	Storage battery chg. sta.	2·0
Firemen's wash room	2·0	Ship's store	2·0
Foundry	3·0	Torpedo room	2·0
Fire room (treated as special)	—	Turrets (special)	—
Fuel oil relay tank room	2·0	Water closets	1·0
General condiment and issuing room	2·0	Wireless room	3·5
		Workshop (additional special illumination to be provided at machines)	1·5
		Windlass space	1·5

During the discussion following the reading of the Paper it was claimed that the Sperry projector was in many respects superior to the Beck, giving less shadow from the carbon supports, having a smaller crater area for the same current, and needing no supply of gas. Mr. Sperry pointed out that when in Berlin he had had an opportunity of observing a very powerful arc lamp made in Germany, and that whilst he had been working with "effect" carbons, the Germans were working along quite different lines. Mr. Beck compared the craters of hard carbons and flame carbons. A suggestion was made that by using focus type incandescence lamps suitably silvered, for ardois signalling, the effective range might be greatly increased.

In reference to the foregoing it is of interest to note that Mr. E. G. Sperry has applied for two U.K. patents, numbered 12,999 of 1915 and 6,129 of 1916, and also that Mr. Heinrich Beck has two U.S.A. patents, Nos. 1,029,787 and 1,086,311. The latter was filed at Washington on Nov. 29, 1913, Mr. Beck's place of residence being given as Meiningen, Germany. It concerns projector arc lamps, refers to his former patent No. 1,029,787, and evinces an apparently clearer understanding of the principles involved in obtaining those specially high-current density arcs that by reason of their great intrinsic brilliance per unit area of crater are of the greatest value when searchlight beams of parallel characteristic are desired.

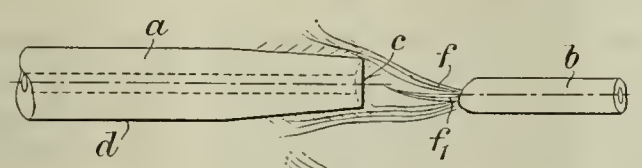


FIG. 1.

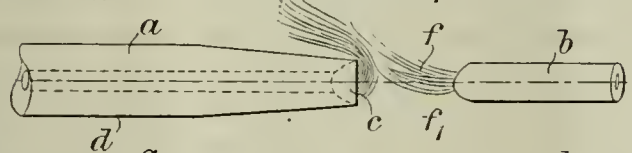


FIG. 2.

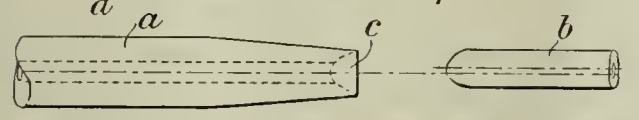


FIG. 3.

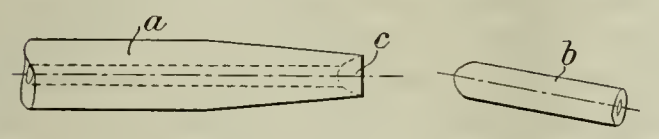


FIG. 4.

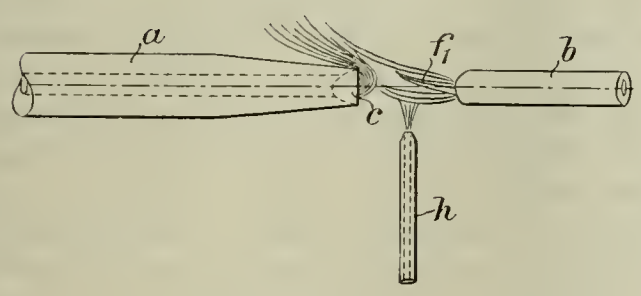


FIG. 5.

The inventor points out that when (and as in ordinary working with small carbons and big currents) the vigorously projected negative flame envelops the end of the positive carbon, current is able to leave the positive carbon over a large portion of its surface other than the crater. The voltage and crater luminosity under these conditions both remain low. Also that when the apex of the central blue "tongue" or cone-like core of the negative flame produced under these special conditions (small carbons and large current) strikes against any part of the positive crater the positive flame, of less vigour, is spread or repressed, and the crater is of insufficient concavity and luminosity.

In order to prevent these difficulties Mr. Beck in one case sets the carbons in horizontal line, the negative being coaxial with the positive or on a slightly higher axial line or inclined upwardly towards the point of the horizontal positive. The positive flame may be given greater vigour by the use of a rapidly burning flame carbon, and the flame of the arc may also be controlled by gas jet action or other means.

In the above drawings from the patent specification Fig. 1 shows the arc as it should not be allowed to burn, and Fig. 2 its production under conditions suitable for parallel beam projections. Figs. 3 and 4 show other settings of the electrodes, and Fig. 5 is a diagram illustrating the disposition of parts for deflection of the arc by gaseous pressure. The first of three claims is for: "The method of operating arc lamps which consists in employing a high current density which produces a tongue in the negative flame and deflecting said tongue from the centre of the positive electrode."

ELECTRICITY SUPPLY IN GREATER LONDON.

At the last meeting of the Conference of Metropolitan Borough Councils owning electricity undertakings, which was held on July 21, it was resolved:—

That the conference of Metropolitan Borough Councils owning electricity undertakings authorises the committee of engineers to invite a technical representative of every electrical undertaking in Greater London area, whether owned by local authorities, electricity supply companies, railway companies, or the London County Council, to attend future meetings of the Engineers' Committee to assist in preparing, as completely as possible, a report on linking-up generating stations in Greater London area;

That the area of the conference's operations shall include the areas of such local authorities owning electricity supply undertakings as are within or cut by a circle having a radius of 20 miles with its centre at East Ham Town Hall, including the Urban District of Watford, and that such local authorities be invited to appoint two representatives, together with their respective town clerks and electrical engineers, as members of the conference;

That the title of the conference be amended to read as follows: "Conference of Local Authorities in Greater London owning Electricity Undertakings."

The Engineers' Committee referred to was appointed to consider taking immediate steps to link up the whole of the generating stations in Greater London area in order to comply with the request made by the Board of Trade in their circular letter of May 25, 1916, on the subject of economy of fuel. Up to the present the companies which have appointed representatives to the Engineers' Committee are as follows: —

North Metropolitan Electric Power Supply Co. (Mr. E. T. Ruthven Murray), Charing Cross, West End & City Electricity Supply Co. (Mr. H. W. Kingston), Brompton & Kensington Electricity Supply Co. (Mr. R. S. Downe), Twickenham & Teddington Electric Supply Co. (Mr. M. Farrer), London Electric Supply Corpn. (Mr. G. W. Partridge), City of London Electric Lighting Co. (Mr. F. Bailey), Great Eastern Railway Co. (Mr. H. W. Firth), Chelsea Electricity Supply Co. (Mr. P. Still), Hendon Electric Supply Co. (Mr. R. G. Drummond), London & South Western Railway Co. (Mr. C. Jones), Kensington & Knightsbridge Electric Lighting Co. (Mr. H. Miller), Notting Hill Electric Lighting Co. (Mr. A. P. McDouall), Metropolitan Electric Supply Co. (Mr. J. S. Highfield), Harrow Electric Light & Power Co. (Mr. G. W. Spencer Hawes), and Richmond (Surrey) Electric Light & Power Co. (Mr. H. G. Alger).

Owing to the autumn recess few of the local councils have held meetings subsequent to the issue of the invitation to join the conference, but up to the time of writing the following have complied—viz., Ealing, East Ham, Bexley Heath, Leyton, Finchley, Barnes and Beckenham, and the following have signified their intention not to come in at present—viz., Willesden and Grays. At a meeting of the Metropolitan Municipal Authorities held on March 26, 1915, the following resolutions were adopted:—

That, in the opinion of this committee, subject to the adoption of the following conditions, a central autority should be established to deal with the supply of electricity for London, viz:—

1. The central authority shall include representatives of the London County Council and adequate representation of Borough Councils being authorised distributors.

2. No attempt shall be made by the central authority to hamper or restrict the economic development of any existing Borough Council generating station, and for this purpose all existing and future powers shall be conserved for the purpose of this clause. The London County Council shall sanction loans to the Borough Council on terms which shall not be more onerous than any it imposes upon any undertaking.

3. The purposes for which the central authority shall be established shall be:—

(1) The supply of electricity in bulk to authorised distributors.

(2) The supply of electricity for traction purposes.

(3) The standardisation of the London Supply by a scheme and on terms to be jointly formulated by the County and Borough Councils.

4. The central authority shall not compete in distribution with the Borough Councils who are authorised distributors.

5. If the London County Council purchase the undertakings of the companies, it shall transfer to the various Borough Councils the distribution of electricity within each area.

6. Deficiency rate shall be levied on any Borough Council which does not take a supply under any scheme formulated by the central authority.

7. No attempt shall be made to purchase compulsorily any Borough Council undertaking, and no Borough Council shall be prejudiced by reason of its refusal to sell.

8. The provisions of the London Electric Supply Acts (1908 and 1909) for closer co-operation between existing undertakings shall, with suitable safeguards, be made compulsory.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Journal" of the Institute of Metals. Vol. XV. Edited by G. Shaw Scott. (London: Institute of Metals.) Pp. viii.+392. 21s. net.

"Treatise on the Theory of Alternating Currents," by A. Russell, M.A., D.Sc. Vol. II. 2nd Edition. (Cambridge: University Press.) Pp. xiv. +566. 15s. net.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.

Published every Friday, Price Sixpence, Post Free, Sevenpence.

Editorial, Publishing and Printing Offices,

1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.

(ONLY ADDRESS.)

Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury-court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*

All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential and a World-wide circulation.** *This statement is guaranteed.*

Advertisement Rates, &c., forwarded on application.

TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*

CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d.; Canada and India, 2s.; Australasia and South Africa, 3s.; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preparation.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRIC SWITCH AND CONTROLLING GEAR. By Dr. C. C Garrard. *Nearly Ready.* 15s. nett, post free 15s. 6d.

SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson, M.I.E.E. *New Edition in preparation.*

ELECTRICAL LABORATORY NOTES AND FORMS. Arranged by Dr. J. A. Fleming, M.A., F.R.S. Single copies 4d. nett, or in dozens at 3s. 6d. nett. Complete Sets of 50 Notes and Forms, 12s. 6d. nett, or in strong portfolio, 14s. nett; or bound in strong cloth, 15s. nett. Spare Copies of Tabular Sheets, 1s. per dozen. Portfolios, 1s. 6d. each. Sectional paper, 1s. per dozen sheets. *Complete Prospectus post free on request.* These Notes and Forms are kept revised as new printings are required.

HANDBOOK OF THE ELECTRICAL LABORATORY & TESTING ROOM. Very fully illustrated. By Dr. J. A. Fleming. *Revised Editions.* Vol. I., 12s. 6d. nett. Vol. II., 14s. nett.

SECONDARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.

THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.

INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903), Full Report of Proceedings at, 8s. 6d.; post free, 8s. 9d.; abroad, 9s.

INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.

BRAKES FOR TRAMWAY CARS. By H. M. Sayers. Price 2s. 6d. nett.

ELECTRICITY IN HORTICULTURE. By Prof. S. Lemstrom. Illustrated. 3s. 6d. nett.

RADIO-ACTIVITY: AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M.A. Price 4s. nett.

MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by G. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.

ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.

A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Geipel and H. M. Kilgour. Price 7s. 6d. nett.

THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol. I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.

THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.

ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.

THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. G. Bond, M.I.E.E. Price 2s. 6d. nett.

A RELIABLE WORK OF REFERENCE.

THE LOCALIZATION OF FAULTS IN ELECTRIC LIGHT AND POWER MAINS.
By F. C. RAPHAEL.

THIRD EDITION: *Now Ready.* Price **8s. 6d.** nett, post free **9s.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.

Cases for binding Vol. LXXVI., price 2s.; post free, 2s. 4d.

REFORM OF OUR PATENT LAWS.

At a recent conference of the Society of Chemical Industry attention was drawn to the urgency of reform in our patent laws. There is no question that this is a subject which should be taken up energetically when our legislators have time once more for their normal activities; indeed, something in a preliminary way should be done before that time, with a view to clearing the ground and forming an opinion as to what is desirable to place patentees in this country in a satisfactory position. Patent law should be for the actual, not nominal, benefit of the patentee, it should give our manufacturers proper means of maintaining their position in the international industrial struggle which will shortly come upon us, but above all it should be so framed as to maintain our pre-eminent position as a manufacturing and industrial country.

One of the hardships that bears most heavily upon the English inventor is the high cost of a patent in this country. It is quite true that the first cost is low; but actually, if a patent is to run for 14 years, the total cost in fees alone is £99. This compares very unfavourably with many other countries. Take, for example, the United States, where the Government fee is £7 for protection which lasts for 17 years. There is, of course, a good deal to be said in favour of the fees being comparatively small for the initial protection, but the continual payment of an increasing fee each year may in many cases be a serious burden.

Moreover, in the United States the search which is made by the Patent Office authorities is more rigorous than in this country, and consequently the patent, although very much cheaper, is valued at a higher figure. The same may be said of Germany. The question of search is one that is important, and it would do much to smooth the path of the patentee if information were made available of a thorough character on not only patent literature, but "common knowledge." Perhaps it is too much to expect such a costly task to be undertaken.

The suggestion was made by Mr. J. W. GORDON that a patent grant would produce a maximum public advantage if only a qualified monopoly were given, such that the patentee had a right to grant licences, but only in exceptional cases the right to restrain by an injunction the use of his invention. The effect of this would be that anyone who so desired would be able to obtain a licence: in other words, an inventor might be forced to give any number of licences. There is, however, a very strong objection to such a policy. It must not be forgotten that some patents require a considerable expenditure of time and money for their development, and manufacturers will not incur this risk if they are liable to open competition by licensees. Again, the idea that an article of value would be made readily if anyone were free to make it is quite false unless the cost involved is nominal. Actually an article is usually manufactured by some particular firm simply because other firms have not the right to manufacture. In suggesting that licences should be granted wholesale, it is forgotten that the cost of selling, apart from manufacturing, is considerable. In fact, in some cases the cost of selling may be the largest cost incurred. A manufacturer, therefore, is usually unwilling to undertake the manufacture of an article unless he has the exclusive handling of the particular article for some time, otherwise his expenditure in obtaining a

market would be largely incurred for the benefit of his competitors.

A number of other interesting points were raised at this Conference. Thus attention was drawn to the great cost of patent actions in this country. It is undoubtedly the case that no firm is willing to go into the Law Courts to fight a patent action unless ample funds are at hand for the purpose, and that the gain by so doing is likely to be considerable. From this point of view we might do well to follow German practice, where judges are assisted by a certain number of scientific or technical assessors, as distinct from expert witnesses, with the result that the procedure is much shorter and the cost correspondingly less. A point raised by Prof. ARMSTRONG referred to what are termed "blocking" patents—namely, patents on side lines—such patents not being used except for the purpose of preventing investigators working along those particular lines. Prof. ARMSTRONG described this as "an infernal form of interference." It is difficult to see, however, that any action can be taken in a matter of this kind. Anyone is free to invent, and if he wishes to protect any particular line, to the disadvantage of a competitor, he must be free to do so; otherwise our whole patent fabric would fall to the ground. It might, however, be advisable to set up some form of tribunal to investigate the effect of a blocking patent upon complaint being made by an interested manufacturer or dealer, for any national system of patent law should have the general good of the country always in view.

Perhaps one of the most keenly debated provisions of our patent law at the present time is that which necessitates compulsory working of patents. Some people hold that this is good, others that it is bad. From the point of view of employment in this country, we think it must be admitted that the provision is good, as it has led to the building of factories over here and the employment of British labour. On the other hand, it has necessarily led to the introduction of aliens in our industries who may be more or less undesirable. Recent experience has shown that these people certainly are undesirable from the point of view of interfering with our industries for political purposes. Therefore it might be better to provide for compulsory licences in this country, the working of these to be carried out by British firms. With the licences there should be complete disclosure of methods of working, &c. This is important in most cases, especially in chemical patents. There are, however, many difficulties in securing the desired end, and it might be advisable to have discretionary power to insist upon compulsory working in this country or, alternatively, to call upon the patentee to grant licences.

Although many so-called inventors may well be discouraged, it is time to realise that the true inventor is a national asset, and his path, which at best is thorny, should be made as easy as possible. The whole question should be discussed on a broad basis in the near future. A point which was not discussed at the Conference, and which we consider of some importance, is the desirability of having a uniform imperial patent law. In the future it is to be hoped there will be closer political and commercial relations between the various parts of the Empire; and although it may not be possible, in the first instance, to have one patent which would be valid in every dominion and colony, yet much might be done to improve and simplify our present system.

The endeavour should be made so to frame the patent laws as to ensure that the community and individual benefit by the granting of a patent. Under existing conditions an inventor, particularly a poor or timid inventor, runs the risk of being involved in costly legal actions; and an effort should be made to improve his position.

REVIEWS.

Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

The Engineers' Year Book of Formulæ, Rules, Tables, Data and Memoranda for 1916. Compiled and edited by H. R. KEMPE. (London: Crosby Lockwood & Son.) Pp. 1967. 15s. net.

This book, which is a compendium of modern practice of all branches of engineering, has now been published annually for 23 years. In its preparation the author has received assistance from a large number of specialists, who have subjected their respective sections to a careful revision, making important alterations to bring them into line with present requirements.

First published in 1894 with 586 pages, the book has grown year by year till the text matter has now reached a total of 1,866 pages, and the work calls for more than 1,500 figures for its illustration.

Prominent among the new features in this issue are authoritative contributions on the Catenary Curve, Hyperbolic Functions, Astronomy in Field Work, Engineering Drawings, Properties of Beams, Steel Roof Framing and Covering, Railway Signals, Reinforced Concrete Roads, Ropeways, Clutches, Blast Furnace Practice, Compressors, Hydro-electric Plants, Pumps, Engine Design, Forced Draught, Materials of Construction, Workshop Ventilation and Metallurgy.

The section on Coal and General Mining has been considerably improved, while the sections dealing with Cranes, Power Transmission, Machine Tools, Bearings, Steam Practice and Mechanical Engineering have been amplified, and a considerable amount of valuable data added.

A former edition of the book was called by a reviewer "A veritable encyclopædia of engineering knowledge," and another reviewer said: "Among the most useful books of reference of its class which exists, if, indeed, it is not actually the most useful." Of the present edition it may be said that besides containing all the useful parts of former editions on which time and money have been spent to keep them useful, it contains a large amount of new matter, in the choice of which the author has shown rare judgment. Praise is due to all those who have been concerned in the handling of the book, which, notwithstanding the many difficulties on account of the war, fully maintains the very high level reached by former editions.

Continuous-Current Engineering. By ALFRED HAY. (London: Constable & Co.) Pp. xii.+360. 6s. 6d. net. 2nd edition.

The first edition of this book was reviewed in these columns about eight years ago. It was reprinted in 1912. Owing to important advances in various directions since the appearance of the first edition, many of the sections in the present edition have been largely re-written. In common with everything else that is for sale at the present time the price of the book has been increased by 25 per cent., but this is not the author's fault; maybe the price has been advanced in spite of the author, for publishers, like all other traders, have to endeavour to work for a profit.

We have used "Hay" during the last eight years, not because it gave every satisfaction, but because it gave more satisfaction than other elementary works on the same subject. In fact, the book falls far short of our ideal. We had hoped that in preparing the new edition the author would use as a model his book on alternating currents, in order to get a well-balanced whole. To arc lamps of different makes 22 pages are given, and no less than 16 pages are devoted to the description of electricity meters, and a like number of pages is given to a very sketchy account of conductors and insulators.

Had some of these pages been given to considering the effect of inductance, to calculating the energy stored in magnetic fields, to the design of electromagnets for a given duty, to the winding of coils for a specified performance, to the rating of machinery, and to the many highly important problems connected with motor starting and control, we venture to think that a still more useful volume would have been the result. Having used the book for so long it is likely that the omissions are the more noticeable. As it stands, the book is still the best of its kind, and any student who works conscientiously

through the book, and tackles the exercises at the end of each chapter, will undoubtedly do well in any examination, the syllabus of which is covered by "Hay." In addition to enabling a student to pass examinations, the book is full of useful information, and paves the way to a thorough understanding of more ambitious works.

Mechanical Engineers' Pocket Book. By W. Kent. (London: Chapman & Hall.) Pp. xliv.+1,526. 21s. net.

This volume is the ninth edition of a work that is probably as well known in this country as in America. In its preparation Prof. Kent has had the assistance of his son, who has been responsible for the revision of many of the tables, as well as for practically the whole of the revising of several of the subjects. That the work is to be found on the engineer's bookshelf is evident from the fact that the total issue now reaches one hundred and eight thousand a figure of which even the writer of a popular novel need not be ashamed.

A book having such an enormous circulation needs no further recommendation. It will suffice if we briefly set out the several changes and additions that have been made in the present edition. The revision has necessitated changes in over 400 pages, and the addition of over 150 pages of new matter. Extensive revision has been made in the subjects of materials, mechanics, fans and blowers, heating and ventilation, fuel, steam-boilers and engines, and steam-turbines. The new matter in the rewritten and enlarged chapter on machine-shop practice includes an elaborate treatment of the subject of machine-tool driving, together with extensive data on planing, milling, drilling and grinding. The chapters on electrical engineering have been completely rewritten and brought into agreement with modern practice.

In looking through the book it is evident that the author has endeavoured to bring the matter up to date. His treatment of many of the sections is surprisingly complete, and the very full index will be welcomed by the many who require information in a hurry. In the next edition we should like to see more space devoted to references. Reference libraries of technical books are the exception in this country, and it is necessary for an engineer in any of our large manufacturing towns to have a search made at one of the libraries in London for references on a given subject. For the results to be of value, the making of a search requires considerable time, and is an expensive business. No doubt Prof. Kent has a useful list of references in connection with each chapter.

As it stands, however, the book is invaluable to the engineer, irrespective of the branch in which he practises, and the whole of the press work is excellent.

EARTH CONNECTIONS FOR TELEPHONE EXCHANGES.

BY W. H. GRINSTED, A.C.G.I.

The systems of earth connections in a well-designed modern central battery exchange are two in number, namely, that used for protection against high-tension currents and that in connection with the central battery. The two systems should preferably be distinct, so that in the event of a failure of the earth connection, risk of high tension being conveyed to the telephone plant is minimised. Further, since the first, or protective, system must be in connection with the building structure, there is a possibility of fairly large currents flowing in cable racks and in parts of the building framework, if the systems are interconnected. However, the two systems are often combined without giving rise to serious difficulties, so these objections are possibly of little practical importance.

Protective System. This system is used for the protection of the telephone circuits and apparatus against excessive pressures, and currents due to lightning or contacts with power wires, &c., and also to protect the staff against shocks in the event of a breakdown of the insulation of the motors or their controlling gear. The apparatus earthed by this system usually comprises the main frame, the frames, couplings and shafts of the charging machines and ringing machines, the frames and cases of the controlling switches and starters, the framework of the power board, the lead-covering of the power cables and the conduits for the latter. The main frame carries the "protectors," which include arresters, heat coils and fuses protecting the exchange apparatus from high-tension or excessive currents. The operation of the arrester or of the heat coil connects the line to the frame plate of the protector strip, which is earthed partly through the frame itself, but mainly through a copper strip soldered to a bare copper wire which passes up behind each vertical row of protector strips and terminates in a bare copper bar running the length of the frame. This bar is in turn connected to the earthing 'bus bar. The shafts and couplings of the machines are connected to the frame by means of brushes specially fitted and running on the coupling or on the end of the shaft. The frame of the power board and the apparatus mounted on it are usually connected to the earthing 'bus bar by means of bare copper wire of the cross section required by the wiring rules of the undertaking, from which the power supply is drawn.

Since the earth lead from the main frame is in reality a lightning conductor its route to the earth connection should be as direct as possible. It is usual to connect the other points to be earthed by separate cables or wires to an earthing 'bus bar situated on the power board, from which a common earthing cable runs to the earth connection. In many cases the main frame cable is also connected via this 'bus bar. Since this is generally an indirect route for the cable this practice is not good. It is preferable to run a separate lead by as direct a route as possible to the earth connection.

The water-main or hydrant system is best used for the earth connection for the protective system, as the currents are not permanent and are not likely to affect the building fabric. The connection to the water system should be made on the main side of any water meter or apparatus likely to present a high resistance, or to be temporarily disconnected. If this is not possible such apparatus must be permanently bonded across.

Insulated cable should be used for the connections, except for those local to the power board. Bare connections might possibly be in contact with gas-pipes or with parts of the building to which the lightning flash or high-tension cross might strike through, causing damage at some distant point in the building, especially if the earth connection had deteriorated. As far as possible, too, individual cables should be run for connecting each machine frame, &c., to the earthing bar, and in any case where one lead serves two pieces of apparatus it should be looped in to one lug at the first connection. If, then, the earth connection at this point is removed, for instance, during replacement or repairs, the second piece of apparatus is not disconnected from earth.

System in Connection with the Central Battery. The uses of the connection to earth of one pole of the central battery are not generally realised. It is usually looked upon as providing a return circuit for signalling currents. In this connection it is used chiefly for completing signalling circuits on junction lines, and in some almost obsolete systems for calling or clearing on subscribers' lines. It is also largely used to serve as the return for the current supply to subscribers' private branch exchange switchboards of the common battery type. On large exchanges the current supplied over earth circuit power leads for this purpose may amount to as much as 30 to 50 amperes.

There are, however, other important reasons for earthing the battery. They are briefly:

1. To reduce the number of fuses required, and to avoid the need for insulating some of the return conductors. For these reasons the earth is connected to one pole of the battery and not to the centre.

2. To prevent cross talk and other disturbances due to leakage and capacity currents between the circuits connected to the central battery. As far as telephone currents are concerned the connecting or cord circuits can be reduced to the elements shown in Fig. 1. The central battery, connected at points b_1 and b_2 can be regarded as a short-circuit for speech currents, and is not shown. Suppose the out-of-balance

capacity and insulation of circuit 1 can be represented by an equivalent fault at e_1, and those of circuit 2 by an equivalent fault at e_2. Points b_1 and b_2 on the two circuits are common, being connected together at the central battery. Between points a_2 and b_2 there exists half the potential difference created by the transmitter T_2. This will cause a current to flow through the two faults as follows: From a_2 through e_2, earth, e_1, d, b_1, to b_2. The circuit b_1, a_1, R_1, e_1 forms a shunt to the part of the previous circuit b_1, d, e_1, so that the receiver R_1 on circuit 1 receives part of the current from the transmitter T_2, and is disturbed by speaking, ringing or tone signals passing on circuit 2. If, however, the common points b_1 and b_2 are connected to earth the current is shunted out of circuit b_1, a, R_1, e_1, by the earth connection between the equivalent fault e_1 and the common points b_1, b_2. This connection amounts practically to a short-circuit, so that the disturbance of circuit 2 is prevented. When the number of circuits between which such inter-action

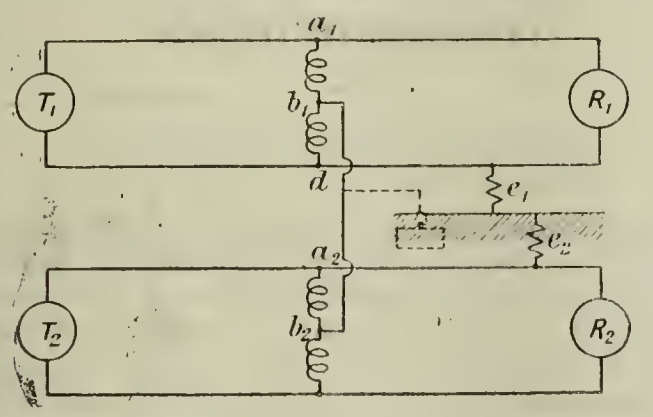


Fig. 1.—Circuit Illustrating Cross-talk.

is possible is considered it will be seen that the earth connection plays a very important part in securing a "quiet" exchange system. These considerations show also one reason why the earth connection should be of as low resistance as possible.

3. To ensure prompt indication of faults and assist in locating them. If the insulation to earth of any part of the system fails a circuit is completed via the earth connection on the battery, and thus perhaps the fuse serving that part is blown, or relays are operated, drawing attention to the fault at once. Without the earth connection the circuit would only be completed via some other faulty section. In this way most peculiar effects may be caused; the fault only shows up when both faulty sections happen to be taken into use together, so that great difficulty in locating the trouble is caused. To assist in preventing troubles of this sort all the mounting plates, racks, frameworks, &c., in the exchange are specially connected to the earthed pole of the central battery,

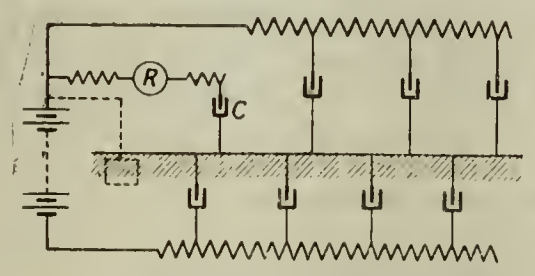


Fig. 2.—Circuit Illustrating False Engaged Test.

the chance connection to earth through cable racks, fixing bolts, &c., not being relied upon.

4. To ensure a reliable engaged test on the multiple jacks. The wiring and apparatus in circuit with the operator's receiver, and that in circuit with the multiple jacks, each have a certain, not inconsiderable capacity, and a certain leakage or insulation resistance to earth. Other circuits connected to the opposite pole of the battery have also similar capacities and leakage resistances to earth. With an unearthed battery each side of the system thus takes up a potential relative to the earth determined by the respective capacities and leakage resistances of the apparatus, wiring and lines connected to either pole of the battery. The amount of apparatus, wiring and lines connected up is constantly varying so that the potential of the poles of the battery relative to the earth will be continually changing. Included in the apparatus and wiring on the positive side are the operator's testing circuits, as shown in Fig. 2. The wiring of these circuits will possess a certain capacity to earth, c, the charge in which will depend upon the potential of the positive pole of the battery relative to earth. As this fluctuates, the capacity c will charge and discharge through the operator's receiver, giving rise to clicks which will tend to invalidate the real engaged clicks. By connecting the battery to earth all disconnected circuits are caused to take up a definite potential with respect to earth, namely, that of that battery pole to which they are connected (provided their insulation resistance is reasonably high) so that no fluctuations in the charge on the testing circuit, wiring, &c., can be caused.

5. To assist in identifying wires in outside lines or in distant exchanges. In some cases it is necessary to distinguish between the two wires of one circuit, for example when each side of the line is employed separately for signalling. If, as is usually the case, the wires are connected at the outgoing end to the two poles of an earthed battery, they are readily distinguished by noting their potential against earth by means of a galvanometer or voltmeter.

In telephone exchanges, contrary to the practice on traction systems, the earthed pole is almost always the positive. This ensures that the whole of the lines and apparatus which differ in potential from the earth are negative to the latter, so that any leakage currents that exist flow from earth towards the apparatus. Were the opposite the case, the line wires. and particularly the coil windings connected to the free pole of the battery, would be positive to the earth, and so suffer corrosion from leakage currents. This effect is inappreciable with the large conductors and high insulation employed in heavy current engineering. On telephone systems, however, serious trouble can arise from this cause. Even although the insulation were not abnormally low, an extremely small leakage current, flowing, say, from the winding of a relay to its core, and thence to the rack and the negative pole of the battery, would corrode the fine wire sufficiently in the course of a few weeks to cause a disconnection. The instrument wiring and coil windings of subscribers' instruments are particularly liable to trouble of this kind. By earthing the positive pole of the battery instead of the negative, the effect is practically eliminated. In cases where a winding connected to the positive pole is in close proximity to another connected to the negative pole, so that direct leakage can take place apart from any connection with earth, similar trouble can still occur, especially with unfavourable atmospheric conditions.

A second reason for earthing the positive pole is that partial earth faults show up more definitely on test when the conductor is negative to the surroundings. When its potential is positive, the fault is liable to seal up owing to oxidation of the conductor.

It is the usual practice to employ an earth plate for earthing the battery. The value of this earth connection, as it is usually installed, is open to considerable doubt. It generally happens, owing to the use of uninsulated earth bars on frames and racks, that the frame of the building, the main frame earth and the battery earth are all interconnected. Added to this, the sheathings of the cables entering the exchange are often bonded together, and connected to the water main. The current has, therefore, the choice of several paths, of which the earth plate is often not the most favourable. Its resistance to earth is often higher than that of the building frame work, or that of the water system. An E.M.F. up to about half a volt can usually be observed between the copper earth plate surrounded by carbon and the iron water pipe or building framework, before they are connected up to the battery, the earth plate being positive. This E.M.F. therefore tends to decrease the current flowing via the earth plate. Further, it seems reasonable that the earth plate itself, being connected to the positive pole of the battery, is subject to corrosion in the same way as wiring and coil windings when the negative pole is earthed. If so, one wonders whether anything remains of it a few years after its installation. It would be very interesting to hear of any examination that has been made of a plate some years after the exchange has been brought into use.

On the whole, therefore, it is very doubtful whether the earth plate acts in the way in which it is supposed to act. The following proposals would secure a more definite return path for the current, and a more efficient and less expensive system of earth connections. It will be noticed that of the various purposes served by the earth on the central battery, only one involves any appreciable currents—namely, its use as a return for private branch exchange power currents. It is desirable, in order to avoid damage to water pipes, &c., that a metallic return conductor should be provided for these currents. Such a conductor is available in modern systems with complete underground distribution, in the shape of the lead sheathing of the cables. The common return conductor for the power leads at the private branch exchange would be connected to the sheathing of the cables entering the building, and at the exchange the sheathing of the cables would be bonded together and connected to the positive pole of the battery. To provide for the few subscribers' switchboards, for which the return could not be provided in this way, the water main would also be connected in parallel at the exchange. The proposed arrangement has the further advantage that the current through the cable sheath would tend to keep the latter at a potential negative to earth, and so reduce the risk of electrolytic corrosion.

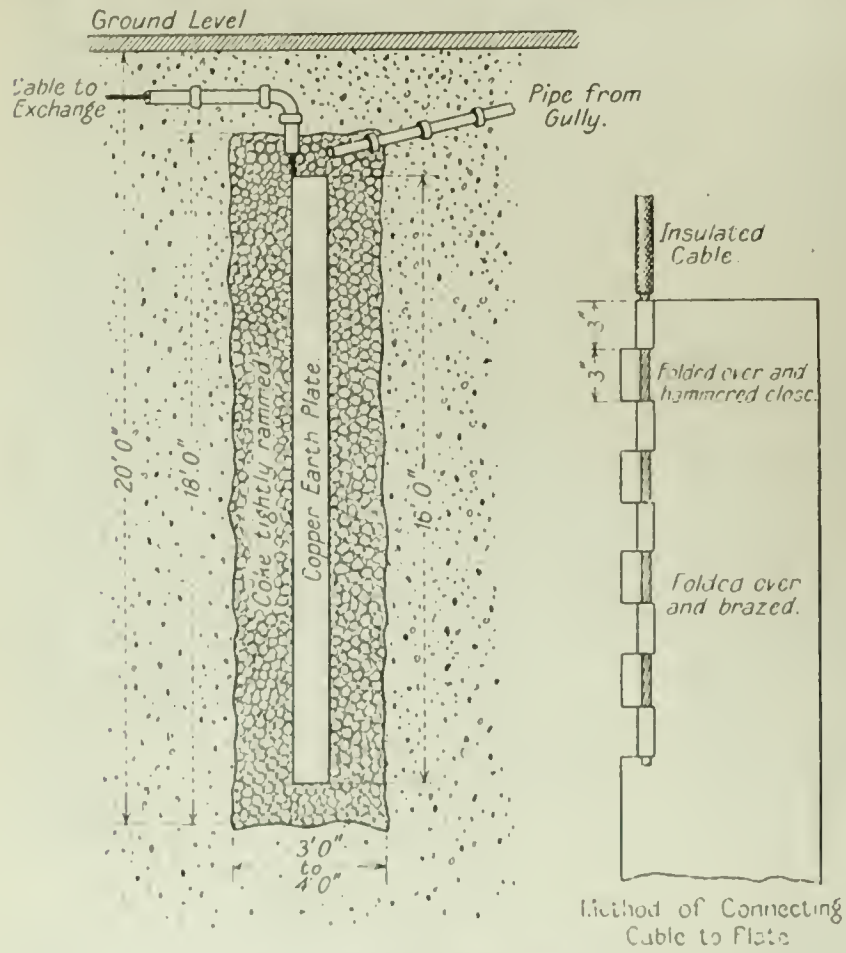


Fig. 3.—Coke-well Earth.

The protective or main frame earth system would be entirely separate, and would be earthed by means of a plate or preferably by means of a group of iron pipes in the well-known way.

Considerable difficulty is often experienced in securing a sufficiently low resistance with an earth of the plate type. The method shown in Fig. 3 has been used with success, and in dry high-resistance soils it gives very much lower resistances than the usual method of laying the plate flat, surrounded above and below with beds of coke. The excavation is made in the shape of a well, 3 ft. to 4 ft. in diameter, and is filled in with coke, well rammed around a narrow plate, 16 ft. long by 1 ft. wide, of 16 S.W.G. copper sheet, placed vertically in the centre. Instead of this copper plate a 9-in cast-iron pipe might be used. An earthenware pipe is provided for the cable, and a second pipe, reaching to the upper surface of the coke only, is taken to a water gully, if possible one which will be in constant use, so that the soil in the neighbourhood of the plate is kept moist. In one case where a direct comparison with the usual method was possible the improvement effected by this method was most marked. The exchange was situated on the top of a hill which consisted almost entirely of sand, the ground water level being at least 60 ft. below the surface. The excavation was carried to a depth of 21 ft. 6 in. without any signs of sufficient moisture being found, but the earth plate, 8 ft. × 2 ft., was installed in the usual way, horizontally between two layers of coke. The resistance measured between the plate and the water-main system was 55·9 ohms. On installing the same plate vertically, in the centre of a column of coke 3 ft. to 4 ft. square and extending a foot above and below the plate, the resistance fell to 13·3 ohms. Even this figure, of course, is far too high to be satisfactory. The resistances usually attained vary from 0·01 ohm to 1·6-ohm., when the plate can be installed below ground-water level, and from about 2 ohms up to as much as 15 ohms when ground-water level cannot be reached. Resistances above 2 ohms cannot be looked on as satisfactory.

CORRESPONDENCE.

GERMAN BOUNTY-FED STEEL.

TO THE EDITORS OF THE ELECTRICIAN.

This matter wants further ventilation, as until a definition of "fair trade" has been arrived at, the necessity or otherwise of "protection" cannot be settled, as we want to know exactly what we are to be protected from. I enclose some notes on one view of the subject. The other side of the case has purposely been omitted. H. Gurney Wood.

[The notes referred to by our correspondent are given below. —Eds. *E.*]

The notes published in this journal under the above heading are interesting, but as published give a rather one-sided view of the position. Did Sir Robert Hadfield not know of combines in this country with similar methods and yet he calls the competition the English manufacturer has to meet "an unfair method of selling below cost by the aid of bounty." Why unfair? When it is admitted that the so-called below cost "pays the German, because by doing so he is able to keep his furnaces fully going." On the face of it, therefore, the notes are contradictory, and can only be made a plea for protection, and it is hardly surprising that no Government action was taken. Let us examine this unfair method and find where the unfairness lies. A combine has been formed including practically the whole of the steel furnaces in a country with the result that, having eliminated internal competition, the requirements of the country can be evenly divided among all the members of the combine in, say, proportion to their total possible output. Hence all the firms find that their now steady output is below the maximum possible, and that more profits could be made if their furnaces were all working continuously.

The selling price of any material may be taken as the sum of four items.

1. Raw materials, including fuel.
2. Wages.
3. Establishment charges or on costs.
4. Profit or dividend, calculated as a percentage of the capital invested or on the value of the order.

We will assume that the combine has fixed the price at a figure which allows a definite profit, and that each firm on its normal output will be able to recover the total establishment charges each year, the normal output representing the internal trade of the country. It is therefore evident that, for any extra orders that can be obtained, say, export orders, there need be made no allowance or only a small one for establishment charges. This will mean that a lower figure can be quoted, and yet the profit on the order will remain the same. This is so because items 1, 2 and 4 are roughly proportional to the tonnage output, while item 3 is almost a fixed charge independent of output, and can only be kept at a minimum when the maximum output is continuous. This method of estimating prices is not confined to trusts, but applies just the same to any competitive business, and no one would think of calling it unfair. In the assumed combine then, what more

natural and reasonable policy can there be adopted under the circumstances but to agree to treat export orders on this basis, *i.e.*, that, for export, prices shall be quoted which do not carry full establishment charges.

At this point the advantage of the combine is apparent. The export orders could be divided among the members of the combine in their correct proportion. As probably some firms are more favourably situated either by existing trade with foreign firms or freightage facilities, it will be obvious that they could secure a larger proportion of these export orders than other firms, so much so that their whole output might go abroad. If this was so they would be unable to recover their establishment charges, and hence the bounty scheme is adopted, simply as an internal adjustment among the firms of the combine. A business proceeding perfectly well understood among the many combines in this country. Now where does the unfairness come in ? The scheme if not the method is so common in this country that no one in sending out enquiries for almost any contract abroad would fail to specify that the goods were required for export in the expectation of getting more favourable prices. H. Gee.

THE METALLURGY OF THE RARER METALS.*

BY JOSEPH W. RICHARDS.

There are many metals which may be called "the rarer metals." Among them the most interesting are those whose compounds are relatively cheap, but which now command a high price because of the difficulty of their reduction. Aluminium is now out of that class, but in 1886 it was selling at £2 per pound, although its ores were common. The genius of the profession then expended its best talents on the problem of the cheap reduction of the metal, with the result, in 10 years, of reducing the market price to less than one-tenth its former figure.

Silicon furnishes another example in point. Silica is the most abundant material in nature, yet silicon was selling in 1900 as a chemical curiosity at *over* £20 *an ounce.* At the present time, 10 cents per pound is a good market price for silicon, which is often sold by the carload.

Among the metals at present of high price, but which by improved metallurgical processes might be made very cheaply, are the following :—

Beryllium.

A light, alkaline-earth metal, its ore is not as rare as is ordinarily supposed. Massive beryl, looking like green quartz, is common, and ever abundant in some localities. The beryl crystals of Acworth, N.H., are sometimes as large as a barrel, and contain 14 per cent. of BeO. When chemically treated, both the Al_2O_3 and the BeO which it contains could be separately obtained.

Up to the present, no one has succeeded in isolating the metal except by reducing a haloid salt of beryllium by potassium or sodium, or by electrolysis of double chloride, bromide or fluoride of beryllium and sodium or ammonium. These methods are tedious and costly, but it is not to be expected that beryllium can be made cheaply until someone masters the direct electrolysis of the oxide, dissolved or suspended in a more stable melted salt. This is by no means an impossibility ; a similar solution was found for the aluminium problem, and systematic, determined search would in all probability find the answer for beryllium. In such a case, the cost of the metal should not exceed 2s. 1d. a pound. At present the price is about £60 an ounce.

Lebeau has produced beryllium bronzes by reducing in the electric furnace a mixture of beryllium oxide, copper oxide and carbon ; 0·5 per cent. of beryllium makes copper hard and sonorous ; 1·5 per cent. makes it yellow, and 5 per cent. makes a fine golden yellow bronze.

Beryllium, like any other rare metal, must find uses which justify its cost. Being white, malleable and unchanged in air, its specific gravity, 1·64, would make it particularly useful for objects where great lightness and permanence in air are the first consideration and cost secondary. So far we practically know nothing about its tensile strength or rigidity, about how it might be strengthened or stiffened by small additions of magnesium or aluminium, or even of zinc, or copper, or manganese, or some other metal. We do not yet know the mechanical properties of its fine bronzes, except that they are somewhat similar to aluminium bronze, but in what respects they might be superior or perhaps unique is unknown. Finally, the metal may easily possess special properties, now unknown, which may render it particularly useful for some specific purpose. Its specific heat, for instance, is the highest of any useful metal, and its latent heat of fusion must be abnormally high, possibly 300 calories, and its latent heat of vaporisation probably higher than that of any known element, except carbon or boron. Such charcteristics might give it special uses in electrical instruments, or for physical apparatus, where its cost would not exclude its use. Beryllium is, therefore, a metal which, in the opinion of the writer, is likely to repay extended metallurgical research and minute physical and chemical study of its many unique properties.

Magnesium.

We prepare by tedious methods the anhydrous double chloride, and then electrolyse it in much the same way as Matthiesen did 50 years ago. Using magnesium oxide costing a few pence per pound, the metal sells for about four times as many shillings, and is scarce.

Dr. W. M. Grosvenor places the actual cost of the metal at 4s. per pound, 3s. 9d. being, in his opinion, the cost of its extraction. In the opinion of the author a modern, up-to-date attack on this problem ought to result in producing magnesium at 2s. per pound.

The first endeavour should be to reduce the oxide directly. The halogen salts are hygroscopic, and the halogen is destructive to the reducing apparatus. Research might enable the electrometallurgist to feed MgO directly into an electrolytic bath of fused salts, and take magnesium or magnesium alloy from it. The pure metal will float on almost any fused salts, but its alloy with heavier metals may be made such as to sink, and many of its alloys have immediate useful applications.

The possibilities held out to the metal industry by reasonably cheap magnesium are extremely interesting. The stiffening of magnesium to produce strong alloys with specific gravity not over 2 has not been properly studied. It is quite possible that alloys analogous to *duralumin* may be discovered, as strong as soft steel and only 30 per cent. of its weight, which will find extensive use in aeroplanes and dirigibles. Such alloys may also largely displace aluminium alloys, which are used by thousands of tons annually in the automobile industry, with a saving of one-third in weight, which will compensate for a higher first cost.

Calcium, Strontium, Barium.

These are highly interesting elements, common enough in nature, but all scarce and of high price because of the metallurgist's lack of efficient and cheap methods of reduction. With burnt lime, one of the cheapest of common materials, strontium sulphate, a mineral found in considerable abundance, and barium sulphate, so common as heavy-spar that it is used as an adulterant for some cheap paints, the metallurgist is again faced with the demand for cheap methods of reduction. Calcium is sold at a few dollars a pound, and strontium and barium cost several dollars an ounce.

The method of electrolysing the fused chloride of calcium and lifting the metal away from the surface, as an irregular stick, has been fairly successful, and since the chloride is not difficult to dehydrate, the whole operation is not very expensive. With a specific gravity of 1·85 the possible alloys of calcium with other light metals should be exhaustively studied ; some of them may be strong, resistant to air and water, perhaps even to acids. Calcium tarnishes easily in the air, and magnesium also, but it is quite possible that some alloy of the two does not tarnish and may have valuable mechanical properties. Calcium-silicon-aluminium alloy has already found application as a deoxidising agent in steel, because while aluminium oxide and silicon oxide and their combination with each other are infusible at steel-melting temperature, and therefore are eliminated slowly from the metal, calcium oxide forms with these an easily fusible slag, which rises out of the molten metal. It is quite possible that a small addition of metallic calcium may in a similar manner reduce the amount of sulphur and phosphorus in steel, because it is either as calcium sulphide or calcium phosphate that these elements are eliminated in refining steel. Many alloys of calcium have not been studied ; until they are, no one knows how many useful mixtures may exist with particular properties of industrial value. The question of adding calcium to the light stiff aluminium alloys, for instance, is worthy of attention, but has not been touched.

Strontium, a silvery-white, soft metal, with properties similar to calcium, density 2·54, is a rare metal only because of the difficulty of its isolation. It is chemically very active, and electrochemically extremely hard to manage. It has about the same specific gravity as its fused salts, so that it neither rises nor sinks in any of them quickly ; it seems also to redissolve in its melted salts with great velocity, so that very high current density is required to obtain any metal at all. Its surface tension appears to be abnormally high, so

* Abstract of a Paper read before the American Institute of Chemical Engineers.

that it separates out in more or less minute globules which are highly indisposed to running together into one mass. In the innumerable possible combinations of metals strontium might have properties different from any other element, and which would lead to its employment on a large scale.

Barium is common in its compounds, and almost unknown in itself. Under electrolytic conditions where calcium comes out *en masse*, and strontium separates as small globules, barium is obtained only as a fine powder. Its density is 3·75, but its salts are heavier than the corresponding strontium and calcium salts, so that the fine powder may sink or swim, largely according to the temperature. Fused barium salts are manageable, easily obtained anhydrous and melting clearly. Their electrolysis, however, is nearly the most difficult task that the electrometallurgist can take up. But it should be taken up and mastered, because a metal so common in its compounds could be obtained in large quantities if uses for it were developed.

Boron.

A semi-metal, cheap and abundant in its compounds, and yet almost unknown as an element. Although quoted at several dollars an ounce, there are possibilities of it being made for 1s. per pound.

Boron occurs in nature as its oxide, sassolite (31 per cent. boron), as borax (11·5 per cent. boron), and as colemanite (18·9 per cent. metal). These sources are comparatively abundant, the oxide being found in volcanic districts, borax near dried-up lakes, and colemanite (calcium borate) being literally a waste product of the borax mining for which no use has yet developed.

Quite recently, Weintraub has decomposed boron chloride by hydrogen in a high-tension arc, and obtained purer boron and in larger quantity than any previous investigator ("Transactions" of the American Electrochemical Society, 1909, XVI., 165).

The properties of pure boron are fusing point between 2,000°C. and 2,500°C. (it was fused in a boron nitrite crucible under the pressure of its own vapour); boiling point near to its fusing point; and it has considerable vapour tension as low as 1,600°C. It has a conchoidal fracture, and is nearly as hard as the diamond. *At room temperature it is electrically almost a non-conductor, but at* 500°*C. its conductivity has increased* 2,000,000 *times; at* 1,000°*C. its conductivity is of the order of that of the metals. Applying moderate voltages to a cold piece, it soon warms up and makes itself a good conductor. Such extraordinary properties suggest its use for many interesting electrical contrivances.*

Boron, or even boron sub-oxide (B_4O, or, perhaps, boron saturated with B_2O_3), added to melted copper enables a perfect copper casting to be obtained of practically 100 per cent. electrical conductivity; a trade product sold as boronised copper has similar effects in producing sound copper castings.

For use in steel, a good uniform quality of ferro-boron is needed, and the manufacture of this in satisfactory uniform quality has not yet been mastered. Some years ago, the Pacific Coast Borax Co. offered a prize of £100, to be awarded by the American Electrochemical Society, for a practical electric furnace method of producing ferro-boron directly from calcium borate (colemanite), a waste product of the borax mines. A few years later the prize money was returned by the society to the company as not having been earned, although several attempts were made.

Chromium.

This element is also common as a compound, but rare and expensive as a metal. Pure chromium, carbon free, is produced only by reduction of chromium oxide by aluminium, and commands 3s. 1d. per pound. Chromium electroplating is white and durable, and for many purposes may be superior to nickel and almost equal to platinum plating, but the technique of always getting perfect plating has not been satisfactorily mastered. Cobalt-chromium alloys have been made which have some of the remarkable properties and uses of high-speed tool steel, and are an excellent example of unexpected and valuable physical properties being discovered by systematic investigation.

As for the methods of reduction, ferro-chromium alloy carrying high carbon (6·8 per cent.) is produced quite cheaply in crucibles, cupola furnaces, blast furnaces, or electric furnaces. Low carbon ferro-chromium commands three to five times as high a price, because of the difficulty of decarbonising the raw product. It is very much to be hoped that tests will be made in the electric shaft furnace to see if it is not possible to produce directly from the ore a low-carbon product. The thing has been done in the case of pig iron, producing a low-carbon product which is called pig steel: there is no inherent impossibility in similarly mastering the conditions for producing directly the low-carbon ferro-chromium. The present prices of the two products, £20 and £100 per ton respectively, would warrant great efforts in that direction.

If electrolysis of aqueous solutions of chromium salts could be controlled, so as to produce heavy deposits, this might give us cheap and pure chromium. Electrolysis of molten relatively-fixed salts in which chromium oxides are dissolved (similar to the Hall aluminium bath) is not a hopeless proposition. The working temperature would be below the melting point of chromium.

Titanium.

With titanic iron ore carrying 10 to 15 per cent. of titanium as cheap as iron ore, and iron free material rutile (60 per cent. titanium), at 5 to 7 cents per pound, there is no lack of cheap raw material. If uses are found for pure titanium, however, some other than the electric furnace must be used to reduce it, because, in absence of iron, titanium carbide would result. The methods for producing pure titanium are, like its prospective uses, still in the future, but they nevertheless are worth study and work. One can buy titanium metal at about the price of silver, but if the problem were properly faced it could probably be made as cheaply as chromium.

Molybdenum.

Molybdenum sulphide, MoS_2, 60 per cent. molybdenum, looks almost exactly like graphite, and is about as widely distributed. Normally, it can be purchased as 90 per cent. concentrates at 1s. per pound. This would make the raw material for 1 lb. of molybdenum cost nearly 2s.; the selling price of the metal is about 8s. This leaves a large margin to pay for reduction. In fact, 4s. per pound of contained molybdenum ought to return the reduction works a good profit.

If molybdenite were sold cheaper, there is little doubt that ferro-molybdenum, 50 to 85 per cent. molybdenum, could be sold at half its present price, and the uses of molybdenum in steel correspondingly increased. New uses have also been found, such as the molybdenum wire so useful in electric resistance furnaces. This wire is very useful in that it resists the alloying action of many liquid metals even at very high temperatures. *See* Dr. C. G. Fink's Paper in the "Transactions" of the American Electrochemical Society (Vol. XVII., p. 229, 1910.)

Zirconium.

Zirconium oxide has recently been found in considerable abundance in Minas Geraes, Brazil, 75 to 95 per cent. pure. It sells at 2d. to 2½d. per pound, and is being used in large quantities as a refractory material, on account of its high melting point (2,000°C.), high resistance to all kinds of slags, low thermal conductivity and low coefficient of expansion. The metal, however, is almost unknown. Fused, it is white, density 6·4, melting point 1,500°C., hard enough to scratch quartz. Ferro-zirconium has been made in the electric furnace, and used in small amounts in steel with rather indefinite results. And yet, if some very useful proportions of zirconium were discovered, the metal should undoubtedly be prepared at a reasonable price—only a fraction of the £1 per ounce now asked for it as a chemical curiosity.

Cerium.

Hundreds of tons of fairly rich cerium material are lying on the waste heaps outside the incandescent gas-mantle factories. The thorium ore used by these factories is monazite—a phosphate of the cerium earths plus thorium silicate. On extracting the thoria, the residue is worthless for mantle fabrication. It is known as "commercial cerium carbonate," and contains cerium, lanthanum, neodymium, praesodymium, samarium, gadolinium, yttrium, ytterbium, a little thorium, and considerable alkalies, iron, phosphoric acid and silica. By treatment with acids, precipitation of the rare earths, and ignition, a chocolate-brown mixture of oxides of the rare earths is obtained, in which cerium oxide predominates, and which contains nearly 50 per cent. of metallic cerium. When this mixture is reduced directly, without further separation, to the metallic state, an alloy of the rare earth metals is obtained which is known as mixed metal (mischmetal) or impure or commercial cerium. The composition of mischmetal naturally varies, but may be taken as approximately 30 to 50 per cent. of cerium, 15 to 25 per cent. of lanthanum, 10 to 15 per cent. of the didymiums, up to 20 per cent. of the yttrium metals, and 1 to 5 per cent. of thorium.

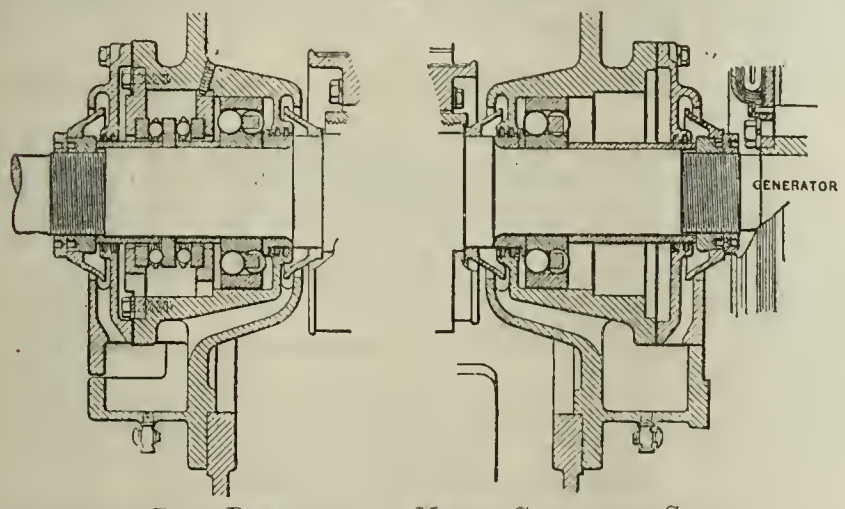
Dr. Auer von Welsbach was the pioneer in the commercial manufacture and use of mischmetal. Annoyed by the sight of heaps of the cerium residues around his mantle factories, he experimented with their reduction to mischmetal and with the possible uses of the latter. Finding that it gave off sparks when scratched he conceived the idea of using it in automatic lighters, but found it sparked far too feebly and unreliably to be practical. He then thought that if he purified the cerium it might give sparks more freely, but on making the purest cerium he found it to spark less than the impure

metal. Turning in the opposite direction, he took mischmetal and added to it alloying metals not of the rare earth class, and found that they increased the sparking property. Iron, for instance, when increased to 30 per cent. gave an alloy with remarkable spark-giving properties, such as to make it most efficient and reliable in automatic lighters. This has formed the basis of the "pyrophoric alloy" industry, since although other metals have similar effects, the 30 per cent. iron alloy is probably the best sparking alloy for general use so far made.

BALL BEARINGS FOR MOTOR GENERATOR SETS.

The motor-generator set of the 282-ton electric locomotives of the Chicago, Milwaukee & St. Paul Railway consists of a 3,000-volt direct-current series motor, having a double winding and two commutators for operating in series at 3,000 volts, a small generator for furnishing control current at 125 volts, a 120-volt motor-generator furnishing current for regeneration and for charging storage batteries, and a blower of 13,000 cubic ft. capacity for ventilating the main driving motors.

The shaft upon which the revolving element of the motor-generator is carried is supported by two S.K.F. radial ball-bearings, and is protected from shocks due to end thrust by a double-thrust ball-bearing, as shown in the accompanying illustrations. The set is installed



Ball Bearings for Motor Generator Set.

longitudinally in the locomotive cab and the thrust bearing takes up shocks incident to switching and train handling. According to "Machinery" this bearing has a capacity of over 5,000 lb. at the normal speed of the set. The outside diameter of the radial bearing is a little over 10 in., the bore is 4·7 in., and the weight 33·5 lb.

EFFICIENCY OF LABOUR.

The "Commonwealth Engineer" of Melbourne, Australia, in its issue of June 1 last, and referring to the progress of the engineering industry in America during the past three decades, considers it has been largely helped in that country by the premium and bonus system and other labour encouraging devices there commonly in use. It goes on to suggest that, good as may be protection as an encouragement to home production, the only real way to benefit the country as a whole is to increase the efficiency of the machine, the works and the worker. There is universal complaint that the efficiency of the worker in Australia is decreasing, and the gospel of limitation of output is being generally preached, practised and enforced, and that it holds sway, not only in private undertakings, but also in socialistic institutions, such as the State railways. Until labour recognises that limitation of output means in the long run loss of work, and until the general body of workers is prepared to give the employer a square deal, the prospect of establishing a sound engineering industry in Australia is remote. Only recently a caucus member of the present Commonwealth labour Ministry felt compelled to protest publicly against the exorbitant cost of building warships at the naval dockyard, and he threatened the employees that if the present state of things continued the building of warships in Australia would cease.

There is no reason why the fast worker should slow down to the speed of the slowest man in the shop, but that is the tendency of the minimum wage that is also a maximum. Employers would welcome a chance to pay higher wages to the better men, and by instructing men in the best methods and by providing the best tools the output of most shops could be considerably increased. The Australian workers as a body would, in the opinion of the writer of the article, be likely to respond to such a proposition if a bonus or a fixed scale for all work turned out above *a general average* were given; the rate to be fixed by a committee of all parties interested. The article concludes with an appeal to the progressive labour party, pointing out that the process of decreasing output and increasing wages cannot go on indefinitely, and asking that legislation shall in the future encourage efficiency in the conjoint interest of the workers, the employer and the State.

LEGAL INTELLIGENCE.

Liabilities of Tramcar Companies.

In the Edinburgh Sheriff Court, Sheriff Guy has given his reserved judgment in an action by Mr. John Hendry against the Edinburgh Tramway Co. It appeared that on two occasions Mr. Hendry took a tramcar and paid his fare. The car broke down each time, and he had to take a cab to his destination at a fare in each case of 1s. The company maintained that there was no breach of contract, as the stoppages were not due to the fault of the company.

In his judgment, Sheriff Guy found that there was breach of contract. The contract was for a continuous journey on the day of issue of the ticket and only available between the stations opposite the punch hole on the ticket. Defenders, who were unable to fulfil their contract, conceded that they were not entitled to retain the fare paid by the passenger, which they tendered back to him. Pursuer, however, said that he was entitled to more than his money back, because by taking a cab he completed for himself the journey which defenders had contracted to perform for him. In a railway case cited, a passenger took a special train to carry him to his destination, but the Court of Appeal did not allow that expense. The rule, however, was laid down in that case that if one party did not perform his contract the other may do so for him as reasonably near as may be and charge him for the reasonable expense incurred in so doing. He could see nothing unreasonable in the pursuer taking a cab to complete the journey. Had any person been present at the foot of the Mound when pursuer took his cab who could have acted for or bound defenders, and if that person had been asked then to provide accommodation to pursuer for the completion of his journey he could conceive of no easier or more reasonable way than for him to have hired a cab for the pursuer. Certainly no easier or more reasonable way had been suggested. It was said pursuer might have gone round to the Tron Church by a different route, but that would have been to carry him away from his destination, and his Lordship felt certain that the conductors on that route would not have allowed him to travel with the ticket which he had. Defenders did not admit that the pursuer actually did incur the expenditure for which he sued, and therefore there must be proof or parties should ascertain that small matter of fact. It would be obvious that passengers who did not take cabs in such circumstances would not be entitled to recover the expense as if they did.

Breach of Mining Regulations.

At Alfreton Police Court last week John Askew was charged with a breach of the Home Office special rules for the use of electricity in mines.

Mr. Swanwick, in prosecuting for the owners (the Babington Coal Co.), said Askew was the deputy, and the authorised shot-firer at No. 3 Tibshelf Colliery. They were engaged in driving a stone-head out of the main road, necessitating blasting operations. It was the duty of Askew to make the inspection of the face in the stone-heading, and himself attach the electric cable, and see that all was ready for firing. Instead of doing that he allowed a man named Chapman, who was helping him, to go into the stone-head and attach the cable. A third man was placed in an opposite direction in the main road to prevent any person from approaching the vicinity of the stone-head. The result of some misunderstanding was that a second shot was fired while Chapman was attaching the cable. The third man came from his look-out towards Askew, and the latter, thinking that it was Chapman, attached the battery, and discharged the second shot. Fortunately the shot was high up above Chapman's head, and much of the debris was blown over his head. However, Chapman was struck on the face, eyes and head, and he was damaged about the face.

Defendant said he was misled by Marshall, the look-out man, who should have stopped in his place.

Defendant, who was given an excellent character, was fined 30s.

PARLIAMENTARY INTELLIGENCE.

TRADING WITH THE ENEMY.

In the House of Commons last week Mr. Hudson asked the President of the Board of Trade if he was aware that a winding-up order was made by the Court on July 30, 1915, nearly 12 months after war was declared, in the case of the Adnil Electric Co. (Ltd.), the bulk of the capital being of German origin; whether that company was practically the English branch of the Bergmenn Company; and could he say in what position the creditors of British, neutral and enemy countries stood with regard to priority of claim on the assets.

In reply, Mr. Harcourt said the facts stated with regard to the Adnil

Co. were correct. As the liquidation was not being carried out under the Trading with the Enemy Amendment Act, 1916, but under the ordinary law, claims of British, neutral and enemy creditors ranked equally against the assets, but any amount due to an enemy creditor would be paid to the Board of Trade.

Mr. HUDSON asked also if it was intended to bring in a further amending Bill to the Trading With the Enemy Amendment Act, 1916, in order to safeguard that in the winding-up of all enemy alien companies British and neutral creditors should have first claim.

Mr. HARCOURT said that as at present advised he did not think is desirable to extend the priority given to creditors who were not enemies in a winding-up under the Trading with the Enemy Amendment Act, 1916, to liquidations carried out under the ordinary law.

WOMEN MUNITION WORKERS' WAGES.

In the House of Commons last week Mr. ANDERSON asked the Minister of Munitions whether an Order had been issued under sec. 6 of the Munitions of War (Amendment) Act, 1916, prescribing the wages for women and girls on munition work not recognised as men's work; whether that Order was to be applied forthwith to controlled firms in the main munition area engaged in the production of the armaments, ammunition and ordnance and in all branches of mechanical engineering and shipbuilding; the reason for excluding certain areas; why controlled firms engaged in electrical engineering, rubber, miscellaneous metal goods, and the other trades coming within the scope of the National Insurance (Part II.) (Munition Workers) Act, had not been dealt with under the Order.

In a written reply, Dr. ADDISON stated the answer to the first two parts of the question was in the affirmative. The Order applies practically to the whole of the United Kingdom, with the exception of a limited number of small towns and country districts, the case of which was being specially considered, having regard to the special conditions of those districts. The reason why the Order had not been applied forthwith to certain classes of munition work was that it was desired to consider the applicability of the Order to those classes of work more closely. The position of all those classes of work was under careful consideration, and the application of the Order was being pressed forward.

NITRATES AND WELSH WATER POWER.

In the House of Commons on Tuesday, Mr. HAYDN JONES asked whether the attention of the Government had been called to the fact that the United States proposed to appropriate $20,000,000 for the purpose of determining the best process, securing the necessary water-power, and erecting suitable plant for the production of nitrates; and whether the Government would appoint a committee to ascertain the possibility of utilising the water power of Wales for this and kindred purposes.

In reply, Mr. ACLAND (Parliamentary Secretary to the Board of Agriculture) said the question of increasing supplies of nitrate was being actively considered. It, however, appeared doubtful whether our available water supplies were sufficient to make production by water power the means best suited for this country. If his hon. friend would come to the Board's office and talk over the matter he should be obliged. He had not received any particulars of the proposed action by the Government of the United States of America which he mentioned.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1913 SPECIFICATIONS.

26,934 SOC. MARIUS LATOUR ET CIE. Transformation of the frequency of high-frequency alternating currents for wireless telegraphy and telephony by means of dynamo-electric machines. (22/11/12.)

Relates to the transformation of frequency of alternating currents for the direct feeding of radio-telegraphy antennæ by means of a machine having a monophase winding on its rotor and a polyphase winding on its stator, the stator being connected to the antenna by a self-inductive coupling and by a capacity situated respectively in each of the phases and creating a wattless or idle current, in advance in one phase and lagging with respect to the other phase, and having approximately the same intensity in both phases.

1914 SPECIFICATIONS.

,530 ALDENDORFF. Telephone exchange systems in which the connections are established through electro-mechanically controlled switches.

9,908 NEULAND. Combined lighting and ignition systems for use with internal combustion engines.

9,934 TRAUTMANN. Small or pocket electric flashlamps. (Cognate application 12,377/15.)

9,981 READ. Electric clock.

10,067 HORSTMANN & HORSTMANN GEAR CO. Electric time switches.

10,121 CASOTTI. Incandescent electric lamps and holders therefor.

10,453 SIEMENS-SCHUCKERTWERKE GES. Electrical driving of spindles for spinning, twisting and like machines. (20/7/14.)

10,454 B.T.-H. CO. (G.E. Co.) X-ray tubes.

An electron discharge tube having extending from the anode over the face thereof and electrically connected thereto a body of conductive material allowing free passage of the cathode and X-ray beams.

10,938 HOUSE. Electrical switch controlling device.

A switch controlling device for main control electric switches consisting of a pair of solenoids controlled by low voltage power from a two-way switch (or a number of such switches), having a permanent "off" position, a pivoted double quadrant or rocking lever connected at opposite ends to said pair of solenoids, and an insulated link connecting said quadrant or rocking lever to the main switch arm.

11,201 BURT. Mounting of switches and other electrical apparatus in wall boxes.

11,322 STRIPP. Cord grips for electrical purposes.

14,382 CODD. Contact breakers of induction coils.

11,425 BONARD. Safety apparatus for submarines.

14,496 W. T. HENLEY'S TELEGRAPH WORKS CO. & HARRIS. Filling with insulating compound of electric cable junction boxes.

16,797 NARKS. (Interstate Electric Novelty Co.) Casings for portable electric flashlights.

17,022 JULIUS PINTSCH AKT.-GES. Filament supports for electric incandescent lamps. (11/2/14.)

17,023 JULIUS PINTSCH AKT.-GES. Incandescent electric lamp filaments and the method of mounting the same. (16/2/14.)

17,328 JONES. Anodes for electro-plating.

18,222 HADDAN. (Soc. Française des Electrodes.) Method for connecting together carbon electrodes used in electro-chemical and electro-metallurgical processes.

1915 SPECIFICATIONS.

6,486 DE FOREST. Wireless telegraph and telephone systems.

Comprises the use in a high-frequency oscillating system for wireless telegraphic or telephonic transmission work of an oscillation generator provided with a hot electrode and two cold electrodes, the latter having an oscillating circuit connected between them.

9,496 UNITED TELEGRAPH & CABLE CO. & BRUCE. Telegraph relays.

The support for the mercury contact consists in a metallic support which has an affinity for mercury, means being provided for adjusting said support so that the side wall of the mercury is exposed to the needle point of the vibrating arm for closing the local circuit.

9,690 B.T.-H. CO. (G.E. Co., U.S.) Electron discharge apparatus and method of operating the same.

An electrostatic field is established radially about the cathode in synchronism with the periodicity of the impressed voltage, this field having an electrostatic charge over any desired range of voltage values suitable in polarity and potential to reduce or even entirely suppress the electron discharge. During the intervals that current flow is desired—for example, near the voltage peaks of each current wave—the intensity, and if desired also the polarity, of the field is changed to promote the electron discharge.

9,828 DOWSING & HUNTLEY. Manufacture of electric heating elements.

9,852 RELAY AUTOMATIC TELEPHONE CO. & BYGRAVE. Impulse transmitters for telephone systems and the like.

9,921 HARLOW. Electrical transformers.

9,964 SCHOLES. Electric joint.

11,776 DAHL. Telegraph transmitting apparatus.

11,831 MARCONI'S WIRELESS TELEGRAPH CO. & TROST. Transmitters for wireless telephony.

Means are provided for setting up in an aerial two or more sets of oscillations, the phases thereof being such that the oscillations normally neutralise each other, the phase of one set being controlled by a microphone or the like. When the microphone is in action it alters the phase of one or more of the sets of oscillations, so that they no longer neutralise each other, and oscillations corresponding to those of the microphone are consequently emitted. Preferably the oscillations are controlled by a circuit of small power, which in its turn is controlled by the microphone.

12,276 BULLERS LIMITED & DAGNALL. Attachment of insulator carrying arms to telegraph and like poles.

13,807 BELLAMY. Miners' electric lamps.

13,943 HUNTER. Method of manufacturing the caps for electric incandescent lamps.

14,783 CRARY. Electric stoves.

15,459 GENERAL ACCESSORIES CO. (Rosenthal & Seymour.) Electric lamp-holders.

1916 SPECIFICATION.

100,800 BACHELET. Electromagnetic therapeutic apparatus. (11/1/16, 469.)

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

July 10, 1916.

9,701 HASLER AKT.-GES. VORM. TELEGRAPHEN-WERKSTATTE VON. G. HASLER. Speed indicators. (4/8/15, Switzerland.)

9,702 ELIESON & PAYNE. Electric controllers.

9,714 CHEMISCHE FABRIK GRIESHEIM-ELEKTRON. Process for production of alloy containing magnesium and serving for deoxydization of cast iron or steel. (28/4/15, Germany.)

9,696 HARRISON & RUSSELL. Incandescent electric lamps.

9,697 FAWLEY. Shades or screens for electric lamps.

July 11, 1916.

9,728 MILLIGAN. Mine signalling apparatus.

9,730 FAWCETT. Stage arcs, search lights, &c.

9,738 MACINTOSH CABLE CO. & SANKEY. Machines for making electric cables, &c.

9,742 WESTWOOD. Portable electric lamps.

9,745 ALLMANNA SVENSKA ELEKTRISKA AKTIEBOLAGET. Electric couplings. (21/7/15, Sweden.)

9,749 BAYSDORFER & BAYSDORFER. Spark plugs.

9,750 MCLEOD. Electrical signalling or telegraphing systems.

9,753 HASTINGS, MADDICK & ROBINSON. Transmitting-gear of ships' telegraphic, &c., apparatus.

9,762 MARTINEZ. Selenium cell.

9,763 MARTINEZ & SALERNI. Device for electric or magnetic registration of images.

9,766 B.T.-H. (G.E.C.) Regulators for polyphase transmission systems.

9,776 JANE. Automatic method of electrical heating.

July 12, 1916.

9,790 MOORE. Arc-light stand.

9,797 DAVIS & DEARLE. Mine signalling.

9,804 GULSTON. Electric lamp.

9,812 B.T.-H. Co. (G.E. Co., U.S.) Regulators for polyphase transmission systems.

9,817 CHEMISCHE FABRIK GRIESHEIM-ELEKTRON. Process for producing azo-dye-stuffs from nitrosamine colours in multi-colour printing.

9,819 ALLISON. Flanging glass tubes for electric lamps.

9,825 D.P. BATTERY CO. & DRAKE. Electric accumulator containers.

9,826 BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. Time-limit electric relays. (12/7/15, U.S.)

9,833 INDO EUROPEAN TELEGRAPH CO., RIVERS-MOORE & MORSE. Electric oscillating or wireless systems and apparatus.

July 13, 1916.

9,848 COWPER-COLES. Electrolytic process for manufacture of metallic wire and strip.

9,850 CRAIG. Electric time switches.

9,860 FLEMING & KIRK. Method of electric bell alarm.

9,865 LANGTON. Field telephones.

9,866 MCLEOD. Electrical operating or controlling apparatus.

9,895 GOLDSMITH. Electric torches.

9,892 BLAKE. Process of and composition for brazing or welding aluminium or its alloys.

July 14, 1916.

9,909 FRANCE. Electrical terminal or connection.

9,921 DUNSEY. Intercommunication telephone systems.

9,926 PICARD & STEINMAN. Electric pocket lamps.

9,937 BRESLAUER. Dynamo-electric gears of the unipolar type. (10/7/14, Germany.)

9,938 B.T.-H. (G.E.C., U.S.) Protection of electric transmission systems.

9,942 DAWE. Electrical resistance apparatus.

July 15, 1916.

9,966 BERRETTI. Wave meters.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	679	Charging Electrics at Rugby	148
Imports and Exports of Electrical Manufactures	680	Electrically-Operated Flow Meter	148
Educational	680	Some Uses for Ferodo	148
Business Notices	681	Japanese Central Stations	148
Electricity Supply	681		
Lighting and Power Notes	682		
Traction Notes	682		
The Round Table	141	Foreign Notes	683
New "J. & P." Lists. Illus.	142	Miscellaneous Notes	683
Wotan Monoplane Models. Illustrated	144	Tenders Invited	684
"Westinghouse Supplies." Illustrated	146	Tenders Received & Accepted	684
Conducting a House-Wiring Campaign	146	Municipal Accounts	684
		New Companies, &c.	685
		City Notes	685
		Electrical Companies' Share List	686

COMMERCIAL TOPICS.

Insurance Extension. Under the new Insurance Act the provisions of the National Insurance Act (Part II.) has been extended to several trades and employments in connection with the war.

The Act is only five clauses, but it passed through Parliament without discussion, and according to the Board of Trade estimate nearly 2,000,000 workers and their employers will be affected. The system of compulsory insurance against unemployment is extended to the following additional trades, whether the worker is engaged on munitions work or not :—

The manufacture of ammunition, fireworks and explosives.
The manufacture of chemicals, including oils, lubricants, soap, candles, paints, colour and varnish.
The manufacture of metals and the manufacture or repair of metal goods.
The manufacture of rubber and goods made therefrom.
The manufacture of leather and leather goods.
The manufacture of bricks, cement, and artificial stone and other artificial building materials.
Saw milling, including machine woodwork, and the manufacture of wooden cases.

All workpeople, whether men or women, over 16 years of age employed wholly or mainly by way of manual labour are included. All these additional classes of workmen are to be insured as from the 4th prox. Under the principal Act of 1912 the trades requiring to be compulsorily insured against unemployment were : Building, construction of works, shipbuilding, engineering, construction of vehicles, ironfounding. The Board of Trade are making arrangements to meet the new heavy burden imposed on them, and it has been decided to withdraw the various provincial offices that certify for unemployment benefits and centralise the whole staff at Kew.

* * * *

Company Returns. A memorial is in preparation by the Institute of Directors for presentation to the Board of Trade in order to get their sanction to the suspension of the obligation upon companies to file the annual summary and make returns of names and addresses of shareholders during the period of war. The Council of the Institute of Directors has been in communication with the Registrar of Joint Stock Companies, but, as the latter is bound by statute, the Council now hope that the Board of Trade may be induced to grant the relief sought for as a war measure.

* * * *

Trade with Russia. In reply to a question in the House of Commons last week, as to what steps were being taken to form a corporation, with Government support, to encourage and develop the trade between Great Britain and Russia on the lines recently adopted in the formation of a corporation for developing trade between Great Britain and Italy, the Chancellor of the Exchequer (Mr. R. McKenna) said that no proposal had at present been received, but he should be prepared to consider further suggestions if suitable arrangements were proposed. In that matter the Treasury was bound to act in the first instance on the recommendation of the Board of Trade.

British Interests in Enemy Countries. As will be seen from our list of new companies formed the "Association for the Protection of British Capital and Property in Enemy Countries (Ltd.)" was registered on the 11th inst. as a company limited by guarantee for the purpose of advising and assisting members and others by all lawful means in protecting and recovering the proceeds of any business, &c., in enemy territory. There are a number of electricity supply and gas works, engineering undertakings, &c., in enemy territory, and the Association should have plenty of scope for its operations.

* * * *

Exports to the United States. The Board of Trade states that its attention has been called by the Foreign Office to cases in which British firms have consigned to one of H.M. Consular Officers in the United States of America (on account of certain United States approved importers) materials in connection with which the importers are required to sign (and in the case of any previous shipments received have signed) guarantees before a British Consular Officer to the effect that they will take certain precautions to prevent the materials from reaching the enemy.

On arrival of the particular shipments in question, however, the importers have in certain cases refused to sign the requisite guarantees in respect of them, and the British exporters have been compelled to store the goods, with little prospect of selling them to other importers prepared to sign the guarantees. The Board of Trade suggest that, with a view to obviating such difficulties, exporters of such materials should include in their contracts with United States importers a condition that the necessary guarantees will not be withheld in the case of any of the goods covered by them.

* * * *

Gas and Electricity Supply. At the meeting of the South Metropolitan Gas Co. last week the chairman (Dr. Chas. Carpenter), after explainting the report and accounts, said there was little doubt that the gas undertakings should be the fuel suppliers of the future, not only gaseous but solid.

In other words, the raw coal should pass through their hands for the extraction of the valuable residuals, and the solid fuel passed on to the steam raiser. It might well be considered whether the policy adopted by Parliament of putting the suppliers of gaseous and electrical energy into competition had not had its day. Both industries stood firm to-day as necessities of life. When the war was over no one could foresee what might happen. But it was perfectly certain that British manufacturers would have to work together in much greater harmony than was the case in the past, both to avoid waste and reduce cost of production.

* * * *

Company Tax in Canada. The Canadian Manufacturers' Association has recently protested against the Alberta Corporation Tax Act. A somewhat similar but less comprehensive Act is projected in the province of Ontario.

It is stated that manufacturing and commercial companies in Ontario will not be taxed as in Alberta, and no company will be taxed on any business except that done within the province. The Ontario Act confines the taxation to banks, insurance, loan and trust companies, gas and electric supply, telegraph and telephone companies, steam and electric railways, express companies, &c.

* * * *

U.S.A. Electrical Exports. The exports of electrical goods and apparatus in May was of the value of $3,500,000, or $500,000 more than in February, the previous highest record.

Excepting insulated wire and cable and interior wiring supplies, exports were higher than those during the preceding May in every item. The most marked increases were in metal filament lamps ($100,000), motors ($220,000), telephones ($300,000), transformers ($173,988) and miscellaneous equipment ($1,372,175). The total exports for the first five months of 1916 were $14,214,086, against $8,977,060 for the corresponding period of 1915, and it is expected that the aggregate for this year will be $34,000,000, which will break all records.

* * * *

Electric Motors Displace Gas Engines. At the recent meeting of Bradford Corporation, the chairman of the Gas Committee (Mr. J. H. Barraclough) stated that the number of firms who had taken advantage of the reduced price of gas for power and had adopted gas engines since July, 1913, was 138. The number of firms who had during the same period employed

the electric drive as a substitute for gas was 50, and the gas used by these firms previously was 19,075,700 cubic ft. per annum. In the same period 121 new gas-engine customers had been obtained.

No efforts had (he said) been made by the department to prevent a gas engine being replaced by an electric motor when the latter had been obviously more suitable for the particular purpose required. He took it that the duty of the Corporation was to oblige the ratepayers, and to supply them with electricity if it suited their purpose better than gas. Indeed, the Gas Committee had themselves already installed on their new plant at Birkshall gasworks 13 electric motors.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From Aug. 5, 1916, *to* Aug. 11, 1916.

IMPORTS.

FOLKESTONE.—*France:* Unenumerated, 27 pkgs.
HULL.—*U.S.A.:* Elec. cable, 21 C.L.S. *Sweden:* Electrodes, 122 cases.
LIVERPOOL.—*U.S.A.:* Unenumerated, 42 cases.
LONDON.—*U.S.A.:* Carbon candles, £205; wire and cable, £381; insulating tape, 344 pkgs.; elec. carbons, 19 pkgs.; glow lamps, £543; unenumerated, £5,311—194 cases. *Holland:* Elec. lamps, 1,291 pkgs.; elec. glow lamps, £3,849; caps elec. lamps, 290 cases; unenumerated, £494. *Japan:* Electrolyte cathodes, £4,996; electro-copper ingots, 13,883 n.o.; elec. copper, 13,305 pkgs.; unenumerated, £985—89 cases. *France:* Carbon candles, £359; elec. glow lamps, £360; elec. lamps, 4 cases; unenumerated, £160. *Switzerland:* Carbon candles, £686; unenumerated, £2,447. *Italy:* Elec. machines, 210 cases; unenumerated, £3,672. *Sweden:* Unenumerated, £777.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Unenumerated, £708. *Melbourne:* Wire and cable, £2,746; elec. machinery, £115; telegraph material, £148; unenumerated, £1,285. *Sydney:* Elec. machinery, £1,179; wire and cable, £3,859; elec. lamps, 1,650 n.o.; telegraph material, £280; unenumerated, £411. *Wellington:* Elec. machinery, £1,038; wire and cable, £1,328; unenumerated, £325. *Lyttelton:* Telegraph material, £85; unenumerated, £16. *Dunedin:* Wire and cable, £18; unenumerated, £44. *Adelaide:* Wire and cable, £131; unenumerated, £481. *Brisbane:* Elec. machinery, £58; wire and cable, £76; unenumerated, £11. *Christchurch:* Elec. machinery, £70; wire and cable, £554; unenumerated, £148. *Fremantle:* Unenumerated, £20. *Townsville:* Unenumerated, £243. *Perth:* Unenumerated, £188. *Newcastle:* Elec. machinery, £317. *Napier:* Unenumerated, £34.
AFRICA.—*Durban:* Elec. machinery, £176; wire and cable, £1,609; unenumerated, £604. *Cape Town:* Telegraph material, £224; unenumerated, £463. *Port Elizabeth:* Elec. machinery, £34; wire and cable, £29; unenumerated, £309. *East London:* Unenumerated, £186. *Beira:* Unenumerated, £31.
EGYPT. *Alexandria:* Wire and cable, £367; unenumerated, £165. *Port Sudan:* Unenumerated, £19.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay:* Wire and cable, £558; unenumerated, £1,154. *Singapore:* Unenumerated, £34. *Calcutta:* Wire and cable, £3,180; unenumerated, £2,625. *Madras:* Wire and cable, £652; unenumerated, £558. *Colombo:* Unenumerated, £37. *Karachi:* Unenumerated, £15. *Bankok:* Unenumerated, £144.
CANADA. *St. Johns:* Unenumerated, £102. *Halifax:* Elec. machinery, £20.
CHINA. *Hankow:* Unenumerated, £97.
U.S.A. *New York:* Telegraph material, £35; unenumerated, £33.
SOUTH AND CENTRAL AMERICA.—*Rio Janeiro:* Elec. lamps, 1,350 n.o.; telegraph material, £467; unenumerated, £650. *Santos:* Elec. lamps, 2,000 n.o.; unenumerated, £65. *Valparaiso:* Unenumerated, £40. *Rosario:* Unenumerated, £84. *Buenos Ayres:* Wire and cable, £5,008; unenumerated, £605. *Guayaquil:* Telegraph material, £224. *Monte Video:* Unenumerated, £80. *Punta Arenas:* Unenumerated, £135. *Callao:* Wire and cable, £191. *Puerto:* Unenumerated, £20.
WEST INDIES. *Barbadoes:* Unenumerated, £105.
HOLLAND. *Amsterdam:* Wire and cable, £2,401; unenumerated, £96. *Rotterdam:* Wire and cable, £1,601; unenumerated, £165.
FRANCE. *Dieppe:* Elec. machinery, £260; wire and cable, £132; unenumerated, £22. *Paris:* Elec. machinery, £175; telegraph material, £300; unenumerated, £788. *Boulogne:* Wire and cable, £90; elec. machinery, £112; unenumerated, £90. *Calais:* Wire and cable, £176; unenumerated, £416. *Havre:* Telegraph material, £349; unenumerated, £287.
MALTA. Elec. machinery, £140.
RUSSIA. *Vladivostok:* Elec. machinery, £187.
SWEDEN.—*Stockholm:* Unenumerated, £50.
PORTUGAL. *Lisbon:* Elec. machinery, £125.

FOREIGN GOODS (duty paid and free).

Amsterdam: Unenumerated, £52. *Bombay:* Unenumerated, £59. *Sydney:* Unenumerated, £265. *Dieppe:* Elec. machinery, £617. *Christiana:* Unenumerated, £48. *Lyttelton:* Unenumerated, £21. *Port Elizabeth:* Unenumerated, £10. *Valparaiso:* Unenumerated, £377. *Wellington:* Unenumerated, £48.

IN TRANSIT.

Melbourne: Elec. lamps, £1,318. *Napier:* Elec. lamps, £130. *Hongkong:* Elec. lamps, £2,967; glow lamps, £248. *Shanghai:* Glow lamps, £605. *Wellington:* Elec. lamps, £630.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

EDUCATIONAL.

University of Bristol.—In the faculty of engineering complete courses of instruction are provided in civil, mechanical, electrical and automobile engineering.

The autumn term commences on Sept. 3, but in the faculties of arts, science and medicine it begins on Oct. 3. There are also complete courses of instruction in the evening classes. Particulars from the registrar, Mr. James Rafter, M.A.

University of Edinburgh.—The next session of the engineering department commences on Oct. 10th. The preliminary or entrance examination is held in September. Complete courses of instruction in civil, mechanical and electrical engineering are provided; they qualify for the degree of B.Sc. in engineering and extend over a period of three years. Particulars of entrance examinations, scholarships, &c., may be obtained from the Matriculation Offices, the University of Edinburgh.

University of Birmingham.—At this University there are courses in mechanical, civil and electrical engineering. The full courses extend over four years, and students who enter after matriculation and pass the examinations at the end of each year will be entitled to the degree of Bachelor of Science in Engineering. The next session commences on Tuesday, Oct. 3. Syllabus, with particulars of courses, fees, &c., can be obtained from the Secretary.

University of Manchester.—In the physics department the lecture and laboratory courses prepare for both the ordinary and honours degrees of the university. Particulars can be obtained on application to the Registrar, and Prof. Sir E. Rutherford will meet intending students on Thursday, Oct. 5.

In the electrical engineering department complete theoretical and practical training is given to students preparing for the higher positions in the electrical engineering profession, and at the end of a three years' course students may obtain either the ordinary or honours degree of B.Sc. in electrical engineering. There is a special course extending over three years which prepares for the certificate in electrical engineering. The John Hopkinson Laboratories have been recently extended and they are equipped with modern electrical machinery and testing appliances, while good facilities are given for research work, &c. The next session commences on Oct. 5. Further particulars may be obtained from the Registrar.

Armstrong College (University of Durham) Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

Northampton Polytechnic, London.—In the day engineering college full-day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

City and Guilds of London Institute.—On the report of the Delegacy of the City and Guilds (Engineering) College, the Council of the City and Guilds of London Institute have awarded the diploma of "Associate of the Institute" to the following matriculated third year students who have completed a full course of instruction as prescribed by the Council:—

In Civil and Mechanical Engineering.—A. H. Aillond y Péon, E. H. N. Augier, H. Bateman (Henrici Medal), A. N. A. Calderón y Flores, F. Dyson (Bramwell Medal), H. E. R. Finch, G. M. McCann, E. Marsden, K. V. Müller, M. C. Rajada, L. Ratner, K. Siemnicki, F. A. Swann, J. Swayne y Pró, D. Watson and A. G. A. Winter.

In Electrical Engineering.—F. de Arana y Bengoechea, C. A. Beer, A. L. de Calheiros e Menezes, C. Chagaloff, W. Greenwood, W. G. Messer, E. K. Ramaswami, A. H. E. Rogers and H. J. Tapsell.

South-Western Polytechnic.—This Polytechnic will reopen on Sept. 25 for day and evening classes. The Engineering Courses include lectures in electrical and mechanical engineering, physics, chemistry and mathematics, and practical instruction in the laboratories.

Students are prepared by recognised teachers of the University of London for the B.Sc. degree in engineering, for the examinations at the Engineering Institutions and of the City and Guilds of London Institute. The evening courses also include classes in electric wiring and other trade subjects. In the electric wiring department an advanced course has been arranged for the preparation of candidates for the final wiremen's examination of the City and Guilds of London Institute. Arrangements have been made for placing students who have passed satisfactorily through the three years' day course in positions with large engineering firms, and hitherto such firms have offered more vacancies than the Institute has been able to fill with its students. Prospectuses may be obtained from the Secretary, Manresa-road, Chelsea, London, S.W.

BUSINESS NOTICES.

Owing to the completion of the extensions to the works of Pritchett & Gold and Electrical Power Storage Co., Ltd., at Dagenham Dock the company has now closed its works at Millwall, formerly the works of the Electrical Power Storage Co., Ltd., with which company Messrs. Pritchett & Gold amalgamated last year. All communications previously addressed to Millwall should now be addressed to the company at Dagenham Dock, Romford, Essex. The closing of what is one of the oldest electrical works in this country is a matter of considerable interest to the industry. The Millwall works were opened by the Electrical Power Storage Co. in 1881, and they have been continuously occupied in the manufacture of storage batteries during the last 35 years.

The registered offices of New Transport Co. (Ltd.) have been removed to 27, Queen Victoria-street, London, E.C.

Sale by Tender.—Messrs. Wheatley Kirk, Price & Co. have also been instructed to sell by public tender, in lots to suit purchasers, the entire stock of electric lamps, cable, sheds, electric fans, electric cooking utensils and accessories, office furniture, &c., upon the premises (39, Victoria-street, London, S.W.) of Krupka & Jacoby (Ltd.), which is being wound up under the Trading with the Enemy Act, 1916. Catalogues may be obtained gratis on application to the Agents for the Controller, Messrs. Wheatley Kirk, Price & Co., 46, Watling-street, London, E.C., and at Manchester and Newcastle-on-Tyne. On view Aug. 23, 24, 25 and 26, and tenders must reach Messrs. Wheatley Kirk, Price & Co., 46, Watling-street, London, E.C., by Aug. 28. *See also an advertisement.*

Sale by Auction.—By order of the Controller (Mr. G. S. Pitt, F.S.A.A.) to conduct the winding up of Isaria (Ltd.), Mr. Ernest Owers will sell by auction the whole of the stock-in-trade of the company, including about 1,200 electricity meters, 100 prepayment meters, 750 electric fans, some starters, rheostats, 90 motors and d.c. dynamos, &c.; also the office furniture. On view Aug. 28 and 29,' and catalogues of Messrs. Bolton, Pitt & Breden, Incorporated Accountants, 200, Finchley-road, N.W., and at West Hampstead and Golder's Green. *See also an advertisement.*

Increase of Prices.—Ozonair Ltd., 96, Victoria-street, London, S.W., notifies that, owing to the increased cost of all materials, metals and labour, in addition to the ordinary cost of production, it is compelled to increase its list prices temporarily by 15 per cent. advance, discounts remaining the same. All estimates which have been priced nett will also be increased by 15 per cent. The increases will date from the 20th inst.

ELECTRICITY SUPPLY.

EXTENSIONS.

Ashton-under-Lyne.—The Chairman of the Electricity Committee and the Borough Electrical Engineer have been authorised to negotiate with the appropriate Government department for sanction to a loan for additional generating plant.

Burton-on-Trent.—At the last meeting of the Council it was reported that arrangements had been made for giving a supply of electricity to the new works of the India Rubber, Gutta Percha & Telegraph Works Co. at Horninglow. The estimated cost of laying cables, &c., is £4,000, but £1,000 will be repaid by the company.

Leek.—Last week the Council adopted Prof. Watkinson's report recommending the acceptance of Messrs. Crossley Brothers' tender for new gas producer plant for the electricity works, and it was decided to apply for sanction to borrow the necessary money, and for authority to carry out the work.

Stafford.—The Council has authorised the laying of an electric cable at the north end of the town at an estimated cost of £1,000. Sanction has been received to borrow £6,280 for a 500 kw. turbo-generator, condenser, &c.

GENERAL.

Alnwick.—Mr. F. Scott, a resident of the town, is erecting hydro-electric works on the Linn, and he proposes to supply electric current for public and private lighting.

Callington.—A town's meeting has been held in order to discuss a question as to the purchase of Frogwell Mills, with the view of utilising the water power for the generation of electric current for public and private lighting. The result of the meeting was to refer the matter back to the Council in order to collect information about electricity schemes in similar districts.

Chepstow.—The Urban Council have authorised the Chepstow Electric Light Co. to use overhead wires in the Cattle Market-road for supplying electrical energy to new works.

Dundee.—On Monday the Electricity Committee decided to apply for permission to increase the borrowing powers of the department by £27,000.

Treasurer SOUTAR stated that the amount authorised to be borrowed was £487,000, and the capital expenditure to May 15 last was £469,175, leaving £17,825, and the Town Council were already committed to the expenditure of that amount, contracts having been placed for machinery, cables, &c. The general manager (Mr. Richardson) had estimated that additional borrowing powers would be required to cover the cost of works to the amount of £27,000. Application had been received for power from the Caledon Shipbuilding Co., and taking into account the power which would be required in the immediate vicinity for King George Wharf and other large consumers, it was suggested it would be better to build a new sub-station on the spot, and thus reduce the length of heavy cables to a minimum.

Edinburgh.—The question of the inspection of alterations made to the electrical stage fittings of theatres in Edinburgh was considered at a recent meeting of Edinburgh Magistrates.

Hitherto the city electrical engineer (Mr. F. A. Newington) has undertaken the inspection of such fittings where alterations have been made, and no performance is allowed to take place until such an inspection has been carried through. The Electric Light Committee now claim payment for this service, and the magistrates have postponed the matter, in order that a report might be made as to the practice in other town .

Extension of Provisional Electric Lighting Orders.—The Board of Trade has extended by one year from July 31, 1916, the periods of two years and 18 months respectively mentioned in Gelligaer (Bedlinog and Fochriw), the Rickmansworth and Chorleywood and the Abercarn Electric Lighting Orders of 1914 (laying of mains, &c.).

Glasgow.—Work at the new Dalmarnock power station is still proceeding, although progress is somewhat slow, owing to the scarcity of men and the difficulty of procuring the necessary material.

Up to the present 500 tons of steel have been required on the foundation and digger work, but when this section of the contract will have been completed it is estimated that another 250 tons will be encased in the concrete walls and foundation piers. Certain of the cables which will eventually be linked up with the new power station are being laid in the east end and also in the Govan and Partick areas. These cables are required before the coming winter to improve the distribution of electricity to the outlying districts where most of the new works are situated. The requirements along these lines are so urgent that it may be necessary to obtain the services of outside working parties, and it has even been suggested that German prisoners should be used for this work.

Loughborough.—The Corporation have agreed to release the borough electrical engineer (Mr. W. H. Allen) as and from the 31st inst. During the period that elapses before Mr. R. B. Leach, the new electrical engineer, takes up the duties Mr. J. H. Dent, the chief assistant, will have control of the electricity department and a special honorarium will be paid for the services rendered.

Sheffield.—The renewed recommendation of the Electric Supply Committee to revise the scale of charges for the supply of electrical energy caused considerable discussion at the Corporation meeting last week.

Councillor EVANS, Chairman of the Committee, said it was quite evident that the Committee could not produce electric power when coal was costing 15s. 6d. per ton at the same price as when it cost only 7s. 6d. It meant an increased charge to the department of over £87,000 in that one item alone. It seemed to him that the increase in the charges was only a plain business proposal, and if the undertaking were in private hands there would not be the slightest hesitation about increasing the charges compatibly with the increased cost of production. There was also another item of £32,000 which would have to be provided for year by year, an item which went against the Electric Supply Committee in the way of increased charges. In addition to that, there was no doubt in his mind that further increased charges would have to be met. If they were not going to increase the charges to the consumer they were going to have a very serious loss. He was quite aware that it was their duty, and it always had been the policy of the Committee, to provide power and also electricity for lighting at the very lowest possible charge, and he did not think anybody in Sheffield could have a word of complaint as to the way the Committee had treated its customers. He produced a list of 109 electric power stations, every one of which had increased its charges for electricity since the war began owing to the extra charges for coal. In their own case there would be an increase during the next six months of £35,891. That was estimated on a sale of 120,000,000 units, which was making a very liberal allowance for a large increase. Excluding the tramways, the increase would amount to £28,891, but he could not think the Tramways Committee would object to such a small increase. He often wondered what would have happened to the tramways had it not been for the fact that some time ago the Electric Supply Committee had sufficient foresight to couple up the Neepsend and Kelham Island stations. It would have meant a very large increase in the plant there, probably at a cost of £70,000 or £80,000, to enable them to drive the cars which were being used at present. The power they were now taking was very much in excess of what it was in pre-war days, and they still had something to fall back upon. They made a profit last year of about £33,000. They commenced the last financial year with £30,000 more than they had when they started this. They had made favourable contracts, and but for those they would have come out with a very serious loss. The

situation was altogether different this year, and with an item of £87,000 staring them in the face as an increased charge, they could not possibly supply electricity at pre-war rates.

It was moved by Ald. Hobson and seconded by Councillor Smith, that the accounts be not confirmed, but that the matter be referred back to the Committee for further consideration.

Ald. Hobson said he believed the increase of price was necessary, and he was prepared to vote for a general increase of charges. On the question of the special bargain between the Electric Supply and Tramways Committees he had not had any particulars before him and so he reserved his opinion. On the question of the accounts he took the course he did because they were the accounts of a very important department in a very critical position. It was in a very critical position because it suffered more than any other department from the increased prices of fuel and the increased cost generally which followed on the war. It was having to be enormously expanded at a time when capital expenditure was carried out at very inflated prices, and the money now being spent would be doubtfully represented by good assets when peace-time came. The appropriation of the profits had been carried out in such a manner that the Committee could spend them entirely as they liked. He was decidedly of the opinion that money should not be put into a fund where it could be played with exactly as any Committee liked. In an undertaking of that magnitude, with a million and a-half of capital, the amount of the reserve fund was much too small.

Col. Hughes did not see that they could throw any blame whatever on the Electric Supply Committee, who had the hardest task of anybody during the war period. In his opinion it was absolutely uneconomical not to raise the rates. He criticised the smallness of the reserve fund, but he hoped nothing would be done to hinder the operation of the increased charges.

Councillor Neal was not satisfied either with the form or substance of the accounts. He was satisfied that two items of the capital value did not appear in the accounts, and he was also satisfied that the suggested appropriation of £39,000 to the renewal and special purposes fund was one which could not be justified. He was strongly in favour of building up a strong reserve fund for the electricity undertaking which should not be subject to being voted away or applied except for purposes defined by statute. He understood the difficulty of the Committee in dealing with extensions when borrowing powers were suspended, and if it were suggested that a reasonable amount, say, £5,000, should be specifically taken out of the accounts and ear-marked for extensions during the year, he would be prepared to support that rather than close down all extensions except for power.

Ald. Styring objected to the disparaging remarks which had been made with regard to the undertaking. The accounts were presented in precisely the condition that the Committee recommended and the Council approved. They could not compare a statutory undertaking with a limited company, for the conditions of the two were absolutely different. In the case of the former, it was provided that the entire cost of the undertaking should be liquidated out of revenue. They had paid the interest year by year, and had also paid into sinking fund £383,885, in addition to which they had to the credit of renewals and expenses fund £53,000, outstanding book debts, stock on hand, &c., £55,986, and other items which brought up the total accumulated assets out of revenue, to £504,528, or one-third of the total capital expenditure. In the case of a limited company, the capital cost would have been written down from time to time, but a statutory undertaking must keep up its original capital outlay, and must show that it had a sinking fund which would at the appointed time be sufficient to meet the obligations. In those circumstances, any criticism as to the financial status of the undertaking was beside the mark. Having regard to the lines on which they had to carry on, the accumulation of a reserve fund would be a very great mistake, particularly at a time like this, when it was important to have fresh capital available for what might happen. He strongly advised that they should keep the money loose, so that they might have it for whatever purposes were required. They had heard a lot about unproductive assets, but he regarded these in the light of goodwill. If they had to sell the undertaking now, he had no doubt that they would get back every shilling of this capital.

Councillor Blanchard referred to an item of £2,200 for motors provided out of revenue. That appeared at exactly the same figure last year, and he contended that it ought to be depreciated. He thought the increased charges were justified, but was not sure that it was good policy to attempt to bring about those increases in the way now proposed.

Sir William Clegg was against the idea that any account must receive the imprimatur of the Finance Committee before it was submitted to the Council, but he had no objection to the amendment, as it allowed the Electric Supply Committee to please themselves whether they called in the assistance of experts from the Finance Committee or not.

The amendment was defeated, as was another to exempt the tramways department, and the accounts were then approved.

Southend-on-Sea.—The Electricity Committee propose to retain the present canvasser (Mr. W. Huggett), and he is to be paid a standing wage of £1 per week with a commission of 1d. for each 30-watt lamp (or its equivalent), including all lamps and motors, but excluding radiators, which have been connected to the mains as a direct result of his efforts.

Stockport.—Subject to the consent of the Board of Trade it has been decided to purchase property in Millgate for £2,000 to serve as a site for a generating station.

Weybridge.—The Council and the local electric supply company have come to an agreement as to the maximum charge to be made for electrical energy during the war.

The parties have now fixed upon a flat rate of 7d. per unit, but the old rate of 6d. will be resumed within six months after the end of the war, unless it is obviously necessary to keep up the price, in which case the Council will not unreasonably withhold their consent.

LIGHTING & POWER NOTES.

Church Lighting.—The Chester Consistory Court has authorised the introduction of electric lighting and electric organ blowing in St. Anne's Church, Birkenhead.

Electric Driving of Rolling Mills.—It is reported that the Sociedad Metalurgica Duro-Felguera has placed a contract with the Sociedad Espanola de Electricidad, of Madrid, for the electrical equipment of a large rolling mill. The latter will be driven by a direct-coupled motor of 2,000 H.P.

Electricity in Ironworks.—At the annual meeting of the Consett Iron Co. (Ltd.) last week the chairman, Mr. Mark Fenwick, referred to the electrical developments of the company during the last 10 years, and said they had now one of the largest electrical installations in the country, which had enabled them to use coal cutters and conveyors to work seams which it would otherwise have cost too much to work, and generally to reduce costs, thus contributing to the financial stability of the company.

Electricity in Petroleum Works.—In the report of the Baku Russian Petroleum Co. for the past year it is said that the consumption of oil for fuel purposes has been further reduced by nearly 50 per cent. The reduction has been effected by the extended use of electric power, the net saving from which is computed at not less than Rs.100,000.

Oldham.—The Electricity Committee has agreed to give a supply of electrical energy to the Lancashire and Yorkshire Railway Co. for the Shaw goods yard.

TRACTION NOTES.

Aldershot.—At the Council meeting last week the Clerk reported on the question of a traction scheme between Aldershot, Farnborough and Farnham.

Of the methods which might be considered—viz., (1) tramways or light railways, (2) petrol-driven motor omnibuses, and (3) electrically-propelled railless traction cars—the clerk stated that the first method had for its great advantage the fact that once the track was laid the annual cost of upkeep and maintenance was considerably less than in the other schemes, while, in addition, the upkeep of roads was very materially reduced, and there was nothing like so great a nuisance from dust in the summer and mud in the winter. The initial capital cost of a tramway schemewas considerably more than that of omnibuses or rail-less cars, and vehicles of the latter description being of a more mobile character, there was not so much difficulty in passing through crowded thoroughfares. For such a district as Aldershot, however, he would most strongly recommend a tramway or light railway scheme. With the particularly heavy traffic on the Aldershot and district main roads, due to the exceptional requirements of the military the roads must of necessity suffer considerable deterioration, and consequently the cost of upkeep of any system of traction without permanent way, whether driven by petrol or electricity, must be immensely heavy, while the comfort of travelling would not be assisted by the inevitable dusty condition of the roads. It was an undisputed fact and acknowledged by all engineers that no vehicular traffic had such a bad effect on the roads as omnibuses, owing to their heavy weight and high speed. When there was added the extraordinary traffic required by the military it was easy to appreciate that it was almost an impossibility to keep the roads in good condition. To that must be added the cost of petrol, which of recent years had considerably increased. Tramway construction in the Aldershot district should, and could be of a particularly cheap character, as practically the whole length of the track through the camp would be on the waste at the side of the road, the result being that there would be merely the cost of a sleeper track without any charge for foundation or paving. So far as the remainder of the route was concerned that, in all probability, would have to be the ordinary type of tramway construction, but a tramway between Aldershot and Farnborough would, he thought, be of a comparatively inexpensive character. When one realised also that along the whole of that route would be "pick-up" traffic it could be at once appreciated that a scheme such as that should of necessity be financially successful. A traction scheme in connection with Farnham was of a different character, because it would mean that for practically the whole of the route it would be necessary to construct the usual tramways, and not light railways, and there would be little "pick-up" traffic. It

seemed to him, therefore, that, in the first instance, the scheme should be considered only between Aldershot and Farnborough.

The Council decided, after discussing the report, to defer the proposal for six months.

Gateshead.—The Gateshead and District Tramways Co. has been authorised to double the track on the Bensham route between St. Cuthbert's Church and Ravensworth-terrace.

Glasgow.—The consideration of the question of giving extra remuneration to the traffic staff of the tramways department for their work in war time has been adjourned by the Council, as the Tramways Committee has taken its report recommending that the war bonus of 6s. per week recently applied for by the drivers and conductors be not granted.

FOREIGN NOTES.

Bolivia.—A special agent of the United States Department of Commerce reports that there is a regular demand for electrical supplies in this country.

Danish West Indies.—The United States Vice-Consul at St. Thomas, Danish West Indies, reports that the recent completion of electricity supply works in St. Thomas has opened up a new market for electrical supplies, and there should be an especially attractive field there for good but moderately-priced electric fans.

The principal town (Charlotte Amalie) of the Island lies on the southern slope of a high ridge of mountains, where refreshing breezes are lacking most of the time, and the employment of electric fans would be appreciated everywhere. At the cinema shows a number of large hand-made fans (punkahs) are suspended from the ceiling and are operated by cords pulled from behind the screens. In hotels, business offices and private houses, there are no such appliances, and it is believed that immediately after the electric fan has been introduced those goods will become popular. Correspondence with St. Thomas traders should be in English.

Electric Furnace Development in America.—It is announced that the United States Steel Corporation has during the past six months granted licences for 28 Héroult electric furnaces for the manufacture of steel in the United States and Canada.

This number is said to be four more than the total licences granted during 1915. At present there are 72 Héroult units either in operation, in the course of building, or authorised in the United States and Canada, and arrangements for a large number of additional furnaces have been made by various companies.

Electricity in U.S.A. Coal Mines.—In an article in the "Electrical World" of July 22 some particulars of the progress in the use of electricity in coal mining is given. It is stated that in the central district of West Virginia the Virginian Power Co. supplies electrical energy to about 75 mining companies (each operating from one to 18 mines) from its station at Cabin Creek Junction on the Kanawha River. The generating plant at the station consists of two 10,000 kw. steam-driven units, but provision is made for two additional units of 20,000 kw. The company is operating about 300 miles of transmission line, of which 200 miles at 44,000 volts is in mine service.

In the northern mining counties of West Virginia the Consolidation Coal Co. has a central station which supplies electric current to some 30 of its plants, and the Davis Coal & Coke Co. also operates its 24 miles electrically from its own generating station. In the southern counties of West Virginia there are three electric power companies which supply energy for mining. At New River the hydro-electric station of the Appalachian Power Co. there is plant of 29,000 H.P., with provision for future developments for 6,600 H.P. additional. The company has also three reserve steam plants of over 10,000 kw. Power is transmitted from these to the coal fields of West Virginia and in some of the Virginian mining counties at 88,000 volts; but this voltage is reduced to 13,000 at sub-stations for local distribution. At present there are 500 miles of transmission line, 237 of which is at 88,000 volts, and the company is serving 70 coal mining companies, which operate from five to 15 mines each. The Logan County Light & Power Co. has a new power station in the centre of the Guyan Valley coal field, and 19 of the 65 mines are operated from the station. The Tug River Power Co. supplies electrical energy to about 20 mines in the Thacker and Pocahontas coal fields, and the Black Mountain Power Co. supplies electricity to 15 mines in the Wise and Lee county mining district. In Kentucky the Consolidation Coal Co. supplies energy to its great new mining plants at Jenkins and McRoberts, and to the mines of the Elkhorn Mining Corpn. at Fleming. The Kentucky Public Utilities Co. has electric power plants in the Harlan and Bell county mining districts and in the New Hazard field.

It is stated that practically all new mines are being equipped for electric operation, and power is purchased where available; while a large number of companies are discarding their own power plants in order to purchase energy from central stations. The reasons for the change are stated to be (1) lower costs of operation; (2) enables mine operator to "stick to his business"—mining and shipping coal; (3) reliability of service; (4) reduced expense when mine is shut down; (5) leaves capital free for new development and improvements (6) increased output and additional power can be obtained with but small increase in capital; (7) no change in speed of ventilating fan or pumps due to falling steam pressure; (8) absence of danger from high-pressure boilers; (9) easy comparison of power expense per month; and (10) conservation of labour supply.

Norway.—"Engineering" reports that the Norwegian Motor & Dynamo Factory, Hasle, near Christiania, and the old firm of Per Kure have been amalgamated under the style of Per Kure, Norwegian Motor & Dynamo Factory, with a capital of £110,000. The new company has taken over the representation of the General Swedish Electric Co.

MISCELLANEOUS NOTES.

British Westinghouse War Relief Fund.—The balance-sheet of the British Westinghouse Employés War Relief Fund for the period ended June 30 has been issued. The number of employés who have joined H.M. Forces is over 2,100.

The receipts from Aug. 22, 1914, to June 30 last, amounted to £27,965. 15s. 8d., including £18,942. 2s. 4d. contributed by employees, and £8,790. 18s. 3d. by the Company, donations, bank interest, &c., making up the balance. The payments to dependents amounted to £15,647. 18s. 3d., Christmas gifts to £885. 6s. 7d., and donations to local and national funds £780. The amount transferred to disablement and dependents' fund is £6,089. 15s., leaving a balance in hand of £4,390.

Cuba–U.S.A. Telephone Communication.—It is announced that President Menocal, the President of Cuba, has granted a concession to the International Telephone & Telegraph Co. to establish public telephone service between Cuba and the United States of America.

Employment of Disabled Men as Tramcar Drivers.—Some time ago the Home Office appointed a Departmental Committee to consider the advisability of licensing men partly disabled as drivers of motor cabs, motor omnibuses, or tramcars.

The Committee has now issued its report. It is stated that though the members entered on the inquiry with a strong sympathy for the men who are handicapped in earning a living by having suffered some serious physical disability in the service of their country, they are anxious that the public should not be exposed to undue risks of street accidents, and they report:—

> There is no margin of safety at present, and the Licensing Authority is not, in our view, justified in taking any steps which may increase the number of accidents and fatalities . . . . We are not prepared to take the responsibility of recommending that less efficient drivers should be admitted.

Returns show that in London 7,157 drivers (5,149 omnibus and tramcar and just under 2,000 cab) had entered the Army, mostly as transport drivers, and it is hoped that the great majority will return to their occupations as licensed vehicle workers. With regard to loss of hand, or arm, or foot, the Committee cannot recommend that a licence to drive a motor cab, bus, or tramcar in the London police district should be granted.

On the question of lost sight, it is pointed out that the right eye is more important than the left in the case of motor-car driving, and with tramcars the possession of the left eye is more important. The licensing of a man with only one eye would not be altogether without precedent, as the Commissioner of Police, some years ago, in sympathy with men already licensed who met with accidents and lost an eye, decided to continue their licences. But the Committee say they are doubtful whether such a decision would have been arrived at under present traffic conditions. The members conclude:—

We are of opinion that every man licensed should have two eyes, and that one of them, at least, should be a good and normal one. If the other eye were to some extent defective, but the vision fair, and the field of vision good, we do not feel that this defect need be a bar, but we would not recommend any concession beyond that.

As to minor disabilities—loss of fingers, stiff joints, or a short limb—the Committee recommend that the existing practice should continue, and that, in arriving at a decision, the safety of the public should be the first consideration.

Enemy Firms Wound Up.—The Board of Trade has ordered the winding up of 309 businesses controlled by alien enemies. The latest additions to the list are:—

Bohler Bros. & Co., Styrian Steel Works, Renton-street, Sheffield, steel manufacturers &c. (Controller: G. Colin Webster, 6, Orchard-street, Sheffield.) S. Reich & Co., 15, Clerkenwell-road, E.C., glass manufacturers. (Controller: Wm. Alfred Slade, 9, Old Jewry-chambers, E.C.) International Metal Co. (Ltd.), 1 & 2, Bucklersbury, E.C., metal merchants. (Controller: W. Hardy King, 13, Basinghall-street, E.C.)

Tribunal Cases.—At Blackpool last week Mr. C. Furness, engineer and manager of the electricity department, in applying for the exemption of a number of skilled men, said he had advertised throughout the country without success.

It was with considerable reluctance he applied for two of the men who had not attested, but circumstances compelled him to do so, because they were in certified occupations. Conditional exemption was allowed to two men, and the remainder were exempted to the end of September.

TENDERS INVITED.

Telephone and Telegraph Material, Instruments, &c.

Tenders are invited for the supply to the Postmaster-General's Dept., State of South Australia, of Telephone Material in accordance with schedule No. 428, and tenders are invited (up to Oct. 4) for the supply to the Postmaster-General's Dept., State of Western Australia, of Telephone and Telegraph Instruments in accordance with schedule No. 501. Tender forms, specifications, &c., may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also advertisement.*

The Deputy Postmaster-General, Perth, requires tenders by 3 p.m. Oct. 4 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General, Perth, W.A.

Tramcar Tyres.

LONDON County Council requires tenders by 1 p.m. Aug. 22 for Supply of 1,000 Forged Steel Driving Wheel Tyres, and 500 Forged Steel Trailing Wheel Tyres. Forms of tender from the Chief Officer of Tramways, 62, Finsbury-pavement, E.C.

Transformers.

ROCHDALE Electricity Committee invite tenders for supply and delivery of Static Transformers for 12 months. Particulars from Mr. C. C. Atchison, Electricity Works, Rochdale.

Steam and Feed Pipes, &c.

MANCHESTER Electricity Committee invite tenders for supply and erection at Stuart-street station of high and low-pressure Steam and Feed Pipes, &c. Specifications, &c., from Mr. F. E. Hughes, secretary, Electricity Department, and further particulars can be obtained from the chief electrical engineer (Mr. S. L. Pearce), Dickinson-street, Manchester. Tenders to Chairman of Electricity Committee by 10 a.m. Aug. 25.

Trolley Wire.

MANCHESTER Tramways Committee invite tenders for supply and delivery of Hard-drawn Copper Trolley Wire. Specifications from the general manager (Mr. J. M. McElroy) and tenders to the Chairman of the Tramways Committee, 55, Piccadilly, Manchester, by 10 a.m. Aug. 22.

Turbo-Alternator, Condenser, &c.

The Town Clerk, INVERCARGILL (N.Z.) will receive tenders until 4 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 40). Specification, &c., from the Town Clerk.

Tramway Stores.

PORTSMOUTH Tramways Committee require tenders (by Aug. 29) for Stores, including Overhead Materials, Lamps, Oils, &c. Tenders to Town Clerk.

Meters.

DUBLIN Corporation require tenders (by noon Aug. 29) for year's supply of Electricity Meters. Tenders to Chairman of Electricity Supply Committee, Lord Edward-street, Dublin.

Metallic Filament Lamps, Wire, Tramcar Spares, &c.

Tenders are invited (until Sept. 4) by JOHANNESBURG Municipal Council for supply and delivery of 10,000 drawn-wire Metallic Filament Traction Lamps and 10 miles of 19/14 "Underwriter's" Wire (lightly insulated wire for outdoor use); and (until Sept. 21) for Tramcar Spares. Specifications, &c., from the Town Clerk, Johannesburg.

Electric Crane, Air Compressor, Crane Motors, &c.

The VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

Electrical Goods, &c.

The directors of the POWELL DUFFRYN STEAM COAL Co. require tenders for Stores (including Electrical Goods, Indiarubber, &c.) from Oct. 1. Particulars from Stores Manager, Aberaman Offices, near Aberdare, and tenders to the directors of the company, 101, Leadenhall-street, London, E.C., by Sept. 6.

TENDERS RECEIVED AND ACCEPTED.

MANCHESTER.—The Corporation has accepted the following tenders:—

Liverpool Electric Cable Co., cable; Ferranti (Ltd.), transformers; L. Andrew & Co., asbestos goods; Bell's United Asbestos Co., asbestos metallic sheeting; W. T. Glover & Co., paper-insulated cables; General Electric Co., elec. accessories; British Thomson-Houston Co., metal, carbon and radiator lamps; Dowsing Radiant Heat Co., radiator lamps; Bullers (Ltd.), insulators; Doulton & Co., cable protectors; L. Andrew & Co., armature tape; W. T. Glover & Co., diatrine sleeves and paper tape; W. T. Henley's Telegraph Works Co., bitumen and linen tape; C. Macintosh & Co., rubber strip; British Elec. Transformer Co., transformers; W. Lucy & Co., l.t. trifurcating boxes; British Insulated & Helsby Cables, tinned fuse wire and h.t. trifurcating boxes; Liverpool Elec. Cable Co., rubber covered wire; C. Macintosh & Co., flexible cables; A. F. Goodwin & Co., binding and fuse wire, &c.; A. H. Hunt, Hellesen dry cells; H. Wiggin & Co., nickel chrome wire and strip; W. N. Brunton & Co., steel and armature wire; Connolly Bros., enamelled wire and Blackley tape; Callender's Cable & Construction Co., box compound, bittite tape and resin oil.

BARROW-IN-FURNESS.—The Corporation has accepted the following tenders:

Ferranti (Ltd.), switchgear, £185; British Thomson-Houston Co. sub-station switchgear, £470 and £239; British Westinghouse Elec. & Mfg. Co., rotary converter, £735; H. Morris (Ltd.), crane, £68.

LEEK.—The Council have accepted the tender of Crossley Bros. for a "G" type gas producer with motor-driven exhausting fan at £468; an "S. E. 228" engine with accessories at £1,997; a Mather dynamo at £773; and indicator gear £16.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Aberdeen. The revenue of the tramways department for the year ended May 31 was £91,328, an increase of £6,326 over 1914-15.

Working expenses were £58,198, an increase of £6,672 17s. 9d., mainly owing to income tax, war bonus, permanent way repair and allowances to dependents of soldiers, the last item being £2,595 10s. The year's profit was £9,697, which, although not quite so large as in previous year, was creditable considering the circumstances. Out of that profit the Corporation had power to dispose of £3,232, and they were recommended to allocate £2,000 to the Common Good and £1,232 9s. 2d. in carrying out city improvements. The accumulated funds of the department were £267,567, while the total capital expenditure was £368,769. The cars had run 59,605 additional miles, and they were now running practically the whole of their stock at rush times and on Saturdays. Unfortunately they could not at present time obtain any more cars, but as soon as the war was over the department would require a large number of extra cars in order to cope with the growing traffic. The tramways department had carried their own third party risks, and the results had justified the policy of taking over that risk. They employed 118 women, of whom 107 were conductors, 10 clerks, and one an inspector. They were very well pleased with the work of the women. Of their tramway employés 165 had joined the Services, and six of them had died while serving. The success of the undertaking was entirely due to the management of their general manager (Mr. Pilcher), supported by a loyal staff.

Greenock. The balance-sheet of the electricity undertaking shows a net surplus of £7,000 for the year ended May 31.

Total revenue was £85,650, increase of £22,945 over 1914-15, and gross expenditure £52,612 (against £52,612), leaving a gross profit of £33,038. Debts redeemed were £11,211 6s. 8d.; capital expended was £13,876; amount set aside for depreciation £1,667. The reserve fund amounts to £25,389. The number of units generated was over 23,000,000, against an estimate of 19,000,000, and of 17,000,000 in the year preceding.

Hove.—Last week the Council discussed the accounts of the Electric Supply Department.

Ald. CLARK said that they had all anticipated that the result of the year's working would be unsatisfactory. The receipts had fallen off, and the expenses had increased. He estimated that they ought to have about £3,000 over the amount required for interest in order to cover depreciation. He did not think it fair that the ratepayers should suffer by the reduction of receipts, and he thought the Committee should have some means of increasing the income to cover the increased cost. He did not think it advisable to carry on at the expense of the ratepayers. There were a number of small consumers who were a positive loss to the undertaking, and he thought there should be a limit put on the price paid for the supply of current to them. That limit was suggested by the Committee at 10s.

Ald. B. MARKS thought they ought to congratulate themselves that they were able to get the electric light at the price they were paying. If the undertaking had been in the hands of a Company they would have had to pay considerably more than the Corporation were charging. They had only a surplus of £138. 15s. 11d., but they all knew that they had to pay bonuses and increases in salaries, while there was also the tremendous outlay on coal. He disagreed with the suggestion to put £3,000 away for depreciation, as the instalment of principal repaid was £3,706, and he did not think they should have both items. There was no reason why posterity should not have to pay for the benefit of the undertaking. He hoped that in the future the Lighting Committee would not aim at putting £3,000 on one side for that purpose. As to the proposed minimum of 10s., he did not agree with that either. He thought the man with one lamp should have just as much right to use it as the man with fifty or fifty thousand. It might be a loss to the undertaking, but they had to take the good with the bad. He looked forward to the near future, when the whole of Hove would be lit by electricity. On the whole, he did not think they should take a pessimistic view of the balance-sheet.

The accounts were approved, but the recommendation to make a minimum charge of 10s. a quarter was referred back.

Newcastle-under-Lyme.—The net debt on the electric supply department at March 31 was £13,143. 18s. 9d., amount paid off being £7,534. 3s. 10d.

The annual income from sale of current, meter rental, &c., was £3,475. 10s. 3d. and total expenses (including cost of generation and distribution, management expenses, &c.) were £921. 19s. 4d., leaving £1,553. 10s. 11d. to meet interest (£568. 5s. 9d.), instalments of loans (£1,038. 13s. 11d.), sinking fund (£15. 5s. 9d.) and income tax (£47.5s.3d.), so that the nett deficit was £115. 19s. 9d. 351,877 units were generated against 270,783 in previous year. Units sold were 257,216 (against 200,064), including 151,635 (against 91,571) for power and 105,581 (against 108,493) for lighting. The maximum load was 210 kw. (against 182 kw.), the cost of fuel per unit generated was 0·33d., against 0·29d.

In his report the borough electrical engineer (Mr. A. J. C. de Renzi) states that the units sold increased by over 57,000, due to the large increase in the sale of current for power. The total working costs per unit generated were reduced from 1·45d. to 1·31d., and for the first time in the history of the undertaking the units sold for power exceeded those sold for lighting. To show the great advantage of the largely increased power supply Mr. de Renzi points out that the total revenue expenditure for the year was only £345 more than for the year ended March 31, 1914, but the output had nearly doubled, and the increased income from power supply was over £600, thus proving conclusively that it was a paying proposition to supply power at very low rates in order to secure a day load. There was a further increase in the mains losses due to the fact that with the present staff it has been impossible to give consumers' meters any attention whatever. There is no fitter, outside assistant or shift engineer, the only remaining assistant engineer being the chief assistant, Mr. Gandy. Under these circumstances it is impossible to give adequate attention to anything except the machinery in the works. Fuel is now costing double the price paid last year, and it seems probable if the war continues through the winter that the output for the year will be reduced at least 20 per cent. It is hoped to make certain alterations in the Diesel engines so as to be able to use tar oil instead of American fuel oil. The loss of £116 on the year's working is due to several causes, chiefly the restricted lighting order which came into force early in the New Year. Nearly £300 extra has been paid in interest and repayment of loans, and £80 has been paid out of revenue on the new switchboard.

It should, however, be remembered that the department has made no advance in their charges since the commencement of the war.

South Shields.—The accounts of the tramways department were passed by the Council last week.

The chairman of the Tramways Committee (Ald. W. G. Wylie) said that the past year had been a very strenuous one, beset with difficulties that were almost unsurmountable. Notwithstanding that, there had been a greater revenue than in any previous year. The expenses showed an increase of £800, and £1,900 had been paid to make up the wages of men who had joined the colours. After paying interest and sinking fund charges, the surplus was £6,500, which was a very creditable performance. Of that sum £2,400 had been earmarked for relief of rates, and the balance would be placed to reserve, which would in consequence amount to £35,600, or 19·6 per cent. of the capital outlay. As they were only allowed to accumulate an amount equal to 20 per cent. of their expenditure as reserve, they could only place another £700 to that fund.

Willesden.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £235,715 (increase £3,281), of which £144,025 is outstanding.

Revenue was £37,646, working expenses and special charges amounted to £26,463, leaving gross profit £11,182 (£9,268). Interest on loans required £4,174 and instalments of loans £7,937, cost of works executed on capital account £50, interest on bank overdrafts £104 and on deposits £1, and purchase of motors £631. The net debit on the year's working was £1,276 (£3,094). Units sold were 4,829,979 (3,992,580).

The Council's accountant reports that, although revenue from sales of current other than for public lighting increased considerably, little benefit was derived from this, as the cost of purchase of electricity in bulk increased by nearly a similar amount. The increases of charges which were to come into force at the end of the June quarter were expected to considerably increase the revenue, and the electrical engineer estimated that the surplus for the year ending March 31, 1917, would be £1,618.

NEW COMPANIES.

ASCOG METAL PRODUCTS (GLASGOW) (LTD.) (9,651.)—Reg. in Edinburgh on Aug. 9, capital of £1,000 in £1 shares (250 5 per cent. cumulative preference and 750 ordinary), to carry on the business of electrical engineers and dealers in electrical goods as carried on by A. Schonfield & Co. Private company. First directors are Herman Schonfield, J. C. Samuel, E. Samuel, G. Samuel and W. Samuel. Secretary, H. Schonfield. Reg. office, 57, Hope-street, Glasgow.

ASSOCIATION FOR THE PROTECTION OF BRITISH CAPITAL AND PROPERTY IN ENEMY COUNTRIES (LTD.) (144,578.)—Reg. Aug. 11, as company limited by guarantee, with an unlimited number of members, each liable for £100 in event of winding-up, to advise and assist members and others by all lawful means (*a*) in protecting and recovering the proceeds of the sale of any business or of the sale of any shares or interests in any company incorporated or trading in enemy territory, or in protecting and recovering loans made to any company or individual in such territory, and (*b*) in protecting, recovering, realising or obtaining compensation for loss of or injury to property, rights or interests of any kind whatever and wheresoever situate, domiciled or enforceable (including stock of and shares in companies, capital in partnership concerns, bills of exchange, mortgages and securities, trade marks and patent rights belonging to or vested in any member or members, &c.), or in subsidiary companies of which the member or members is or are the majority shareholder, which has been seized, attached ,requisitioned, appropriated, made use of, forfeited, destroyed, lost or injured by or at the instigation, or with the connivance or neglect of any enemy country or state, or by any public body or authority (military or otherwise) situate in or acting or purporting to act by the authority or in the name of any such country or state, or by any firm, company or person domiciled, established, trading or residing in any enemy country or in a country invaded or occupied by the miltiary forces of any enemy country, &c. The management is vested in a council, the first members of which are Sir Arthur P. Du Cros, Bart., M.P., Right Hon. Thos. R. Ferens, M.P., Joseph Hood, Sir Charles J. Jessel, W. Hulme Lever, John McDowell, and Sir William E. B. Priestley, M.P. The original members and all British subjects, companies and firms who shall be duly nominated and elected to membership shall be members until death, dissolution or retirement. No fixed annual subscription is payable, but the expenses are to be borne by members for the time being in such proportion as (in the absence of agreement) the council may decide. The "original members" include the Dunly Rubber Co., the Imperial Continental Gas Association, London, and the first members of the council. Sir William Priestley, M.P., represents the Bradford Chambers of Commerce.

BUTLER JONES (NAMEPLATES) (LTD.) (144,499.)—Reg. Aug. 1, capital £5,000 in £1 shares (1,200 7½ per cent. cumulative preference) to adopt an agreement with G. Butler Jones, and to carry on the business of manufacturers of and dealers in nameplates, instruction plates and similar articles, bronzes, gas and electrical fittings, metal workers, &c. Private company. First directors are G. Butler Jones (permanent governing director, subject to holding 500 shares) and others to be appointed by subscribers. Reg. office, Dartmouth Works, 47, Dartmouth-road, Forest Hill, S.E.

JAMES TAYLOR & BATES (LTD.) (144,455.)—Reg. July 26, capital £10,000 in £5 shares, to carry on the business of civil and mechanical engineers, electricians, founders, machinists, tube makers, wire drawers, &c. Private company. First directors are W. B. Bates and J. C. Taylor (both permanent). Reg. office, Bridge Wharf, Chertsey, Surrey.

CITY NOTES.

MEMORANDA (Aug. 16).—**Bank rate 6 per cent. (since July 13, 1916). Consols 59¼. Consols Pay Day, Sept. 1. Stocks and Shares Ticket Day, Aug. 30. Pay Day, Aug. 31. Price of silver, 31 1/16d.**

ASCOT DISTRICT GAS & ELECTRICITY CO.—An interim dividend at rate of 5 per cent. per annum (less tax) has been declared.

ELECTRO-BLEACH & BY-PRODUCTS CO. (LTD.)—An interim dividend of 3½ per cent. on the 7 per cent. preference shares is announced.

W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)—The directors have declared an interim dividend on the preference shares at the rate of 4½ per cent. per annum (less tax), and on the ordinary shares at the rate of 10 per cent. per annum (less tax) for the half-year ending June 30 last, both payable Sept. 1 next.

NAIROBI ELECTRIC POWER & LIGHTING CO. (LTD.)—The directors have declared a final dividend at rate of 4 per cent. per annum on the ordinary shares (less tax) for the year 1915.

NEW TRANSPORT CO. (LTD.)—The directors, in their report for the year 1915 state that a considerable amount of work has been done. Demonstrations and lectures had taken place constantly, and it is felt that these, operating together with the new spirit created by the war, have done much to leaven the general ignorance of the public on the important question of economic transport. The influence of the Press has been freely invoked and has been as freely given. The Board has been materially strengthened by the acquisition of the services of Lord Headley, Mr. R. H. Jackson and Mr. Roy Horniman; Captain Louis Rottenburg and Captain Vernon Gattie having retired for military reasons. The staff has also been materially strengthened by the acquisition of the services of Mr. John Rickie in the capacity of mechanical engineer. The directors are of opinion that the prospects of the Company have never been better than at present, and the adoption of its policy has become a matter of urgent national necessity.

TYNESIDE TRAMWAYS & TRAMROADS CO.—The half-yearly accounts show a divisible balance of £3,741, and a dividend at the rate of 1¾ per cent. per annum is proposed, adding £938 to reserve, writing £330 off formation expenses, and carrying £700 forward.

UNDERGROUND ELECTRIC RAILWAYS CO. OF LONDON (LTD.)—The interest on the 6 per cent. 1st cumulative income debenture stock and income bonds for half-year ended June 30 is payable on Sept. 1.

WASTE HEAT & GAS ELECTRICAL GENERATING STATIONS (LTD.)—An interim dividend of 2½ per cent. has been declared.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date Aug. 15, the following as the present basis prices of—

New Metals.	per lb.
Solid Drawn Brass Tubes	14¼d.
Solid Drawn Copper Tubes	17¼d.
Brazed Copper Tubes	17¼d.
Brazed Brass Tubes	16¼d.
Brass Wire	14¾d.
Copper Wire	18d.
Rolled Brass	14⅝d.
Brass Sheets	15⅝d.
	Per ton.
Copper Sheets	£146 0 0
Spelter	49 0 0

	Per ton.
English Lead	£30 10 0
Antimony	Nominal.
Old Metals.	Per ton.
Clean Copper Scrap	£95 0 0
Clean Brass Scrap	58 0 0
Braziery Copper Scrap	84 0 0
Old Lead	25 10 0
Old Zinc	38 0 0
Hollow Pewter	115 0 0
Black Pewter	70 0 0
Gun Metal	74 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date Aug. 15, the following approximate prices of Scrap Metals:—

	Per ton.
Aluminium Cuttings	£110 0 0
Clean Mixed Brass	66 0 0
Clean Copper	102 0 0
Braziery Copper	86 0 0
Gun Metal	84 0 0

	Per ton.
Old Lead	£4. under English lead price
Old Zinc	38 0 0
Hollow Pewter	125 0 0
Shaped Black Pewter	85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £97, Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

What were known as "official quotations" are not now issued, but we give below the latest prices at which actual transactions took place on or before Tuesday, Aug. 15. The greatest care is taken in compiling these figures, but the difficulty of verification is now much increased.

Shrs.	Last Dividend	Name.	Price, Tues., Aug. 15	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	8⅛	6 19 2	Mar., Sept.
10	4½%	Do. 4½% Cum. Pref.	8⅛	5 11 8	Feb. Aug.
10	6%	Do. 6% Cum. 2nd Pref.	10⅛	5 19 3	Feb. Aug.
5	10%	Brompton & Kensington Ord.	6⅞	7 12 5	Mar. Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St.	80	5 0 0	..
St.	4%	Charing Cross West End & City Debs.	79½	5 0 8	Jan, July
5	2/3	Do. 4½ Pref.	3⅛	6 4 2	..
5	5%	Do. Ord.	3⅛	6 17 7	Aug, Feb
5	4½%	Do. City Pref.	3⅛	6 18 6	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3⅛	6 8 0	Mar, Sept
St.	4½%	Do. do. Deb.	84½	5 6 4	Jan, July
10	8%	City of London Elec. Lt. Ord.	12⅛	5 6 9	Feb, Aug
10	6%	Do. 6% Pref.	10½	5 14 3	Mar, July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun, Dec
St.	4½%	Do. 4½ Debs.	80	5 2 6	Jun, Dec
10	7%	County of London Ord.	10⅛	6 8 0	Mar, Sept
10	6%	Do. 6% Pref.	10½	5 11 7	Feb., Aug.
St.	4½%	Do. 1st Deb.	84½	5 4 0	Jan, July
St.	4½%	Do. 2nd Deb.	85½	5 7 9	May, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	78½	5 18 10	July
5	7%	Kensington & Knightsbridge Ord.	5	6 11 9	Feb, Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6%	London Elec. Supply 6% Pref.	4⅞	6 11 6	..
St.	4%	Do. 4% Mort. Debs.	82½	4 17 0	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2⅜	6 6 4	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St.	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Debs.	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E.P. Supp. 6% Pref.	1	6 0 0	Apl, Oct
4	5%	South London E.S. Ord.	2⅜	6 16 2	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price Tues., Aug. 15	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	6⅜†	6 9 4	Feb, Aug
5	7%	Do. do. Pref.	5⅛†	5 19 2	Feb, Aug
St.	3½%	Do. do. Debs	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	73	6 3 3	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations	1	6 11 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6½	5 12 0	Mar, Sept
5	4½%	Do. 4½ Cum. Pref.	4½	5 4 1	Jan, July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	85	5 17 8	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	80½	7 12 2	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	75½	5 6 4	..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	..
St.	4½%	Do. 4½% Pref.	81½	5 10 5	Jan, July
St.	4%	Do. 4% Deb. St.	76	5 5 3	Jan, July
St.	4%	City & S. London Deb.	74¾	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70¾†	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2½†	5 11 1	Jan, July
St.	4%	Do. 4% Pref.	67½†	5 18 6	Mar, Sept
St.	4%	Do. 4% Debs.	75½	5 6 0	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	24⅛†	4 0 3	Feb, Aug
St.	3½%	Do. 3½% Pref.	62½†	5 11 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	58½	5 19 8	Feb, Aug
St.	3½%	Do. 3½% A Debs.	68½	5 2 2	Jan, July
St.	3½%	Do. 3½% Debs.	70	5 0 0	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 4	May, Nov
St.	4½%	Do. 4½ First Pref.	73	6 3 3	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	107	5 12 1	Jan, July
St.	4%	Do. 4% Debs.	77	5 3 11	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	78	5 2 7	Jan, July
St.	4%	Do. 4% Guar. Stock	70†	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2⅞	5 4 4	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅝	5 9 3	Mar
100	5%	Do. Prior Lien Debs.	92⅛	5 10 8	Jan, July
1	6%	Do. 6% Pref.	⅞	6 6 4	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12⅜	7 3 6	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛†	5 15 8	Jan. July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	⅛	6 8 0	Mar, Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	5 17 1	April
100	6%	Do. 6% Prior Lien Debs.	102	5 17 8	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	66½	6 0 4	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅜	8 1 7	Jan, July
5	5%	Do. 5% Pref.	4¼	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	June, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅞	7 2 3	Sept.
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	⅞	..	Feb, Aug
St.	4%	Do. 4% Deb.	60	6 13 4	Jun, Dec
1	7½%	Elec. Construction Ord.	⅝	8 5 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	66	6 1 3	Jan, July
10	10%	General Electric Ord.	13½†	7 12 4	July
10	6%	Do. 6% Pref.	9⅞	6 2 0	June, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	16½	6 3 0	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4	5 12 6	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G.P. &c., Ord.	12⅛	8 6 0	Feb, Aug
10	5%	Do. Pref.	8	6 3 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39	6 3 1	Mar, July
100	4%	Do. 4% Debs.	95½	4 4 1	Jan, July
1	7½%	Vickers Ord.	1⅝	4 1 4	May, Aug
1	6d.	Do. 5% Pref.	⅞	5 3 3	May, Aug
St.	4%	Do. 1st Debs.	79½	5 0 4	June, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	June, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40½	10 3 8	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	103	5 16 6	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23½	6 16 0	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	70⅛	5 12 10	Ja. Ap. Jly.O
10	5%	Cuba Submarine Ord.	8⅛	5 17 8	May, Nov
10	10%	Do. 10% Pref.	13⅜	7 5 5	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅞	6 4 3	Ja.Ap.Jly.O
St.	8%	Eastern Tel. Co. Ord.	148½	5 7 5	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	67½	5 3 8	Ja.My,Jly,O
St.	4%	Do. 4% Debs.	79	5 1 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78½	5 2 2	Feb, Aug
10	8%	Do. Ord.	14⅛	5 8 0	Ja.Ap.Jly.O
10	22%	Gt. Northern Tel. Co. With Coup. 11	38½	5 14 3	Ja. My. Jly
25	13%	Indo-European	48½	6 14 8	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3⅜	3 4 7	April
1	7%	Do. 7% Pref.	2⅛	2 13 4	July
10	1%	West India & Panama Ord.	1⅛	9 4 8	May, Nov
10	6%	Do. 1st Pref.	7⅛	7 12 5	May, Nov
10	8%	Western Telegh. Co.	14⅛	5 8 11	Mr. Jly.O.Dec
St.	4%	Do. 4% Deb. St.	77	5 3 11	June, Dec
..	4½%	Western Union 50-yr. Bds.	99½	4 10 10	May, Nov
		Telephones.			
1	7½d.	Monte Video Teleph. Ord.	⅝	7 13 7	Nov
1	10%	Oriental Telephone Ord.	2⅛	4 18 6	Apl, Oct
St.	4%	Do. Db. St.	79	5 1 0	Jan, July
St.	4½%	Teleph. Co. of Egypt Db. St.	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅛	5 19 6	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅛	5 6 8	Jan, July
St.	4½%	Do. Deb. Stk.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Teleph. & Trust	12⅛	4 13 7	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	11	5 9 1	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	85½	5 17 6	Ja,Apl,Jly,O
..	4%	Do. $100 Pref.	70½	5 13 6	Ja,Apl,Jly,O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, &c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	5	6 0 0	Mar, Sept
St.	5%	Do. 5% Deb.	94½	5 5 10	Jun, Dec
10	6/0	Bombay E.S. & T. 6% Pref.	10½	5 14 3	..
St.	4½%	Do. 4½% Deb.	83	5 8 5	Jan, July
5	9%	Calcutta E.S. Corp. Ord.	6⅛	7 0 1	May, Nov
5	5%	Do. 5% Pref.	4½	5 11 1	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,997. [No. 21. Vol. LXXVII.] **FRIDAY, AUGUST 25, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 687
Arrangements for the Week .. 689
30,000 Kw. Turbo-Alternator Unit. Illustrated 690
Long-Distance and Cable Telephony (Underground and Submarine). By B. S. Cohen and J. G. Hill. Illustrated.—*Continued* 691
Electrical Prospects in South Africa 694
Approximate Solution of Short-Circuit Problems. By E. G. Merrick. Illustrated 694
An Approximate Method of Calculating Short-Circuit Current in an Alternating-Current System. By H. R. Wilson. Illustrated 696
Paisley Automatic Telephone Exchange. By J. Hedley. Illustrated 698
Construction of an Electrostatic Voltmeter. By E. R. Wolcott. Illustrated 702
Occurrence and Utilisation of Zinc 703
Thomson Meters and Their Maintenance. Illustrated. 703
THE ANOMALOUS POSITION OF THE SKILLED MUNITION WORKER 704
REVIEWS 705
Elementary Applied Mechanics [Alexander and Thomson].
The Air-Gap Field of the Polyphase Induction Motor. By F. T. Chapman, D.Sc. Illustrated.—*Continued*.... 705
A Sensitive Magnetometer. By P. E. Shaw, B.A., D.Sc., and C. Hayes, B.Sc. Illus. 708
The Rating of Incandescent Lamps According to Their Watts. By R. Naujokz. Illustrated 710
PARLIAMENTARY INTELLIGENCE 711
The "Electrician" Commercial and Industrial Section .. 713–720

NOTES.

The Awakening.

LAST week it was announced that, on the initiative of the Royal Society, a Board of Scientific Societies had been established for the furtherance of the following objects: Promoting the co-operation of those interested in pure or applied science; supplying the means by which the scientific opinion of the country may on matters relating to science, industry and education find effective expression; taking such action as may be deemed necessary to promote the application of science to our industries and to the service of the nation; and discussing scientific questions in which international co-operation seems advisable. The Board at present consists of representatives of 27 scientific, including technical, societies, and the regulations give power to add to this number. We need not tell our readers that we applaud this vigorous and effective action of the Royal Society. For many months, in fact, for so long that we were almost beginning to weary of so doing, we have urged the formation of such a Board, free from the fetters of the State. If we may venture to offer a criticism we would advise the Board at once to add to the number of societies by including Labour, for without the co-operation of Labour all schemes intended to promote industrial prosperity in the future must be futile. Notwithstanding two years of war our people, or, rather, sections of our people, still vainly imagine that they can do useful work by ignoring the opinions of other sections. To the thinking it is plain as the day that unless we see to it, and the sooner the better, Labour is the rock on which we are going to split.

The Outlook in South Africa.

As a result of the war, the prospects of electrical trade in South Africa should be considerably improved, for the British market will now be larger in that part of the world than it has been in the past. We hope that British engineers will keep this fact in view. It may be remembered that after the Boer War the Germans stepped in and obtained a large proportion of the trade which ought to have fallen to our own people. Any mistake of this kind should not be repeated. Apart, however, from securing the actual trade, it is well to bear in mind that the conditions so far existing are not all they might be. This fact is emphasised by some notes which we publish in another column, these notes being based on a discussion with Mr. JOHN ROBERTS, the borough electrical engineer of Durban, during his recent visit to this country. We would refer particularly to the question of the standardisation of electrical supplies. In this country every engineer responsible for an electricity undertaking is free to go his own sweet way and to use those supplies which appear to him to be best. There is no objection to such a course when the supplies are ample and are easily obtainable. In South Africa, however, the case is quite different. The stocks that can there be held are much smaller, and if, for example, a large number of sizes of cable are to be stocked, then the quantity that is held of each size must be much smaller than if the number of sizes that are used can be kept within some narrower limits. There is no reason why cables for all practical purposes should not be limited to a comparatively few sizes. Not only would this enable a larger stock to be carried, but it would obviously tend to cut down costs. The same remark applies to many other electrical supplies. It would be well, therefore, if electrical engineers in South Africa would come together and decide, as far as possible, what supplies should be stocked. In taking any such steps care must be taken not to render it difficult for new devices to find their way on the market; but we think that any such difficulty can be avoided, and at the same time the industry placed upon a more satisfactory footing.

False Economy.

AT the present time we are confronted on all sides with appeals to economise, to avoid unnecessary expenditure, and to invest the money saved in War Loans. We frankly own—nay, we have repeatedly urged, and we still urge—that it is the duty of citizens to practise economy in every legitimate way and to assist the Government in the present crisis. It is not, however, every postponed liability, every deferred expenditure, that is an economy. Frequently, false attempts to economise have disastrous results and lead to the Bankruptcy Court. One of these spurious economical steps has recently been taken by the Government. With the view no doubt of giving the public a lead in methods of saving, the Government appointed a Retrenchment Committee in order to consider and report upon possible economies in public expenditure, and as the result of this Committee's recommendation the Government decided some time ago not to publish any more consular reports during the period of the war. Our readers will readily believe us when we say that there is ample room for the practice of

economy in public expenditure, but one of the last things to economise upon should have been the reports of our consular service. It is true that these reports are somewhat belated when published; they are badly edited, and in many cases they compare unfavourably with the reports of the consular officials of the United States and other commercial rivals. There is no more urgent question at the present time than the reform and reorganisation of our consular service, and yet the Government think it an opportune time to deprive the commercial and trading community of the information they may be able to get from these reports about the activities of our commercial rivals, and more particularly of our enemies. Indeed, we are urged to capture the trade of the enemy, but the Government appears to have peculiar ideas of how to encourage the efforts of our exporters and manufacturers to open up new markets. The actual economy effected by suppressing the publication of consular reports must be very slight, while the loss to exporters and the commercial community must be great. Indeed, our consular officials are still paid and are presumed to be carrying on their normal work, but the results of their activities on our behalf are to be suppressed. We would strongly urge the Government department concerned to reconsider the matter, and, at least, to issue the reports from the more important commercial centres, especially those relating to South America, China and the Far East, &c.

After-War Higher Technical Education.

In the House of Commons last Tuesday, Sir Joseph Larmor asked the Prime Minister whether, having regard to the active steps now being taken by neutral nations to organise their agencies for higher education with a view to national scientific development and to meet the conditions that will arise after the war, he could state what were the steps, other than departmental, the Government had taken in that direction; whether he could give the names and scientific qualifications of the secretarial staffs attached to the committees that had been appointed; if he would state whether any reports would be made public for the consideration of persons interested, including members of the House of Commons, and how soon the first reports might be expected. In commenting upon this, the Birmingham "Daily Post" gives the pronouncement *ex cathedra* on behalf of the Incorporated Association of Assistant Masters in Secondary Schools: "We shall never have an adequate educational system in this country . . . unless we realise that the only expert in this matter is the teacher actually engaged in teaching; he alone is fully qualified to appreciate the various and complex problems that arise out of the business of teaching, and to determine under what conditions this business can best be carried on." Our contemporary pointed out that head masters of secondary schools and the National Union of Teachers had yet to be heard on the point, and hit the nail on the head by observing that in the end it will be for Parliament, the tax-paying public, and the parents to decide, and the decision is not to be expected to give over to the school teachers the rights and privileges of these bodies. To the Incorporated Association of Assistant Masters in Secondary Schools, to the head masters of secondary schools, and to the National Union of Teachers, we would observe that the organising of the agencies for higher education with a view to national scientific development is none of their business. Even if it were, they have not the qualifications, technical or business, for organising such agencies. The work, manifestly, is work for the universities, university colleges and technical colleges, and for the large employers of labour, and we grow a little tired of outsiders and "schoolmasters" meddling in business which does not concern them. In the past they have been tried and found wanting. Now let someone else try.

The Chaffee Gap.—Entitled "Some Small Direct-Current Sets," by Mr. B. Washington, an article appears in the current issue of the "Proceedings" of the Institute of Radio Engineers in which the construction of the commercial Chaffee gap (copper and aluminium electrodes in hydrogen) is described. The use of such gaps in connection with "starting" and "tone" circuits for the production of sustained waves modified into groups of audio frequency are considered. The phenomena are illustrated by Braun tube oscillograms. Impulse excitation is obtained. The construction and operation of a $\frac{1}{4}$ kw. panel set and a $\frac{1}{6}$ kw. aeroplane set of this type are given in detail, together with performance data.

Five-ton Shipyard Tower Cranes.—A description was given in a recent issue of "Engineering" of a number of 5-ton electrically-driven cranes by the Officine Elettro-Meccaniche installed at Genoa. The cranes were designed to lift a load of 5 tons at a maximum radius of 115 ft. and were tested with a load of 6 tons at that radius. Each crane has a total height of 141 ft. Under full load the lifting speed is 39 ft. 4 in. per minute, traversing speed 82 ft. per minute, and the slewing speed allows one complete revolution of the crane to be made in two minutes. The crane is operated by continuous-current at 240 volts, and separate motors are used for each motion. The lifting motor is rated at 20 H.P., the slewing motor at 10 H.P., and traversing motor at 4 H.P. Each crane complete weighs 105 tons. The whole of the electrical and mechanical equipment was designed and built by the Officine Elettro-Meccaniche, Rivarolo, Ligure.

Watts versus Wallpaper.—In an article having this title in the current issue of the "Electric Journal," Mr. S. G. Hibben deals with the effects of interior colours and finishes on the lighting of rooms. A number of useful tables are embodied in the article.

Difference in Longitude.—In the "Wireless World" it is stated that the determination of the difference in longitude between Paris and Washington with the aid of wireless telegraphy, which has been in progress since October, 1913, has been completed. The distance between the stations is 6,175 km. The result, expressed in terms of time, is 5 hours 17 minutes 35·67 seconds, and has a probable accuracy of the order of 0·01 second.

An Aluminium Industry for India.—In the June issue of the "Indian and Eastern Engineer" a leading article gives many interesting particulars in reference to the production of aluminium, and calls attention to the fact that the bauxite necessary is obtainable in India, as is also ample water power for the generation of electricity, and it, therefore, strongly urges that India should not be dependent upon foreign, and possibly enemy, countries for a supply of such an essential commodity as this metal.

Electrically-driven Coke Oven Chargers.—In a recent issue of the "Journal" of the American Society of Mechanical Engineers, a description appears of a charging machine or truck for coke ovens, driven electrically. It appears that formerly at the plant in question small hand-pushed V-shaped hopper trucks were used; then, without changing their design, two of them were connected in tandem and a motor fixed in the angle space between them. The motor is of the totally-enclosed direct-current type running at 110 or 220 volts and rated at 5 H.P. to 6 H.P. The power is transmitted through gearing and a chain to the axle of the truck. The operation of the truck is so simple that unskilled labour can manage it without previous training. As soon as three trucks have been filled from the coal bunker and switched in one after another, two of them are sent forward by themselves to the proper oven, while the operator follows in the third truck. In this manner a battery of 60 to 80 ovens is looked after by a single man, so that there is a large saving in attendance in addition to which the safety of operation is materially increased.

Battery-Propelled Fire Engines.—Mr. A. J. Marshall, secretary of the Electric Vehicle Section of the National Electric Light Association of New York City, in "Motor Traction," calls attention to the fact that in the United States a number of municipalities have changed their horse-drawn fire engines

for electrically-propelled apparatus. In addition to the usual advantages accruing from getting rid of the horse, in these cases there is the valuable advantage of a reduced "fire hazard," on account of the speed with which the engine reaches the fire. The engines prove so simple in working that the old horse-vehicle drivers are employed to control them. In the cold American winter, too, it is a great advantage to have an outfit not affected by cold, as horses and petrol-driven vehicles are. One of the recent examples is that of Camden, N.J., where the entire equipment has been modernised, it is stated, with results far in excess of expectation, and recently a parade of the new vehicles was held. At Peterson, N.J., too, recently there was held a hill-climbing test, and it is stated all previous records of such vehicles were considerably lowered. A motion picture showing the engines in use is now in preparation.

Sensitivity and Shielding Galvanometers.—A Scientific Paper by Mr. W. W. Coblentz entitled "The Sensitivity and Magnetic Shielding Tests of a Thompson Galvanometer in Use for Radiometry" has recently been issued by the Bureau of Standards.

The Paper gives the results of an investigation of the force exerted by various galvanometer coils when operated under standard conditions. Some of the coils were wound according to theoretical requirements while others were wound empirically. Numerical data are given relating to coils having various resistances. A sample coil is described wound with a single size of wire which is as efficient as a compound coil wound in three sections of graded wire upon the same mandrel, and a 9-ohm coil of graded wire is described which is very efficient and is well adapted to be used with the bismuth silver thermopiles described in an earlier Paper. A comparison is made of various astatic magnet systems, and data are given showing the importance of using small mirrors in order to increase the sensitivity. Experiments are described on shielding the galvanometer from external magnetic disturbances. The galvanometer coils are mounted in cavities cut in blocks of Swedish iron, which reduce the air space and act as a magnetic shield. This elimination of convection currents greatly improves the steadiness of the needle system. Various shields are described consisting of laminated cylinders made from transformer iron and solid cylindrical shells cut from wrought-iron pipe. By embedding the galvanometer coils in blocks of Swedish iron which are surrounded by cylindrical shells of transformer iron and of wrought-iron, the effect of the external magnetic perturbations upon the astatic needle system is easily reduced to one two-thousandth of its original value. Experiments on a vacuum galvanometer are described in which a sensitivity was attained which is more than tenfold that used in Mr. Coblentz's previous work on stellar radiation.

Palladium and Hydrogen.—Mr. H. F. Briggs, B.A., has a Paper in the "Philosophical Magazine" entitled "The Decrease in the Paramagnetism of Palladium caused by Absorbed Hydrogen." A preliminary experiment seemed to contradict Graham's results, and indicated that palladium when saturated with hydrogen was practically neutral. To test this a disc of palladium foil was placed so that it fitted within a small coil carried in the arm of a torsion balance swinging in a non-uniform magnetic field. A current was then passed through the coil so that the force, exerted by the field on the current, balanced the force in the palladium and in the matter of the arm itself. This was repeated with the palladium removed. The difference of the balancing currents multiplied by the total area of the coil gave directly the magnetic moment of the palladium. The field intensity was measured by the throw of a galvanometer connected to the same coil when the circuit of the electromagnet was broken. The results of the experiment showed that the susceptibility gradient had no systematic variation, although palladium itself showed a marked decrease with increase of field. This effect was probably due to some interaction of the hydrogen and palladium, whereby the paramagnetism of the latter was reduced. So far as the experiments went, the susceptibility gradient was independent of the field impressed and the hydrogen contents.

OBITUARY.

George Keith.—As we go to press we learn, with regret, that Mr. George Keith, chairman and managing director of the Amazon Telegraph Co. and the Chili Telephone Co., chairman of the Cuba Submarine Telegraph Co., and a director of the United River Plate Telephone Co., died on the 22nd inst.

Killed in Action.—With deep regret we record the death in France on August 1, from wounds received on July 30, of Lieut. Harold Ashcombe Chamen, Bedfordshire Regiment, younger son of Mr. W. A. Chamen, engineer and general manager of the South Wales Electrical Power Distribution Co. Lieut. Chamen, who was 22 years of age, was educated at Wells House School (Malvern Wells), Lancing College, Aspatria Agricultural College in Cumberland, and before the outbreak of the war was a student at Reading University College, in the agricultural department. He was a member of the Officers Training Corps throughout. On the outbreak of war he volunteered for service, and after a month's special training in camp at the Queen's University, Belfast, was gazetted to the South Wales Borderers as 2nd lieutenant. After two or three months he decided to make the army his permanent profession, and proceeded to the Royal Military College, Sandhurst, from which he was given a commission in the Bedfordshire Regiment, and went out to France in May, 1915. He came home accidentally wounded at the end of July, 1915, but returned to France in January, 1916. He was in the heavy fighting at Trones Wood on July 12 and 13, and came through without injury; but in an attack on the German position south of Guillemont on July 30 his battalion was heavily shelled and young Chamen was badly wounded by a shell.

Second Lieut. Albert J. Brockman, King's Own Royal Lancaster Regt., was educated at the City of London College, and was formerly with the Eastern Telegraph Co.

Second Lieut. Albert Armitage Nuttall, West Riding Regt., who has died of wounds received in action on Aug, 15, was for two years with the National Gas Engine Co. when he secured a scholarship tenable at the Manchester School of Technology, and he was taking the full three years' course in engineering when he joined the Colours.

PERSONAL.

Lieut. A. C. Gilling (R.F.C.), electrical engineer to Epsom Urban Council, has been promoted to the rank of Captain.

Another member of the Western Electric Co.'s staff has gained military distinction. On this occasion we are pleased to record that Second-Lieut. A. J. Pearson, telephone engineer, has been awarded the Military Cross. Second-Lieut. Pearson is attached to a machine-gun section.

APPOINTMENTS VACANT AND FILLED.

An assistant is wanted for the patent department of a telephone company. *See advertisement.*

The Western Electric Co. advertise for draughtsmen for their automatic department, 34, Norfolk-street, Strand, London, W.C.

Heywood Corporation require an electrical engineer to take charge of their electricity undertaking. Salary £200 a year. Applications to Town Clerk by Aug. 28.

West Ham Council require a manager of their electric tramways system. Salary £600, rising by annual increments of £50 to £750 per annum. Applications to the Town Clerk by Aug. 31.

The local education authority invite applications for the position of principal of the Barrow Technical School. Salary £400. Particulars from the Director of Education, Town Hall, Barrow-in-Furness, to whom applications by Sept. 2.

The Borough Electrical Engineer of Newport (Mon.) has appointed Mr. R. D. Sheppard a Junior Engineer-in-Charge, at a commencing salary of £2. 5s. a week.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for August.

Headquarters and Range.—The headquarters will be closed during August, except on Tuesday evenings. The range will be open on Thursday evenings only. On these evenings the Sergeant-Major will take charge and be responsible for the maintenance of order and discipline. Recruits are urged to take advantage of this arrangement for drill and shooting.

Instruction Classes.—Instruction classes at Regency-street will be held as usual for Platoons Nos. 9 and 10.

Camp.—The camp at Otford will be available until Aug. 31. Members wishing to attend should enter their names at headquarters on the sheet provided for the purpose. The cost will be about 3s. per day. Members should provide themselves with two blankets, knife, fork spoon, plate, mug and a spare pair of boots.

Entrenching.—As many members as possible should endeavour to attend the Sunday entrenching parades, in order that the work to be done may be completed as expeditiously as possible. Parade in uniform as usual at Victoria Station (S.E. & C. Railway) Booking Office, 8.45 a.m. Members are reminded that this work is of national importance, and therefore all who are able to put in Saturdays or occasional week days are urged to do so. They are reminded that they can obtain railway vouchers from the booking clerk by showing their cap badges.

30,000-KW. TURBO-ALTERNATOR UNIT.

A 30,000-kw. turbo-alternator unit has recently been put into service by the Commonwealth Edison Co., of Chicago, and the following details of the unit are taken from an article in "Power."

PRINCIPAL DATA OF 30,000-KW. TURBO-ALTERNATOR UNIT.

Turbine.

Maker	General Electric Co. (U.S.A.)
Type	Horizontal compound
Capacity, horse-power	45,000
Number single stages, high-pressure element	10
Number of double stages, low-pressure element	2
Speed, revs. per min.	1,500

Condenser.

Maker	Wheeler Condenser & Engineering Co.
Number of tubes	11,000
Size of tubes, inch	1
Surface in condenser, square feet	50,000
Surface per kilowatt of generator rating, square feet	1·67
Capacity, lb. of steam per hour	360,000
Steam condensed per square foot of surface, lb.	7·2
Weight of condenser, empty, tons	176
Weight of cooling water in condenser, tons	66·5
Circulating-pump capacity, gallons per minute	52,000
Circulating-pump capacity, lb. per hour	26,000,000
Cooling water per lb. of steam, lb.	72
Condensate pump, gallons per minute	1,200

Generator.

Maker	General Electric Co. (U.S.A.)
Capacity, rated k.w.	30,000
Voltage	9,000
Frequency, cycles per second	25
Speed, revs. per min.	1,500
Number of field poles	2
Length of complete unit, overall, ft.	59·5
Width, ft.	18·33
Floor area covered, sq. ft.	1,091
Area per kilowatt of generator rating, sq. ft.	0·036
Exciter voltage	220

Boilers.

Maker	Babcock & Wilcox Co.
Type	Cross-drum, water-tube
Pressure, lb. per sq. in. gauge	230
Superheat, deg. F.	200
Temperature of steam, deg. F.	600
Number of boilers in unit	5
Number of tubes per boiler	588
Diameter of tubes, in.	4
Length of tubes, ft.	18
Steam-making surface in boiler, sq. ft.	12,200
Stokers per boiler	2
Type of stoker	B. & W. chain-gate
Active area of two stokers, sq. ft.	273
Ratio grate area to boiler-heating surface	1 to 45
Per 1,000 sq. ft. of boiler-heating surface :	
Connected grate area, sq. ft.	22·3
Stack area, sq. ft.	4·17
Economiser surface, sq. ft.	538·2
Capacity of each boiler, lb. steam per hour	85,000
Evaporation per sq. ft. of heating surface, lb.	7
Coal capacity of each boiler, lb. per hour	12,600
Coal per sq. ft. of grate, lb.	46
Size of steam main to turbine, in.	20
Boiler-feed pumps :	
Maker	H. R. Worthington
Type	Turbine driven, three-stage, double-suction impeller
Capacity, lb. per hour	450,000
Speed, revs. per min	2,500
Water temperatures :	
In feed-water heater, deg. F.	100–120
Leaving economiser and entering boiler, deg. F.	270

Economisers.

Maker	B. F. Sturtevant Co.
Type	High-pressure
Number of economisers	5
Number of tubes in each	456
Length of tubes, ft.	12
Heating surface in tubes	6,566
Maker	B. F. Sturtevant Co.
Type	Multivane
Capacity, cubic feet hot gases per minute	90,000
Horse-power of motor	100
Draft in boiler uptake, in. of water	2·4
Height of stack above boiler-room floor, ft.	250
Diameter of stack, inside, ft.	18

This machine has high- and low-pressure turbine elements on one shaft with the generator rotor. Steam is carried in a 20-in. header from a battery of five boilers; in the high-pressure chest there are 14 admission valves all under control of the governor. There are also four overload valves discharging into the fourth stage. In passing through the high-pressure element the steam is expanded to 7 lb. below atmospheric pressure; it then enters the centre of the low-

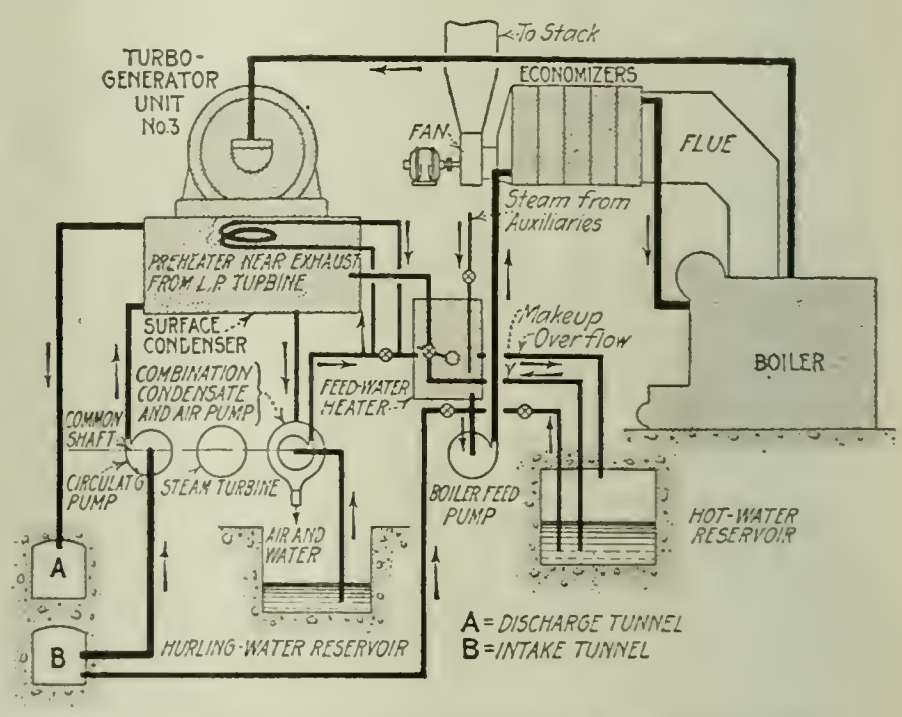


FIG. 2.—DIAGRAMMATIC SKETCH OF STEAM AND WATER CIRCUITS.

pressure element and flows in opposite directions through double stages on either side, and finally goes to the condensers. The steam and water circuits are shown diagrammatically in Fig. 2.

The shaft has a maximum diameter of 24 in., and is supported by four bearings. The latter are water-cooled by pipes embedded in the "Babbitt"; oil is supplied by forced circulation. The generator is a three-phase 25-cycle 9,000-volt machine rated for 30,000 kw. at 100 per cent. power-factor, but it has carried 35,000 kw. with moderate temperature rise. A 220-volt exciter is mounted on the end of the main shaft.

The condenser is a two-pass surface type maintaining vacuum within ½ lb. of absolute. It will take 360,000 lb. of steam per hour, or 7·2 lb. per square foot normally: the maximum steam-condensing capacity is 100,000 lb. The circulating water is drawn from an intake tunnel by a 48 in. double-suction tri-rotor pump driven by a 650 H.P. noncondensing turbine. The normal hourly quantity of circulating water is 3,120,000 gallons. On first entering the condenser the steam comes in contact with the preheating feed-water tubes. Air and condensate are taken from the condenser through a

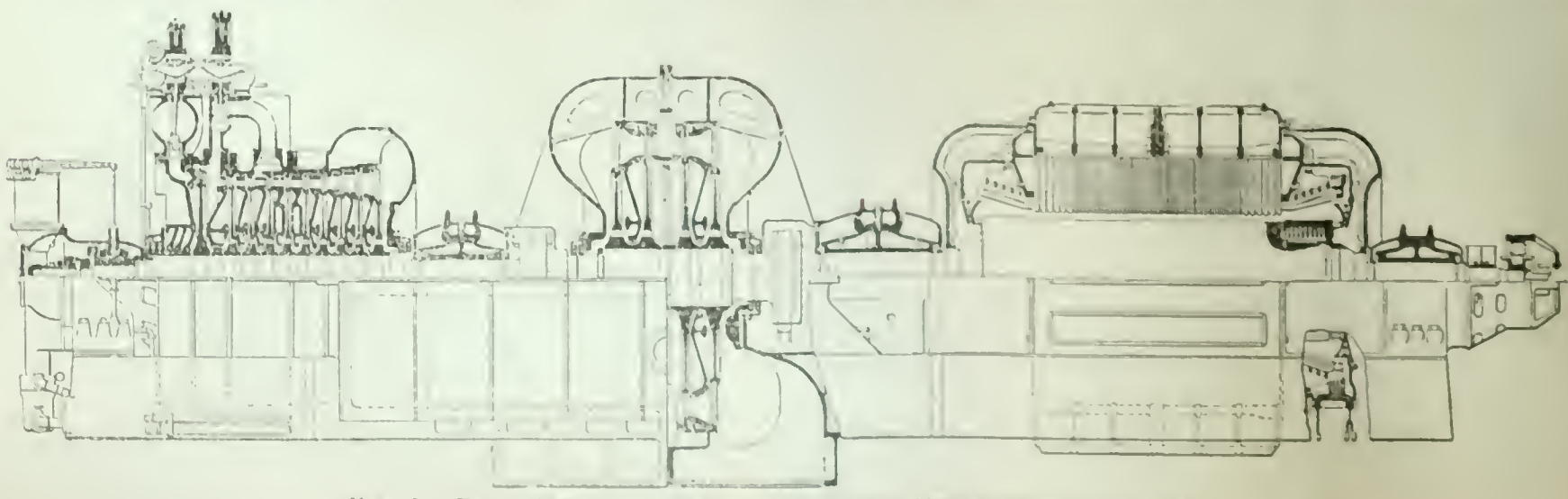


FIG. 1.—PART SECTIONAL VIEW OF 30,000 KW. TURBO-ALTERNATOR UNIT.

single outlet by a turbo air pump on the shaft with the circulating pump. In a separating chamber the air turns off into a separate compartment, and is discharged by separate impellers. From Fig. 2 it is seen that the condensate passes from the heater to two turbine-driven boiler-feed pumps, thence to the economisers above the boiler and to the boilers. The accompanying table shows the principal data of turbines, condenser, generator and boilers.

LONG-DISTANCE AND CABLE TELEPHONY (UNDERGROUND AND SUBMARINE).*

BY B. S. COHEN AND J. G. HILL.

(*Continued from p.* 663.)

PART II.

EFFICIENCY OF THE SPEAKING APPARATUS IN LONG-DISTANCE TRANSMISSION.

55. The efficiency of the speaking apparatus naturally plays a very important part in long-distance telephony. In considering this question it is necessary to study the volume output and articulation of the transmitter, receiver and transforming apparatus, if any, also the amount of side tone and frying, sensitiveness to external noises, inherent variability, amount of packing, and, lastly, ageing. In the case of local battery apparatus, an additional factor of importance is the direct-current consumption.

56. All these factors are now made the subject of special study, and no apparatus should be generally utilised unless of proved efficiency in the above respects. A few remarks on these factors may prove of interest.

I. VOLUME OUTPUT AND ARTICULATION OF SPEAKING APPARATUS.

57. The volume output of a transmitter or receiver is not the only factor of very great importance. This applies particularly to transmitters. Articulation is of prime importance, and, as is to be expected, apparatus, which, to some extent, tends to exaggerate the higher harmonics of the voice generally proves the most efficient in respect of articulation, as it to some extent thus compensates for the selective action of the lines.

58. The testing for articulation efficiency is at present a somewhat slow and laborious process if a reliable quantitative result is required, but recently a more rapid quantitative method has been tried, which it is hoped will ultimately prove of considerable value. The method in brief as applied to a transmitter is to measure the current output over a range of frequencies and plot a curve which can be compared with a similar curve given by apparatus of proved articulation efficiency.

II. SIDE TONE.

By side tone is understood the speech interaction of the sending transmitter on its own receiver.

59. It is unfortunate that some of the most efficient circuit arrangements of speaking apparatus from the volume standpoint suffer from an excess of side tone. With any particular circuit, the side tone will, of course, depend to some extent on the volume efficiency of the transmitter and receiver, although the exact relationship has not been determined, and there are cases known where the side tone has been found to depend more on the quality of the transmitter output than on its volume.

It is unnecessary to say anything with respect to variability, frying and packing of transmitters, as these defects are generally inherent, and caused by faulty design.

III. SENSITIVENESS TO EXTRANEOUS NOISES.

60. Sensitiveness to extraneous noises is occasionally met with to such an extent that otherwise satisfactory apparatus is incapable of being used for conversation over even comparatively short lines when the apparatus is installed in a moderately noisy office.

61. Generally, transmitters with the lighter types of diaphragm are the worst offenders in this respect. The design and material of the mouthpiece and shell has, however, considerable bearing on this factor, and, in the case of receivers, even the method of affixing the cords has some effect.

IV. AGEING.

62. With respect to ageing much still remains to be studied. Some types of transmitters, notably those with heavy diaphragms, have been found to actually improve in efficiency with use. In one particular case some transmitters recovered after working for about 10 years in the first common battery exchange in the United Kingdom were found to be in a condition of abnormally high efficiency. Many types of transmitter, on the other hand, show signs of rapid deterioration in efficiency with age.

63. Receivers, on the other hand, deteriorate at a somewhat rapid rate, and it can be readily proved that demagnetisation is mainly responsible for this loss. Fig. 6 illustrates this. The investigation was carried out on 12 common battery 60-ohm Bell receivers, which were put into normal use for a period of two years and tested at intervals of six months. At the end of the period, after testing and obtaining the last point of curve A, the receiver caps which had been sealed were unscrewed for the first time since being put into service and the particles of dust and magnetic filings which had collected on the poles brushed off.

64. The receivers were then retested and curve B thus obtained.

65. The conclusion to be drawn from this and other investigations is that the deterioration in efficiency of speaking apparatus with age requires careful consideration, and some allowance must be made for this when studying long-distance transmission.

* *Note.*—Hereafter, transmission values are expressed in terms of miles of standard cable, followed by the equivalent value in attenuation length, often termed attenuation factor, this value being placed in brackets.

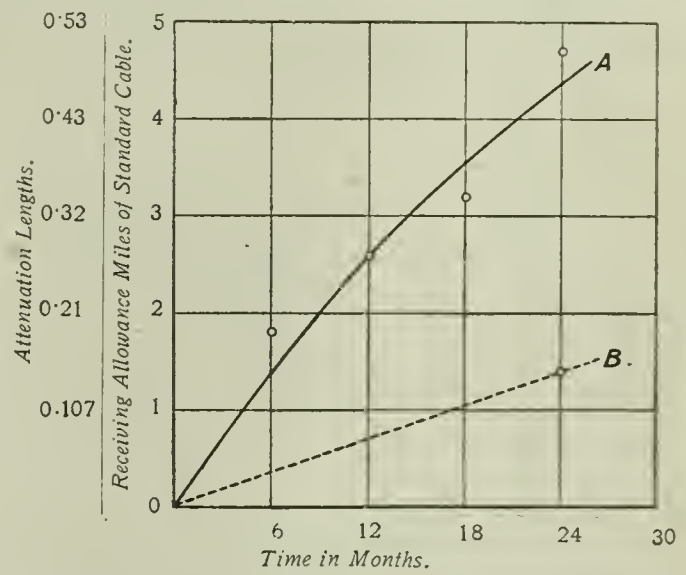


FIG. 6.—AGEING OF COMMON BATTERY RECEIVERS.

A=Receivers tested without being opened.
B= ,, ,, after opening and removing filings from poles.

66. The following table for standard cable values may be of interest. The values are all based on a mean speech frequency of 800 periods.

* *Standard Cable Value.*

Factor.	Constants per mile of loop.	Constants per kilometre loop.
Resistance	88 ohms.	55 ohms.
Capacity	0·054 mfd.	0·0337 mfd.
Inductance	1·0 millihenrys.	0·621 millihenrys.
Leakance	1·0 micromhos.	0·621 micromhos.
Complex attenuation constant or Propagation constant	0·154 $\underline{46° 6'}$.	0·0956 $\underline{46° 6'}$.
Simple attenuation constant	0·106	0·0662
Wave-length constant	0·111	0·0689
Wave length	56·6 miles.	91·1 km.
Wave velocity	44,900 miles per sec.	72,300 km. per sec.
Characteristic impedance	$571\overline{\backslash 42° 50'}$.	$571\overline{\backslash 42° 50'}$.

STANDARD TALKING CIRCUIT.

67. The standard adopted is a common battery telephone instrument with 60-ohm Bell receiver and solid-back transmitter and induction coil with 17-ohm and 26-ohm windings.

This instrument is connected to a toroidal repeating coil with four 22·5-ohm windings, a supervisory relay of 70-ohm resistance shunted by a 30-ohm non-inductive resistance coil, and 22 volts.

THE EFFECT OF SPEAKING AT A DISTANCE FROM THE TRANSMITTER.

68. The distance at which the subscriber speaks to the transmitter has, of course, a decided effect on the transmission efficiency. Generally, transmitters with the lighter pattern of diaphragm show less falling off in volume with distance than those with the heavier and stiffer moving parts, but, on the other hand, they naturally give more trouble from sensitiveness to extraneous noises. The former are also likely to possess more inherent variability than the latter.

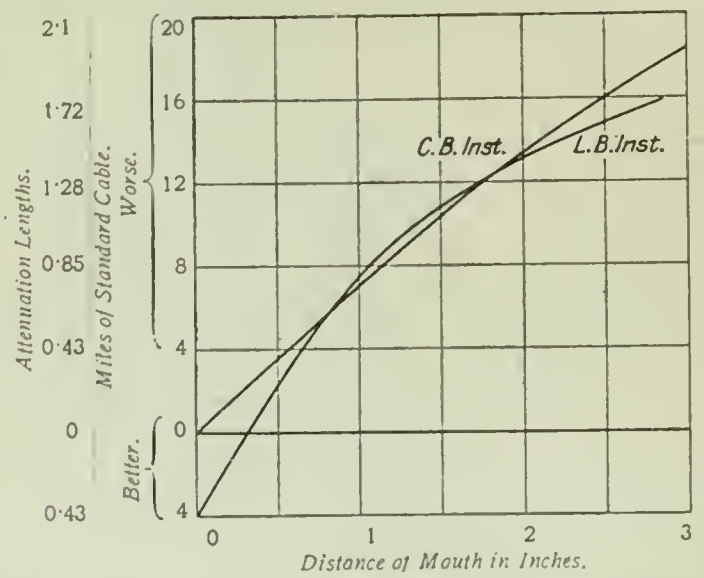
* A Paper prepared for presentation at the International Telegraph and Telephone Engineers' Conference, Berne, Sept., 1914, abandoned owing to the outbreak of war. Reproduced, with permission, from the Post Office Electrical Engineers' "Journal."

69. Fig. 7 includes two curves, one for a solid-back common battery transmitter and the other for a light diaphragm local battery transmitter of the type fitted to the hand microtelephone combination. The importance of speaking close to the transmitter is emphasised by these curves.

Commercial Speech Limit and the Effect of Extraneous Noise and Disturbance on Long-distance Speaking.

70. In determining suitable commercial limits for long-distance transmission it is necessary carefully to consider the conditions under which it is intended that the limit should apply. With the most efficient types of speaking apparatus and lines, the commercial limit will be greatly reduced directly the receiving or sending end is subjected to extraneous noises or the lines subjected to any form of disturbance. Some figures obtained in investigating the effect of extraneous noise on the commercial limit of transmission may prove of interest. With common battery speaking apparatus in first-class condition installed in absolutely quiet offices, conversation could be carried out by expert telephone users over 55 miles of standard cable (attenuation length of 5·9), it being necessary to repeat about 4 per cent. of the words spoken. This is above the value of 5·0 given for normal speakers in Part I., paragraph 3.

71. The limit was, however, reduced to 44 miles of standard cable (4·7) immediately the usual noises of a rather quiet office, such as turning over papers, &c., were allowed ; and, even with this reduction, it was necessary to repeat 8 per cent. of the words.



Allowances in Miles of Standard Cable and Attenuation Length for Speaking at Different Distances from Common Battery and Local Battery Instruments.

Fig. 7.—Effect of Speaking away from Instrument.

72. The mileages given represent the total line in circuit, as the subscribers' lines were of negligible length.

73. Using local battery hand microtelephone apparatus and repeating the tests, the limit for a quiet office was found to be 46 miles of standard cable (4·9), words requiring repetition being 5 per cent. ; and in ordinary noise 30 miles (3·2) with 20 per cent. of words requiring repetition.

74. All these values were, of course, obtained with absolutely quiet lines and apparatus. Directly the slightest disturbance is evident in the lines or transmitter the limit undergoes rapid diminution.

Effects of Line Disturbances on Transmission.

75. It is naturally extremely difficult to obtain any very definite quantitative result with regard to the effects of line disturbance on transmission. The disturbances usually met with are indefinite and very variable. A few values which may be taken as a rough guide have, however, been obtained in the laboratory. A definite volume of disturbance was applied to a long cable line terminated by common battery speaking apparatus.

76. Five kinds of disturbances have been tried :—

(*a*) Ordinary cross talk.

(*b*) Hand-sent Morse signals.

(*c*) Phonopore signalling.

(*d*) Variable frequency alternating-current disturbance as produced by tramway or electric railway induction.

(*e*) Scraping noise often heard on lines due to dry joints or intermittent earthing.

77. By means of a potentiometer each of these disturbances was shunted down until in the general opinion of the observers the loudness was about equal to that often experienced in practice. The effect of each disturbance on conversations over various limiting standards was then ascertained. Four overall limiting standards were tested, viz., 40, 45, 50 and 55 miles of standard cable, or attenuation length values of 4·3, 4·8, 5·3 and 5·9. It should be borne in mind that these overall values include the subscribers' local line at either end, and if the latter were 300 ohms in resistance and not included, the standard tested would be reduced to the following values in miles of standard cable, 28, 33, 38 and 43, or expressed in attenuation lengths, 3, 3·5, 4 and 4·6. With the 40 miles standard, cross-talk disturbance (*a*) had an inappreciable effect, and so had ordinary Morse signals (*b*), phonopore (*c*) and railway induction (*d*). Scraping noise (*e*), however, caused a small percentage of the received conversation to be lost. With 45 miles standard (*a*), (*b*) and (*c*) had an inappreciable effect, whilst (*d*) caused about 50 per cent. loss, and (*e*) about 20 per cent.

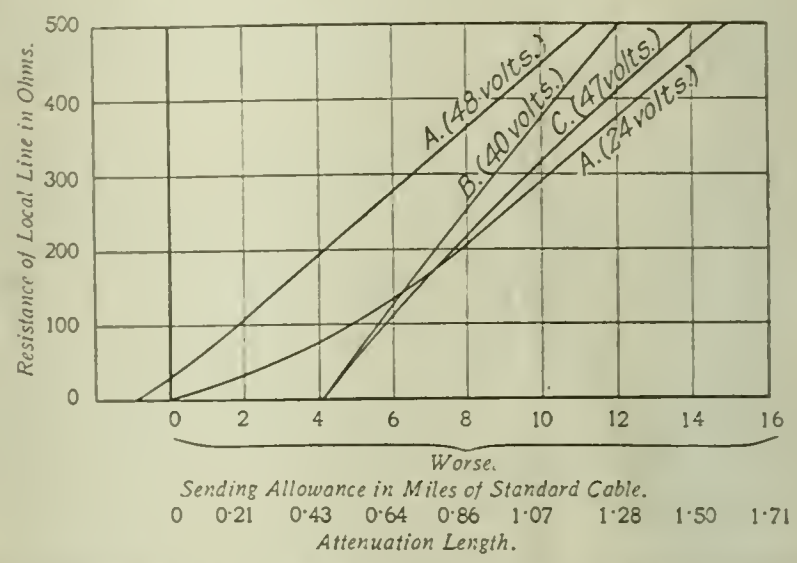


Fig. 8.—Sending Allowance for Local Lines on Various Common Battery Exchanges.

78. With 50 miles standard (*a*), (*b*) and (*c*) had again no appreciable effect, but (*d*) caused nearly 75 per cent. loss, and (*e*) stopped practically everything. With the 55 miles standard (*a*) and (*b*) again had no effect, (*c*) caused a loss of about 25 per cent., whilst (*d*) practically stopped, and (*e*) entirely stopped all conversation.

78. These results confirm that scraping noises and alternating-current induction are the most serious disturbing factors. It should be mentioned that, although the effect on conversation of these two forms of disturbance are more serious than cross-talk, yet the latter is likely to be far more objected to by the telephone user, as its effects

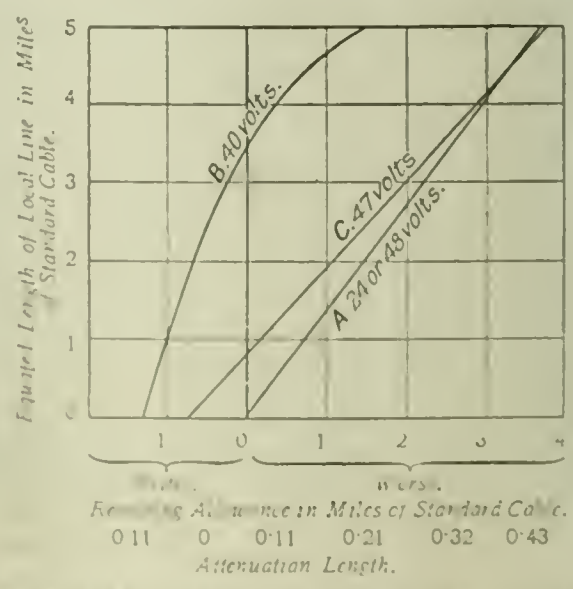


Fig. 9.—Receiving Allowance for Local Lines on Various Common Battery Systems.

are decidedly more annoying. It may be mentioned that the limiting standard which it is proposed to adopt in Great Britain is 47 miles of standard cable overall, or an attenuation of 5.

Common Battery, Local Lines of Various Types.

79. The transmission value of the local line in a common battery system is of such fundamental importance for the calculation of the talking efficiency over any circuit that it has been exhaustively studied for all the systems in use, and the final results are embodied in the curves shown in Figs. 8 and 9.

80. Fig. 8 shows the value for sending corresponding to various resistances of the local line from 0 to 500 ohms for three different systems now in use, denoted respectively A, B and C.

A is a manual system with repeating coils.
B is a manual system without repeating coils.
C is an automatic system without repeating coils.

81. By "sending allowance" is meant the allowance necessary to be made in consequence of the decreased efficiency relative to the standard, resulting from having the given resistance in the sending end of the line. The standard is a local line of zero resistance, and the sending allowance is expressed in miles of standard cable.

82. The sending allowance is expressed relatively to the resistance of the local line. The reason for this is, of course, that it is mainly dependent upon the feeding current through the transmitter, and this current is governed by the resistance of the local line. But it has also been found that a considerable variation arises from the particular transmitter used, and Fig. 10 shows some observations made with seven different transmitters, the local line being in cable with conductors weighing 10 lb. per mile (0·62 mm. diameter). Curves have been drawn for the two transmitters which have extreme values, and it will be seen that the variation in allowance due to the particular transmitter may be as much as 4 standard miles (0·43) on a local line of 500 ohms. There is a further variation due to the particular type of line employed in the local line, that is to say, whether it is 10 lb. cable, 20 lb. cable, open wire, &c. The allowance is increased in proportion as the capacity is greater relatively to the resistance, but the range of variation in this case is smaller than that caused by the transmitter and only amounts to about 0·5 standard miles (0·16) on a 500-ohm local line. In the curves shown in Fig. 8 both the variations referred to have been taken into account; they embody the results obtained with local lines of 20 lb. cable, 10 lb. cable, and pure ohmic resistance, and the transmitters used are considered to cover the range which is met with in practice. The curves, therefore, may be taken to represent average conditions.

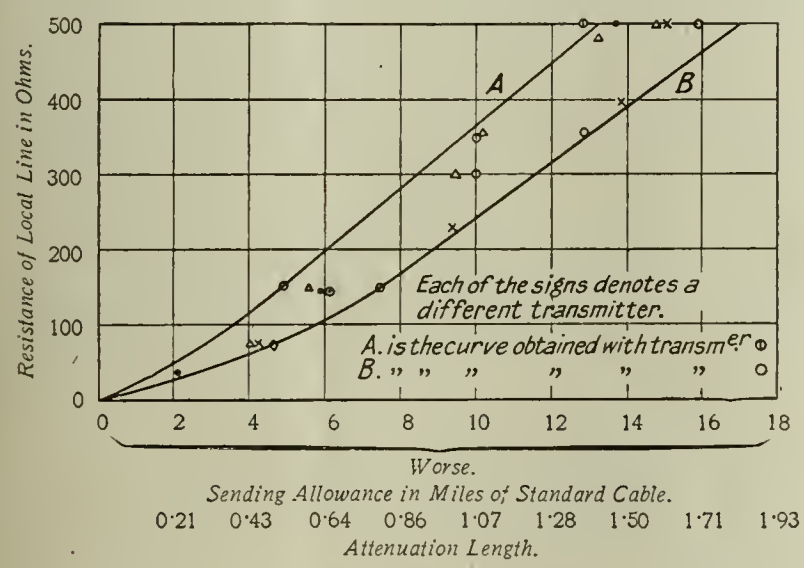


FIG. 10.—SENDING ALLOWANCE CURVES, SHOWING THE VARIATIONS DUE TO THE PARTICULAR TRANSMITTER.

83. Fig. 9 shows the receiving allowances for the same three common battery systems as the sending allowances of Fig. 8. It will be noticed that the allowance is given relative to the "equated length" of the local line—the term equated length denoting the transmission value of any particular line, expressed in miles of standard cable. This is due to the fact that the allowance is, in this case, a function of the attenuation caused by the local line, diminished by some gain due to the tapering effect of the apparatus in the cord circuit. Thus it will be seen from curve A that the receiving allowance of 4 miles of standard cable is not its attenuation—viz., 4·0 S.M. (0·43), but 3·0 S.M. (0·32), there being a gain of 1·0 S.M. (0·11), due to the tapering effect of the apparatus.

84. In making both the sending and receiving allowance curves, the results obtained by eight to twelve different observers have been incorporated, as, of course, in all transmission tests the value depends to a greater or less extent on the particular combination of speaker and listener. In the present case, the variation due to this was not very large, varying according to the resistance of the local line, up to a maximum of 2 standard miles (0·21) at 500 ohms.

LOSSES IN BRIDGING APPARATUS.

85. On all telephone circuits the presence of a certain amount of apparatus necessary for signalling or other purposes, but not required for the subscriber's talking, is an unfortunate necessity. Such things, for example, as supervisory apparatus in the exchanges, exchange multiple wiring and fuses, the presence of party line instruments, main and distribution frame wiring, all introduce losses in transmission, each item, though small in itself, helping to form an appreciable total. Some idea of the amount of loss to be expected from these various items is given in the following notes.

EXCHANGE SUPERVISORY APPARATUS.

86. This may be divided into two classes, viz., series apparatus in the line, such as the supervisory relay with non-inductive winding shunting the active coil as used in one form of manual common battery system; and shunting apparatus across the line, such as is used in "Stone" type cord circuits; and the shunting indicators occurring in magneto systems.

87. The series apparatus is always designed with some low impedance such as a condenser or non-inductive resistance across the active coil, but even so the amount of loss introduced by this supervisory coil is seldom less than 0·4 miles of standard cable (0·043). In any talk between two subscribers on different common battery exchanges, there will always be two and generally three of these relays in circuit, making a total loss of 1·2 miles of standard cable (0·13). In one form of manual common battery circuit largely used, in addition to the three relays mentioned above, is another bridging relay (also introducing a loss of about 0·5 miles of standard cable) to keep the originating operator advised as to when the called subscriber clears. The series supervising apparatus in a connection between two common battery exchanges thus accounts for between 1·5 and 2·0 miles of standard cable (0·16 to 0·21).

88. These series shunted relays are not very sensitive in action, and in those cases in which the junction between exchanges is of high resistance it is often necessary to add apparatus at the outgoing end to enable the supervisory relay on the junction side of the repeater to operate. This additional apparatus introduces a loss of from 1·0 to 1·5 miles of standard cable (0·11 to 0·16). The supervisory apparatus on a connection between two common battery exchanges may thus introduce a loss of 3·5 miles of standard cable (0·37). If the call is passed via any intermediate exchanges the loss is, of course, still greater.

89. In "Stone" type cord circuits, the supervisory relays occur as shunts across the line, and are used to feed current to the subscribers' instruments. To introduce little loss, the impedance of those shunts to alternating current must be high, while the ohm resistance must be low, or the battery voltage necessary to supply the required current to the transmitter becomes dangerously high. A high resistance coil also means large energy losses in the coil itself. For 22-volt working, battery current is fed to A and B lines through two 50-ohm coils, and for 48-volt working through two 200-ohm coils. At 800 periods the impedance of a 200-ohm coil, such as is used for this purpose, varies from about 2,000 /45 to 5,000 /45 ohms, depending upon the conditions of test. In an A cord circuit there will be four of these coils arranged in series parallel, thus giving the same impedance as one coil. The loss due to this supervisory and feeding apparatus, if one neglects differences due to the different feeding currents, is about 0·5 miles of standard cable (0·053) less than that of the corresponding series supervisory circuit. These relays placed across the line can also be made more sensitive than series relays, so that in many cases it is not necessary to use the special equipment previously mentioned for long junctions.

90. The great objection to the "Stone" type of circuit lies in its liability to unbalance. By careful construction, however, and arrangement of coils forming one component of the cord circuit in balanced pairs, this trouble can be considerably minimised.

91. The loss introduced by the ordinary magneto circuit ring-off indicator is about 0·5 mile of standard cable (0·053), but it should be noted that the losses when two or more occur in the same circuit are not usually additive. The loss per indicator generally decreases with the number in circuit.

PARTY LINE LOSSES.

92. Party lines with long-distance facilities require careful consideration from the transmission standpoint, and it may be of interest to investigate the losses occurring on these lines.

93. To begin with, the presence of party lines on magneto exchanges usually necessitates the provision of a special cord circuit at the exchange and introduces a loss of the order of 1 mile of standard cable (0·11). To this must be added the losses due to the additional instruments permanently shunted across the line and also losses due to the fact that, unless the parties on the line are placed close together, there will be tapped across the line various lengths of circuit, most of which will be open wire.

94. So long as the branch lines are short, *i.e.*, the capacity does not exceed 0·03 mfd., the loss may be taken as 0·05 miles of standard cable per station (0·0053). As the branch lines become longer the effect of the bells becomes less and that of the lines more, and it may then be taken that the loss can be given as a function of the total additional capacity bridged across the talking line. This loss in miles of standard cable is approximately equal to 10 times the additional capacity in microfarads, or the value of the latter approximately equals the attenuation length.

Exchange Wiring Losses.

95. This same figure may be used in determining the losses occurring in the multiple wiring in exchanges. Taking a 10,000 line exchange the subscribers' multiple wiring may be 500 ft. in length and the junction 400 ft. Assuming a call answered on the first subscriber's position, the whole of this multiple will be tapped across the line. The capacity will be about 0·02 mfd., corresponding to a loss of about 0·2 (0·021) miles standard cable. Should the call be answered on the end position the multiple wiring will occur in the subscriber's local line and will add about 20 ohms to it, corresponding to a loss of about 0·4 miles standard cable (0·042) instead of 0·2 (0·021). In addition to this, there is the loss due to the wiring between distribution frames and switchboard. This may amount to a total of 400 ft. (200 ft. each way). 200 ft. occurs in the junction and introduces a loss of about 0·1 mile of standard cable and 200 ft. in the subscriber's local line, thus adding with the heat coils and fuses about 15-20 ohms to the circuit. This corresponds to a loss of about 0·4 miles standard cable (0·042).

96. No figures are at present available for the losses due to the insulation of the circuits in the exchange, but there is reason to suppose that in many cases it is not light, and in fact is introducing a further loss, especially on high impedance loaded lines.

97. The total wiring losses in a large exchange may thus be at least 0·7 miles standard cable (0·075) and very probably more.

(To be concluded.)

ELECTRICAL PROSPECTS IN SOUTH AFRICA.

The following notes are based on remarks by Mr. John Roberts, Borough Electrical Engineer of Durban, who recently paid a visit to this country. They are of interest as showing the trend of progress in South Africa and the prospects in the near future, and the impression formed on progress in this country.

In regard to the electrical prospects for business in South Africa, and in fact for business generally, things in Durban are very much in the same condition as in England. The state of trade is what would be called "good," though brought about to a great extent by the amount of money the Government has been spending in the country in its prosecution of the German South West and German East Africa campaigns, but there is the same difficulty as is experienced in England, namely, shortage of labour and materials. Merchants and dealers of all kinds could sell a great deal more stuff than they can procure from England. Another factor which is tending to make things very brisk is that in the engineering line a good deal of stuff is being made locally owing to the difficulty of getting it imported, and several large engineering works in Durban are extremely busy. The number of men who are at the front is, of course, responsible for the shortage of labour, and skilled engineers are almost unobtainable.

In regard to the prospects of electrical development, so far as Durban is concerned, Mr. Roberts looks upon them as good. Everyone there is very much alive to the advantages of electricity, both for domestic and industrial purposes. For any new proposition nothing but electric motive power is even considered, but, of course, this is brought about by the low prices charged for current. Large consumers at Durban are charged ½d. per unit, and the output more than doubled during the last six years. The sales at Durban at the end of the current year will be practically 20-million units, which, for a total population of less than 80,000, is a very good showing.

When Mr. Roberts was home in England last, he returned to Africa with a feeling that electrical development in this country was beginning to make a groove for itself, and that startling developments were not to be expected for the next few years at any rate. This was, however, a mistaken idea, for although there have been no revolutionary discoveries, he finds that great strides have been made in extending the uses of electricity, and there have been wonderful improvements in the efficiency of generating stations. In Durban a little less than 3¼ lb. of coal of about 12,000 B.T.U.s is being used per unit delivered from the works. This figure appears to compare quite favourably with those obtained in similar sized stations in England, but with sets of moderate size, say, 3,000 kw. to 5,000 kw., and with a good load-factor, nearly one-third can be taken off this coal cost, and it will be quite a commercial proposition to scrap ruthlessly some of the Durban station plant, although it has not been running for many years yet. There have also been great strides in this country in the distribution side of modern high tension systems. The new protective systems which have developed during the past two or three years have gone a long way towards the simplifying of the control of high-tension systems. They have not only promoted efficiency in mains and reduced the number of stand-by feeders wanted, but have gone a long way in helping us to give absolute continuity of service, which is so essential to large industrial undertakings and consumers. Mr. Roberts feels so much impressed by the advantages made in this direction that he believes his trip to England would have been worth while if he had confined himself to gathering information on this one point.

Regarding the supply of current for domestic purposes, Mr. Roberts does not find such rapid progress, although taking all the circumstances into account he is not surprised. The conditions of manufacture brought about by the war are such as practically to shelve all development of electric heating, which is probably looked upon as a luxury, especially in view of the perfect system of gas heating which is almost universal among English householders, but in Durban, electric heating, at ½d. per unit, has proved that electricity can be used as extensively in South African towns as gas is now used here, and if it had not been that when the war broke out two years ago the supply of stoves was almost cut off, the heating business would have been booming by now. As it is, the demand exceeds the supply, and Mr. Roberts is very confident that the electric stove will give better results than the gas stove, and on the question of water heating, there are quite sufficient people in Durban having their morning bath in water heated by electricity to prove that this problem has been solved.

One of the great needs in South Africa is the proper standardisation of electrical supplies. Although Mr. Roberts is anxious to avoid over-standardisation, he feels that there is a very pressing need for a certain uniformity among electricity supplies in South Africa, the need being greater than would be felt in England, owing to the great distance from the seat of supply. One of the great handicaps arises from the time taken in procuring plant and materials, because the local electrical stocks are small. The suppliers cannot lay in large stocks owing to the great diversity of the requirements. If there were greater uniformity, larger stocks could be laid in of certain standard sizes, which would be a great advantage to everyone concerned. The Durban Corporation has already approached the Union Government with a request to appoint a small Commission to report and make some representations, with the object of compelling those responsible for new electric plants to adopt some standards. As an example we may take electric cable. Cables being expensive are not stocked in South Africa to any extent worth mentioning. The supply companies appear to fix the sizes for use without any regard to what is being adopted in other towns, and therefore it is impossible to lay down stocks to suit everyone. There should be no difficulty for supply authorities to come to some agreement as to the types and sizes of underground cables, so as to limit them to quite a small number. Another example is overhead conductors. The consumption of such conductors in South Africa is large, and a few sizes could be selected which would meet all reasonable needs. Attention to a few of these points would make all the difference to rapid progress in electricity supply in South Africa, and probably in other parts of the Empire also.

APPROXIMATE SOLUTION OF SHORT-CIRCUIT PROBLEMS.*

BY E. G. MERRICK.

Summary.—The author shows, by examples, the method of determining short-circuit values in various circuits with widely differing characteristics. The solutions are approximate, but are typical of actual practice, and are accompanied by results derived from actual test values. The objectionable features of reactance coils are emphasised.

At the instant of short circuit, the armature current rises to many times its normal value, being limited only by the self-inductive reactance of the armature circuit. Gradually the field flux is reduced by the opposing armature flux and the armature current diminishes to a constant value, determined by the combined reactance, resistance and armature reactions, or what is termed "synchronous impedance," giving the condition of sustained short circuit.

Fig. 1 is an oscillogram of a typical three-phase short circuit, the generator being short-circuited at the terminals of the armature winding. Referring to the middle curve, the short circuit occurred when the phase voltage was near its maximum value, giving an approximately symmetrical relation of the current crests with respect to the zero axis; for the upper curve, the short circuit occurred when the phase voltage was near its zero value, giving an unsymmetrical current wave as the result. For both cases, the total amplitudes of the current waves at the instant of short circuit are the same and are equal to $I_0 = 2\sqrt{2}I$, where I is the effective value of the current. If we take into account the damping action of the field circuit, the total

* Abstracted from the "General Electric Review" (of America).

amplitude will be reduced approximately 10 per cent. and the maximum possible value of the instantaneous current is, therefore, equal to

$$I_0 = \frac{1{\cdot}8 \text{ effective volts per phase} \times \sqrt{2}}{\text{reactance} \times \sqrt{3}}.$$

In calculating the instantaneous value of the short-circuit current which may occur under the worst possible conditions, one should, therefore, assume the case of an unsymmetrical current wave. For example, if the reactance of an alternator based on normal voltage and current is 10 per cent., and the short circuit occurs when the machine is operating at normal voltage, the maximum possible instantaneous current equals $(100/10) \times 1{\cdot}8 I_n \times \sqrt{2}$; where I_n = effective value of rated full-load current.

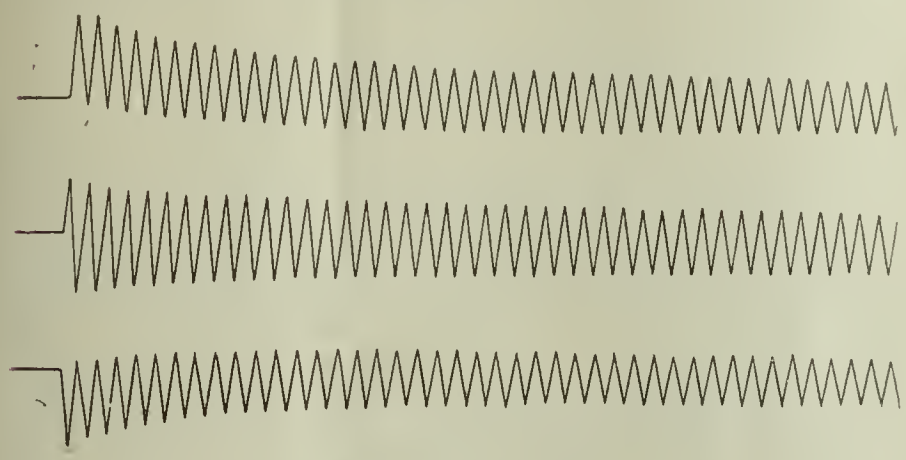


Fig. 1.—Oscillogram of a Three-phase Short-circuit on a 10,000-k.v.a., 6,600-volt 63-cycle Generator.

If any external impedance is included between the alternator and the point of short circuit, the internal and external impedances add directly to limit the flow of current.

Fig. 2 shows the no-load saturation and synchronous impedance curves of a 10,000 k.v.a. three-phase 11,000-volt 25-cycle alternator. This machine was short circuited at its terminals when operating at no load and with a field excitation of 115 amperes which gave 6,000 volts per phase. Fig. 3 is the oscillogram taken for this condition and indicates an average maximum possible instantaneous current for two of the phases of 11,150 amperes. From the given formula the impedance per leg equals 0·792 ohm.

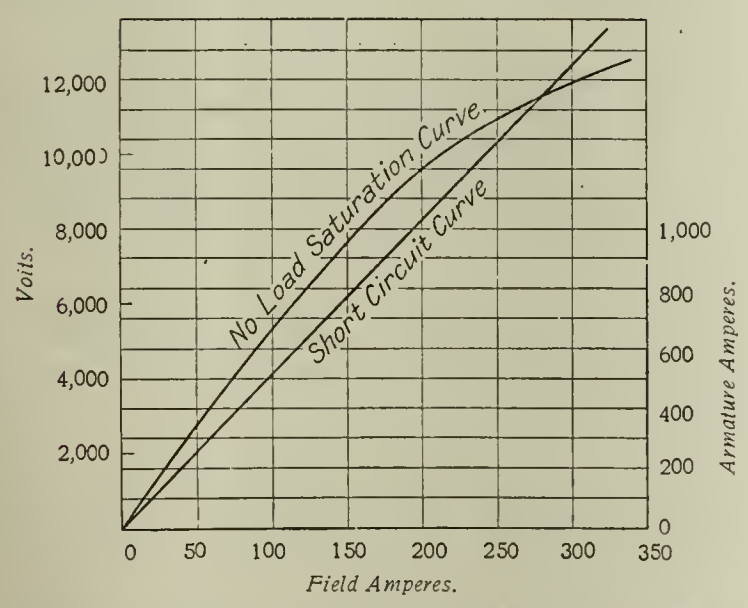


Fig. 2.—The No-load Saturation and Synchronous Impedance Curves for a 10,000-k.v.a., 11,000-volt, 25-cycle Generator.

The rated full-load current of the generator is 525 amperes and the per cent. reactance based on normal voltage and current is therefore

$$525 \times 0{\cdot}792 \times \sqrt{3} \; 11{,}000 = 6{\cdot}55 \text{ per cent.}$$

The alternator was then connected to an external circuit consisting of reactance coils, step-up transformer with a voltage ratio of 11,000 : 70.000 and transmission line ; the total actual external impedance being equal to 16·4 per cent. based on normal current and voltage. The total impedance was, therefore, equal to 16·45 + 6·55 = 23·0 per cent. The short-circuit test for this case was made at no-load with 190 amperes field current. As the impedance is practically constant with the usual range of excitation, a straight line saturation should be assumed, tangent to the lower portion of the magnetisation curve ; for the given excitation, we then have 10,000 volts low tension equals 63,500 volts high tension. The per cent. impedance based on the test voltage is, therefore.

$$23 \times 70{,}000 \; 63{,}500 = 25{\cdot}3 \text{ per cent.}$$

The normal high-tension current is 82·5 amperes per phase. The maximum possible instantaneous value of the current from the above equation equals $(100/25{\cdot}3) \times 1{\cdot}8 \times 82{\cdot}5 \times \sqrt{2} = 835$ amperes.

The oscillogram of Fig. 4, taken on this test, gives an average maximum possible value for the three phases of 863 amperes.

Sustained Short Circuit.—The armature current has now reached a constant value which is determined by the combined effect of armature impedance and armature reaction ; this quantity, which is termed "synchronous impedance" can be dealt with the same as armature impedance and can, therefore, be combined directly with any external impedance.

Taking again the case of the 10,000 k.v.a. alternator just mentioned ; the synchronous impedance equals the no-load voltage divided by the corresponding short-circuit current for the same value of field current. As the resultant field flux is that corresponding to the voltage necessary to force the current through the impedance of the circuit, there is no saturation of the magnetic paths within the usual limits of excitation, and the no-load voltage corresponding to any value of field current should, therefore, be taken from the straight line portion of the saturation curve or a continuation of this straight line. From Fig. 2, the short-circuit current corresponding to 275 amperes excitation = 1,405 amperes or 2·68 × normal current ; the synchronous impedance based on normal voltage is, therefore, 100/2·68 = 37·4 per cent.

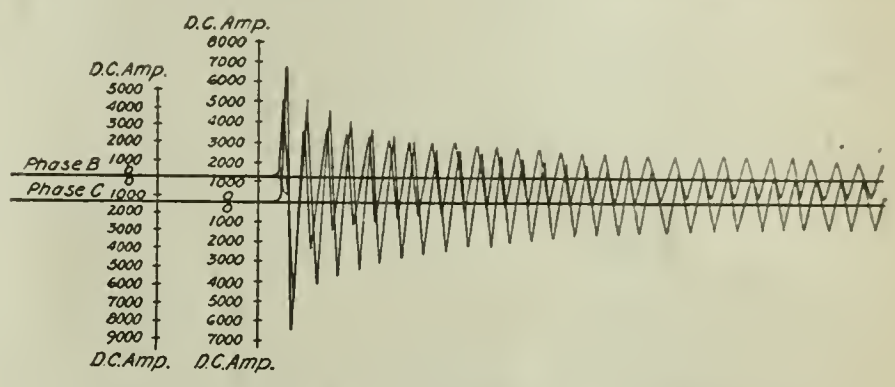


Fig. 3.—Tracing of an Oscillogram of a Three-phase Short Circuit on a 10,000-k.v.a., 11,000-volt, 25-cycle Generator.

With the same field excitation the sustained short-circuit current was then measured with reactance coils, transformer and transmission line in the circuit ; the external impedance based on normal voltage and current equals 16·2 per cent. As the excitation at no load for normal voltage is 211 amperes (straight line saturation), the corrected value of external impedance = 16·2 × 211 275 = 12·4 per cent. The total impedance = 37·4 + 12·4 = 49·8 per cent.

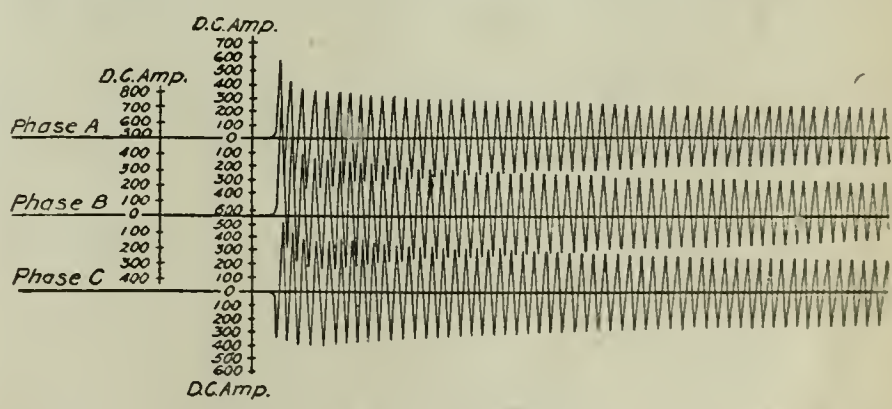


Fig. 4.—Tracing of an Oscillogram of a Three-phase Short-circuit on a 10,000-k.v.a. 11,000-volt 25-cycle Generator, including Impedance of Transformers, Reactance Coils and Line.

Therefore, the short-circuit current = 100 49·8 = 2·01 × normal current.

The normal high-tension current = 82·5 amperes, therefore, 2·01 × 82·5 = 165 amperes. The actual measured current was 160 amperes.

With an external impedance of 22·3 per cent. based on normal voltage and current or 22·3 × 211/275 = 17·1 per cent. based on excitation of 275 amperes, the total impedance = 37·4 + 17·1 = 54·5 per cent., or 100/54·5 = 1·83 × normal current, therefore, 1·83 × 82·5 = 151 amperes. The observed value in this case was 145 amperes.

Fig. 5 indicates diagrammatically a large generating station containing six 30,000 k.v.a. 11,000-volt turbo-alternators, operating on a "ring" 'bus and with reactors between each two generators having

a reactance of 10 per cent. based on the normal current and voltage of one machine. Each generator is equipped with an automatic voltage regulator, and the maximum excitation obtainable is 3·0× the excitation for normal voltage, no load (straight line saturation curve). The sustained short-circuit current with maximum excitation is 2·5×normal, or the synchronous impedance=100/2·5=04 per cent. The per cent. 'bus reactance corrected for the increased excitation=10/3·0=3·33 per cent.

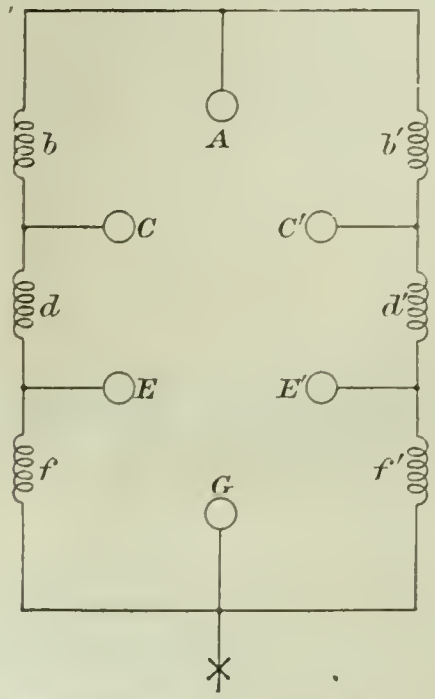


Fig. 5.—A One-line Diagram of a Station Layout, showing the Generators Connected to a Ring 'Bus.

For a short circuit occurring at "x" the total impedance of the station is obtained by combining the individual impedances as follows :—

$$A+\begin{bmatrix} b \\ b' \end{bmatrix}=40+(3{\cdot}33/2)=41{\cdot}67 \text{ per cent.} \quad (1)$$

$$(1)+\begin{bmatrix} C \\ C' \end{bmatrix}=\frac{1}{(1/41{\cdot}67)+(2/40)}=13{\cdot}5 \text{ per cent.} \quad (2)$$

$$(2)+\begin{bmatrix} d \\ d' \end{bmatrix}=13{\cdot}5+(3{\cdot}33/2)=15{\cdot}17 \text{ per cent..} \quad (3)$$

$$(3)+\begin{bmatrix} E \\ E' \end{bmatrix}=\frac{1}{(1/15{\cdot}17)+(2/40)}=8{\cdot}64 \text{ per cent.} \quad (4)$$

$$(4)+\begin{bmatrix} f \\ f' \end{bmatrix}=8{\cdot}64+(3{\cdot}33/2)=10{\cdot}31 \text{ per cent.} \quad (5)$$

$$(5)+G=\frac{1}{(1/10{\cdot}31)+(1/40)}=8{\cdot}2 \text{ per cent.}$$

100/8·2=12·2 normal current of one generator, *i.e.*, the current corresponding to 12·2×30,000=366,000 k.v.a.

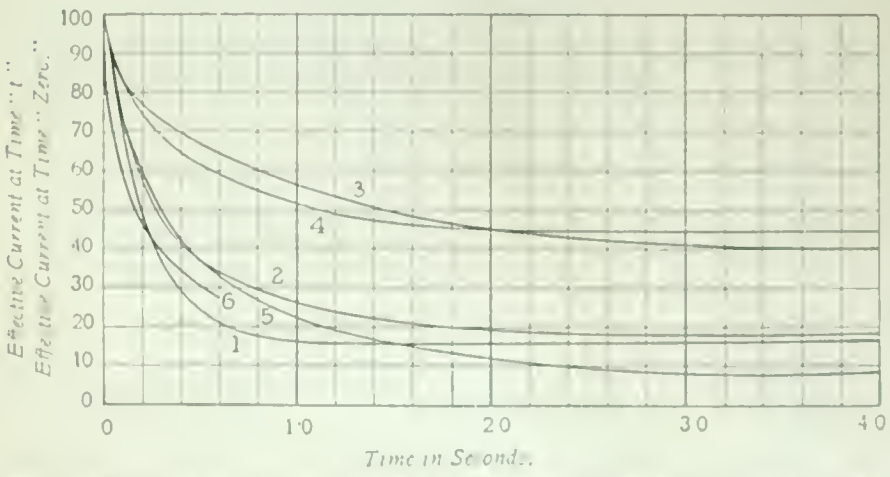


Fig. 6.—Curves showing the Decay of Short-circuit Current as a Function of Time.

As the current divides among the parallel circuits inversely as their impedances, we obtain the following results :—

Generator.	Current × normal.
A	1·79
$C(=C')$	1·88
$E(=E')$	2·08
G	2·5

Reactance.	Current × Normal.	Per cent. volts drop.
$b(=b')$	0·89	8·9
$d(=d')$	2·77	27·7
$f(=f')$	4·85	48·5

Therefore the voltages of the different generators will be :—

Generator A	9,360 volts
Generator $C(=C')$	8,380 volts
Generator $E(=E')$	5,340 volts
Generator G	0·0 volts

On sustained short circuit, the individual generators will, therefore, operate approximately under the conditions of voltage and current as indicated.

Fig. 6 shows the decrease of the short-circuit current at different time intervals with constant field excitation. These results were obtained from oscillograph records of tests on different machines. The ordinate at any time t indicates the ratio of

$$\frac{\text{effective value of current at time } t}{\text{effective value of current at first crest}}.$$

For symmetrical waves, the same curves would also show the ratio of instantaneous values of the current.

An analysis of many oscillograms of short circuits taken on both 25- and 60-cycle generators indicates that even when the current wave is unsymmetrical at the start it becomes approximately symmetrical from 0·2 to 0.5 seconds ; therefore, the current which the switch must rupture becomes a more definite quantity and has a fairly definite relation to the sustained short-circuit current, providing the excitation remains constant.

An interesting comparison is obtained from curves No. 1 and No. 3 ; curve No. 1 is for a generator alone and curve No. 3 for the same generator with external impedance. The slow decay of current in the latter case emphasises the objectionable feature of reactance coils in relation to instantaneous switch operation, namely, that although the instantaneous and sustained currents are reduced by the added reactance, yet the values of current for the two cases, at the instant of opening of the switch contacts, may possibly be approximately the same. As far as the switch is concerned no gain would have been made in such a case, and a new element of danger would have been added on account of the possibility of high voltage discharge due to the reactive effect of the coil.

AN APPROXIMATE METHOD OF CALCULATING SHORT-CIRCUIT CURRENT IN AN ALTERNATING-CURRENT SYSTEM.*

BY H. R. WILSON.

Summary.—The author first points out the importance of determining the short-circuit current values in an alternating-current system, and then differentiates between the instantaneous and the sustained values. From this point on, the article consists of a detailed diagrammatic and mathematical work-up of a typical set of calculations for reactance, current, &c., as applied to a representative large alternating-current system.

Since probably the most lucid form of an explanation of the practical method for calculating short-circuit factors is an example, a typical installation has been selected for this article and the calculations applied to it are worked out in detail in the following.

Consider a 60-cycle three-phase system as shown by the one-line diagram in Fig. 1. The groundwork was laid down several years ago. As time went on, the system grew and considerable equipment was added. In accordance with the modern design tendency, the more recently installed apparatus has the higher reactance.

The *instantaneous* per cent. reactance of each generator and each transformer, based on its rated capacity and the per cent. of each based on an arbitrary value of 4,000 k.v.a. will be as in Table I.

Table I.

Station No.		Per cent. reactance based on rated capacity.	Per cent. reactance based on 4,000 k.v.a.
1	4,000 k.v.a. generator	12·0	12·0
2	2,500 k.v.a. "	12·0	22·6
3	6,000 k.v.a. transformer	6·0	4·0
4	1,500 k.v.a. "	11·4	30·4
5	1,500 k.v.a. "	11·6	31·0
6	6,000 k.v.a. "	7·3	4·9
6	2,000 k.v.a. generator	4·0	8·0
6	2,250 k.v.a. transformer	3·9	7·0
6	9,375 k.v.a. generator	22·0	9·4
7	4,500 k.v.a. transformer	5·5	4·9
8	1,500 k.v.a. "	11·7	31·2

* Abstracted from the "General Electric Review" (of America).

The single-phase reactance in ohms per 1,000 ft. of a three-phase circuit is

$$\frac{2\pi fL}{1{,}000}=\frac{\left\{2\times\pi\times f\times(0{\cdot}141\log\frac{D}{d}+0{\cdot}0576)\right\}}{1{,}000},$$

in which D=interaxial spacing of conductors,
and d=diameter of conductor.

The per cent. reactance is

$$\frac{\text{k.v.a.}\times\text{reactance ohms}}{(kv.)^2\times 10}.$$

The lines from station No. 1 to station No. 3 and from station No. 2 to station No. 3 consist of 500,000 circular mil. cable with 3 ft. spacing.

The reactance per 1,000 ft. is

$$\frac{\{2\times\pi\times 60\times(0{\cdot}141\times 1{\cdot}64+0{\cdot}0576)\}}{1{,}000}=0{\cdot}11 \text{ ohms},$$

or, based on 4,000 k.v.a., is

$$\frac{4{,}000\times 0{\cdot}11}{(13{\cdot}2)^2\times 10}=0{\cdot}025 \text{ per cent.}$$

Now, for a specific example of what will occur when a short-circuit takes place, consider a fault on the 13,200-volt 'bus of station No. 6—all the apparatus being in service and all switches closed. The instantaneous reactance to the fault may be diagrammatically expressed as in Fig. 2.

The total per cent. reactance to the fault will be as follows :—

Station No. 1 : Four generators in parallel
12·0 per cent./4=3·0 per cent.

Station No. 2 : Three generators in parallel
22·6 per cent./3=7·5 per cent.

Stations No. 1 and 2 : In parallel
$\frac{1}{(1/3{\cdot}0)+(1/7{\cdot}5)}=2{\cdot}1$ per cent

Station No. 3 : Four transformers in parallel
4·0 per cent./4=1·0 per cent.

Two lines : In parallel
$\frac{1}{(1/2{\cdot}1)\times(1/3{\cdot}2)}=1{\cdot}2$ per cent.

Station No. 6 : Three transformers in parallel
4·9 per cent./3=1·6 per cent.

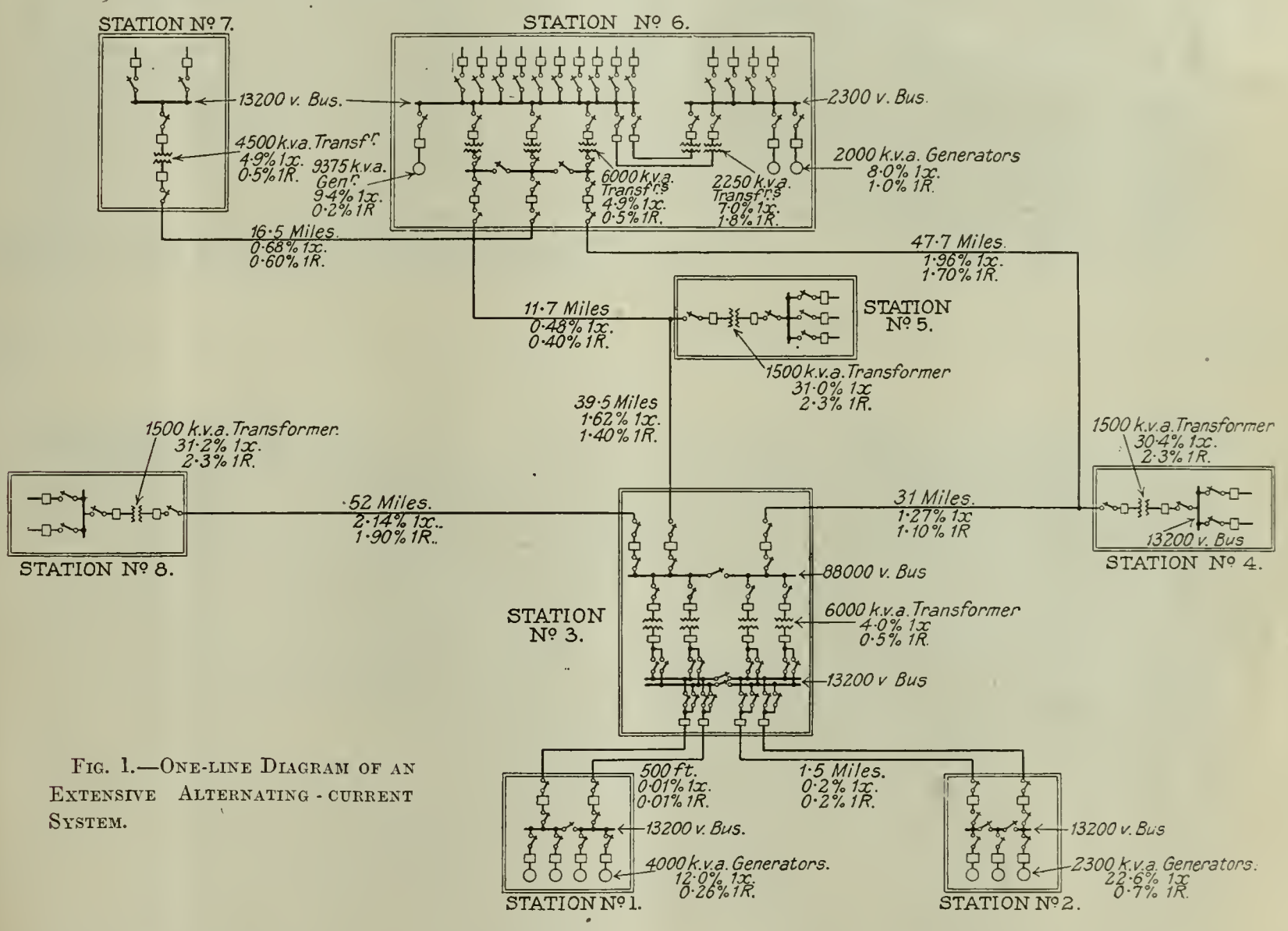


Fig. 1.—One-line Diagram of an Extensive Alternating-current System.

As these lines are of such short length, the reactance is comparatively small and will be neglected in the further calculations.

The lines for transmission at 88,000 volts consist of No. 0 conductor with 96-in. spacing.

The reactance of this conductor per mile is

$$\frac{5{\cdot}28\{2\times\pi\times 60\times(0{\cdot}141\times 2{\cdot}41+0{\cdot}0576)\}}{1{,}000}=0{\cdot}8 \text{ ohms},$$

or, based on 4,000 k.v.a., is

$$4{,}000\times 0{\cdot}8/\{(88)^2\times 10\}=0{\cdot}041 \text{ per cent.}$$

The several 88,000-volt lines will, therefore, have reactances as shown in Table II.

Table II.

—	Miles.	Per cent.
Station No. 3 to station No. 4	31·0	1·27
,, No. 4 ,, No. 6	47·7	1·96
,, No. 6 ,, No. 7	16·5	0·68
,, No. 3 ,, No. 5	39·5	1·62
,, No. 5 ,, No. 6	11·7	1·48
,, No. 3 ,, No. 8	52·0	2·14

The total reactance from station No. 1 and No. 2 to the low voltage 'bus of station No. 6 is 2·1+1·0+1·2+1·6=5·9 per cent.

Station No. 6 : Two generators in parallel
8·0 per cent./2=4·0 per cent.

Two transformers in parallel
7·0 per cent./2=3·5 per cent.

Generators and transformers in series=7·5 per cent.

One generator 9·4 per cent.

Therefore, at station No. 6 there are in parallel 5·9, 7·5 and 9·4 per cent. reactances which give

$$\frac{1}{(1/5{\cdot}9)+(1/7{\cdot}5)+(1/9{\cdot}4)}=2{\cdot}4 \text{ per cent. total reactance.}$$

The instantaneous current at the fault is equivalent to
$\{100/2{\cdot}4\}\times 4{,}000=167{,}000$ k.v.a., or 7,300 amperes.

The total resistance to the fault, determined by the same method as just described for total reactance, is 0·16 per cent. and if the total reactance is 2·4 per cent., the total impedance is $\sqrt{\{(2{\cdot}4)^2+(0{\cdot}16)^2\}}$ or 2·405 per cent., so, for all practical purposes, simply the reactance values need be used.

Calculations to determine the *sustained* short-circuit current will be sufficiently accurate if the synchronous reactance of the generators is added directly to the reactance of the remainder of the system.

Table III.

Station No.	——	Per cent. reactance based on rated capacity.	Per cent. reactance based on 4,600 k.v.a.
1	4,000 k.v.a. generator	17·3	17·3
2	2,300 k.v.a. ,,	18·5	32·2
6	2,000 k.v.a. ,,	25·0	50·0
6	9,375 k.v.a. ,,	51·0	21·8

The synchronous reactances of the generators in this system are as given in Table III., it being assumed that all the generators are provided with voltage regulators which will increase the exciter

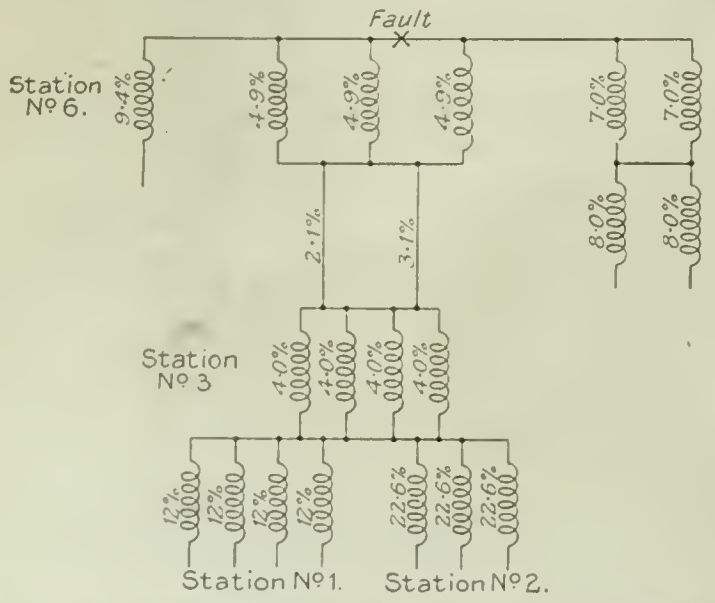


Fig. 2.—A Diagrammatic Representation of Instantaneous Reactance when a Fault Occurs on the 13,200-volt Bus of Station No. 6, Fig. 1.

voltage above normal voltage. Substituting these synchronous reactance values for the instantaneous values in the previous calculations, the sustained short-circuit current will be found to be equivalent to 91,000 k.v.a., or 4,000 amperes.

The switch in this feeder would be required to rupture the instantaneous short-circuit current of 7,300 amperes if it operated at the exact moment the fault occurred; but, as there is an element of lag in even the fastest moving automatic switch and as the short-circuit current decreases very rapidly, the current which the switch will break is more likely to be nearer to the sustained value, *i.e.*, 4,000 amperes.

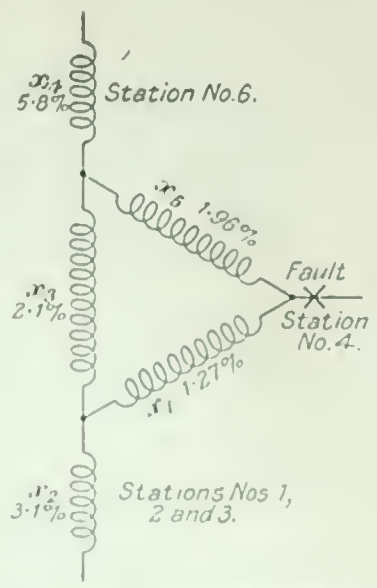


Fig. 3.—A Diagrammatic Representation of Instantaneous Reactance when a Fault Occurs on the High-tension Bus of Station No. 4, Fig. 1.

The reactance of the system when a fault occurs in the transformer at station No. 4 may be diagrammatically represented by Fig. 3, in which x_1, reactance of line from station No. 3 to station No. 4, is 1·2 per cent.; x_2, total effective reactance of station Nos. 1, 2 and 3, is 3·1 per cent.; x_3, reactance of line from station No. 3 to station No. 6, is 2·1 per cent.; x_4, total effective reactance of station No. 6, is 5·8 per cent.; x_5, reactance of line from station No. 6 to station No. 4, is 1·9 per cent.

By Kirchoff's law:—

$$X_2=\{K(x_1+x_2)+x_1x_2(x_4+x_5)\}/(K+x_1x_4)=4\cdot3 \text{ per cent.}$$

$$K=x_3x_4+x_3x_5+x_4x_5=27\cdot7 \text{ per cent.}$$

$$X_1=X_2x_1/(x_2-X_2)=4\cdot5 \text{ per cent.}$$

$$X_4=X_1X_2x_4/\{X_1(x_2+x_3)+X_2x_3\}=7\cdot8 \text{ per cent.}$$

The total effective reactance to the fault

$$=\frac{1}{(1/X_4)+(1/X_2)}=2\cdot77 \text{ per cent.}$$

The instantaneous equivalent short-circuit current

$$=(100/2\cdot77)\times4{,}000$$

$$=145{,}000 \text{ k.v.a., or } 650 \text{ amperes.}$$

Substituting the synchronous reactance of the generators, the total effective reactance to the fault will be 3·17 per cent. and the sustained short-circuit current will be 830 amperes.

Now, if a fault occurs on the feeder side of the transformer at station No. 4, the reactance of the transformer (30·4 per cent.) will be added to the instantaneous reactance of 2·77 per cent., giving 33·17 per cent. and the instantaneous equivalent short-circuit current will be equivalent to 121,000 k.v.a. The inherent reactance of the transformer would limit the equivalent short-circuit current to the value of 13,200 k.v.a., so that the transformer should be designed to withstand the strains due to practically full short-circuit current with sustained voltage, as the additional effective reactance in the system reduces the short-circuit current only 8 per cent.

Similar calculations will give the short-circuit current at the other stations and the requirements of the apparatus can thus be determined.

PAISLEY AUTOMATIC TELEPHONE EXCHANGE.

BY J. HEDLEY.

An important stage in the progress and development of automatic telephony was reached when the above exchange was brought into use on July 15th last.

Automatic exchange working for public service was first introduced in this country in 1912, when the Epsom exchange was opened with a capacity of 500 lines, and since that date exchanges have been opened at Hereford (500 lines) and Darlington (800 lines) in 1914, Accrington (700 lines), Chepstow (65 lines), and Newport, Mon. (2,000 lines) in 1915, and Portsmouth (5,200 lines) in April last. Equipment for 1,200 lines has been provided at Paisley, and some details of the plant will prove of interest. The installation is the first of its kind in Scotland, and embodies the latest developments in automatic telephone exchange working.

1. Facilities are available on primary line switch units for cross-connecting subscribers' lines to any line switch, thus affording means for distributing the originating traffic equally throughout the exchange.

2. When the called subscriber is engaged, a "busy back" tone is given to the originating subscriber; if the engaged subscriber is called from the manual board, a "busy" flash signal is transmitted to the operator's cord circuit.

3. When a called subscriber replies, the ringing current is tripped immediately.

4. The number of routes incoming to any unit of 100 lines can be varied without altering the permanent wiring. Increases in load incoming to any unit can thus be dealt with by merely inserting a connector switch on one of the spare multiple banks provided.

5. The meter of the originating subscriber is operated for completed calls between two automatic subscribers only. The meters are mounted on racks in such a position that the records are readable from the manual switchroom.

6. In the case of trunk and junction calls via the manual board, talking current is supplied to the subscriber's telephone direct from the manual board cord circuit, thus improving transmission. In order to effect this, the connector circuit is arranged to switch the feeding coils of the automatic plant out of circuit when the subscriber replies.

7. The operators at the outlying manual exchanges "dial" the Paisley subscribers direct over the junction circuits. Standard supervision is afforded to the sub-exchange operator.

8. Each switch and the outgoing and incoming routes for each switch are so designated as to enable calls to be traced backwards or forwards to the next switch without difficulty.

9. An alarm circuit is extended to the manual board during the night and on Sundays, when no engineering staff is on duty in the automatic exchanges. The alarm is associated only with those circuits which actually affect the working of the exchange, such as fuses blown and failure of ringing.

10. The master switch controlling the line switches associated with each primary line switch unit can be removed without displacing the subscriber's line switches.

The whole of the equipment is fitted on the first floor of the head post office, and from a maintenance standpoint the lay-out of the plant may be considered to be ideal. The underground cables are led via a cable chute to the main frame on which fuses for 2,400 circuits are provided. The lines are then cross-connected to the protector side of the main frame according to the numbers allocated to the subscribers; permanent

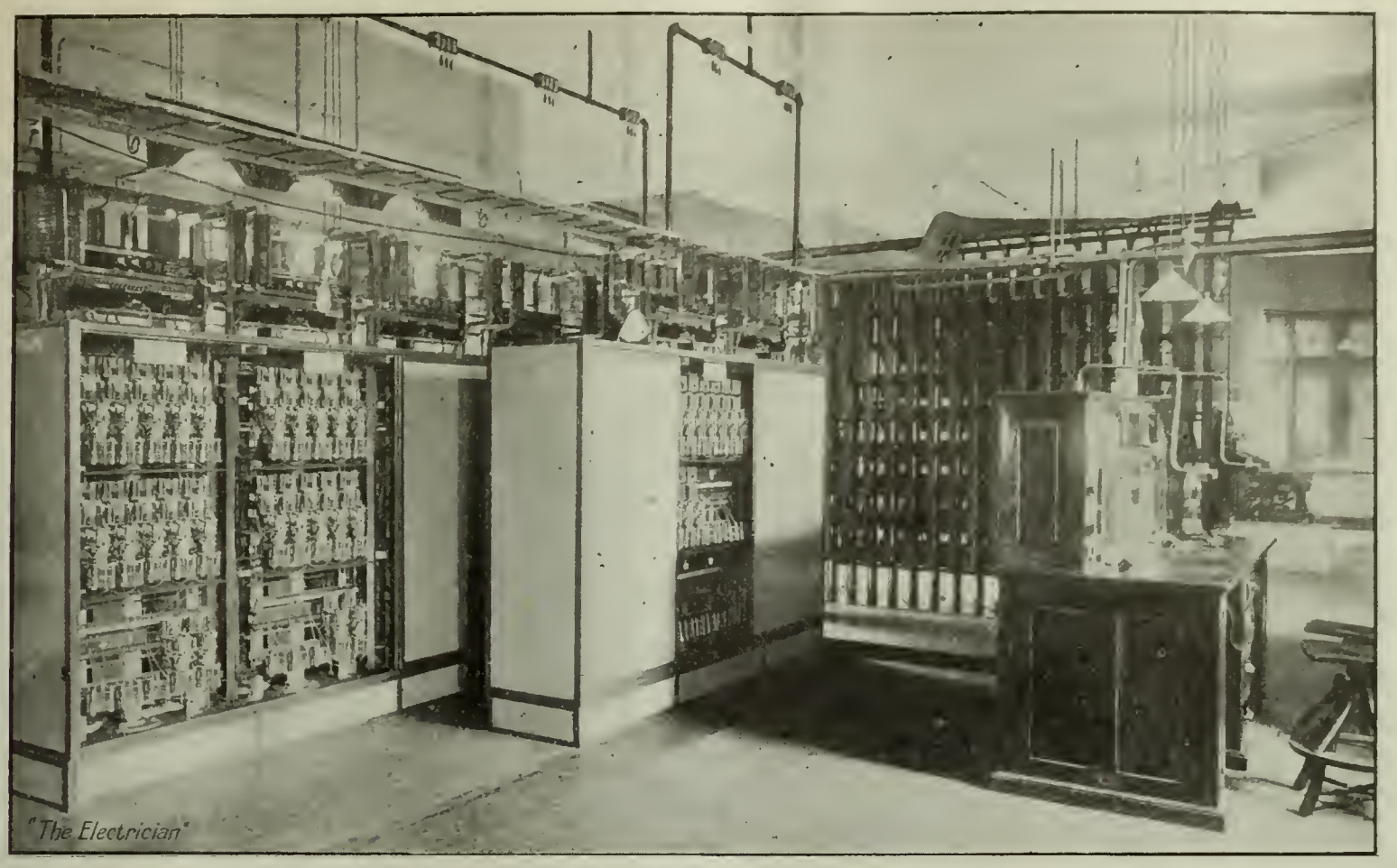


Fig. 1.—Main Frame and Primary Line Switch Units.

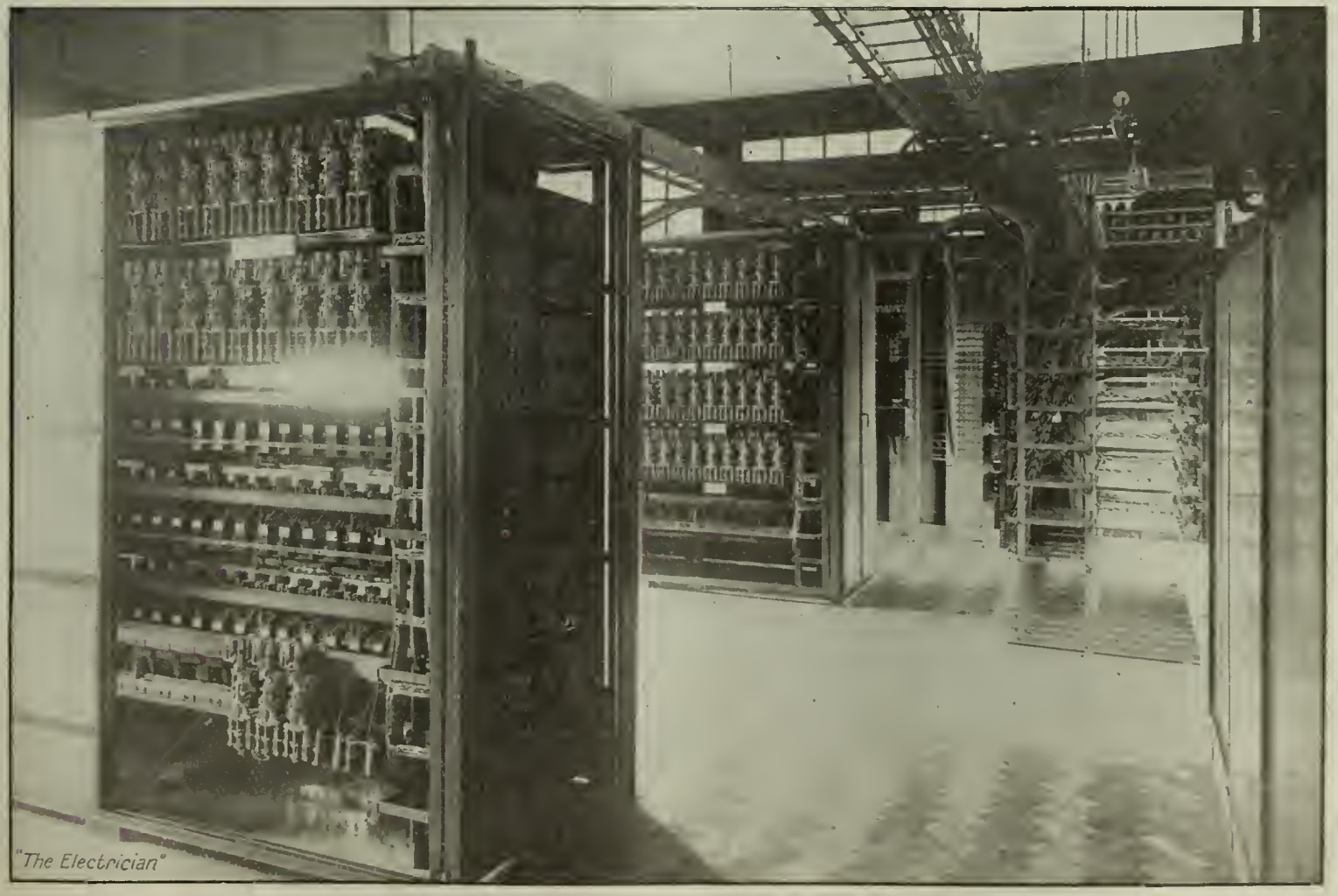


Fig. 2.—View of First and Second Selector Boards.

switchboard cabling is provided between the subscriber's protectors and the primary line switch units. Figs. 1 and 4 show the respective location of the main frame and primary line switch units. The latter are shown on the left.

Fig. 3 shows a detailed view of the line switch side of a 100 line unit. The line switch is operated immediately the subscriber takes his receiver off, and connects the subscriber with a free switch ready to receive the impulses from the calling dial.

The four ceiling lamps are for the purpose of indicating faults requiring prompt attention—*e.g.*, "M.S." is a blue lamp, which glows when the master switch rotates due to all trunks being engaged.

There are 12 primary line switch units, two for private branch exchange subscribers and 10 for ordinary subscribers, numbered 2,000 to 3,199 inclusive; each unit is wired for 20 outgoing trunks and equipped with apparatus for 10 outgoing



Fig. 3.—Detail View, showing Primary Line Switches for Individual Subscribers. Terminal Strips for Cross Connecting. Ceiling Alarm Lamps for Urgent Faults.

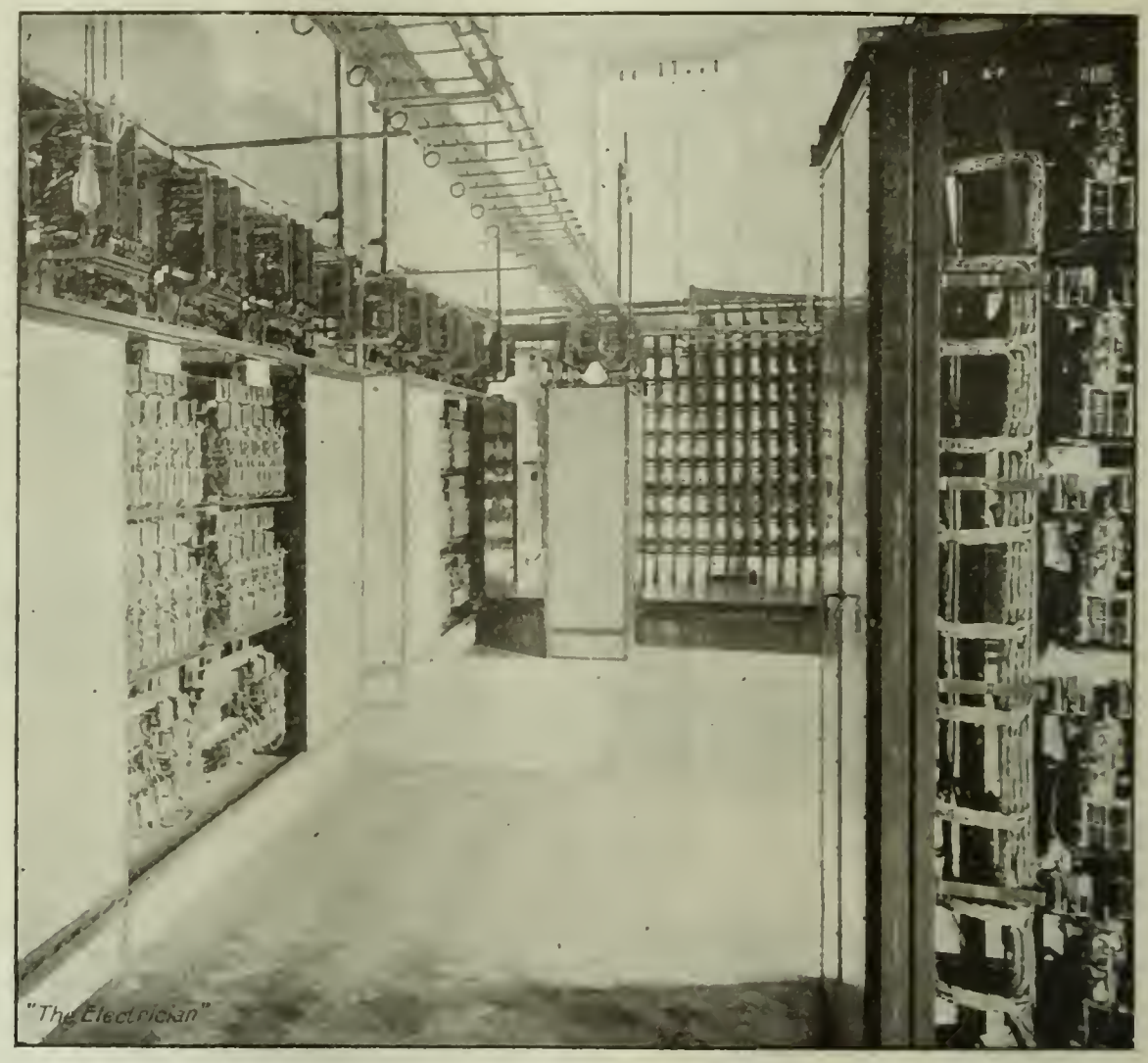


Fig. 4.—Main Frame in Rear. Primary Line Switch Units at Left.

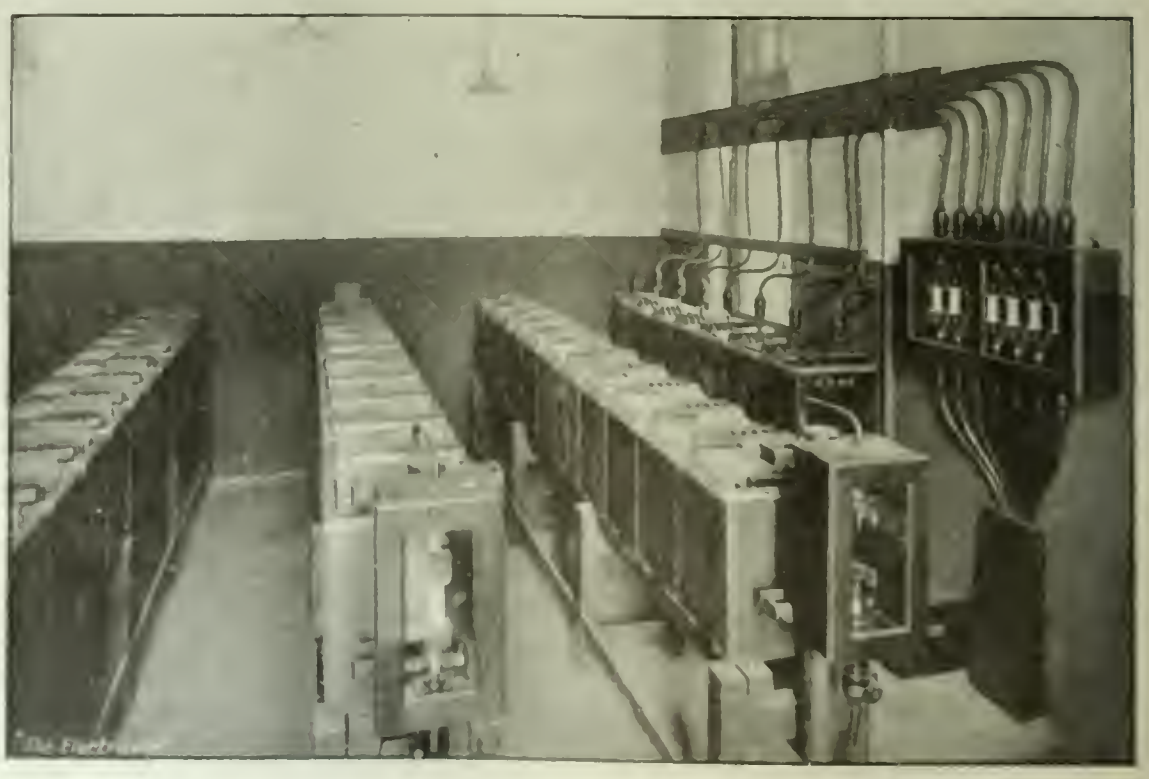


Fig. 5.—View of Secondary Cells.

The terminal strips at the top of the unit are for the purpose of fulfilling the cross-connecting condition outlined under (1). The two strips at the sides each accommodate 25 subscribers' line switches—*i.e.*, 50 for each side. Two of the centre strips are associated with the trunks outgoing to the first selectors, 10 per strip. The remaining strip accommodates the cables incoming to connectors from second selectors.

trunks. The two P.B.X. units are wired for 19 incoming rotary connector switches and fitted with 10. The remaining units are wired for 13 incoming straight connector switches and fitted with 10. The 120 outgoing trunks are cabled from the 12 primary line switch units to an intermediate distributing frame, where they are cross-connected to 120 first selectors.

Fig. 2 shows the first selector board in the centre. The

first selector switches deal with the first number dialled by the calling subscriber. One hundred and ninety first selectors are provided, 70 of which are directly associated with jacks on the manual board for trunk and junction service, and the banks of these 190 first selectors are cabled to 140 second selectors fitted on the board shown to the left of Fig. 2. The second selector switches deal with the second figure dialled by the subscriber. The banks of these switches are cabled to the 120 connectors distributed over the 12 primary line switch units.

conversation, prevents interference during conversation from other calling subscribers, and releases the switches when the originating subscriber restores his receiver.

Fig. 6 shows the manual switchboard of 12 positions—four spare, two for enquiries, one for party line subscribers, one for coin box subscribers, and four for the completion of originated and incoming trunk and junction calls.



Fig. 6.—Manual Switchboard for Enquiries. Trunk and Junction Service.

The power plant consists of a power board, two motor-generators, two ringing machines and two sets of accumulators of the Chloride Electrical Storage Co.'s type, with a capacity of 272 ampere-hours at the nine-hour rate of discharge. The machines are of the shunt-wound type with an output of 80 amperes at 35 volts, and were manufactured by Messrs. Crompton & Co., Chelmsford. Fig. 7 shows the two charging



Fig. 7.—View of Power Plant.

The connectors can be seen clearly from Figs. 1 and 4. The connector switch responds to the last two figures dialled by the subscriber, and in addition to fulfilling the conditions referred to under 2, 3, 5 and 6, tests the line of the called subscriber, supplies talking current to the subscriber's telephone during

sets, two ringers, power board and fuse panel, and Fig. 5 shows the secondary cells with the counter E.M.F. cells at the right, for maintaining the voltage for the automatic plant constant.

The subscribers now joined to the automatic exchange were previously connected to a magneto exchange of the multiple type. There are 915 direct lines working, including 22 coin box circuits, and 20 party line subscribers. The 42 latter circuits are arranged to operate as standard common battery manual telephone circuits on two positions on the manual board. The coin box circuits are arranged so that calls incoming to these subscribers are obtained automatically.

In connection with the transfer of the subscribers' lines, trunk and junction circuits to the new exchange, extensive underground and overhead construction work was carried out by the Post Office engineers.

The whole of the automatic plant was manufactured and installed by the Automatic Telephone Mfg. Co. (Ltd.), Liverpool, according to a specification prepared by the engineer-in-chief to the Post Office (Sir William Slingo), and from the results of the working of the exchange, and the satisfactory reports received from subscribers, the transfer from manual to automatic service may be claimed to be a complete success.

CONSTRUCTION OF AN ELECTROSTATIC VOLTMETER.*

BY E. R. WOLCOTT.

An electrostatic voltmeter for measuring root-mean-square values of either direct or alternating-current voltages up to 75,000 volts is shown in the accompanying illustrations. The voltmeter has been constructed on the principle of the Kelvin guard-ring electrometer, which can be readily calibrated as the force of electrostatic attraction is balanced by a known weight and the reading is taken in absolute C.G.S. units.

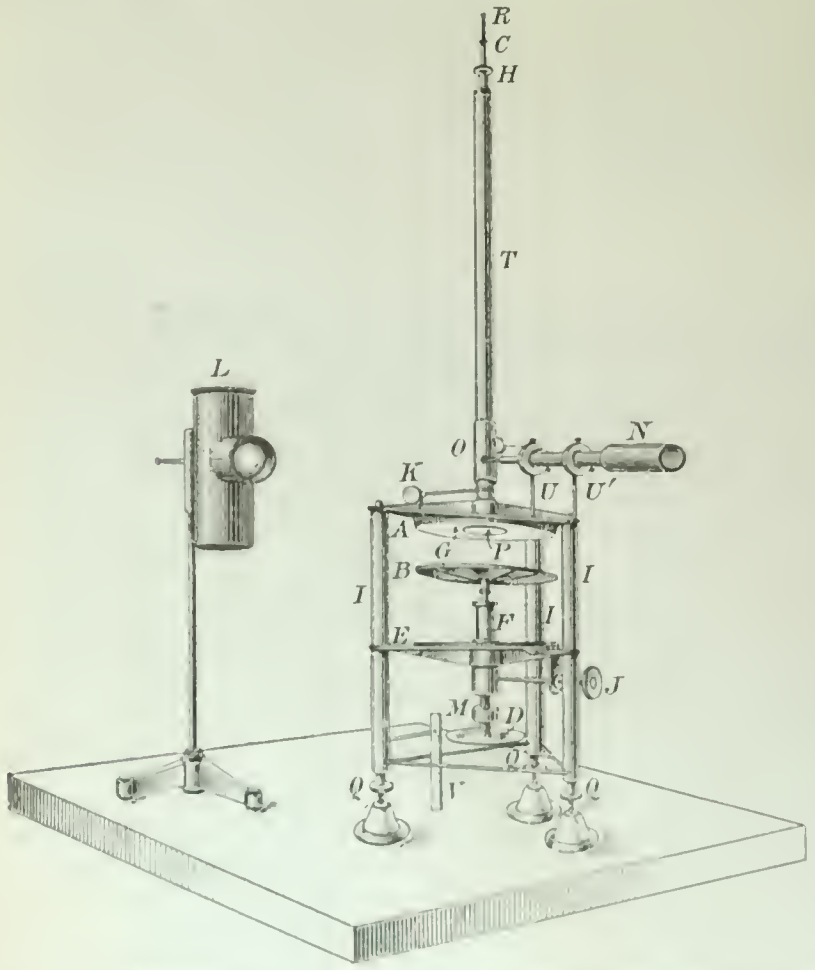


Fig. 1.—Electrostatic Voltmeter, showing High-potential and Grounded Plates.

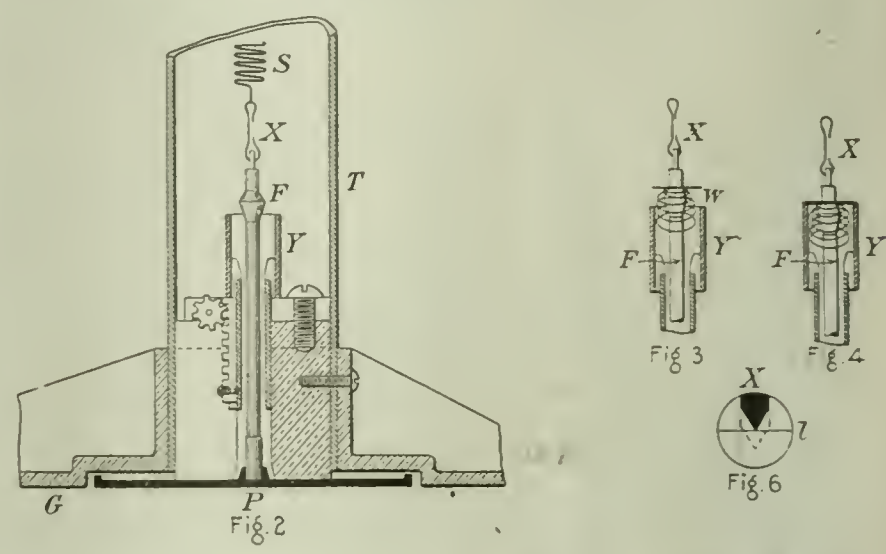
As shown in Fig. 1, A and B are two conducting surfaces, A being connected to the source of high potential and B to ground. M is a micrometer screw for adjusting the distance d between A and B. The surface A consists of two parts, the rigid guard ring and the movable plate P, which is hung from spring S (*see* Fig. 2) mounted in the tube T. These two plates are normally in the same plane.

If the spring S be so adjusted that a certain upward force F be exerted on the plate P, having an area p, which is at a distance d from the plate B, then the E.M.F. in volts that must be applied to A again to bring P into the plane of G equals $e=kd\sqrt{(8\pi f)}\ p$, where k is the constant of transformation from electrostatic units into volts and is approximately equal to 300.

This relation holds only when the diameter G is large compared with that of P, and when the distance d is not too large as compared with P. An experimental determination of these limitations may be expressed as follows :—

$$R\ :\ r\ :\ d\ ::\ \cdot 8\ :\ 3\ :\ 12,$$

where R is the diameter of the plate G, r is the diameter of the disc P and d the distance between A and B.



Figs. 2, 3, 4 and 6.—Details of High-potential Element, showing Spring and Weights.

The instrument is calibrated by means of a known mass, that is the platinum spiral w, which may be added to or removed from the plate P by the knurled head K, which lifts the hollow cylinder Y, so that the mass w rests on it, as shown in Fig. 4, instead of on the shoulder F, as shown in Fig. 3.

Referring to Fig. 1, R is a small rod from which is suspended a spring, S, and which is securely held by the clamp C. The knurled head H permits of fine adjustment in raising and lowering the plate P, which is suspended from the spring S (*see* Fig. 2). The brass tube T encloses spring S and has two opposite windows, O, near its lower end, through which a beam of light from the lamp L passes. By means of the microscope supported at U and U′ a magnified shadow of the tip of the loop X is focussed on the translucent screen, as

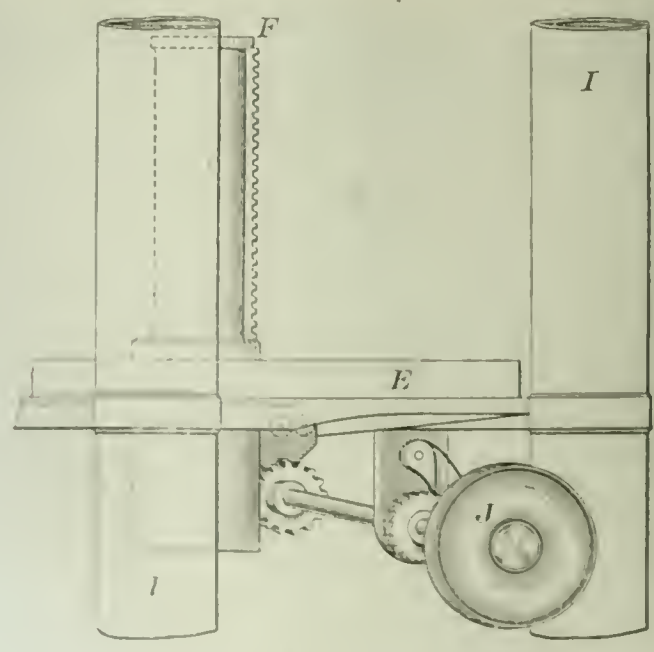


Fig. 5.—Rack and Pinion Elevating Mechanism for Adjusting Plate B.

shown in Fig. 6. X is a hollow cylinder of hard rubber to darken the translucent screen and at the same time prevent the observer from getting too close to the highly charged upper part of the instrument. The insulating supports I are of hard rubber. E is a fixed plate which supports the movable plate B. J is a knurled head for rapid adjustment of the plate B, as shown in Fig. 5. Fine adjustment may be obtained by turning the micrometer screw at M. D is graduated disc which indicates the distance E between plates A and B on the scale V, and may be calibrated to read directly in volts. Q, Q, Q are levelling screws.

* From the "Electrical World," slightly abbreviated.

The method of operation is as follows: The instrument is levelled so that the plate P swings freely. B is then moved up to make contact with A and the disc D and scale V set to read zero. The microscope is adjusted so that the tip of the shadow of X touches the line L on the translucent screen, as shown in Fig. 6.

The plate B is then lowered and the mass W (in this case 514 mg.) allowed to rest on the shoulder F by lowering the hollow cylinder Y by means of the knurled head K, as shown in Fig. 3. The tension of the spring S is adjusted at H, so that the tip of the shadow of X again touches the line L, Fig. 6. The knurled head K is then turned so as to lift the spiral from S, as shown in Fig. 4. The plate P ascends a short distance and the instrument is ready to use. The upper part of the instrument is then connected to the high-tension source, and B is grounded or connected to the opposite terminal of the high-tension source, if so desired, as E is also insulated.

The electrostatic attraction causes plate P to move towards B. B is then adjusted so that the tip of the image of X again touches the line L. The electrostatic attraction between the discs P and B is then equal to the attraction exerted by gravity on the mass W. By substituting the values d, f and p in C.G.S. units in the formula, the reading in volts is determined or the scale may be calibrated to read volts directly. Repeated tests of this instrument have demonstrated its accuracy to one-tenth of 1 per cent.

OCCURRENCE AND UTILISATION OF ZINC.

A recent "Bulletin" of the Imperial Institute refers to the occurrence of zinc ores.

The most important deposits are situated in Southern Corinthia, Styria and the Tyrol. In Bulgaria zinc ore has been raised from a mine six miles south-west of Vratza. In France the most important mines are those of Malines (Gard), Pierreflitte Bulard de Sentein St. Lang, Planioles, Bleymard and Bormettes. The production of zinc was commenced about 1870, and was then mostly carbonate, from the Alps or Pyrenees. At Malines the ores occur in a deposit of the middle Jurassic period. The output from the French mines in 1912 was about 43,000 tons in all. Germany ranks as second only to the United States as a producer of zinc ores, her most important deposits occurring in Upper Silesia, while smaller quantities are obtained from Rhineland, Westphalia, Nassau and the Hartz. Greece has her most important mines in the Laurium district. In Italy the most important mines occur in Sardinia, others in Lombardy, Piedmont and Tuscany; they are amongst the most productive in Europe. In Norway zinc ore has been mined at Hadeland, Modum and Ranen, besides low-grade ores near Christiania. The most important deposits in Russia are those of Poland, the chief mines being near Olkusch. Near Bolishaw the deposits form a mass 2,000 ft. in diameter and 50 ft. thick. Rich deposits also occur in the Caucasus. In Spain 80 per cent. of the output comes from mines in the provinces of Murcia and Santander. China has mines in the Human Province which in 1914 produced 22,875 tons of zinc ore concentrates. Zinc also occurs in Indo-China, the total output being 36,400 tons of ore. The Japanese mines have turned out 10,000 tons of crude ore, irrespective of minor quantities from smaller mines, most of the ore being obtained from the Kamioka mines. In Siberia it has been estimated that ore reserves amounting to 2,000,000 tons have been developed, particularly in the Ridder Mine, Altai Mountains. This mine has been taken over by the Irtysh Corporation, which is building both lead and zinc smelteries at Ekibastus. Little information is available about Turkey in Asia, but the chief source appears to be Karsasu, on the Black Sea. Zinc ores are worked in Algeria in the Constantine Department, and numerous deposits occur in Sonk-Ahras and Tébessa. Tunis has an annual output of about 30,000 tons; these come from concessions about 25 miles from Beja, north of the Sidi-Ahmet Mountains. Several other localities have deposits of zinc ores. In America the United States holds the premier position as producer of zinc ore and spelter, there being important mines in about 13 different States. Missouri, Wisconsin, Kansas and Oklahama are responsible for about 11,000,000 short tons (2,000 lb.) in 1913, and accounting for over 50 per cent. of the total spelter produced in the world. The following are the quantities of spelter produced in 1913 in the chief countries:—

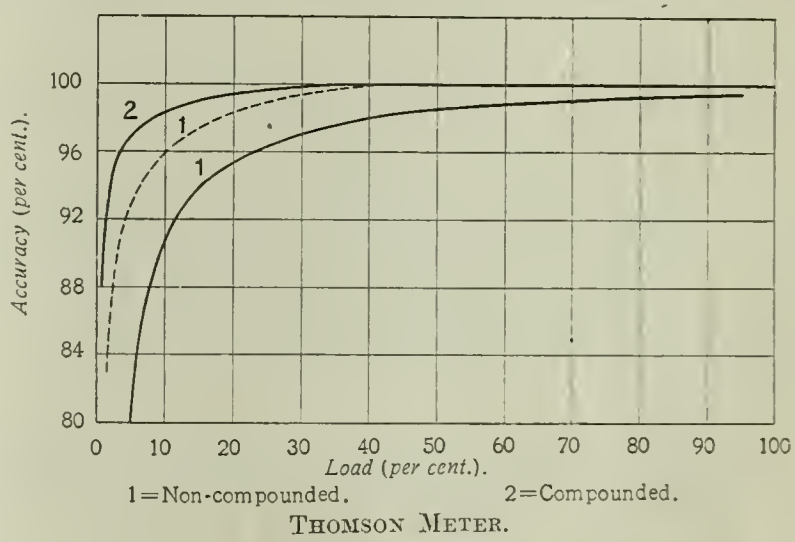
	Metric Tons.
United States	320,283
Germany	283,113
Belgium	197,703
United Kingdom	59,146
France and Spain	71,023
Russia	7,610
Norway	9,287
Australia	3,724

And the world's consumption of spelter in 1913 was 1,012,700 metric tons. In Belgium, since 1856, the production has been insignificant, but a considerable amount of ore is smelted there.

Probably the most successful electric method of smelting zinc ore is the De Laval process, which has been employed in Sweden. In this case the roasted ores are mixed with coal and a flux and smelted in an arc furnace. The product contains zinc, lead and other metals, and has to be refined by distillation. About half the cost of smelting is for electric energy, so that cheap electric power is essential for the process. In the Snyder process, as applied to zinc-lead ores, the ore is roasted to oxide and fluxes are added, so that the mixture will melt at about 1,000°C. This is then treated in an electric furnace, and results in the collection of lead, which falls below the slag and zinc oxide, which volatilises and is condensed in brick chambers. Electric smelting of zinc has not come into general use. Regarding the commercial spelter, the chief impurities are lead, iron, cadmium and arsenic. If the spelter is used for galvanising, lead causes it to peel badly, and if over 7 per cent. it causes brass castings to crack. Iron renders spelter hard and brittle, and cadmium is objectionable, as in brass it acts like lead. Arsenic is only objectionable when the spelter is being used to form hydrogen for use in lead burning, in which case it is impossible when arsenic is present to burn a strong seam. Regarding the uses of zinc, there is, of course, galvanising, and the process called "sherardising." In the latter case volatile zinc enters into combination with the iron surface, giving a protective coating. Another use is in the desilverisation of lead, chiefly by the Parkes process. Finally it is used to extract gold by the cyanide process. Here 5 oz. to 1 lb. of zinc is used for each ounce of gold recovered. In South Africa the consumption of zinc for this purpose amounted to 4,867 tons in 1914. Zinc pigments, of which the most widely used are zinc white and lithopone, others being of less importance. Lithopone is used as a pigment and filler for rubber goods. It is a mixture of barium and zinc sulphates, with 0·5 to 1 per cent. of magnesia. In the United States 29,685 short tons (2,000 lb.) of this material were produced in 1913.

THOMSON METERS AND THEIR MAINTENANCE.*

This meter is well known. A field winding traversed by the metered current and the armature through a commutator and brushes are supplied with a small current from a high resistance across the mains. Any sparking resulting from imperfect contact between the brushes and commutator will occur under the full voltage and, therefore, will be destructive. Risk of damage must not be incurred by running with too light a pressure on the brushes.



THOMSON METER.

A fine wire auxiliary winding to compensate brush friction is connected in series with the armature, but by this means constant compensating torque cannot be provided (5 per cent. voltage increase raises the compounding torque 10 per cent.), and, since approximate compensation is possible merely by this means, the total frictional torque should be as low as possible. The figure shows that a non-compounded watt-hour meter only starts at 1/75-1/50 load, and is inaccurate at low loads, so that the use of oscillating brush gear is advantageous, because by its aid the error curve may be improved, as shown by the dotted line.

The greatest defect of direct-current watt-hour meters is the influence on their accuracy of the earth's magnetic field. This is the less felt the stronger the field of the current winding, but even the best instruments of this type are subject to +4-6 per cent. error at 1/20 load, according to their orientation. Therefore a Thomson meter, accurately adjusted in the workshop, may give incorrect results in service. Simple "control" tests *in situ* are advisable, and persons working this type of meter must reckon with the possible sources of error and must pay special attention to the effect of the earth's field.

Temperature changes also affect the accuracy of these meters, the resistance in series with the armature being generally of constant resistance metal and the braking disc being of copper or aluminium, the meter runs fast with rise in temperature.

Standard types of Thomson meters are independent of voltage and frequency changes when used in alternating-current circuits, but the practical advantages of induction meters are such that the latter type is generally used in alternating-current work.

Thomson meters should be cleaned and tested thrice a year for starting load, and a complete test up to nearly full load should be carried out yearly with a portable resistance frame and standard wattmeter.

* Abstract from the "Schweiz Elekt. Verein Bul."

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential and a World-wide circulation.** *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d.; Canada and India, 2s.; Australasia and South Africa, 3s.; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.
WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preparation.*
THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.
THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*
PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*
SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson, M.I.E.E. *New Edition in preparation.*
THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.
CARBON MAKING FOR ALL ELECTRICAL PURPOSES. By Francis Jehl. Price 10s. 6d.
"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Down, Wh.Ex. & M.I.Mech.E. Price 2s. 6d. nett.
THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C.E., M.I.M.E., &c. Price 5s. nett.
INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 8d. nett.
INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.
ELECTRICITY METERS: THEIR CONSTRUCTION AND MANAGEMENT. By C. H. W. Gerhardt. Profusely illustrated. Price 9s. nett. [Price 10s. 6d.
MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.,
SIGNALLING ACROSS SPACE WITHOUT WIRES: THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.
BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By G. M. Baines. Price 7s. 6d. nett.
THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. 2s. 6d. nett, post free 2s. 9d.
THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone. 9s. nett, post free 9s. 4d.
STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett
ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S. Heather, M.I.E.E. 9s. nett.
AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Alfrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.
THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.
WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.
ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.
LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.

Now Ready.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s.** nett, post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.
Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s.; post free, 2s. 4d.

THE ANOMALOUS POSITION OF THE SKILLED MUNITION WORKER.

Not without reason there has been a good deal of discussion with reference to the high wages that are being paid to unskilled munition workers in various parts of the country. The idea that such workers are being overpaid is so deeply rooted in the public mind that it is well to direct attention to an anomaly in connection with the employment of skilled men such as foremen, charge hands and time workers in munition factories. By so doing it is possible that our readers will look at the matter in a different light to that in which many of the men we have in mind appear to be "slackers." In our opinion so sound is the men's argument and so genuine their grievance that it is a matter for surprise that decisive action has not been taken ere this by the Ministry of Munitions, in order to make more equitable the conditions under which the skilled worker follows his employment.

In order to make our meaning clear we will take the case of a youth of 19 years of age, who is classed in the works register as semi-skilled. Let us suppose that he works a milling machine, and that he is employed on repetition work of a kind which calls for no special skill in its execution. Such a youth can, and often does, earn as much as £6 per week, and beyond his mere keep he has no other expenses. He is, therefore, able to save about £4. 10s. per week. In order to make the tools, jigs and gauges to enable this semi-skilled youth—who need not be an engineering artisan—to follow his employment the part-time services of several highly-skilled engineering artisans are necessary. From the nature of the job it is imperative that the latter should be employed on time work, and that they should be experts in their particular line. The work on which they are engaged imperatively demands a training extending over many years. Such men are getting on towards middle age, the average age being nearer 40 than 30 years; they have families to maintain and a certain degree of respectability to uphold. Notwithstanding their financial obligations and their skill as craftsmen they find themselves faced with the rising prices of commodities and a weekly wage half that received by the unskilled youth engaged on piece-work, and whose work, as we have said, depends absolutely upon their labour.

It might be argued that such skilled men can engage upon the work which the unskilled find so profitable, but a moment's thought will show such argument to be erroneous. The skilled men are indispensable to their employer, for without them the production of munitions would automatically come to an end. It follows, therefore, that the skilled men—the *bona fide* engineering artisans—must of necessity keep to their jobs. Nor is it possible for them to seek employment in other works where higher prices are paid for the work to which they are accustomed. Should they endeavour to do so their employers have the right to prosecute, and the magistrates invariably decide, and, in our opinion, in the majority of cases, rightly decide, in favour of the employer, because it must be remembered that these men are *really indispensable* in the munition factory.

Equally unenviable is the lot of a group of skilled workmen supplying tools to another group of skilled men. Take the case of the diemaker and the smith. If the latter be employed on repetition work he is usually put on piece-work. The diemaker is invariably paid a fixed sum per hour, and his work calls for the highest skill. It may,

and often does, happen that the smith's labourer earns more, and in some cases considerably more, than the highly-skilled and indispensable diemaker, although it would be impossible for the smith to do his work economically were it not for the tools and dies supplied by the diemaker.

Of even greater hardship is the case of the leading hand. Men of this kind are selected partly on account of special ability in their several callings, and partly on account of their ability to control men. They are not of mushroom growth. With the advent of women into munition works it may, and does, happen that a woman, after a training extending over a period of three weeks to a month, can command more on piece-work than the leading hand can command on time-work. It must not be forgotten that the leading hand is able and willing to engage on piece-work, but he is prevented from so doing on the ground of indispensability.

Of much the same kind is the case of the foreman and the semi-skilled artisan. The foreman, on account of his being foreman, knows his work, is able to control men, and is invariably a good timekeeper. Were it otherwise he would not be a foreman. Nevertheless, and notwithstanding his qualifications, he finds himself in receipt of a wage which may be one-third or thereabouts of that earned by one of the semi-skilled men under him. Such examples as these give one some idea of the patriotism of these men and of the true meaning of the removal, for the time being, of trade union regulations and restrictions. But we are strongly of opinion that the patriotism of a desirable section of the community should not be exploited by others for purposes of profit, and we look to the Minister of Munitions to put the skilled men in munition works on a more equitable footing.

REVIEWS.

Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

Elementary Applied Mechanics. By T. ALEXANDER and A. W. THOMSON. (London: Macmillan & Co.) Pp. xx.+512. 15s. net.

This book, dedicated to the memory of Rankine, is now in its third edition, and is deservedly included in the Dublin University Press Series. The scope is set out in the Preface, from which we take the following extract: "The work forms an elementary consecutive treatise on the subject of internal stress and strain, based on the late Prof. Rankine's treatment of the subject. . . . The end kept in view is the scientific and practical design of earthworks, of linkwork structures and of blockwork structures. . . . At every point graphical methods are combined with the analytical, and a feature of the work is that the diagrams are to scale, and, besides illustrating the text, each diagram suits some of the numerical examples."

From the title it must not be inferred that the book is suitable for beginners. It is elementary in the sense that it deals with difficult branches of the subject from fundamental principles. Students who are properly grounded, say, those who are taking a three-year course at an engineering college, will take a delight in reading the book, which covers in a scholarly manner a few of the many subjects that are classed under the heading of Applied Mechanics.

The first two chapters are introductory. They deal with lineal stress and strain, and with simple and compound internal stress and strain. Those who have experienced difficulty in getting clear ideas on the important subject of compound stress will find this book helpful. In reading Chapter II. it occurs to us that many authors of smaller works have followed the lines laid down more than 30 years ago by these old pupils of Rankine. Chapters III. and IV. are devoted to the application of the ellipse of stress to the stability of earthwork, and to the scientific design of masonry retaining walls. In some respects it is to be regretted that the authors have not dealt with reinforced concrete walls, as these are playing an increasingly important part in the works of the civil engineer, but their masterly treatment of the masonry wall leaves little to be said on the theorems which they investigate.

The next 14 chapters, namely, Chapters V. to XVIII., deal with the problems entering into the design of members subjected to bending, and the many examples are well chosen. Of particular merit are the sections dealing with rolling loads. A little more information on the drawing-office side of design would help to strengthen these chapters. As they stand, however, they are particularly good on the purely theoretical side, and it may be that the authors recognise that there are already several important books on structural design. The same remark applies to Chapters XIX. to XXI., which deal respectively with the design of long steel struts, the steel arched girder and the analysis of trianguiar trussing. The arched girder is treated by Lévy's graphical methods, and the two numerical examples, worked out in detail, which serve to illustrate the section add materially to the value of the chapter. The essay on "Triangular Trussing" follows the analytical method devised by Lévy, and will be read with interest by those who are in search of information on a subject about which little has been written.

Chapter XXII. deals with the scientific design of masonry arches. The authors develop in this chapter the method of conjugate load areas to the equilibrium of arches. A semi-graphical method of constructing the load areas is given, and this is applied to the design of segmental, semi-circular and semi-elliptic arches. A discussion of the method of reciprocal figures brings the treatise to a close. The book will go a long way towards keeping alive the work of a man who laboured for many years with the object of introducing scientific methods into the solution of engineering problems, and whose writings have had a profound effect on the works of the engineer.

THE AIR-GAP FIELD OF THE POLYPHASE INDUCTION MOTOR.

BY F. T. CHAPMAN, D.SC.

(*Continued from page* 667.)

SUMMARY OF CONTENTS.

I.—INTRODUCTION.
II.—THE FIELD PRODUCED BY STATOR OR ROTOR WINDINGS ACTING ALONE, THE PERMEABILITY BEING CONSTANT.
Sections 1 to 6.—Analysis of magnetic field due to polyphase currents in stationary windings.
Section 7.—The E.M.F. induced by any component field in a stationary winding.
Section 8.—The E.M.F. induced by any component field in a moving winding.
Sections 9 to 13.—The E.M.F. in a stationary winding due to all the fields acting collectively. The inductance of any winding due to the air-gap fluxes.
Section 14.—Analysis of field due to sine-distributed currents in a squirrel-cage winding.
Section 15.—The inductance of a squirrel-cage winding.
III.—THE REACTION OF ROTOR CURRENTS ON STATOR FIELD (PERMEABILITY CONSTANT).
Sections 16 to 18.—Analysis of field due to rotor currents. E.M.F.s induced by these fields in stator windings.
Sections 19 and 20.—The circle diagram, circle coefficient and air-gap dispersion.
Sections 21 and 22.—Superposition of rotor multiple fields on those of stator. The effects in the case of two- or three-phase rotors and of squirrel-cage rotors.
Sections 23 and 24.—"Crawling." Effects of skewed slots.
IV.—THE EFFECTS OF MAGNETIC SATURATION.
Section 25.—The saturation curve. Fundamental and third harmonic of time-flux wave.
Sections 26 to 28.—Effect of saturation on multiple fields.
Section 29.—Effect of saturation on air-gap dispersion.
Section 30.—Calculation of no-load current.
Section 31.—The actual form of the current locus.
V.—OSCILLOGRAMS ILLUSTRATING PARTS II., III. AND IV.
VI.—CONCLUSION AND TABLE OF AIR-GAP DISPERSION COEFFICIENTS.

TWO-PHASE WINDINGS.

(*a*) *Full Pitch.*—Fig. 4 represents the distribution of the field produced by one phase of such a winding. The number of conductors per slot is $2T/Pm$. If the instantaneous value of the current is i the maximum density is

$$F_1=\frac{iT}{p}\,.\,P, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

and this density is maintained at each pole over a surface equal to $\frac{m+1}{2m} \cdot l\tau$. The total flux per pole in this central portion is $\frac{iT\mathrm{P}l\tau}{p} \cdot \frac{m+1}{2m}$, which links itself in part with $2T/p$ conductors on one side, and for the remainder with $2T/p$ conductors on the other side of it. The total number of line-linkages due to this portion of the fluxes for all the poles is

$$\frac{iT\mathrm{P}l\tau}{p} \cdot \frac{m+1}{2m} \cdot \frac{2T}{p} \cdot \frac{p}{2} = \frac{iT^2\mathrm{P}l\tau}{p} \cdot \frac{m+1}{2m} \quad . \quad . \quad . \quad . \quad . \quad (15)$$

The density opposite the two teeth adjacent to this central portion is

$$F_2 = \frac{iT\mathrm{P}}{p} \cdot \frac{m-2}{m},$$

the flux carried by the two teeth together is

$$\frac{iT\mathrm{P}}{p} \cdot \frac{m-2}{m} \cdot \frac{l\tau}{2m} \cdot 2,$$

and each line of this flux encloses $\frac{T}{p} \cdot \frac{m-2}{m}$ conductors.

These fluxes and those corresponding to them in the remaining poles contribute altogether

$$\frac{iT^2\mathrm{P}l\tau}{p} \cdot \frac{(m-2)^2}{m^3} \text{ line-linkages.} \quad . \quad . \quad . \quad (16)$$

Similarly the next pair of teeth contributes

$$\frac{iT^2\mathrm{P}l\tau}{p} \cdot \frac{(m-4)^2}{m^3} \text{ line-linkages} \quad . \quad . \quad . \quad (17)$$

The total number of linkages in the complete winding is obtained by adding expression (15) to (16), (17), and the remaining corresponding quantities. Thus we obtain

$$L' = \frac{iT^2\mathrm{P}l\tau}{p} \times 10^{-8} \left[\frac{m+1}{2m} + \frac{1}{m^3} \{(m-2)^2 + (m-4)^2 + \ldots .\} \right].$$

The number of terms in the series in brackets $\{\}$ depends on whether m is odd or even; the last term is $(1)^2$ if m is odd or

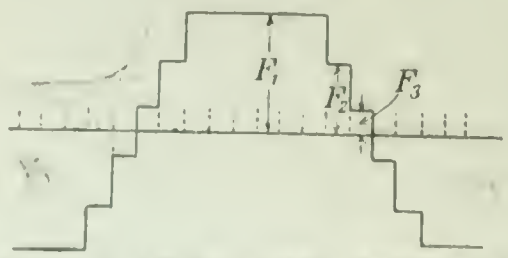


Fig. 4.—Distribution of Field due to One-phase of a Two-phase Winding with Five Slots per Pole per Phase.

$(2)^2$ if m is even. The series reduces conveniently, and we thus get for a full span two-phase winding

$$Q = 0{\cdot}5 + \frac{1}{2m} + \frac{1}{m^3} \{(m-2)^2 + (m-4)^2 + \ldots .\} - \frac{2}{3} + \frac{1}{3m^2}$$

For example, in a two phase machine with 10 slots per pole,

$$Q = \frac{2}{3} + \frac{1}{75} = 0{\cdot}68.$$

(*b*) *Fractional Pitch.*—In the case of a machine with a fractional pitch winding a similar process to the above shows the value of Q to be

$$Q = 0{\cdot}667 + \frac{2m - 3mb^2 + b^3 - b}{6m^3} \quad . \quad . \quad . \quad (19)$$

This formula may be regarded as the general form, the previous one (18) representing the special case of $b = 0$.

11. Three Phase Windings.—In a three-phase machine the linkages in any one phase are due in part to the fluxes produced by the current flowing in that phase, and in part to the fluxes arising from the currents in the other two phases.

Employing the methods of the last section we find the self-produced linkages per phase to be

$$\frac{iT^2\mathrm{P}l\tau}{p} \cdot \frac{1}{3m^3}[m^2(2m-b+1) + 2\{(m-1)^2 + (m-2)^2 \ldots \ldots \ldots$$
$$b \text{ terms, or to } (1)^2,$$
$$+ (m-b-2)^2 + (m-b-4)^2 \ldots \text{ to } (2)^2 \text{ or } (1)^2\}]$$
$$= \frac{iT^2\mathrm{P}l\tau}{p}\left[\frac{7}{9} + \frac{2m - 3mb^2 + b^3 - b}{9m^3}\right] \quad . \quad . \quad . \quad ; \quad (20)$$

the number of linkages which each phase produces in the others is

$$\frac{iT^2\mathrm{P}l\tau}{p} \cdot \frac{1}{3m^3}\left[m^3 + \frac{mb}{2} - \frac{mb^2}{2} + \{(m-1)(b-1) + (m-2)(b-2)\right.$$
$$\left. + \ldots (b-1) \text{ terms}\}\right]$$
$$= \frac{iT^2\mathrm{P}l\tau}{p}\left[\frac{1}{3} - \frac{b^3 - b}{18m^3}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

In Fig. 4A the vectors OA, OB and OC represent respectively the self-produced linkages in one phase, and the linkages due to the other two phases. The resultant of OB and OC is an equal vector in phase with OA. The total inductance per phase is thus obtained by adding together (20) and (21). The complete value of Q is therefore

$$Q = 1 + \frac{1}{3m^3}\left[m^2 - mb\left(m - \frac{1}{2} + \frac{b}{2}\right) + 2\{(m-1)^2 + (m-2)^2 + \ldots .\right.$$
$$b \text{ terms or to } (1)^2$$
$$+ (m-b-2)^2 + (m-b-4)^2 + \ldots \text{ to } (2)^2 \text{ or } (1)^2$$
$$\left. + \{(m-1)(b-1) + (m-2)(b-2) + \ldots (b-1) \text{ terms}\}\right]$$

or

$$Q = \frac{10}{9} + \frac{4m - 6mb^2 + b^3 - b}{18m^3}, \quad . \quad . \quad . \quad . \quad (22)$$

when $b = 0$ this becomes $Q = \frac{10}{9} + \frac{2}{9m^2}$. . . . . (22A)

12. When slot openings are to be taken into account the value to be taken for P is the mean permeance (*see* section 2),

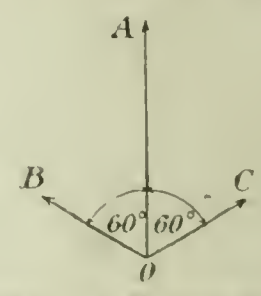


Fig. 4A.—E.M.F.s of Self and Mutual Induction in Three-phase Windings.

for although all the multiple fields are magnified by the presence of the slots some of them are reversed in sign, as we have already noticed, and their combined effect is the same as for a smooth surface stator with the same permeance.

13. Rotor windings with two or three phases may be treated just as easily as stator windings by the foregoing methods with respect both to their total inductance and to the analysis of their fields.

The case of the squirrel-cage winding (though this is only a special form of polyphase winding) deserves separate treatment, and we shall now analyse the field produced and find the value of the total inductance per conductor when sine-shaped currents of polyphase character flow in the conductors.

14. Let the number of the rotor conductors be G, and let a sine-shaped current of amplitude I_G flow in each bar, the phase difference between the currents in successive bars being $\pi p_1 / G$. Such currents would be induced by movement of the rotor in an external field of p_1 poles.

The currents in successive conductors may be represented by equal vectors separated by equal angles, each of which equals $\pi p_1 / G$. The maximum value of the flux issuing from any one tooth is obviously the same as for all the rest—the tooth fluxes

differ only in phase; and, since we may regard the cores of stator and rotor as being at zero magnetic potential, the M.M.F. acting on any line of force passing from one core to the other *via* the teeth and air-gap, has the same maximum value for each of the rotor teeth. If this M.M.F. be expressed in ampere-turns, the difference at any instant between the M.M.F. acting on the lines of force issuing from one tooth, and the M.M.F. acting on those issuing from the next tooth, is equal to the instantaneous value of the current in the interposed conductor. Hence, if the M.M.F. acting at any one tooth is represented by the vector OA in Fig. 5, and that acting at the next tooth by OB, the vector AB will represent the current in the conductor between these two teeth. The vectors corresponding to the other teeth will be obtained by drawing the current polygon and drawing lines from O to the successive corners.

In general, the current polygon will be a re-entrant figure, and if G is not divisible by $p_1/2$ it will finally close itself after $p_1/2$ revolutions. The polygon is equilateral and equiangular, so that the circumscribing circle passes through all its corners. Fig. 5 shows the polygon for a four-pole case with $G=15$. Since the vectors OA, OB, &c., are all equal, the point O must be the centre of the circumscribing circle, and the lengths of the vectors are equal to the radius of it—*i.e.*,

$$\frac{I_G}{2\sin(\pi p_1/2G)}.$$

The permeance of the path on which this M.M.F. acts is

$$\frac{p_1\tau_1 l\mathrm{P}}{G}$$

($p_1\tau_1$ being equal to the circumference $=p\tau$), and the maximum flux per tooth is therefore

$$\varphi_T=\frac{I_G}{2\sin(\pi p_1/2G)}\cdot\frac{p_1 l\tau_1\mathrm{P}}{G}, \quad . \quad . \quad . \quad (23)$$

while the maximum flux density is

$$y_{nM}=\frac{I_G}{2\sin(\pi p_1/2G)}\cdot\mathrm{P}. \quad . \quad . \quad . \quad . \quad (24)$$

We next proceed to analyse the field thus produced into its harmonics and multiples.

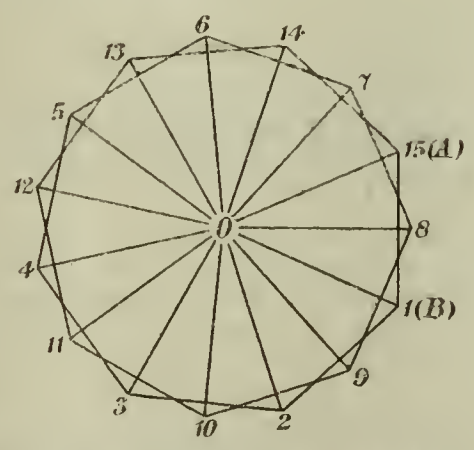


Fig. 5.—M.M.F. Diagram for Squirrel-cage Winding with Sine Distributed Currents. 15 Slots, 4 Poles.

Let the rotor teeth be numbered 1, 2, 3, &c., up to G, the numbers increasing in the direction of motion of the impressed field with respect to the rotor, and let the current in the conductor preceding tooth No. 1 be $I_G\sin 2\pi f_s t$, where f_s is the frequency of the rotor currents. The flux density opposite teeth Nos. 1, 2, . . . n . . . will be

$$y_1=y_M\cos\left(2\pi f_s t-\frac{\pi p_1}{2G}\right),$$

$$y_2=y_M\cos\left(2\pi f_s t-\frac{3\pi p_1}{2G}\right),$$

.....

$$y_n=y_M\cos\left(2\pi f_s t-\frac{2n-1}{2G}\cdot\pi p_1\right).$$

.....

The distribution of the flux-density in the air-gap at any instant will be somewhat of the form shown in Fig. 6, which refers to the same conditions as Fig. 5. We will take our origin between the Gth tooth and the first, and denote by θ the distance of any point on the rotor circumference from this origin; the length of the circumference will be $p_1\pi$ radians. If we write y for the instantaneous density at any point, θ, we have as the amplitude of the sine component of the cth harmonic of the density curve at any instant

$$S=\frac{2}{p_1\pi}\int_0^{p_1\pi} y\sin c\theta\, d\theta,$$

and for the amplitude of the cosine component of the same,

$$C=\frac{2}{\pi p_1}\int_0^{\pi p_1} y\cos c\theta\, d\theta.$$

Substituting for y we obtain for S

$$\begin{aligned}S=\frac{2}{\pi p_1}\Bigg[&\int_0^{\frac{\pi p_1}{G}} y_M\cos\left(2\pi f_s t-\frac{\pi p_1}{2G}\right)\sin c\theta\, d\theta\\&+\int_{\frac{\pi p_1}{G}}^{\frac{2\pi p_1}{G}} y_M\cos\left(2\pi f_s t-\frac{3\pi p_1}{2G}\right)\sin c\theta\, d\theta\\&+\ldots\ldots\ldots\\&+\int_{\frac{(n-1)\pi p_1}{G}}^{\frac{n\pi p_1}{G}} y_M\cos\left(2\pi f_s t-\frac{2n-1}{2G}\cdot\pi p_1\right)\sin c\theta\, d\theta\\&+\ldots\text{ to }G\text{ terms},\end{aligned} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

which reduces to

$$\begin{aligned}S=\frac{2y_M\sin\frac{c\pi p_1}{2G}}{c\pi p_1}\Bigg[&\sin\left\{2\pi f_s t+\frac{(G-1)(c-1)}{2G}\cdot\pi p_1\right\}\cdot\frac{\sin\frac{c-1}{2}\pi p_1}{\sin\frac{c-1}{2G}\pi p_1}\\&-\sin\left\{2\pi f_s t-\frac{(G-1)(c+1)}{2G}\pi p_1\right\}\cdot\frac{\sin\frac{c+1}{2}\pi p_1}{\sin\frac{c+1}{2G}\pi p_1}\Bigg].\end{aligned} \quad (26)$$

Now, G is a whole number and c is an odd number; hence, by

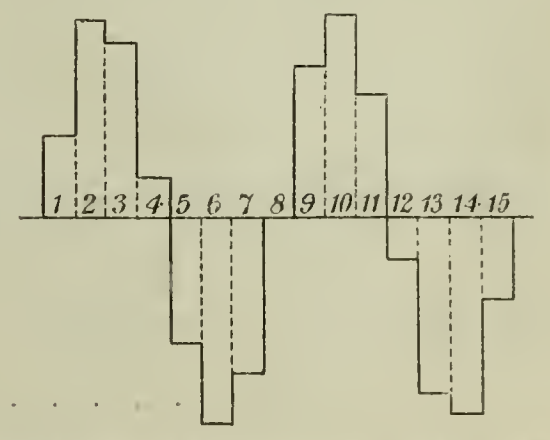


Fig. 6.—Distribution of Magnetic Field due to Sine Distributed Currents in 15-Slot Squirrel-cage Winding—4 Poles.

comparing this equation with equation (4) we see that it reduces to

$$S=\frac{2y_M G\sin\frac{c\pi p_1}{2G}}{c\pi p_1}[\sin 2\pi f_s t],$$ if $p_1(c-1)$ is a positive multiple of $2G$, and to

$$S=\frac{2y_M G\sin\frac{c\pi p_1}{2G}}{c\pi p_1}[-\sin 2\pi f_s t]$$ if $p_1(c+1)$ is a positive multiple of $2G$.

By the same process we find

$$C=\frac{2y_M G\sin\frac{c\pi p_1}{2G}}{c\pi p_1}[\cos 2\pi f_s t]$$ if either $(c-1)$ or $(c+1)$ is a positive multiple of $2G/p_1$.

The density at any point in the air-gap due to the cth harmonic field at any instant is

$$y_{cG}=S\sin c\theta+C\cos c\theta,$$

or if we write $\frac{\pi x'}{\tau_1}$ for θ we have

$$y_{cG}=S\sin\frac{c\pi x'}{\tau_1}+C\cos\frac{c\pi x'}{\tau_1}.$$

Substituting for S and C we obtain

$$y_{cG}=\frac{2y_M G\sin\frac{c\pi p_1}{2G}}{c\pi p_1}\left[\sin 2\pi f_s t\,.\,\sin\frac{c\pi x'}{\tau_1}+\cos 2\pi f_s t\cos\frac{c\pi x'}{\tau_1}\right.$$

$$\left.\text{or}-\sin 2\pi f_s t\,.\,\sin\frac{c\pi x'}{\tau_1}+\cos 2\pi f_s t\,.\,\cos\frac{c\pi x'}{\tau_1}\right]$$

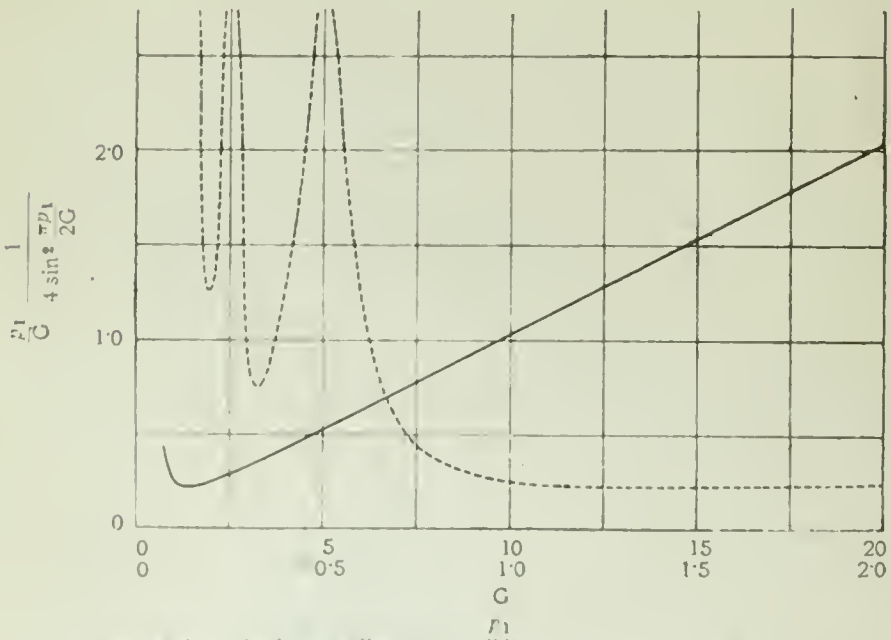
$$=\frac{2y_M G\sin\frac{c\pi p_1}{2G}}{c\pi p_1}\left[\cos\left(2\pi f_s t-\frac{c\pi x'}{\tau_1}\right),\text{ or }\cos\left(2\pi f_s t+\frac{c\pi x'}{\tau_1}\right)\right]. \quad (27)$$

In the same way as before we may write

$$\mathbf{c}=\frac{2\mathbf{G}d}{\mathbf{p}_1}+1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

where d is any positive or negative integer

$$\mathbf{y}_{cG}=\frac{2\,\mathbf{y}_M\,\mathbf{G}\sin(\mathbf{c}\pi\mathbf{p}_1/2\mathbf{G})}{\mathbf{c}\pi\mathbf{p}_1}\,.\,\cos\left(2\pi\mathbf{f}_s\mathbf{t}-\frac{\mathbf{c}\pi\mathbf{x}'}{\tau_1}\right) \quad (29)$$



The upper scale of abscissæ applies to the full line curve which is drawn to scale.
The lower „ „ „ „ dotted „ „ approximate only.

Fig. 7.

velocity of cth multiple field with respect to rotor

$$\mathbf{v}_{cG}=\frac{2\mathbf{f}_s\tau_1}{\mathbf{c}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

If we substitute in (29) the value of y_M given in (24) we obtain

$$y_{cG}=\frac{I_G PG\sin(c\pi p_1/2G)}{c\pi p_1\sin(\pi p_1/2G)}\,.\,\cos\left(2\pi f_s t-\frac{c\pi x'}{\tau_1}\right). \quad . \quad . \quad (31)$$

It will be clear that if the current in the slot at the origin had been $I_G\sin(2\pi f_s t-\varphi)$, instead of $I_G\sin 2\pi f_s t$, equation (31) would have been

$$y_{cG}=\frac{I_G PG\sin(c\pi p_1/2G)}{c\pi p_1\,.\,\sin(\pi p_1/2G)}\,.\,\cos\left(2\pi f_s t-\varphi-\frac{c\pi x'}{\tau_1}\right). \quad (32)$$

In ordinary squirrel-cage windings the possible values of c form a very limited series, as an example will show.

Suppose $p_1=4$, $G=11$. By equation (28)

$$c=\begin{cases}1, & 21{\cdot}5, & 42, & 62{\cdot}5, & \&c.\\ -19{\cdot}5, & -40, & -60{\cdot}5, & \&c.\end{cases}$$

The number of poles in the corresponding multiple fields are

$$p_1c=\begin{cases}1, & 86, & 168, & 250, & \&c.\\ 78, & 160, & 242, & \&c.\end{cases}$$

None of these fields except the first is of any importance. If we take as the impressed field the fifth multiple stator field—*i.e.*, $p_1=20$—the series for p_1c becomes

$$p_1c=\begin{cases}20, & 102, & 184, & \&c.\\ & 62, & 144, & \&c.\end{cases}$$

In such a case the higher multiple fields are more important with respect to the lowest than when p_1 has a smaller value.

15. The maximum number of lines which link themselves with a conductor is the same for every conductor. At any instant the difference between the number linking any one conductor and the number linking its neighbour is equal to the number issuing from the intervening tooth, hence the vector difference between the two linkages is the vector of the tooth flux. If, then, we build up a vector polygon with sides equal to the flux per tooth, lines drawn from the centre of the circumscribing circle to successive corners of the polygon will be the vectors of the linkages in successive conductors. The length of these vectors is obviously

$$\frac{?_T}{2\sin(\pi p_1/2G)}\text{ or }\frac{I}{4\sin^2(\pi p_1/2G)}\,.\,\frac{p_1 l\tau_1 \mathrm{P}}{G}.$$

The inductance per bar is, therefore,

$$l\tau_1\mathrm{P}\left[\frac{p_1}{G}\,.\,\frac{1}{4\sin^2(\pi p_1/2G)}\right]\times 10^{-8}\text{ henry.} \quad . \quad (33)$$

The value of the factor in square brackets is given in Table III. below for various values of G/p_1, and its relation to G/p_1 is shown by the curves of Fig. 7.

Table III.

$\frac{G}{p_1}$	$\left[\frac{p_1}{G}\,.\,\frac{1}{4\sin^2(\pi p_1/2G)}\right]$	$\frac{G}{p_1}$	$\left[\frac{p_1}{G}\,.\,\frac{1}{4\sin^2(\pi p_1/2G)}\right]$
20·0	2·028	1·5	0·222
15·0	1·527	1·0	0·250
10·0	1·022	0·75	0·445
5·0	0·523	0·5	∞
4·0	0·427	0·4	1·25
3·0	0·333	0·25	∞
2·5	0·290	0·2	1·25
2·0	0·250		

(To be continued.)

A SENSITIVE MAGNETOMETER.*

BY P. E. SHAW, B.A., D.SC., AND C. HAYES, B.SC.

In a research recently published by one of us there is a description of a torsion balance of special delicacy for gravitation research. A diagrammatic representation of this apparatus is shown in Fig. 1. A fibre, *FF*, 600 mm. long, 15μ diameter, carries a beam, *B*, 35 mm. long, from the ends of which are hung, by fine wires of length 150 mm. and 350 mm. respectively, two small spheres of silver, each weighing about 3 gm. This torsion system is hung in a low vacuum of about 15 mm. pressure. The movements of the torsion beam, carrying a mirror which reflects a distant scale, are observed through the window *W* by a powerful telescope distant about 4½ metres. The vacuum tube *T* is wrapped by several layers of cotton-wool, and this latter is surrounded by a helix of lead "compo" tubing. The cylindrical envelope *C* encloses the cotton-wool and tubing, and all the vacuum tube except the extreme upper portion. The lead helix contains cold water. Further details of this apparatus are given in the Paper quoted.

In the course of the research mentioned it was necessary to heat the vacuum tube. This was attained by the passage of a current through a coil of wire wrapped on the outside of the vacuum tube. It was found later that on account of the field thus produced the silver spheres had become permanently but weakly magnetised with vertical axes.

After searching for authorities on the subject of the susceptibility of the less magnetisable elements, the work of Honda† was taken to be the best on silver up to date. The method employed by Honda was to place a small quantity of the silver in a capsule carried by a torsion beam and to observe the couple produced on the beam when

* Abstract of a Paper read before the Physical Society.

† "Ann. der Physik.," XXXII., pp. 1027 1063.

a very powerful field was applied by an electro-magnet near the capsule. He then deduced that the susceptibility of silver is $K=-2\times10^{-6}$ c.g.s.

In order to observe the effects of a field on our suspended silver spheres, we brought up a solenoid, *ZZ*, of length 38·5 cm., outside diameter 10·8 cm. and having 528 turns of about 16 S.W.G. copper wire, close to the vacuum tube, opposite to the upper sphere *S*, so that the axis of the solenoid was horizontal, and passed through the centre of the sphere. On passing currents through the solenoid and an ammeter, the field developed at the sphere was varied from 1·3 gauss to 12·0 gauss. The silver sphere being in a divergent field, was urged along the axis of the solenoid and a scale deflection was read by the telescope. As silver is diamagnetic we expected that the sphere would be repelled. But, on the contrary, there was an attraction to the solenoid. Thus, there must be, apparently, sufficient iron impurity present to give it a preponderating effect over the diamagnetic silver.

Supposing silver and iron to act independently of one another in a magnetic field, the proportion of iron to silver in one sphere must exceed the ratio of 1 to 80,000,000. But we have no authority for supposing that this principle of proportionality holds good. The experimental evidence is, in fact, that the iron loses some or all of its magnetic power when melted into other metals. To quote two examples of this principle :—

1. A certain alloy of iron and nickel can be made, which has practically no ferromagnetic qualities. Thus each of these strongly magnetic metals loses magnetism through the presence of the other.

2. Honda found that for *very large fields* the magnetic influence of the iron impurity is never more than 50 per cent., and sometimes as little as 5 per cent., of that which it would be on the basis of proportionality.

After obtaining the above preliminary result, the current in the solenoid was varied from 2 to 9 amperes and the scale deflections noted. Next, the solenoid was moved along its axis nearer to the silver sphere, and the experiment repeated with the currents 1 to 9 amperes. The results are shown in Fig. 2. Details as to the form and use of the torsion balance will be found in the gravitation research, as quoted.

It should be observed that care was taken throughout to have the silver sphere in a cyclic state.

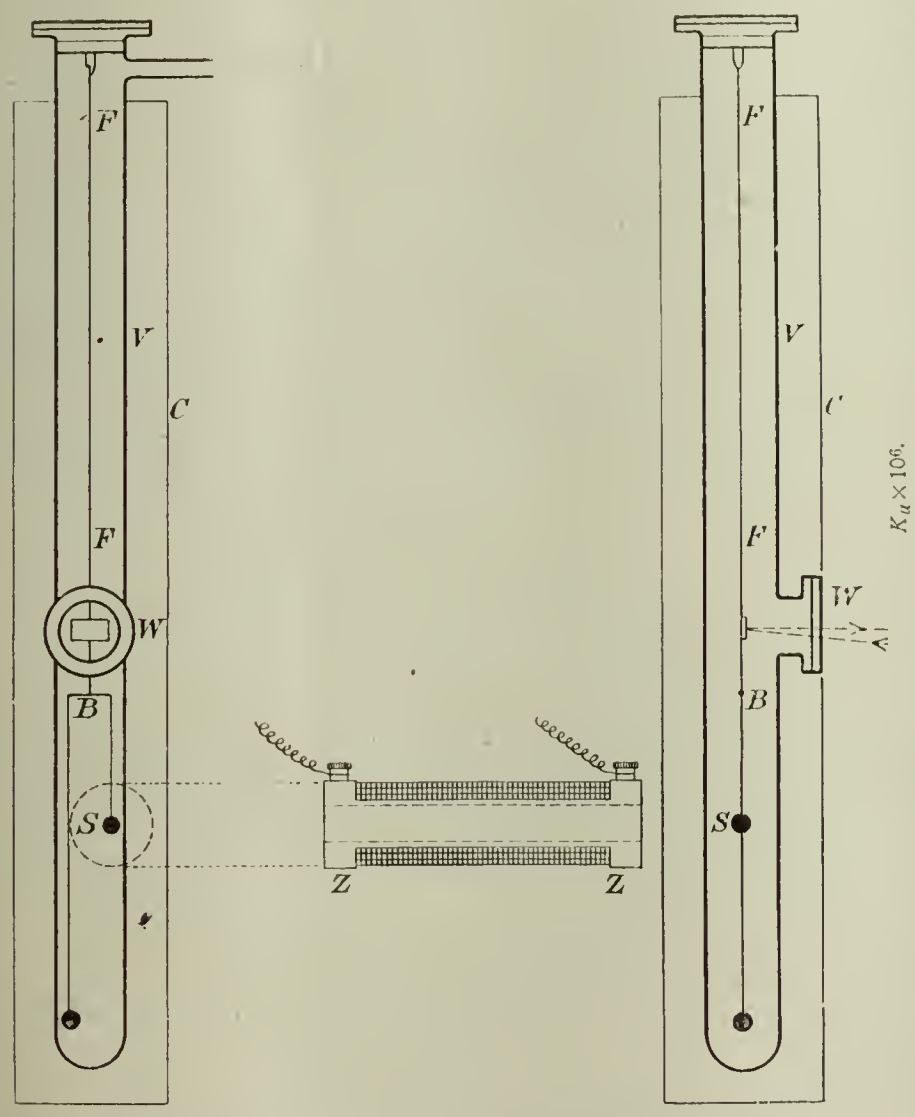


FIG. 1.—FRONT AND SIDE VIEWS OF THE MAGNETOMETER.

The axis of the solenoid is, as shown, in the first case perpendicular to the plane of the paper and in the second case in the plane of the paper.

To Find a Value for the Susceptibility of the Silver Used—

Let K=susceptibility of absolutely pure silver; K_a=susceptibility of the (impure) silver used; V=volume of the sphere; a=arm of the torsion balance; G=couple required to produce a deflection of 1 mm. on the scale. (In this apparatus G has the small value $4{\cdot}5\times10^{-7}$ dyne cm.); P=permanent magnetism (this is a magnetic moment).

Then the sphere is in a divergent field whose gradient along the axis of the solenoid is $\delta H/\delta x$; and we have then—

For a Direct Current—

Couple acting on torsion balance

$$=(VK_aH+P)\delta H/\delta x\,.\,a=G\,.\,d_1, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where d_1=scale deflection.

For a Reverse Current—

$$\text{Couple}=(VK_aH-P)\delta H/\delta x\,.\,a=G\,.\,d_2, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where d_2=scale deflection.

Whence

$$K_a=\frac{G(d_1+d_2)}{2VH\delta H/\delta x\,.\,a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The value of H is calculated from the usual expression—

$$H=2\pi ni(\cos\beta-\cos\alpha),$$

and $\delta H/\delta x$ is calculated from a graph for H/x, specially drawn for the purpose.

The results for $H-K_a^*$ are shown in Fig. 2. It will be seen that the value of K_a rises with an increasing field, and attains a maximum for a field $H=3{\cdot}0$ gauss. This is the field which gives the maximum susceptibility for pure soft iron, and we might expect that, since the value of K for iron drops rapidly as the field increases thereafter, the curves in Fig. 2 would also drop rapidly. But, in fact, the value of

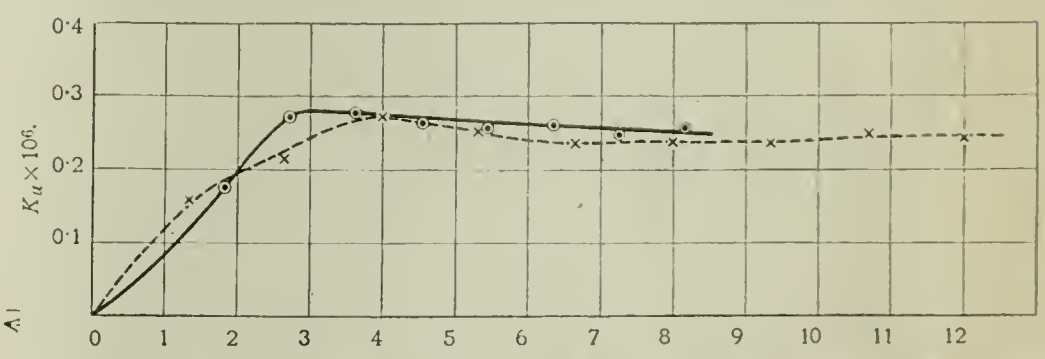


FIG. 2.—CURVE SHOWING THE RELATION OF FIELD IN GAUSSES TO APPARENT SUSCEPTIBILITY $\times10^6$.

K_a is practically constant with increasing field. This means that, at least for fields of 3·0 to 9·0 gauss, either the values of K for iron and for silver vary together, or neither of them changes. Supposing (as is generally done) that the susceptibility of *pure* silver is constant, then that for the iron impurity is also constant over this range.

The proportion of iron to silver in Honda's specimens was about 6/1,000,000 (as shown by chemical analysis). For these fields the effect was diamagnetic, *i.e.*, the silver effect preponderates over that of the iron. This again is another disproof of any simple superposition theory, as the figures for purity and susceptibility show.

For the very large fields used, Honda found a hyperbolic relation—

$$\chi=\chi_\infty+\sigma/H,$$

where χ=specific susceptibility for the silver specimen in a field H: χ_∞=specific susceptibility for an infinite field; σ=a constant, the specific intensity of magnetisation for the iron impurity.

In our experiments there is no trace of a hyperbolic relation; in which case σ, in the above expression, is not constant, but variable.

The researches of Wills and Fleming and Dewar are referred to.

The torsion balance being required for other work the authors were forced to leave the problem at this stage. It is suggested that further investigations would open up untrodden ground.

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Colour and its Application," by M. Luckiesh. (London: Constable & Co.) Pp. xii.+357. 16s. net.

"Practical Mathematics for Technical Students." Part II. By J. S. Usherwood, B.Sc., and C. J. A. Trimble. (London: Macmillan & Co.) Pp. x.+565.

"Principles of Electrical Design Direct-current and Alternating-current Generators." By A. Still. (London: Hill Publishing Co.) Pp. xiv.+364. 12s. 6d. net.

THE RATING OF INCANDESCENT LAMPS ACCORDING TO THEIR WATTS.*

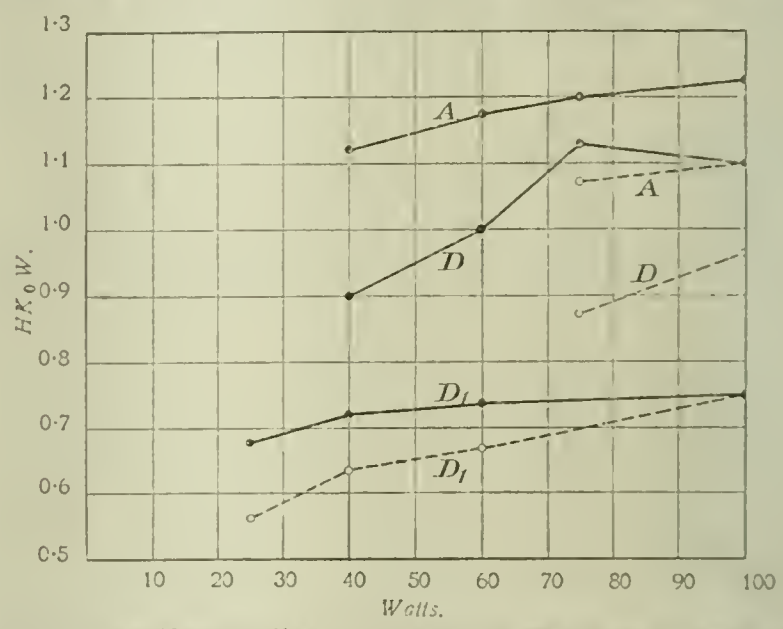
BY R. NAUJOKZ.

For some time past it has been common to find incandescent lamps rated according to their watts instead of their candle-power; the older forms of rating were said to lead to misunderstandings. In statements published by the makers it is stated that the buyer is mainly interested in the effective illumination given by a lamp, and that for this the mean spherical candle-power is the proper measure. One would, therefore, expect to find this marked on the socket of the lamp, but as a matter of fact this is not done. No information is given as to candle-power. A statement as to the watts consumed is considered sufficient. But in practice it is much easier for the buyer to determine the current taken by a lamp than to ascertain the candle-power, though the latter is the more important. An ammeter or a wattmeter, or even the bill to be paid, tell all about the current. But an examination on exact lines of the candle-power is only possible in very rare cases. The makers' lists probably give the desired information, but they very rarely reach the hands of the consumer.

The trouble would be less serious if all lamps of the same kind but of different makes had the same efficiencies. The efficiency certainly differs with the size and voltage of the lamp, but it also differs with the make, though in other respects the lamps are similar. The following figures show how great these differences may be. The values given in the appended table are taken from the price lists of four of the best makers, and these makers are denoted by the letters A, B, C and D. The list prices are the same in all cases, except for the fact that the 150-watt lamps of the firm B are about 40 per cent. cheaper than those of the other makers. If we compare the illuminations (either the mean spherical candle-power or the maximum candle-power in any direction) we find things are no longer on an equal footing. The differences between the candle-powers of lamps of the various makers amount sometimes to more than 25 per cent. They are noticeable both with low and high candle-powers, and are, generally speaking, greater with regard to the spherical candle-power than the maximum candle-power.

Naturally, this matter of candle-power is not of indifference to the buyer. A man who has five lamps of 40 watts of make D in his shop window will have the same amount of light as if he had four of make A. The difference in the cost of current may be considerable. It may be admitted that the ordinary consumer has very little idea of the value of candle-power, and that he has no knowledge of the meaning of a watt. It is probably sufficient for him to know that the candle-power means in general terms the illumination, and the number of watts is in proportion to the amount of the bill.

If this method of rating lamps is not altogether in the interest of the consumer, it can also be said that it gives the contractor a lot of trouble. The first thing he wants to know is the candle-power: the watts are of secondary interest. When lamps were rated according to candle-power things were simple; with carbon lamps or with one-watt lamps the efficiency was well known, and led to very simple calculations; but nowadays it is almost impossible to remember the efficiencies of all the different types and sizes of lamp on the market. It is no longer possible to calculate on the basis of the watts being in proportion to the size of the room to be lighted. As things now are, for each kind of lamp and for each make, the contractor requires to know the candle-power per watt, and has then to calculate the candle-power from the watts. The curves in figure show how confusing such calculations become, and how the factors vary; these curves are constructed from the stated spherical candle-powers of the lamps of the firms A and D. The curves show the spherical candle-power corresponding to the consumption of one watt for incandescent lamps, taking between 25 and 100 watts. Another set of curves, not here reproduced, shows similar results for lamps taking between 100 and 1,500 watts. The full-line curves relate to lamps taking about 130 watts, and the dotted curves to lamps taking about 250 volts. The curves marked D_1 relate to lamps which are sold under the name of spiral lamps. Now the figures which show the ratio of candle-power to watts are the factors by which the watts, as stated on the sockets, must be multiplied in order to obtain the mean spherical candle-power of the lamp. As can be seen at a glance, this ratio varies by 120 per cent. for lamps between 25 and 100 watts; for lamps between 100 and 1,500 watts it varies by 85 per cent. The contractor, therefore, does well to confine his estimates to the assumption that lamps of some particular maker are used. His figures would be incorrect for any other maker. Suppose he substitutes 750-watt lamps of make D for those of make A; if the voltage is 240 the candle-power would be reduced by 20 per cent., if the difference is calculated on the basis of mean spherical candle-power. It would be still worse if it were the case of lighting the floor of a room, and reckoning that the maximum



SHOWING THE HEFNER CANDLE-POWER PER WATT FOR LAMPS TAKING BETWEEN 25 AND 100 WATTS.

The data are taken from the spherical candle-power given in the price lists of firms A. and D. The full-line curves relate to lamps taking about 130 volts; the dotted-line curves relate to lamps taking about 250 volts.

candle-power was in a vertical direction, it was then found that the lamps gave their maximum illumination in a horizontal direction: the differences might then be very marked. It seems, therefore, very necessary that particulars as to candle-power should be given as well as the number of the watts taken. If these things were stated on the socket the consumer could probably choose for himself among the different makes, and the contractor would not have to bind the buyer to a particular firm.

The new system of rating lamps provides no method of distinguishing between them. It is not possible to say how the average consumer is to choose the lamp which is best suited to his requirements. All lamps look very much alike, and it is not very easy at a glance to distinguish between them. And if, as is very likely, lamps of higher efficiency should be introduced, the confusion will become greater still. The rating according to watts leads to wrong values being placed on the lighting capacity of a lamp, and just as a man has every right to know the output of a machine which he is proposing to buy, so he ought also to be provided with information as to the light which may be expected from a given lamp.

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 13, 1916.

Table.

Watts.	Incandescent lamps for voltages about 130.								Incandescent lamps for voltages about 270.							
	Mean spherical candle power.				Maximum candle-power.				Mean spherical candle-power.				Maximum candle-power.			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
40	45	40	36	36	55	50	43	42	...	...	...	...	...	...	...	...
60	70	60	63	60	85	70	73	70	...	...	..	...	...	...	...	...
75	90	95	...	85	110	120	...	96	80	70	67	65	100	85	78	75
100	120	125	...	110	160	165	...	140	110	100	95	95	140	130	107	125
150	210	200	...	175	240	260	...	225	180	185	...	155	200	240	...	200
200	300	275	...	265	340	350	...	345	260	250	...	220	290	330	...	290
300	490	425	...	400	550	550	...	520	430	380	...	355	480	485	...	460
500	880	720	...	715	980	950	...	925	800	670	...	665	880	860	...	865
750	1,340	1,200	...	1,070	1,500	1,500	...	1,390	1,270	1,200	...	1,000	1,420	1,500	...	1,290
1,000	1,820	1,500	...	1,420	2,040	1,900	...	1,850	1,760	1,500	...	1,420	1,960	1,900	...	1,850
1,500	2,780	2,400	...	2,300	3,060	3,200	...	3,000	2,680	2,400	...	2,300	3,000	3,200	...	3,000

PARLIAMENTARY INTELLIGENCE.

TELEGRAPH (CONSTRUCTION) BILL.

This Bill has now passed both Houses of Parliament.

In the House of Lords last week the Committee stage was taken, when, on clause 1, Viscount MIDLETON moved an amendment to give the County Court judge power to order the proposed telegraphic wire to be carried underground in any case in which the amenities or value of any land may be affected.

Lord ALLENDALE, on behalf of the Government, opposed the amendment, as, in the opinion of the Postmaster-General, the interests of landowners were already adequately protected by the setting up of a tribunal to settle disputes.

The Marquess of SALISBURY pointed out that all the tribunal had to consider, according to the clause, was the public interest. It was not likely that amenities would be regarded as things essential to the public interest. The consequence might be that telegraphic wires—which had increased enormously of late—would be carried right across private houses, parks and gardens, when they could be just as well placed underground or carried by road.

After further discussion the Government agreed to accept words empowering the tribunal to stipulate for the carrying of a portion of the telegraph wire underground if necessary.

The Bill passed through Committee, and the Bill has since been read a third time.

Boiler Tubes.—In the House of Commons last week the President of the Board of Trade was asked if he was aware that the practical monopoly of the supply of boiler tubes suitable for water-tube boilers in this country was in the hands of the British Mannesman Tube Co., and that on June 30, 1915, of 15,000 ordinary shares and 19,000 preference shares in the company 14,830 ordinary shares and 18,873 preference shares were held by enemy aliens resident in Germany; if that firm was a controlled establishment under the Munitions of War Act: and if any steps had been taken under the Trading with the Enemy (No. 2) Act, 1916, to transfer the enemy interests in the concern to British shareholders.

In reply, Mr. HARCOURT said the British Mannesman Tube Co. (Ltd.) was a controlled establishment under the Munitions of War Act. The right to transfer the shares belonging to enemies had been vested in the Public Trustee, who informed him that he had now completed negotiations for their sale.

LEGAL INTELLIGENCE.

Tramcars and Lighting Regulations.

At Blackpool last week Charles Beckett, a Corporation tramcar driver, was summoned for a breach of the lighting regulations. The defence was that the conductor had charge of the car's lighting arrangements and not the driver, and this view was corroborated by the Chief Inspector.

The magistrates' clerk held that both were responsible and he advised the Chief Constable to proceed against both on the next occasion.

The driver was fined 20s.

EDUCATIONAL.

University of Bristol.—In the faculty of engineering complete courses of instruction are provided in civil, mechanical, electrical and automobile engineering.

The autumn term commences on Sept. 3, but in the faculties of arts, science and medicine it begins on Oct. 3. There are also complete courses of instruction in the evening classes. Particulars from the registrar, Mr. James Rafter, M.A.

University of Edinburgh.—The next session of the engineering department commences on Oct. 10th. The preliminary or entrance examination is held in September. Complete courses of instruction in civil, mechanical and electrical engineering are provided; they qualify for the degree of B.Sc. in engineering and extend over a period of three years. Particulars of entrance examinations, scholarships, &c., may be obtained from the Matriculation Offices, the University of Edinburgh.

University College, University of London.—The Goldsmid engineering entrance scholarship, of the value of £30 a year, tenable for three years, will be competed for at University College in September. Particulars of the scholarship examination can be obtained from the Secretary of the College (Gower-street, W.C.), to whom application should be made before Sept. 1.

Armstrong College (University of Durham) Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

Royal Technical College, Glasgow.—The session 1916-17 begins on Sept. 26.

The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, &c. There are also full courses of instruction in the schools of navigation and wireless telegraphy, and both day and evening classes are held. The diploma courses extend over three or four sessions, and the average fee is £12. 12s. per session. The college is affiliated to the University of Glasgow, and the degrees of the university in engineering and applied chemistry are open to its students. Prospectuses may be obtained from the Director, and the calendar is published at 1s. (post free 1s. 4d.).

Northampton Polytechnic, London.—In the day engineering college full-day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 SPECIFICATIONS.

7,758 KETTERING & CHRYST. Electrical ignition systems for internal combustion engines. (16/7/14.)

10,711 MOND. (Maschinenfabrik Oerlikon.) Cooling or ventilating devices for dynamo-electric machines.

10,726 BACHELET. Electromagnetic levitating apparatus.

10,752 SCHATTNER, TRAVIS & WALTON. Electric motor starters and controllers. (Cognate application, 661/16.)

10,755 WADE. (Leeson.) Coil for electrical purposes and method of winding same.

10,785 LANE & HONEYMAN. Rumblers and like for electrolytic purposes.

11,011 MARINO. Process for electrolytically depositing a strongly adherent and malleable layer of tin on iron and other metallic surfaces.

11,172 BRITISH INSULATED & HELSBY CABLES (LTD.) & ASTLEY. Means for suspending and adjusting electricity overhead conductors.

11,263 B.T.-H. Co. (G.E. Co.). Electrical windings.

11,603 BROADBENT & SONS, B.T.-H. Co. & WISE. Control of electric motors for driving hydro-extractors.

11,658 B.T.-H. Co. (G.E. Co.) Electric motor control systems and pneumatically operated controllers employed therein.

Consists in a controller for the motor circuits comprising a plurality of unit switches, each having a normally open movable contact arm and a stationary contact arranged to be engaged thereby, a pneumatically operated cam shaft provided with cams so arranged as to close said switches in a predetermined order, the motion of the cam shaft being in the same direction for either direction of rotation of the motors, and a master controller provided with connections adapted to cause a step-by-step movement of the cam shaft to close the switches in response to movement of the master controller.

11,723 GUTH. Lampholders for electric lamps. (21/1/15.)

12,379 WILKINSON. Electromagnetically operated switches.

12,666 B.T.-H. Co. (G.E. Co.) Rectifiers for electric currents.

The rectifier comprises a refractory cathode, such as tungsten filament, adapted to be heated to incandescence so as to emit electrons, and an anode of volatilisable reconstructing material, such as mercury, the arrangement being such that the anode is heated during operation so as to maintain sufficient pressure of vapour to suppress electrical disintegration of the cathode.

12,747 B.T.-H. Co. (G.E. Co.) Protective devices for electric systems.

13,679 LEWIS. Electro-magnetically operated brake or other mechanisms.

13,799 NORTH. Conductors for the ignition system of motor vehicles and other purposes.

16,407 REDMAN. Apparatus for receiving or detecting submarine sounds.

17,119 MASCHINENFABRIK OERLIKON. Braking electric motors actuating lifting, lowering, hauling, winding and like apparatus. (11/12/14.)

1916 SPECIFICATIONS.

100,056 KAWAKAMI. Electric motor pump. (1,526.)

100,361 KETTERING & CHRYST. Electrical systems for internal-combustion engines. (Divided application on 7,757/15.) (5,841.)

100,533 SIEMENS-SCHUCKERTWERKE GES. Electrical connecting devices. (6,977.)

100,739 SIEMENS & HALSKE AKT. GES. Electrolytic apparatus. (8,111.)

100,859 ALDENDORFF, F. Switching apparatus for interconnecting telephone lines by electro-mechanically controlled switches. (30/1/14, addition to 28,502/13 and divided application on 2,530/14.) (4,699.)

100,863 MANDER, J. W. Pocket and other electric flashlight batteries. (3/5/16, addition to 7,079/14.) (6,302.)

100,872 IGRANIC ELECTRIC CO. (Cutler-Hammer Mfg. Co.) Electric motor control systems. (3/2/16.) (1,643.)

Relates to means for controlling an electric motor comprising a push-button control station adapted to be set, so that with one setting the operation of a single push-button switch will effect starting and stopping to inch the motor, and so that with a further setting the operation of the same single push-button switch will effect starting, accelerating and deceleration of the motor.

100,879 Woods, R. S. Electric lighting means. (7/1/16.) (288.)
100,916 Clarke. Safety devices for electrically operated lifts and other vehicles. (1,175)
100,933 Mellersh-Jackson. (Champion Ignition Co.) Sparking plugs and the method of making same. (2,020.)
100,994 Mellersh-Jackson. (India-Rubber Co.) Separators for secondary batteries (7,567.)

APPLICATIONS FOR PATENTS

*Note.—The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

July 17, 1916.

9,985 Shone & Shone. Sound transmitting, recording and reproducing instruments.
10,008 Chortik. Method of producing high-frequency oscillations.
10,016 Rosso. Interrupters or make-and-break devices for magneto-ignition in internal-combustion engines.
10,029 Meek. Electric incandescence lamps.
10,036 Bell & Sterling Telephone & Electric Co. Electrically-driven vibratory apparatus.
10,037 & 10,038 Elektromekaniska Aktiebolaget. Portable dust suction apparatus. (16/7/15, Sweden.)

July 18, 1916.

10,047 Link. Mirror reflector to be applied to electrical generating-apparatus for inspection purposes.
10,070 British Insulated & Helsby Cables, Ltd. & Vernier. Electric cable junction or terminal boxes or apparatus.
10,072 Newitt. Electric fuses or cut-outs.
10,088 Brooks, Franks, Read & Walsall Hardware Mfg. Co. Electric switches.
10,096 Bethenod & Girardeau. Spark-gaps for wireless telegraphy. (21/7/15, France.)
10,099 Akt.-Ges. Brown, Boveri et Cie. Multiple control apparatus for electric railways. (29/7/15, Germany.)
10,100 British Westinghouse Electric & Mfg. Co. (Westinghouse Electric & Mfg. Co.) Circuit-interrupting devices.
10,101 British Westinghouse Electric & Mfg. Co. (Westinghouse Electric & Mfg. Co.) Protective relays for electric circuits.
10,103 Chortik. Generation of high-frequency currents.
10,116 Cutler-Hammer Mfg. Co. & Igranic Electric Co. Circuit controllers.
10,125 Crump. Manufacture of zinc, and obtainment of by-products from said manufacture.
10,126 Watkins. Sparking plugs for internal combustion engines.

July 19, 1916.

10,142 Larsens. Pendulum indicators for electric bell systems.
10,162 Halden & Halden. Electric photographic printing or copying frames.
10,174 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
10,176 Marconi's Wireless Telegraph Co. & White. Means for opening and closing electrical circuits.
10,179 Bennitt. Controllers for electric motors.
10,182 Bibbs & Tremellin. Differentially metering electricity for lighting and heating. (23/3/16, New Zealand.)
10,183 Braid. Apparatus for electro-deposition of metals.
10,184 Haefely et Cie Akt.-Ges. Insulation for electrical apparatus. (20/10/15, Switzerland.)
10,193 Marino. Electrolytic process for removing sulphide or sulphide compounds from surfaces of articles of copper or copper alloys.

July 20, 1916.

10,217 M'Colt. Protective devices for alternating-current electric systems.
10,228 Uhlig. Method of galvanising copper to electric non-conducting substances.
10,257 Eastern Telegraph Co. Speed-indicators and counters.

July 21, 1916.

10,274 Siemens Brothers & Brush Electrical Engineering Co. Electrical transformers.
10,292 Lea. Electric motor driving gear.
10,297 Lamkin. Device for attachment to sparking plugs for automatically cleaning and cooling sparking points.
10,306 Automatic Telephone Mfg. Co., Smith & Woodland. Telegraph systems.

July 22, 1916.

10,335 Baur. Contacts or attachment of field telephone induction coils.
10,339 Western Electric Co. (Western Electric Co.) Thermionic devices.
10,361 Thomas-Stevens, Ltd. Means of control for petrol-electric vehicles.

July 24, 1916.

10,386 Collins & Collins. Electrical connection or junction pieces.
10,402 Watson. Interrupter arrangements for electric circuits, chiefly for use with internal-combustion engines.
10,412 Bennett & Gaskin. Supports for accumulators.
10,422 Norsk Hydro-Elektrisk Kvaelstof Aktiebselskab. Manufacture of ammonium nitrate. (31/7/15, Norway.)
10,428 Van den Eynde. Electrical and automatic laying of anti-aircraft guns.

July 25, 1916.

10,457 Electrical Improvements (Ltd.). Reheating working fluids in prime-movers.
10,458 Reynolds & Reynolds. Electric lamp-holders, reflectors, &c.
10,462 Ostwald. Utilisation of town waste by means of waste fields.
10,491 Crochat. Electrical driving of motor vehicles, &c. (9/5/16, France.)

July 26, 1916.

10,519 Lyon & Wrench & Tolman. Electric motors and dynamos.
10,535 Pollak. (Soc. Anon. des Etablissements L. Bleriot.) Electric resistances for compensating, &c.
10,554 Vernier. Electric cable joint boxes.
10,558 Cohen & Sohler. System of electric distribution.
10,561 Igranic Electric Co. (Cutler-Hammer Mfg. Co.) Circuit controllers.
10,563 Cracknell. Galleries for gas and electric fittings.
10,567 Jenkins. Signalling devices for aircraft.
10,571 Ward. Aluminium and aluminium alloy castings.
10,573 Pilkad. Rotatable contact-pieces for magnetos, &c.
10,576 Bethenod & Girardeau. Wireless telegraphy and telephony. (10/8/15, France.)

July 27, 1916.

10,588 Delbergue & Walsall Electrical Co. Attachment of ammeters and voltmeters to supports.
10,589 Delbergue & Walsall Electrical Co. Ammeters and voltmeters.
10,627 Harris. Electrical transmitting apparatus.
10,611 Western Electric Co. Automatic telephone and telegraph systems. (19/12/14, U.S.)
10,646 Igranic Electric Co. (Cutler-Hammer Mfg. Co.) Controllers for electric motor circuits.

July 28, 1916.

10,677 Electric Control (Ltd.) & Eglefsen. Controllers for electric motors, &c.
10,705 Salt. Magneto-ignition devices.
10,706 Electrical Improvements (Ltd.). Treatment of [illegible].
10,713 Clarke & Mullard & Edison & Swan United Electric Light Co. Valves for receiving or producing wireless current.
10,720 Midgley & Vandervell & Co. Combined starter and lighting dynamos.
10,721 Kennington. Magnetos, &c.
10,722 Chortik. Method for producing high-frequency oscillations.

July 29, 1916.

10,734 Lyon & Wrench & Murphy. Field magnets for electric dynamos and motors.
10,745 Jones. Anodes for electro-plating.
10,750 Allgemeine Elektricitats-Ges. Time meter for alternating current. (25/4/15, Germany.)

July 31, 1916.

10,767 Masters. Electrical telephones for field telegraphs, &c.
10,774 Garner. Apparatus for testing electrical ignition plugs.
10,783 Compare & Pizzi. Electric switches.
10,795 B.T.-H. Co. & Young. Magneto-electric machines.
10,809 Stacey & Stacey. Sparking plugs for internal-combustion engines.

August 1, 1916.

10,835 Firth & Rhodes. Driving and controlling dynamo-electric generators.
10,850 B.T.-H. Co. (G.E.Co.) Electron discharge apparatus.
10,855 Vidal. Electric lighting and heating of railway, &c., vehicles.
10,858 Woodland. Ignition devices for internal-combustion engines.

August 2, 1916.

10,875 Williams. Ammeter for alternating currents and electric oscillations.
10,882 Greenhalgh, Longbottom & Electromotors (Ltd.). Dynamo-electric machinery.
10,883 Gunewardene. Life-saving electrical warmer.
10,905 B.T.-H. Co. & Clinker. Wireless transmitting systems.
10,923 Mallinson & Cullen. Sparking plugs.
10,938 Fritsch. Switch controls.
10,939 Newton Bros. & Newton. Motor-starting switches, controllers, &c.

August 3, 1916.

10,950 Donovan & Donovan. Electric switches.
10,973 Igranic Electric Co. (Cutler-Hammer Mfg. Co.) Control mechanism for doors of lifts.
10,979 B.T.-H. Co. & Young. Magneto-electric machines.
10,985 Fessenden. Apparatus for transmitting and receiving sound waves through the ground. (7/10/15, U.S.)
10,996 Perry. Gyro-compasses.
10,998 Perry. Repeaters for gyro-compasses.
10,999 Cross. (Svenska Aktiebolaget Gasaccumulator.) Detectors for wireless telegraphy.
11,001 Davison. Electrical means for locking railway, &c., carriage doors.

August 4, 1916.

11,002 Ellis. Automatic transmission.
11,014 Mack, Nash & Western Electric Co. Electrical screening or jamming systems.
11,043 B.T.-H. Co. (G.E. Co.) Electric motor control.
11,047 Marks. (Kuntziger.) Cut-out for electric circuits.
11,052 Graham. Electric signalling or indicating apparatus for signalling orders and numerical data.
11,055 Indo-European Telegraph Co. & Morse. Electric oscillating or wireless systems and apparatus.
11,058 Cooper. Electrical conducting cloths, &c.

August 5, 1916.

11,064 Jones. Magnetic separators.
11,083 Jelley & Stelfox. Contact breakers for magnetos, &c.

NEW BOOKS AND NEW EDITIONS.

[Copies of the new books mentioned below can be obtained *post free* from The Electrician Offices on payment of the prices indicated in parentheses. It is only necessary to specify the number when sending remittance.]

719. "Municipal Life and Government in Germany." By W. H. Dawson. 7s. 6d. net (8s.)

720. "Practical Mathematics for Technical Students." Part II. By T. S. Usherwood. 7s. 6d. (8s.)

721. "English and American Tool Builders." By J. W. Roe. 12s. 6d. net (13s. 3d.)

722. "Treatise on the Theory of Alternating Currents." Vol. II. By Dr. Alex Russell. Second Edition. 15s. net (15s. 9d.)

723. "Electrical Engineering: First Course." By J. E. Berg and W. L. Upson. 17s. net (17s. 9d.)

724. "Emission of Electricity from Hot Bodies." By O. W. Richardson. 9s. net (9s. 6d.)

725. "The Electrical Contractor: Principles of Cost-keeping and Estimating, Wiring and Illumination Calculations, &c." By L. W. Moxley, jun. 6s. 3d. net (6s. 9d.)

726. "Trade as a Science." By E. J. P. Brien. 2s. 6d. net (2s. 9d.)

727. "Test Questions in Junior Algebra." By B. F. Rosenberg. 1s. 3d. (1s. 6d.); 1s. (1s. 3d.) without answers.

728. "Longman Modern Mathematical Series: Rules and Compasses." By P. Hudson. 5s. net (5s. 6d.)

729. "Lectures on Ten British Mathematicians of the Nineteenth Century." By A. Macfarlane. 5s. 6d. net (6s.)

730. "Pole and Tower Lines for Electric Power Transmission." By R. D. Coombs. 10s. 6d. net (11s. 3d.)

731. "Nitrogen Compounds and Explosives." By Dr. G. Martin and Wm. Barbour. 7s. 6d. net (8s.)

732. "Chlorine and Chlorine Products." By Dr. G. Martin. 7s. 6d. net (8s.)

733. "Sulphuric Acid and Sulphur Products." By Dr. G. Martin. 7s. 6d. net (8s.)

734. "The Salt and Alkali Industry." By Dr. G. Martin. 7s. 6d. net (8s.)

735. "Arithmetic for Engineers." By C. B. Clapham. 5s. 6d. net (6s.)

736. "Gas, Oil and Petrol Engines." By A. Garrard. 5s. net (5s. 6d.)

737. "The Algebraic Theory of Modular Systems." By F. S. Macaulay. 4s. 6d. net (5s.)

738. "Lathe Design, Construction and Operation." By O. E. Perrigo. 12s. 6d. net (13s. 3d.)

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	713	German and Austrian Electrical Industries	156
Imports and Exports of Electrical Manufactures	714	**Electric Vehicle Progress Supplement No. 31.**	
Business Notices	714	Passenger Vehicle Misconceptions. Illustrated	1*
Bankruptcies, Liquidations, &c.	714	Cross Country Driving in an Electric. Illustrated	2*
Electricity Supply	714	A Cross-Country Run. Illus.	4*
Lighting and Power Notes	715	Tenders Received & Accepted	717
Traction Notes	715	Municipal Accounts	717
Empire Notes	715	Companies' Meetings and Reports	719
Foreign Notes	716	New Companies, &c.	719
Miscellaneous Notes	716	City Notes	720
Tenders Invited	716	Electrical Companies' Share List	720
The Round Table	149		
The Brass Tack Brigade Meets Brown. By Frank B. Rae, Jr.	150		
Power "Mutalities"	154		
Arora Three-Bar Fires. Illus.	154		

COMMERCIAL TOPICS.

Minister of Commerce. In the House of Commons last week a question was asked as to whether it was the intention of the Government to appoint a Minister of Commerce and whether any steps were being taken to reorganise and redistribute the duties and work of the Board of Trade so as to place the country in a better position to deal at once with the new economic conditions created by the war. In reply, Mr. Asquith stated that active steps were being taken with a view to placing the Board of Trade in a position to deal effectively with post-war economic and commercial problems, but he was not in a position to go into details. No good object would be attained by the multiplication of Ministers.

With great respect we submit that the time has arrived when the work of the Board of Trade should be sub-divided, and the whole department modernised. Part of the duties of the present Board should be entrusted to a Ministry of Commerce, which is, in our opinion, badly needed, and this is the view of every Chamber of Commerce in the country. The answer of the Prime Minister is disappointing, and no tinkering with the present Board of Trade will satisfy the commercial interests of this country.

* * * *

Preventing Trade With the Enemy. It is announced that for the purpose of ascertaining whether goods of any description are held on account of or for future account or for the benefit or future benefit (direct or indirect) of any person resident or in business in any hostile country or any person of enemy nationality, or are held otherwise to the prejudice of the national interest, the Board of Trade are authorised to require of all persons concerned information as to the nature, quantity, use, origin and destination of goods, and the purpose for which they are held or as to the actual ownership and conditions under which goods are held, or information to establish whether the goods held are in excess of normal requirements of the owners' trade and the reasons for any excess. The Board of Trade may make arrangements with any other department for exercise of these powers if necessary, and the Board may, where the goods do not satisfy these requirements, oblige the owner to dispose of them in a manner and within such time as are subsequently specified.

* * * *

Metropolitan Electric Supply Company. An interesting statement, which has been issued by the company, setting out the progress made, appears in another column.

The units sold in the first six months of each of the years from 1913 to 1916 inclusive, and also the amount available for dividend, &c., are given, and it is clear that, notwithstanding the lighting restrictions, the high price of coal, labour difficulties, &c., very substantial progress has been made. In the half-year ended June last 11,600,918 units were sold compared with 9,536,691 in the corresponding period of 1915, and the amount available for dividend is £35,368, against £31,751. It is evident that there is a greatly increased demand for electrical energy for power, and the directors consider the past half-year's trading satisfactory, especially as the costs of production have largely increased, the price of coal alone being 50 per cent. higher than in 1914.

Exports to Sweden. It is announced that, in consequence of the refusal of the Swedish Government to allow Swedish merchants to give guarantees that goods imported from Britain shall not reach Germany, the British Government have prohibited all exports to Sweden, except under a licence which will only be given on production of a guarantee of destination.

* * * *

Import of American Electric Vehicles. In reply to a request that, notwithstanding the new import restriction, American electric chassis should be specially considered, the Board of Trade promises that if a statutory declaration is made to the effect that the chassis are to be used solely for commercial purposes, the matter of their importation will have consideration.

* * * *

Registration of Business Names. In reply to a question in the House of Commons, Mr. Asquith recently stated that the Government hope to give facilities after the recess for the passing in the House of Commons of the Registration of Business Names Bill, which had already been passed by the House of Lords. We welcome this announcement, and we hope that this year will see an important and much needed alteration in the law relating to the names of firms trading in this country.

* * * *

Australian Zinc Concentrates. The Commonwealth Premier (Mr. Hughes) recently announced that the Imperial Government had agreed to take a large proportion of Australian zinc concentrates during the war, and 100,000 tons yearly for 10 years after.

Mr. Hughes said the Imperial Government had also agreed to advance £500,000 on War Loan terms for the erection of plants in Australia, and to take 45,000 tons per annum of Australian spelter. Negotiations were proceeding with France and Belgium to take the remainder of the concentrated produce in the Commonwealth.

Mr. Hughes has also stated that he proposed to introduce new regulations, designed to ensure the permanency of the steps to be taken to eradicate all enemy influence from the Australian metal industry.

* * * *

American Profit-sharing Scheme. Some time ago we gave some particulars of the scheme of profit-sharing introduced by the General Electric Co. of America, and in making the payment recently the directors of the company issued the following statement to employés participating in the bonus :—

In making this extra payment to those who have been in the company's employ five years or longer, we desire to emphasise the value of mutual co-operation and loyalty between the company and its employés, and trust that by thus working together we may make the future so successful as to permit the continuance of this general plan, with such changes in detail as experience may show to be desirable. As you have been informed, the present plan applies to all employés (excepting directors and executive officers) whether in the shops or offices. The object in adopting a five year limit is to encourage stability of service. We recognise the fact that there are many employés who have been less than five years in the service of the company whose loyalty and devotion are of the highest character, and we hope that from year to year most of these employés by continuity of serving will become participants in the present plan or such other plan as may be developed.

In all the General Electric Co. has paid out in extra compensation more than $550,000 to 19,000 of its employés. We commend the terms of this communication to the manufacturers and capitalists of this country. In the past the relations between capital and labour have not been satisfactory, and in future it will be absolutely essential to avoid labour disputes, otherwise our enemies will take advantage of the position and recapture some of their lost trade.

* * * *

United States Anti-Dumping Legislation. In the Revenue Bill which passed the House of Representatives on July 10th it is provided that it is unlawful for any person importing articles from foreign countries systematically to sell such articles at a price substantially less than the market value or wholesale price of such articles in the markets of the producing country or other countries to which such articles are commonly exported after adding freight duty and other charges and expenses incidental to the importation and sale in the United States. The penalty is $5,000 fine or imprisonment for not more than a year, and the injured person may sue for threefold damages.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From Aug. 12, 1916, *to* Aug. 18, 1916.

IMPORTS.

FOLKESTONE.—*France:* Elec. carbons, 28 pkgs.
GOOLE. *Sweden:* Elec. machinery, 108 cases.
LIVERPOOL. *U.S.A.:* Insulating cloth, 57 cases.
LONDON.—*U.S.A.:* Insulated wire, 137 brls.; carbon electrodes, 12 pkgs.; elec. lamps, £658; unenumerated, £10,280 61 cases. *Holland:* Elec. lamps, £3,452 619 pkgs.; elec. glow lamps, £163; elec. bulbs, 224 cases; unenumerated, £23. *Japan:* Electro-copper ingots, 28,846 n.o.; unenumerated, £861 65 cases. *France:* Elec. meters, 123 cases. *Switzerland:* Unenumerated, £3,967. *Sweden:* Unenumerated, £393.
SOUTHAMPTON.—*France:* Unenumerated, 35 pkgs.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Wire and cable, £40; unenumerated, £79. *Melbourne:* Wire and cable, £345; elec. machinery, £990; unenumerated, £320. *Sydney:* Elec machinery, £1,644; wire and cable, £528; elec. lamps, 18,774 n.o.; unenumerated, £1,154. *Wellington:* Elec. machinery, £560; wire and cable, £147; elec. lamps, 5,519 n.o.; unenumerated, £306. *Lyttelton:* Unenumerated, £34. *Dunedin:* Unenumerated, £594. *Adelaide:* Elec. machinery, £43; unenumerated, £590. *Brisbane:* Wire and cable, £10; unenumerated, £368. *Christchurch:* Unenumerated, £81. *Perth:* Unenumerated, £270. *Newcastle:* Elec. machinery, £62. *New Plymouth:* Unenumerated, £14.
AFRICA.—*Durban:* Elec. machinery, £266; wire and cable, £29; unenumerated, £156. *Cape Town:* Wire and cable, £90; unenumerated, £1,072. *Port Elizabeth:* Elec. machinery, £255; unenumerated, £477. *East London:* Unenumerated, £10. *Zanzibar:* Unenumerated, £22.
EGYPT. *Alexandria:* Unenumerated, £39. *Port Sudan:* Elec. machinery, £644; wire and cable, £17; unenumerated, £36. *Port Said:* Elec. machinery, £1,237. *Suez:* Unenumerated, £95.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Wire and cable, £237; telegraph material, £250; unenumerated, £140. *Singapore:* Telegraph cable, £3,000; unenumerated, £322. *Calcutta:* Wire and cable, £1,609; elec. machinery, £200; unenumerated, £1,172. *Madras:* Wire and cable, £667; unenumerated, £963. *Colombo:* Elec. machinery, £1,282; unenumerated, £390. *Karachi:* Unenumerated, £70. *Port Swettenham:* Elec. machinery, £96. *Penang:* Wire and cable, £184; unenumerated, £70
CHINA. *Hong Kong:* Wire and cable £350. *Shanghai:* Unenumerated, £18.
CANADA. *Halifax:* Telegraph material, £80.
U.S.A. *Philadelphia:* Wire and cable, £18; elec. machinery, £257; unenumerated, £28.
SOUTH AND CENTRAL AMERICA. *Rio Janeiro:* Unenumerated, £319. *Valparaiso:* Wire and cable, £25. *Buenos Ayres:* Wire and cable, £105 elec. machinery, £13; unenumerated, £642.
JAPAN. *Nagasaki:* Wire and cable, £93.
WEST INDIES.—*Demerara:* Unenumerated, £12. *Trinidad:* Unenumerated, £30.
SANDWICH ISLANDS.—*Fiji:* Telegraph material, £15; unenumerated, £10.
HOLLAND. *Amsterdam:* Wire and cable, £362; elec. machinery, £260. *Rotterdam:* Elec. machinery, £119; unenumerated, £1,366.
FRANCE.—*Dieppe:* Elec. machinery, £123; wire and cable, £213; submarine telegraph material, £9,600; unenumerated, £55. *Paris:* Elec. machinery, £240; unenumerated, £542. *Boulogne:* Elec. machinery, £74; unenumerated, £10. *Havre:* Elec. machinery, £20.
DENMARK. *Copenhagen:* Wire and cable, £315; elec. machinery, £90; unenumerated, £60.
MALTA. Unenumerated, £81.
NORWAY. *Christiana:* Unenumerated, £297.
SWEDEN. *Gothenburgh:* Wire and cable, £53.
PORTUGAL.—*Lisbon:* Wire and cable, £376; unenumerated, £301.
SPAIN. *Barcelona:* Unenumerated, £250.

FOREIGN GOODS (duty paid and free).

Sydney: Unenumerated, £335. *Melbourne:* Elec. meters, £529; unenumerated, £20. *Perth:* Unenumerated, £23. *Adelaide:* Unenumerated, £121. *Barcelona:* Unenumerated, £110. *Calais:* Unenumerated, £44. *Calcutta:* Unenumerated, £20. *Colombo:* Unenumerated, £48. *East London:* Unenumerated, £32. *Helsingfors:* Unenumerated, £1,505. *Lisbon:* Unenumerated, £13. *Petrograd:* Unenumerated, £219.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

The name of the Edison & Swan United Electric Light Co. (Ltd.), of 123 125, Queen Victoria street, E.C., Ponder's End, &c., has been altered to the Edison Swan Electric Co. (Ltd.).

The offices of the Electric & General Works (Ltd.) will be removed on Sept. 1 to 128, Stamford street, London, S.E.

Walter John Barker and Edwd. M. Harvey (trading as Barker's), electricians, &c., 11, Dean street, Oxford street, London, W., and 11, Artillery lane, London, E.C., have dissolved partnership. Debts by Mr. Barker.

Sale by Auction. By order of the Controller (Mr. G. S. Pitt, F.S.A.A.) to conduct the winding up of Isaria (Ltd.), Mr. Ernest Owers will sell by auction the whole of the stock-in trade of the company, including about 1,200 electricity meters, 100 prepayment meters, 750 electric fans, some starters, rheostats, 90 motors and dynamos (d.c. and a.c.), &c.; also the office furniture. On view Aug. 28 and 29, and catalogues of Messrs. Bolton, Pitt & Breden, Incorporated Accountants, 200, Finchley road, N.W., and at West Hampstead and Golder's Green. *See also an advertisement.*

Sale by Tender. The engineering plant and machinery on the premises of the McKenzie Engineering Co., Borrowash, near Derby, are offered for sale by tender. The plant includes a number of lathes, planers, milling, planing and drilling machines, &c.; also a number of 8 in. capstan lathes in course of construction, specially suitable for Government work. The machinery is in excellent condition, and may be inspected by appointment. Forms of tender and detailed particulars from the Trustee, Mr. Wm. Hart, C.A., 43, Wardwick, Derby, to whom tenders are to be sent by Sept. 8. Further particulars are given in an advertisement.

Plant for Sale.—Messrs. H. K. Foster & Grace, land agents, Hereford, advertise for sale a 5 H.P. semi-enclosed motor with starting rheostat for 250 volts.

Messrs. Cross, electricians, Tunbridge Wells, advertise for sale a Hindley suction gas plant, with 10-H.P. engine and compound wound dynamo (160 volts, 40 amps).

Increase of Prices.—Messrs. Belling & Co. announce that, owing to the heavy and continued increase in the cost of both material and labour, they are compelled to increase the advance on their 1915/1916 Fire Catalogue (which still holds good for the coming season) from 10 to 20 per cent. as from Sept. 1 next. The trade discount on fires remains the same—namely, 33⅓ per cent.—except for the "Boudoir" series, which now stands at 25 per cent. only.

BANKRUPTCIES, LIQUIDATIONS, &c.

A first and final dividend of 8s. will be payable on Sept. 11 at 2, Bixteth-street, Liverpool, to creditors of John Boult and John Hugh Bolt (trading as John Boult), electricians, 3, Grosvenor-street, Chester. A first and final dividend of 5s. will be payable on same date and at same place to creditors of the separate estate of John Boult.

The trustee in the bankruptcy of James Wm. Tattersall and Tom Whitaker Tattersall, trading as Tattersall & Tattersall, electrical engineers, at Kimberley-road, Willesden-lane, London, N.W., has been released.

A first dividend of 10s. is payable on Aug. 30 at 6, Clement's-lane, London, E.C., to creditors of the Admil Electric Co. (Ltd.), Artillery-lane, Bishopsgate, London, E.C.

High-Tension Insulators (Ltd.) is being wound up voluntarily, and Mr. George Thomas Broadbridge has been appointed liquidator. A meeting of creditors will be held at the office, 32, Sackville-street, London, W., on Monday, Aug. 28, at 11 a.m.

ELECTRICITY SUPPLY.

EXTENSIONS.

Battersea (London).—The Borough Council recently received sanction from the Treasury to borrow £3,728 for electricity supply purposes.

Chesterfield. The Corporation, who are considering a scheme for the extension of the electric supply works, have called in Mr. S. L. Pearce, of Manchester, to advise them on the question.

Ilford. The Urban Council have authorised the electrical engineer (Mr. A. H. Shaw) to prepare specifications for putting down alternating-current plant with a view to utilising the steam at the refuse destructor. The estimated cost is put at £7,000.

Newport (Mon.) The Council is to apply to the L. G. Board for sanction to borrow money for cables, &c., to give a bulk supply of energy to a new consumer.

The Electricity and Tramways Committee has approved of the wages of fitters, electricians, and coach builders, being advanced 3s. a week, and of engine drivers from 37s. 3d. to 40s. a week, stokers from 35s. 3d. to 38s. a week, and greasers from 32s. 8d. to 34s. a week.

GENERAL.

Aldershot. The Lighting Committee recommended the Council not to accede to applications for the supply of electric current for lighting as extensions of mains were involved.

Councillor SNELGAR thought the recommendation showed a retrograde policy, especially as they wanted to promote the growth of the electricity department. Probably outside lighting would be more curtailed this winter than last, and when applications for inside extension were secured it was a short-sighted policy not to push them for all they were worth.

Councillor ATKINS said the Committee arrived at its decision because there was great difficulty in getting labour, and greater difficulty in getting labour to lay mains, while the extra cost of material and labour would not be met by the income. Nothing from the existing mains was refused, but to lay new mains was too expensive at present. Since the Committee met one applicant had agreed to find the labour if the Council would put on the electric light, and that particular case would go back for reconsideration.

The question was referred back to the Committee for further consideration.

The Clerk submitted a demand from the Inland Revenue Commissioners for £73 in respect of excess profits duty on the electric light undertaking, and he was instructed to make all possible inquiries thereon, and appeal, if necessary.

Bedford.—The Board of Trade has made an order permitting Bedford Corporation to supply electricity to the premises of Messrsi W. H. Allen, Son & Co., in Biddenham.

Hove.—A special meeting of the Council is to be held to consider a proposal by Ald. J. J. Clark that a depreciation fund should be established in connection with the electricity undertaking in order to meet the financial situation created by war time conditions. The meeting will be a private one.

The scheme for modernising the plant, which would have produced economies in working, has been suspended during the war, and it is considered possible that a further increase in the charges to consumers will be necessary.

Huddersfield.—At the last meeting of the Corporation, Councillor T. Shires, in moving the adoption of the minutes of the Electricity Committee, referred to the change which would take place at the end of the month in the management of the electricity department.

He said their manager (Mr. A. B. Mountain), who had been with them ever since the inception of the department, would leave them, and he was sure they were all sorry that he was going to modify his connection with them at the present time. However, their good wishes went with him. Mr. Mountain had been a very good and faithful servant of the Corporation, and had engineered the works in a way that could have been surpassed by no man. In Mr. Turner they had a good successor, who had been brought up under Mr. Mountain's direction. They had every confidence in Mr. Turner, and that he would merit the good feelings of the Corporation.

Other speakers spoke in similar terms of Mr. Mountain, and the minutes were confirmed.

Councillor WOFFENDEN hoped that the question of the conveyance of coal to the electricity and gasworks would be properly settled once and for all, so that at the end of the war they would be able to put the scheme into operation.

LIGHTING & POWER NOTES.

Electricity in Coal Mining.—An electric generating station, recently completed at Lord Ellesmere's Mosley Common Collieries, Boothstown, near Manchester, and, in addition to supplying current to the Mosley Common pits, power and lighting current is also supplied for various purposes to his lordship's other collieries in the Walkden district.

Electricity in Collieries.—Last week a deputation from the executive of the Miners' Federation of Great Britain waited upon Mr. H. Samuel, at the Home Office, in order to submit proposals designed to promote the greater safety of work in coal mines.

The deputation asked the Home Office to (1) appoint a largely increased number of sub-inspectors from the ranks of qualified working miners; (2) that Regulation 131 (*a*) of the Coal Mines Act be so amended as to make it illegal for a person in charge of an electrical coal-cutter, whose wages depend upon the amount of mineral gotten, to be appointed as the responsible person to supervise, examine, or adjust the electrical apparatus; (3) with reference to coal-dust danger, that a copy of the analyses of the various districts be sent to the Home Office, and that expert views thereon be given by the deputation, and that experiments in regard to the Bulger-Colloid system of coal dust laying be carried out, also that, in view of the serious danger which exists in mines on account of the presence of coal dust, and as one of the chief causes of dust being deposited is the use of open or faulty tubes or trams in which the coal is conveyed along the roadways underground, the Government introduce a Bill for dust-proof trams to be used in all dry and dusty mines. Other requests related to insufficient illuminating power of certain safety lamps, and the duty of H.M. inspectors to give evidence at inquests and inquiries.

Mr. SAMUEL, in reply, pointed out that some of the proposals might require new legislation, and Parliament at a time like the present would be loth to deal with any new legislation. He personally and the Home Office would give earnest and sympathetic consideration to the different matters. With respect to the suggested appointment of sub-inspectors from the ranks of the miners, he said nothing could be done during the war. Many qualified men were away on active service and nothing ought to be done in that direction during their absence. He agreed as to the desirability of having electrical coal-cutting and conveying machinery, under the supervision of persons whose wages did not depend on results. With reference to dust-proof trams, Mr. Samuel, while generally sympathetic, considered the South Wales suggestion of covered trams to be impracticable.

Leigh (Lancs.).—The Corporation have declined to allow the West Leigh Colliery Co. (Ltd.) to obtain a supply of electrical energy for power from the Lancashire Electric Power Co., but the Corporation are prepared to supply the necessary power at agreed terms, or at rates to be arranged by the Board of Trade.

Pateley Bridge.—Mr. Chas. Pullas has informed the Bishopside Parish Council that as soon as possible he will devote his attention to the question of providing electricity for public and private lighting for Pateley Bridge. No opposition will be offered by the Council.

TRACTION NOTES.

Croydon.—A recent report by the Tramways Committee recommended an increase of wages and the revision of stages.

The Council adopted the report and as a result motormen's and conductors' commencing and maximum wages have been increased by ½d. per hour, and the period required for reaching the maximum has been reduced from three years to 18 months. It had been found that men became fully efficient in 18 months. Provision is made for the payment of time and a-quarter on Bank Holidays and Good Fridays, also for all overtime in excess of 11 hours a day and for work on the seventh day in any week other than a change-over day. Pay on Christmas Day remains at time and a-half. A sum not exceeding £350 is to be distributed amongst the motormen and conductors who remained at work and the inspectors and other members of the staff who remained at work during the strike in April, May and June last. The loss in revenue during the strike was compensated for by decreased expenditure on labour and electricity.

In view of the advance in prices of stores and materials and the increased cost of labour, it has been decided, in order to secure increased additions to the reserve and renewals fund, to revise the fare stages. The average 1d. stage has hitherto been 2 miles 290 yds., but under the revised scheme it will be 1 mile 1,416 yds. The average 2d. stage is reduced from 4 miles 630 yds. to 3 miles 848 yds., and the average 3d. stage from 5 miles 1,320 yds. to 5 miles 1,010 yds.

York.—A report on the working of the municipal electric omnibuses during the year ended March 31 has been issued.

The omnibuses only run in districts in which there is not sufficient traffic for tramways. During the year the three omnibuses ran 65,470 miles, and the units used for charging (including all losses) were 80,661, or 1·23 units per mile. The working costs per 'bus-mile (excluding interest and sinking fund) were 4½d., but in this figure very little is included for tyre maintenance. It is estimated that there will be about ¾d. per mile to add during the second year, making a total estimated working cost of 5¼d. per 'bus-mile. So far the vehicles have been very satisfactory and there has been no trouble with the batteries. The electrical equipment generally has given entire satisfaction, and the omnibuses are quite useful means of transport. Apart from the low working costs, it must be remembered that the revenue derived by the electricity department from the sale of energy for working the omnibuses amounted to £420 during the year.

EMPIRE NOTES.

Australasia.—The Town Board of Hampstead, Ashburton (N.Z.) has been granted a licence for the erection of electricity supply works and the supply of electrical energy for all purposes.

Townsville (Queensland) Harbour Board are considering the question of purchasing electric generating plant for supplying lighting and power on the jetty and wharves.

The Scone (N.S.W.) Municipal Council recently invited tenders for public electric lighting plant, mains, &c.

Kilmore (Victoria) are applying for a loan to purchase the undertaking of the Kilmore Electric Supply Co.

British New Guinea.—At the meeting of the British New Guinea Development Co. last week the chairman (Mr. W. A. Horn) said that it would not be many years before the primitive township of Port Moresby would be replaced by a substantial city, lighted by electricity generated at the Rona Falls, and with an electric railway running from Port Moresby through a large area of fertile country and to the neighbourhood of the copper fields, and then the Commonwealth would be deriving a large and increasing revenue from that pearl of the Pacifics.

Niagara Falls Power.—A development scheme, which will entail an expenditure of $100,000,000 and will give about 2,000,000 h.p. of electrical energy has been submitted to the Dominion Government. A commission of Departmental engineers will report on it.

The scheme is promoted by the Thomson-Porter Cataract Co., headed by two Americans (Mr. T. Kennard Thomson and the Hon. Peter A. Porter). The company applies for a Dominion charter, with rights to construct in the Rapids of the Niagara River, below the Falls, the Canadian half of an international dam to raise the water 100 ft. and develop 2,000,000 h.p., one-half of which would go to Ontario and the other half to New York. The company will submit plans for the approval of the Dominion and Ontario Governments, and it offers to negotiate with the two Governments as to the amount to be paid per horse-power, and it would consent to sell the Canadian half of the dam to the Dominion or Ontario at any time at original cost, plus a percentage.

FOREIGN NOTES.

China.—H.M. Consul-General at Yunnan-fu (Mr. H. Goffe, C.M.G.) reports that the local representative of a British firm in Hong Kong desires to obtain catalogues and price lists from British manufacturers of (inter alia) antimony smelting plant capable of an output of 10 to 50 tons per month, water turbines of small power for high and low falls, fire appliances and extinguishers, high speed steam generating sets, direct coupled three-phase alternators of 2,200 volts, 50 H.P. to 500 H.P., boilers, portable railway rolling stock, narrow-gauge locomotives (20 tons), mono rail trucks, diaphragm pumps, general mining and ore-washing plant, aerial railway equipment for transportation of coal, telephone exchanges (for 50 to 500 subscribers), blasting powders, &c.

Portuguese India.—The "Diario do Governo" of Aug. 5 contains a Decree (No. 2,555) authorising the municipality of Goa to instal electric supply works in the town of Nova Goa. A contract has been awarded to a Bombay firm, which will be allowed to import free of duty material required for the installation. The name of the firm may be obtained by United Kingdom manufacturers and by exporters of electrical material on application to the Board of Trade, 73, Basinghall-street, London, E.C.

MISCELLANEOUS NOTES.

Enemy Firms Wound Up.—Additional enemy firms are to be wound up by order of the Board of Trade. To date 321 firms have been affected. The latest list includes:—

Burchard & Co., 32, Fenchurch-street, E.C., general merchants. (Controller: John Kelday Garioch, 16, King-street, Cheapside, E.C.) Surrey Varnish Works, 43, City-road, E.C., dealers in varnish. (Controller: John Durie Patullo, 65, London-wall, E.C.) F. Turpitz & Co., 150 and 151, Fenchurch-street, London, E.C., iron and steel merchants. (Controller: P. Woodthorpe, Leadenhall-buildings, E.C.); and Haberecht & Co., 75, The Parade, Birmingham, hardware merchants, &c. (Controller: W. S. Aston, 45, Newhall-street, Birmingham.)

Fire.—A fire occurred last week at the premises of Messrs. F. J. Jones & Son, electrical engineers, of Love-street, Chester, causing damage estimated at £1,000.

Inquest.—Last week an inquest was held at Newcastle-on-Tyne on John Dodds, a craneman employed by Messrs. Armstrong, Whitworth & Co.

Joseph Miller, a chargeman craneman, stated that on Monday, Aug. 14, Dodds was driving an electric crane. The cradle in which Dodds sat was 24 ft. from the ground. At midnight Dodds complained that his crane was not working properly, as he had received a slight shock, and the electrician was fetched. A little later Dodds again started work, but at 4.55 a.m. on Tuesday he found Dodds lying at his feet, the crane being a few yards away. He was taken to the ambulance room and later removed to the infirmary.

HAROLD GUNTER, an electrician, said that a little after midnight the crane was reported to him as being faulty. He found that a wire was rubbing against the side of the controller. He placed it in position and remained with deceased for about 20 minutes. Next morning he was again called to examine the crane, and found that the wire was rubbing the controller again, and that one of the protecting bars was missing. There was no possibility of receiving a shock likely to paralyse.

Dr. HEWITSON stated that when Dodds was admitted to the infirmary he was suffering from a fracture at the base of the skull. There was no sign of electric shock.

A verdict of accidental death was returned.

Munitions Tribunal Case.—At the Newcastle Munitions Tribunal last week an assistant engineer, named Albert E. Pryke (22), applied for a leaving certificate on the ground that he had entered into a local electric supply company as a junior assistant engineer, and he was now a qualified senior assistant engineer.

Applicant said he had served since August, 1913, receiving 15s. per week for the first year and 20s. per week for the second year, and he was now receiving only 30s. per week. On several occasions he had applied for a leaving certificate, but had been refused. On one occasion the company said that if he left they would bring him back between two soldiers. At that time the company was not certified, and they had retained his services by deliberate and wilful misrepresentations and threats. The wages paid to him were not in accord with his qualifications. If he was granted a leaving certificate he would have no difficulty in obtaining a position at £2. 10s. to £3 per week.

In reply, the manager said it was true he had told applicant that he could not leave, but at the time they were under the impression that they had the power to refuse him, as, by the Order of 1914, they were not covered. The decision about that time of the tribunal was that electricity was not a "substance." Immediately they applied to become certified, and in May, 1916, they were certified as a controlled works. He strongly objected to the allegation that they had "deliberately and wilfully" misled applicant, who had come to pick up all the information he could in order to better his position as an electrical engineer.

Applicant on oath, stated that he would become a wireman at the rate of £2. 5s. per week for the duration of the war, or, rather than continue at his present rate of wage, he would join the Army.

The manager said he wished to keep applicant, because there were numbers of other men in a similar position who would be affected.

The Chairman, in refusing a leaving certificate, said that, in ordinary times, such young men as applicant would be only too glad to be serving there in order to gain experience.

Military Tribunal Cases.—At Accrington on Aug. 18 Mr. Lupton appealed on behalf of an electrician (single, aged 24), who was the only armature winder available.

It was said that it took several years to make a man competent to do that class of work. The man was granted until Oct. 31, final.

The tramways department appealed for two motor men and an electrician, and conditional exemption was granted.

Mr. Furness, electrical engineer and tramways manager, was successful in his appeal for conditional exemption until the end of the season for 12 motormen, one track superviser, and a skilled mechanic in the electricity department. He said 20 motor men were going from the department within 14 days, and if those men for whom he asked were also taken it would mean withdrawing 15 or 18 cars from a service which it was taking the department all their time to maintain.

Conditional exemption was also allowed to a working foreman and an electrical engineer on condition of joining the V.T.C.

At Bermondsey (London) Benoit Lejeune, Ltd., electric welders, applied for the exemption of an electric welder and factory manager, and for an engineer and workshop manager. The latter was 24 years of age and was a "barber" when registered. He has already had two months' extension at Southwark as a "barber."

The MAYOR: How did he learn this trade—by singeing hair?

APPLICANT: I suppose at the time he registered he was a "barber," but he came to me after. He is a very good man, and has previously been in the trade.

One month's final exemption was granted in both cases.

Trading with the Enemy.—Further lists of persons and firms with whom trading by persons and firms in the United Kingdom is prohibited appear in the "London Gazette" of Aug. 22.

These include: *Netherlands East Indies:* Gummi Fabrick Harburg-Wien (Sourabaya), Technisch Bureau Sunda (Bandoeng): *Norway:* Christianssands Elektrochemiske A S (Fiskar, near Christianssands).

Will.—The late Mr. H. M. Gill, electrical engineer, who died on Nov. 28 last, left £14,371 gross, with £2,497 net personalty.

TENDERS INVITED.

Telephone and Telegraph Material, Instruments, &c.

Tenders are invited for the supply to the Postmaster-General's Dept., State of South Australia, of Telephone Material in accordance with schedule No. 428, and tenders are invited (up to Oct. 4) for the supply to the Postmaster-General's Dept., State of Western Australia, of Telephone and Telegraph Instruments in accordance with schedule No. 501. Tenders are also invited (up to Oct. 11) for the supply and erection at the telephone exchanges of Glenelg and Brighton, State of South Australia, of Automatic Switchboards and all associated apparatus (as per schedule No. 426). Tender forms, specifications, &c., may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

Telegraph and Telephone Material, Instruments, &c.

The Deputy Postmaster-General, Perth, requires tenders by 3 p.m. Oct. 4 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General, Perth, W.A.

Tenders are invited by the Deputy Postmaster-General, Adelaide, for the supply and delivery of Telephones, Telephone Material, Instruments and Parts. (Schedule Nos. 429 to 437). Specifications, &c., and sealed patterns may be inspected at the Office of the High Commissioner in London for the Commonwealth of Australia, 72, Victoria-street, S.W. Tenders by 2 p.m. Sept. 27.

Turbo-Alternator, Condenser, &c.

The Town Clerk, INVERCARGILL (N.Z.) will receive tenders until 4 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 40). Specification, &c., from the Town Clerk.

Tramway Track Work, Stores &c.

MANCHESTER Tramways Committee invite tenders for the supply of Permanent Way Special Track Work, Point Tongues and Crossings. Specifications from Mr. J. M. McElroy, general manager, and tenders to the chairman of the Tramways Committee, 55, Piccadilly, Manchester, by 10 a.m. Sept. 12.

PORTSMOUTH Tramways Committee require tenders (by Aug. 29) for Stores, including Overhead Materials, Lamps, Oils, &c. Tenders to Town Clerk.

Tramway Material.

The Madrid "Gaceta" of Aug. 4 notifies that tenders will be opened on Oct. 7 for the Construction and Working of an Electric Tramway in Barcelona, an extension to Sans of the lines of the Cia Nacional de Tranvias de Barcelona, which holds an option on the proposed concession. Minimum rolling stock required will be Two Motor Tramcars and Two Trailers.

Tenders will be opened on Oct. 11 for Construction and Working an Electric Tramway in Madrid, from the Calle de Alcala to the Calle de Diego de Leon. Minimum rolling stock required will be Four Cars.

In both cases construction work must be commenced within three months and completed within 10 months and a year respectively from dates of concession. An option on the concession is held by the Sociedad Tranvia del Este, Madrid.

Electrical Goods, &c.

The directors of the POWELL DUFFRYN STEAM COAL CO. require tenders for Stores (including Electrical Goods, Indiarubber, &c.) from Oct. 1. Particulars from Stores Manager, Aberaman Offices, near Aberdare, and tenders to the directors of the company, 101, Leadenhall-street, London, E.C., by Sept. 6.

EDMONTON Guardians invite tenders (by Sept. 20) for six months' supply of Electric Lamps. Tenders to the Clerk, Lower Edmonton, London, N.

Metallic Filament Lamps, Wire, Tramcar Spares, &c.

Tenders are invited (until Sept. 4) by JOHANNESBURG Municipal Council for supply and delivery of 10,000 drawn-wire Metallic Filament Traction Lamps and 10 miles of 19/14 "Under writer's" Wire (lightly insulated wire for outdoor use); and (until Sept. 21) for Tramcar Spares. Specifications, &c., from the Town Clerk, Johannesburg.

Electricity Meters.

DUBLIN Corporation require tenders (by noon Aug. 29) for year's supply of Electricity Meters. Tenders to Chairman of Electricity Supply Committee, Lord Edward-street, Dublin.

Electric Crane, Air Compressor, Crane Motors, &c.

The VICTORIAN RAILWAY COMMISSIONERS, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

The NEW SOUTH WALES GOVERNMENT RAILWAYS & TRAMWAYS DEPARTMENT require tenders by noon Sept. 20 for the supply and erection of an Electric Overhead Travelling 50-ton Crane (specification 474); and by noon Oct. 11 for a motor-driven Air Compressor (specification 480) for Zarra-street power house. Specifications, &c., from the Electrical Engineer, 61, Hunter-street, Sydney.

Electric Time-releasing Mechanisms.

The Victorian Railway Commissioners, Spencer-street, MELBOURNE, invite tenders (by 11 a.m. Oct. 18) for the supply and delivery of Electric Time-releasing Mechanisms (100 with two normal and two reverse contacts, and 50 with four normal and four reverse contacts) for automatic signalling. Specifications from the Commissioners, Spencer-street, Melbourne.

TENDERS RECEIVED AND ACCEPTED.

BATLEY.—The Corporation have placed an order with the Brush Co. for supplying spare armature and spare condenser tubes.

SUNDERLAND.—For the supply of cables, the tender of the British Insulated & Helsby Cables (Ltd.) has been accepted.

BOLTON.—The Tramways Committee has accepted the tender of Hadfield's (Ltd.) for points and crossings.

OSWESTRY.—The tender of W. H. Kay has been accepted for electrical installation work at the Arcade Theatre.

MARYLEBONE (LONDON).—The Electricity Supply Committee has accepted the quotation from Babcock & Wilcox (£144. 10s.) for renewing old links, rods, bucket pins and runners of the coal elevator at the generating station.

ALBURY (N.S.W.)—For the installation of electric light plant at Albury Hospital, for the N.S.W. Public Works Department, the tender of the Globe Electrical Co. (at £895) has been accepted.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Aldershot.—The accounts of the electricity department for the year ended March 31, 1916, show gross capital expenditure £32,889 (increase £422), of which £14,287 has been repaid.

Revenue was £8,128 (compared with £7,742 in previous year), and total costs were £6,153 (£4,666), leaving gross profit £1,975 (£3,075). Interest required £629 (£730) and sinking fund £1,550 (£1,394), the net result being a deficit of £204 (compared with a profit of £950). Average price obtained was 3·4d. for private supply and 2·27d. for public lighting; and total costs were 2·57d. (compared with 1·91d. in previous year), of which fuel and cartage accounted for 0·99d. (0·82d.). Units generated were 676,220 (617,836) and sold 556,379 (517,189). Total maximum supply demanded was 451 kw. (407 kw.) and the load factor 11 7 per cent.

Glasgow.—The 24th annual report of the Electricity Committee for the year ended May 31 has been issued.

The gross revenue was £530,720. 2s. 3d. (against £405,373), and working expenditure £322,651. 6s. 7d. (£218,518), leaving £208,068. 15s. 8d., out of which the Committee had to meet interest on loans (£72,232), sinking fund, &c. (£72,413), leaving a balance on the year's working of £63,423 (£52,286). Deducting depreciation written off capital account, which, together with the contribution to the sinking fund, is equal to a rate of rather more than 4 per cent. upon the gross capital expenditure (£58,105), the surplus on the year's operations was £5,317. 17s. 4d., which has been transferred to reserve fund. This fund now amounts to £55,896. 17s. 8d. The revenue account continues to show favourable results, and an increase of income from all sources of £125,347. 5s. 9d. is considered a particularly gratifying feature. Of the increase, £55,325. 10s. 6d. is attributable to the 15 per cent. added to consumers' accounts for the year just closed. On the other hand, the working expenses increased by £104,133. 7s. 9d., principally due, apart from the greater output, to the much higher price paid for coal, an all-round advance in the cost of material, increased rates and taxes, bonuses, &c., to workmen, and to £5,976. 11s. 1d. charged against management expenses, being allowances granted to employés on active service with H.M. forces. A considerable increase in the amount paid for interest and the contribution to the sinking fund has also to be noted. The average price received from consumers for the year was 1·108d. per unit, compared with 1·074d. per unit for the previous year. The rate of interest payable to the Corporation Loans Fund in respect of money borrowed was £3. 10s. per cent., compared with £3.5s. per cent., and the rate of interest payable to bondholders in the former burghs of Govan and Partick varied from 3 to 3½ per cent.

The capital expenditure during the year amounted to £117,069. 8s. 11d. and the total capital expenditure at May 31, less depreciation written off, was £2,636,152. 0s. 2d. The total depreciation written off capital account amounts to £711,308. 17s. 9d. Contracts have been entered into for the supply of coal for the coming year at an increase in price as compared with the year just closed. Notwithstanding this, the Committee recommend that no change be made meantime on the ordinary charges for current, which will, therefore, continue to be as before, plus the 15 per cent. added a year ago. The number of consumers at May 31 was 33,605, against 32,030 in 1915, an increase of 1,575 (4·92 per cent.). The quantity of electricity sold to private consumers was 110,488,622 units (20,358,906 for lighting and 90,129,716 for power), compared with 85,718,795 units, increase of 24,769,827 (28·90 per cent.). The total number of motors in use and supplied from the Corporation mains was 11,472 (against 10,681) of 84,744 H.P. (77,305 H.P.), and the units consumed amounted to 88,596,457 (64,747,371). The number of electric street lamps is 1,856, of which 1,472 are arc lamps and 384 pillars with metal filament lamps. In compliance with the new regulations regarding street lighting, most of the arc lamps have been substituted by metal filament lamps and the globes obscured. The total maximum demand of lamps or other current-consuming apparatus connected at May 31

was 109,370 kw., compared with 101,148 kw., an increase of 8,222 kw., (8·12 per cent.). The number of units consumed by private consumers per lamp fixed, averaged out month by month from the date of connecting up, was 31·2. The maximum load or demand made upon the stations during the winter occurred on Dec. 29 last, when the demand was 45,880 kw., compared with 39 750 kw. last year, an increase of 6,130 kw., or 15·42 per cent. In accordance with arrangement with the electrical contractors in the city, a central showroom, located in Sauchiehall-street, was formally opened on Sept. 30, and to the general public on Oct. 2. Since the opening good business has been done, aided to a certain extent by the active co-operation of the electrical contractors, and, while the appended statement of the result of the trading for the short period involved shows a deficit, the real measure of success should be gauged by the increased use of electricity by the agency of appliances. It is now six years since the system was introduced whereby consumers had the advantage of a cheap rate for cooking, heating, &c., and during that period 1,600 kw. of apparatus was installed in consumers' premises. As the result of the showroom operations for only eight months, 1,400 kw. of apparatus has been installed, which, from the departmental point of view, is highly satisfactory.

At Port-Dundas station the gas producer tests referred to in last report are still being continued. Another 8,000 h.p. turbine is on order, and it is hoped that this plant will be ready for the coming winter's load. The capacity of the station will then be 43,000 h.p. At Pollokshaws-road station the Howden turbo-alternator has not yet been tested owing to trouble with the alternator, but the boilers have had to be removed. Other four Babcock and Wilcox boilers are on order, and will be erected on the site of the Howden boilers. These boilers will be steaming this winter. An 8,000 h.p. turbo-alternator is on order from Messrs. Willans & Robinson, and it is hoped that this plant will be in use before the end of the year. The capacity of the station will then be 37,000 h.p. At Govan and Partick stations there is no change since last report, with the exception that the load has grown in both places, particularly Govan, and that the street refuse at Partick has been transferred to another destructor by the cleansing department. The crushing plant is, therefore, for the present shut down. The capacity of the plant at Govan is 4,450 h.p. and at Partick 2,650 h.p. At Kelvinside sub-station all the steam plant has been removed, and two rotary converters deal with the whole load. One 1,000 kw. rotary converter is being erected at Osborne-street sub-station, and when this work is completed the plant capacity will be 4,000 kw. Another 500 kw. rotary has just been started up at Dennistoun sub-station, increasing the plant capacity to 2,000 kw. No additional plant, with the exception of switchgear and other details, has been installed in any other sub-station run by the electricity department's own staff. Transformers in consumers' premises now number 34, an addition of seven to last year's total. There are other three large jobs going through at Fairfield, P. & W. M'Lellan's and A. & J. Main's Germiston works. In regard to the new Dalmarnock works, there is not much to add to what was said in the last report. The foundation contract and the river work is now practically completed, but no fresh developments are likely to take place until peace conditions are re-established. During the year 1¾ miles of low-tension feeders and 5¼ miles of high-tension feeders, in addition to 3¼ miles of distributors, were laid on the north side of the river, and ¼ mile of low-tension feeders and 3½ miles of high-tension feeders in addition to 5½ miles of distributors, were laid on the south side of the river.

The total cost of generation, distribution and management was 0·5842d. per unit sold (against 0·4709d.), but cost of fuel was 0·3173d. (against 0·2149d.), and the total cost (including depreciation) was 1·1178d. (against 1·0964d.), the gross receipts being 1·1292d. (1·0952d.), leaving a balance of 0·0114d. (against 0·0012d.) per unit.

Heywood.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £42,760 (increase £6,592), of which £14,352 has been redeemed and £1,138 is in the mortgage sinking fund.

Revenue was £8,565 (compared with £7,121 in previous year), working expenses were £6,882 (£5,397), and £14 (£17) was allowed to employees on army service, gross profit being £1,668 (£1,704). Interest, income tax, &c., required £1,727 (£1,513) and sinking fund contributions £991 (£1,088), the net result being a deficit of £1,052 for the year (compared with £927).

Mr. R. B. Leach (engineer) says in his report the charges for current were increased by 10 per cent. from May 1, 1915, and by a further 5 per cent. for lighting and 10 per cent. for power from Jan. 1, 1916., and consumers must now guarantee a minimum payment of £1 per annum. Average price obtained was 1·34d. (1·33d. last year), total works cost was 1·08d. (1·07d.), and total cost, including capital charges, 1·51d. Units generated were 978,615 and purchased from Bury 797,882—total 1,776,497; and sold 1,526,977 (against 1,287,006). Cost of fuel rose 43 per cent. The taking of bulk supply from Bury Corporation was commenced on November 5, and the saving in favour of the bulk supply scheme against the Corporation's own steam plant was about 44 per cent.

The tramway accounts show total capital expenditure £68,272 (increase £173), of which £18,527 has been redeemed and £423 is in sinking fund. Revenue was £11 985 (£11,626) and expenses, including £38 (£8) army allowance, were £8,188 (£7,944), leaving gross profit £3,796 (£3,681). Interest and sinking funds required £1,311 (£1,723), the net deficit for the year being £518.

In his report on the tramways Mr. Leach says power expenses increased £214. Working expenses charged by Bury Corporation ate 4·020d. against 3·711d.) per car mile, and by Rochdale Corporation 4·183d. (4·045d.). Passengers carried were 2,366,551 (2,268,331), car-miles run 263,534 (269,088), and units used 387,787 (376,726)=1·46 (1·40) per car-mile. Receipts per car-mile were 10·89d. (10·37d.).

Oldham.—The gross capital expenditure of the tramways department is £460,831.

Traffic revenue during year ended March 31 was £118,338. 15s. 4d. and total revenue £121,128. 14s. 1d. (against £113,814. 1s. 6d.). Working expenses (including cost of energy) were £81,590. 2s. 4d. (£85,083.17s.8d.), rent of leased lines (less tax) was £4,614. 2s. 4d. (£4,992. 11s. 9d.), interest on capital £9,469. 10s. 4d. (£10,251. 16s. 9d.), and sinking fund was £17,152. 13s. 7d. (£16,391. 12s. 1d.), income tax £3,159. 1s. (£2,311. 17s. 7d. Capital expenditure paid out of revenue was £1,030. 14s. 2d., and net surplus was £4,112. 10s. 4d., against a deficiency of £5,217. 14s. 3d. The car-miles run were 1,983,607 (2,045,840), and passengers 23,477,066 (22,171,712); total number of units used was 3,110,622 (3,158,752), and number of units used per car-mile was 1·568 (1·544). The percentage of working expenses to receipts was 67·35 (74·75); average traffic revenue per car-mile 14·318d. (13·401d.), and average total revenue per car-mile 14·655d. (13·351d.). The average working expenses (including power) per car-mile were 9·871d. (against 9·981d.), average number of passengers per car-mile was 11·835 (10·837), and number of cars in stock 108 (97). The amount of sinking fund applied in reduction of debt is £152 247.15s. 2d. (against £135,777. 15s. 2d.).

Rugby.—The accounts of the Urban Council's electricity department for the year ended March 31 show gross capital expenditure £18,646 (increase £556), of which £8,395 has been redeemed.

Revenue was £6,480, including £77 balance from previous year, and working expenses and special charges amounted to £4,215, gross profit being £1,964, after carrying £300 to next account to provide for bad debts. Interest required £387 and instalments of loans £680, and £386 has been transferred to capital account, while £2,346 is carried forward. Units bought in bulk were 445,788 and sold 404,270.

Sheffield.—In the annual report of the Electricity Committee it is stated that the surplus on the past year's working was over £40,000, and this is to be transferred to renewals and special expenditure fund, with the exception of £500, which is to go to the motors for hire fund.

The surplus at the end of the financial year 1914-15 was £32,725, of which £14,000 was transferred to renewals and special expenditure fund, £10,000 to reserve, £500 to motors for hire fund, and £1,243 to depreciation of emergency coal, leaving £6,981. 19s. 6d. to be carried forward. During the year ended March last new capital to the amount of £169,029. 7s. 11d. was expended, making the total £1,513,377. 11s. 10d. The income from electricity supply for the past year amounted to £277,579. 16s. 4d., and from installation and motors to £36,857. 10s., a total of £314,437. 6s. 4d. The charges amounted to £181,027. 19s., leaving a gross profit of £133,409. 7s. 4d. Interest and sinking fund charges on productive capital amounted to £99,083. 7s. 1d. and on unproductive capital to £10,030. 4s. 3d., leaving a net surplus of £33,295. 16s. to which must be added the accumulated surplus from 1915 of £6,981. 19s. 6d., making a total of £40,277. 15s. 6d. The amount paid into sinking fund (with accumulations) for redemption of debt to March 25, 1916, is £383,885. 3s. 5d. The report states that probably in some measure due to the present abnormal activity throughout the city, the growth in all departments of the undertaking during the period under review has been beyond all precedent. The number of units sold was greater by 32,994,685 (73·5 per cent.) than the number sold during the previous year; records for output have been made almost weekly throughout the year. The revenue increased from £184,658 to £277,580—by 50 per cent. As the whole of the increased output represents sales for power and traction purposes at low rates, the growth in revenue was not in the same proportion as the growth in the number of units sold, the total average price per unit having fallen from 0·97d. to 0·85d. The percentage of working expenses in proportion to total revenue is 53, compared with 43 for the previous year, the whole of such increase being due to the higher cost of coal; all other items in the cost of generation and distribution showing a decrease in the cost per unit. The average price obtained during the last five years is as follows:

	1916.	1915.	1914.	1913.	1912.
Light and heat	2·17d.	2·34d.	2·54d.	2·76d.	2·90d.
Power	0·71d.	0·72d.	0·73d.	0·76d.	0·78d.
Total average price ..	0·85d.	0·97d.	1·13d.	1·21d.	1·30d.

Large extensions to buildings and machinery and plant at Neepsend station have been put in hand during the year, 28,000 kw. of additional generating plant is under construction or completed. The total number of consumers is 7,318, an increase of 409 during the year, and the total connections amount to 98,834 kw., an increase of 17,691 kw., or 26·6 per cent. Applications in hand now awaiting connection amount to 18,000 kw. A record year has also been experienced in the work of the installation and motor department, the turnover for the year being £36,857. This department has been responsible for the installation of 10,480 h.p. of motors, compared with 3,339 h.p. the previous year, which constituted a record at that time. The total number of employees on active service is 160, of whom five have been reported killed. The allowance made to these men and their dependants amounted to £2,240. 14s. 9d. during the year. Female labour has been adopted both on the staff and in the generating stations, the number of women at present employed being 49.

As from the September meter readings the price of electricity will be increased as follows: 10 per cent. where the present price is more than 2d. per unit, 20 per cent. where the present price is 2d. per unit or less; and the increased charges are to apply to current supplied for the tramways.

Wolverhampton.—The income of the Corporation tramways for the year ended March was £59,111 (against £55,323 in 1915).

Traffic receipts were £58,531 (12·145 per car-mile), against £54,593 (11·091d.); total expenses were £34,218 (7·1d.), against £35,066 (7·124d.), and gross profit was £24,894 (£20,257). To this sum should be added the balance of £1,459 on motor char-a-banc account, a total of £26,353. Interest on capital absorbed £6,666, income tax £519 and repayment of loans £5,846. A sum of £5,141 has been appropriated to renewals account, £1,685 to additions and improvements, and £2,478 to cost of repair work in 1916-17 (work suspended during 1915-16), and £4,018 has been applied in aid of borough rate. £56,598 now stands to credit of reserve and renewals fund. Owing to shortage of male labour, women have been employed as conductors on the tramcars from September last. At the end of the year 44 were so employed, and their services have proved satisfactory. A considerable amount of maintenance and renewals work has been held in abeyance. 13,296,146 passengers were carried (against 12,236,785), and 1,156,591 car-miles were run (against 1,181,309).

COMPANIES' MEETINGS AND REPORTS.

ABERDEEN SUBURBAN TRAMWAYS CO.—The profit earned during the half-year to July 31 amounts to £1,054, and the balance at credit of profit and loss account is £3,209. The directors propose to add £1,200 to renewal and depreciation account, which will then stand at £16,700, and to declare a dividend of 5 per cent. for past year, carrying forward £415.

BRITISH DYES (LTD.)—The first annual report states that the board will not be in a position to adjust the accounts for the year ended April 30 until they have arrived at a settlement with the Revenue authorities in regard to the duties payable under the Finance Act, 1916. The issued share and loan capital consisted as at Aug. 1 of share capital subscribed (864,179 shares of £1 each, 10s. per share called up), £864,179, and loan from Government £1,064,179, or a total of £1,928,358. Since the date of the report submitted to the statutory meeting in July, 1915, the subscribed share capital has increased by £208,080 and the loan to which the company is entitled from the Government has increased by £209,629, an increase of £417,709. The Board have established a committee of directors, which gives continuous attention to the affairs of the company, a technical committee, which combines the heads of the technical and scientific departments, with Dr. Forster as chairman; a research department, of which Prof. W. H. Perkin is the head; and an advisory council, which consists of 12 eminent professors of chemistry connected with different universities, in addition to the members of the technical committee. It has been formed for increasing the number of chemists and promoting research in organic chemistry and particularly in that branch of it which relates to coal tar colours. Notwithstanding the restriction caused by the shortage of certain materials, the supply of dyes from the company's works has been greatly increased. New plant has been erected and is in course of erection for further increasing the supply of those dyes which are most in demand, and which can be made in large quantities from the materials available. In the near future the supply will be further substantially augmented. The company has also sent to the Swiss manufacturers considerable quantities of raw materials and intermediate products, without which they would not have been able to continue their supplies to the British markets. After conferring with a number of the leading users of dyes, the directors decided, so far as the new works are concerned, to provide, in the first place, mainly for manufacturing on a large scale raw materials and intermediate products. They desire to call attention to two important considerations: (1) In order to secure a permanent national supply of dyes it is imperative that the manufacture of the intermediates from which dyes are made should be successfully established in this country. (2) The production of these intermediates requires the operation of a series of processes not hitherto worked on a commercial scale in this country, and it also requires complicated and expensive plant. A large amount of research and experimental work has been done, and a considerable quantity of plant has already been erected for the production of intermediates. Other important plants are in course of construction, and as regards raw materials, the benzol and phenol plant has been largely increased. An acid plant sufficient for the requirements of the company is approaching completion, and a large part of it is in operation. When the Turnbridge works of Read, Holliday & Sons were acquired, considerable extensions were in course of construction by that company, and these have been completed. An additional freehold site extending to 343 acres was acquired at Huddersfield. Buildings for the accommodation of a large amount of plant have been completed at Turnbridge works, and on the new site. A portion of the new plant has been installed in these buildings, and important materials and products for making dyes are being obtained from it, including a supply of the acids required. The total contents of the new buildings erected at the old and new works are not less than 25,000,000 cubic ft., and the floor area covered 1,200,000 superficial ft. (about 27 acres). The board have adjusted a provisional agreement with Le Syndicat National des Matières Colorantes (a national company formed in France with the support of the French Government), which provides for a complete exchange of knowledge and processes and for the formation of an inter-allied company to establish co-operation between the two companies in regard to production of intermediates, etc.

METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)—The directors have issued the following statement of the accounts for the first six months of the years 1913, 1914, 1915 and 1916.

—	Units sold.	Increase or decrease on previous year.	Approx. gross revenue.	Increase or decrease.	Approx. net revenue.	Amount available for reserve dividend, &c.
1913	8,847,581	1,399,510	£111,688	£10,313	£57,014	£36,470
1914	9,638,755	791,510	114,635	2,947	58,220	35,801
1915	9,536,691	—102,064	114,312	— 323	54,175	31,751
1916	11,600,918	2,061,227	132,960	18,648	55,611	35,368

The above table shows that, except for a slight decrease in the first six months of 1915, there has been a steady increase in the number of units sold in each succeeding half-year. The increase is most marked in the last half-year (1916) notwithstanding the adverse effect produced upon the lighting load by the "Daylight" Saving Act and by the restrictive regulations under the Defence of the Realm Act. The directors consider the half-year's trading satisfactory, especially as the costs of production have largely increased owing to the war, the price of coal alone being 50 per cent. higher than in 1914. The board has declared an interim dividend of 1s. per share (being at rate of 2 per cent. per annum) on the ordinary shares, payable on the 15th inst., less tax. This will absorb £10,000, and leave an unappropriated balance of £25,368.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—The directors' report for 1915 states that the year's operations resulted in a loss of £3,650, after providing £3,750 for debenture interest and £1,550 for debenture redemption. It is stated that the profit on contracts completed and in progress was £2,652 against £4,324, that the revenue from investments decreased, such revenue (less interest paid) being £3,392 against £4,386, and that there was a heavy loss in connection with an unfortunate accident on the Dewsbury and Ossett tramway undertaking in November last. Of this loss (over £2,000) the past year is bearing one-half. But for the accident, the profit from the Dewsbury, Ossett & Soothill Nether Tramways would have been a record. In the case of several of the undertakings in which the company is interested, particularly those at Rhondda, Mexborough, Swinton and Musselburgh, the shortage of labour has been acute. The price of fuel and of materials required for repairs has increased enormously.

TYNESIDE TRAMWAYS & TRAMROADS CO.—Dr. J. T. Merz, who presided over the meeting last week, said that for the first time they had to report a considerable decrease in revenue. The receipts were £1,018 less than in the corresponding half-year of 1915, and to that they had to add an increase in cost of £267, so that they had £1,285 less to deal with in declaring a dividend and providing for depreciation. A reduction in dividend from 3 to 1¾ per cent. meant £837; the reduction of the amount to reserve, £261; and the reduction in the carry forward £291. They need not be discouraged by the reduction of the dividend, because it was largely explained by the fact that the holiday traffic, which in former years always showed up well, had practically disappeared for the present. It was quite possible that in the second half-year they would have an increase in the receipts, and to date the traffics had increased.

NEW COMPANIES, MORTGAGES & CHARGES.

NEW COMPANIES.

BRITISH AERO MAGNETO MANUFACTURERS ASSOCIATION (LTD.) (144,598.)—Reg. Aug. 14, as company limited by guarantee, with 20 members, each liable for £1 in the event of winding up, to promote and protect the interests of manufacturers of aeroplane and airship magnetos in the United Kingdom, to promote the consideration and discussion of subjects affecting such manufacturers, to conduct and assist in experiments and researches for the purpose of improving aero magnetos or of producing improved machines or contrivances capable of producing the electric spark in aero combustion engines, &c. The subscribers are W. C. Lusk, D. K. Morris, C. H. Kirby, D. Steeley, P. F. Bennett, E. Garton, C. A. Lister and R. B. North. Members must be bona fide British manufacturers of aero magnetos or their authorised representatives. First members are the British Thomson-Houston Co., the M.L. Magneto Synd (Ltd.), Nicole Nielsen & Co., the Thomson-Bennett Magnetos (Ltd.), P. F. Bennett, E. Garton, C. A. Lister and H. B. North. All other candidates are to be elected by the company. Subscription for first year is £25 per member; afterwards as the company shall decide.

BRITISH REVIVAL MFG. CO. (LTD.) (144,501.)—Reg. Aug. 1, capital £1,500 in 1,000 preferred shares of £1 each and 10,000 deferred shares of 1s. each, to manufacture electrical accessories previously made and supplied by enemy countries, and to carry on business in connection therewith. Private company. Secretary (pro tem.), P. H. Robinson. Reg. office, 160, High-road, Chiswick.

MORTGAGES AND CHARGES.

S. BILL & CO. (LTD.)—Particulars of £600 debentures, created June 14, 1916, have been filed, whole amount being now issued. Property charged, company's undertaking and property, present and future. No trustees.

BRILLIANT ARC LAMP & ENGINEERING CO. (LTD.)—Memoranda of satisfaction (*a*) in full on July 27, 1916, of debenture dated June 18, 1915, securing £1,200; and (*b*) to extent of £50 on June 17, 1916, of debenture dated June 22, 1915, securing £90, have been filed.

PITTER'S VENTILATING & ENGINEERING CO. (LTD.)—Memoranda of satisfaction in full on Aug. 4, 1916, of a Land Registry charge, and memorandum of charge, both dated Aug. 6, 1915, securing moneys from time to time owing to the London & Provincial Bank, have been filed.

VENNER TIME SWITCHES (LTD.)—Memorandum of satisfaction to further extent of £550 on Aug. 2, 1916, of debentures dated July 10, 1911, securing £5,000, has been filed. Amount outstanding, £2,950.

CITY NOTES.

MEMORANDA (Aug. 23).—**Bank rate 6 per cent. (since July 13, 1916). Consols** 59. Consols Pay Day, Sept. 1. **Stocks and Shares Ticket Days**, Aug. 30 and Sept. 13. **Pay Days**, Aug. 31 and Sept. 14. **Price of silver**, 35⅝.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and registers of members of this company will be closed from the 28th inst. to the 9th Sept. inclusive.

CROSSLEY BROS. (LTD.)—The directors have declared an interim dividend of 5 per cent. per annum on the ordinary shares.

CUBAN TELEPHONE CO.—The directors have declared a dividend of 1½ per cent. on the preferred shares for the quarter ended June 30.

MONTREAL TRAMWAYS CO. (LTD.)—A quarterly dividend of 2½ per cent. has been declared.

SPANISH TELEPHONE CO. (LTD.)—The directors recommend a dividend of 5 per cent. (less tax) for the year ended May 31, leaving £1,281 to be carried forward.

STEWARTS & LLOYDS (LTD.)—Interim dividends of 6 per cent. on the preference shares and 10 per cent. on the preferred ordinary shares have been declared.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date Aug. 22, the following at the present basis prices of—

New Metals.	per lb.
Solid Drawn Brass Tubes	15d.
Solid Drawn Copper Tubes	18d.
Brazed Copper Tubes	18d.
Brazed Brass Tubes	17d.
Brass Wire	14½d.
Copper Wire	18d.
Rolled Brass	14½d.
Brass Sheets	15½d.

	Per ton.
Copper Sheets	£148 0 0
Spelter	55 0 0
English Lead	£30 15 0
Antimony	Nominal.
Old Metals.	Per ton.
Clean Copper Scrap	£95 0 0
Clean Brass Scrap	60 0 0
Braziery Copper Scrap	82 0 0
Old Lead	25 10 0
Old Zinc	38 10 0
Hollow Pewter	125 0 0
Black Pewter	85 0 0
Gun Metal	76 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date Aug. 22, the following approximate prices of **Scrap Metals**:—

	Per ton.
Aluminium Cuttings	£110 0 0
Clean Mixed Brass	65 0 0
Clean Copper	94 0 0
Braziery Copper	82 0 0
Gun Metal	84 0 0
Old Lead	£3 15. under English lead price
Old Zinc	40 0 0
Hollow Pewter	125 0 0
Shaped Black Pewter	85 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £97; Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

We give below the latest prices at which actual transactions took place on or before Tuesday, Aug. 22.

Shrs.	Last Dividend	Name.	Price, Tues., Aug. 22	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord	8½	6 19 2	Mar., Sept.
10	4½%	Do. 4½% Cum. Pref.	8⅞	5 11 8	Feb. Aug.
10	6%	Do. 6% Cum. 2nd Pref.	9½	6 3 1	Feb, Aug.
5	10%	Brompton & Kensington Ord	6⅞	7 12 5	Mar, Sept
5	7%	Do. 7% Pref.	7	4 19 5	Mar, Aug
St.	4%	Central Elec. Supp. Co. Deb. St.	80	5 0 0	..
St.	4%	Charing Cross West End & City Deb.	79½	5 0 8	Jan, July
5	2 3	Do. 4½ Pref.	3⅛	6 10 11	..
5	5%	Do. Ord.	8½	6 17 7	Aug, Feb
5	4½%	Do. City Pref.	8¼	6 18 6	Jan, Dec
5	4%	Chelsea Elec. Supply Co. Ord.	7	7 5 5	Mar, Sept
St.	4½%	Do. do. Deb.	84½	5 6 4	Jan, July
10	6%	City of London Elec. Lt. Ord.	13½	6 6 9	Feb, Aug
10	6 0	Do. 6% Pref.	10	5 14 3	Mar, July
St.	5%	Do. 5% Deb. St.	92	4 17 6	Jan, Dec
St.	4½%	Do. 4½ Deb.	80	5 2 6	Jan, Dec
10	7%	County of London Ord.	11½	6 8 0	Mar, Sept
10	6%	Do. 6% Pref.	10	5 16 0	Feb., Aug.
St.	4½%	Do. 1st Deb.	84½	5 4 0	Jan, July
St.	4½%	Do. 2nd Deb.	81	5 10 5	May, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Deb.	79½	5 13 10	July
5	7%	Kensington & Knightsbridge Ord.	9⅝	6 11 2	Feb., Aug
St.	4%	Do. Deb. St.	79½	5 1 0	Jan, July
5	6%	London Elec. Supply 6% Pref.	4⅞	6 11 6	..
St.	4%	Do. 4% Mort. Debs.	83	4 16 5	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2¾	6 6 4	Mar, Aug
St.	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corpn. 1st Mort. Deb. St.	92	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Debs.	99½	6 0 6	Mar, Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E.P. Supp. 6% Pref.	1⅝	6 3 10	Apl, Oct
4	5%	South London E.S. Ord.	2	6 16 2	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price Tues., Aug. 22	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	6½	6 8 0	Feb, Aug
5	7%	Do. do. Pref.	5⅞	5 19 2	Feb, Aug
St.	3½%	Do. do. Debs	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	73	6 3 3	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations	1⅝	6 11 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6⅝	5 10 11	Mar, Sept
5	4½%	Do. 4½ Cum. Pref.	4⅛	5 4 1	Jan, July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	84¾	5 18 0	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	80	7 10 0	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	74½	5 7 5	..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	..
St.	4½%	Do. 4½% Pref.	81½	5 10 5	Jan, July
St.	4%	Do. 4% Deb. St.	75½	5 6 0	Jan, July
St.	4%	City & S. London Deb.	74½	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70¾	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2½	5 11 1	Jan, July
St.	4%	Do. 4% Pref.	66½	6 0 4	Mar, Sept
St.	4%	Do. 4% Debs.	75½	5 6 0	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	24⅞	4 0 3	Feb, Aug
St.	3½%	Do. 3½% Pref.	62⅞	5 11 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	58	6 0 8	Feb, Aug
St.	3½%	Do. 3½% A Debs.	67½	5 3 8	Jan, July
St.	3½%	Do. 3½% Debs.	69½	5 1 1	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18½	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 4	May, Nov
St.	4½%	Do. 4½ First Pref.	72	6 5 0	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108¾	5 10 4	Jan, July
St.	4%	Do. 4% Debs.	77	5 3 11	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	78	5 2 7	Jan, July
St.	4%	Do. 4% Guar. Stock	70	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	2⅛	5 1 3	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅜	5 9 3	Mar
100	5%	Do. Prior Lien Debs.	93¾	5 7 5	Jan, July
1	6%	Do. 6% Pref.	1¼	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12⅞	7 3 6	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5¾	5 15 8	Jan. July
1	6%	British L.M. Ericsson Mfg. Co. 6% Pref.	⅛	6 8 0	Mar, Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅜	6 1 6	April
100	6%	Do. 6% Prior Lien Debs.	102	5 17 8	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	66½	6 0 4	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12¾	8 1 7	Jan, July
5	5%	Do. 5% Pref.	4½	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	June, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅜	7 2 3	Sept.
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	¼	..	Feb, Aug
St.	4%	Do. 4% Deb.	59½	6 13 11	Jun, Dec
1	7½%	Elec. Construction Ord.	⅞	8 5 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	68	5 17 8	Jan, July
10	10%	General Electric Ord.	13½	7 10 11	July
10	6%	Do. 6% Pref.	10	6 0 0	June, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	16½	6 3 0	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4	5 12 6	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G.P. &c., Ord.	12⅜	8 5 4	Feb, Aug
10	5%	Do. Pref.	8	6 3 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39	6 3 1	Mar, July
100	4%	Do. 4% Debs.	95½	4 4 1	Jan, July
1	7½%	Vickers Ord.	1 ⅜	4 2 9	May, Aug
1	6d.	Do. 5% Pref.	⅜	5 6 8	May, Aug
St.	4%	Do. 1st Debs.	80½	4 19 5	June, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	June, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40	10 6 3	..
St.	4%	Do. 1st Mt. Deb. St.	56	7 2 10	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	104	5 15 5	Fb,My,Aug N
St.	1½%	Do. Def. Ord.	23½	6 17 1	Fb,My,Aug N
St.	4%	Commercial Cable 4% Debs.	71	5 12 8	Ja, Ap, Jly,O
10	5%	Cuba Submarine Ord.	8½	5 17 8	May, Nov
10	10%	Do. 10% Pref.	13⅜	7 5 5	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6⅞	6 5 6	Ja Ap, Jly,O
St.	8%	Eastern Tel. Co. Ord.	148½	5 7 5	Ja,My, Jly,O
St.	3½%	Do. 3½% Pref.	67½	5 3 8	Ja My, Jly,O
St.	4%	Do. 4% Debs.	78½	5 2 3	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78½	5 2 2	Feb, Aug
10	8%	Do. Ord.	14⅜	5 8 6	Ja Ap, Jly,O
10	22%	Gt. Northern Tel. Co. With Coup. 11	41½	5 6 8	Ja My, Jly
25	13%	Indo-European	47⅞	6 16 1	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3½	3 1 6	April
1	7%	Do. 7% Pref.	2⅝	2 12 8	July
10	1%	West India & Panama Ord.	1	9 10 3	May, Nov
10	6%	Do. 1st Pref.	7¼	7 12 5	May, Nov
10	8%	Western Telegraph Co.	15½	5 5 4	Mr, Jly,O Dec
St.	4%	Do. 4% Deb. St.	77	5 3 11	June, Dec
..	4½%	Western Union 50-yr. Bd.	99½	4 10 10	May, Nov
		Telephones.			
1	7½	Mexico Vision Telegh. Ord.	1⅛	7 13 7	No
1	10%	Oriental Telephone Ord.	2⅜	4 18 6	Apl, Oct
St.	4%	Do. Deb. St.	78½	5 1 11	Jan, July
St.	4½%	Telegraph Construct. & Maint. Deb. St.	83	5 8 5	Jan, July
5	8%	United Kingdom Ord.	6⅛	5 15 4	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4½	5 6 8	Jan, July
St.	4½%	Do. Deb. St.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Telegraph & Trust	12⅞	4 13 2	Ap, Oc, My, Jn
10	6%	Do. 6% Pref.	10⅜	5 9 9	Ap, Oc, My, Jn
100	5%	Marconi Company's Common	8⅝	5 17 6	Ja Apl, Jly, O
..	4%	Do. $100 Pref.	70½	5 13 6	Ja, Apl, Jly, O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, &c.			
5	3 0	Adelaide Elec. Supply 6% Pref.	5	6 0 0	Mar, Sept
St.	5%	Do. 5% Deb.	94½	5 5 10	Jun, Dec
10	6 0	Bombay E.S. & T. 6% Pref.	10⅞	5 15 8	..
St.	4½%	Do. 4½% Debs.	83	5 8 5	Jan, July
5	5%	Calcutta E.S. Corp. Ord.	6⅝	7 0 1	May, Nov
5	5%	Do. 5% Pref.	4½	5 17 8	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,998. [Vol. LXXVII. No. 22.] **FRIDAY, SEPTEMBER 1, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES 721
Arrangements for the Week .. 723
Long-Distance and Cable Telephony (Underground and Submarine). By B. S. Cohen and J. G. Hill. Illustrated.—*Concluded* 724
An Automatic Earthing Protective Device. By Paul Thieme. Illustrated 726
The Open Delta Connection for Transformers. By J. B. Gibbs. Illustrated 727
The Air-Gap Field of the Polyphase Induction Motor. By F. T. Chapman, D.Sc. Illustrated.—*Continued* 730
The Effect of High Continuous Voltages on Air, Oil and Solid Insulations. By F.W. Peek, Jun. Illustrated .. 734
THE LAY PRESS AND TECHNICAL EDUCATION 738
REVIEWS 739
An Intermediate Text Book of Magnetism and Electricity [Woodhouse].
REVIEWS—*Continued.*
Alternating Currents: Their Elements Explained, and their Calculation Effected Without the Use of Hyperbolic Functions [Kempe].
Every Boy's Book of Electricity.
The Application of Telephone Transmission Formulæ to Skin-Effect Problems. By Prof. G. W. O. Howe, D.Sc. Illustrated 739
On a Method of Measuring the Pressure of Light by Means of Thin Metal Foil. By Gilbert D. West, D.Sc. Illustrated 741
The Characteristics of Tungsten Filaments as Functions of Temperature. By Irving Langmuir 742
LEGAL INTELLIGENCE 745
Educational 746
The "Electrician" Commercial and Industrial Section .. 747–754

NOTES.

Effect of High Continuous Voltages.

THE literature on electrical engineering has been enriched by many contributions dealing with the effect of high alternating voltages on insulating materials. Up to the present little has been written concerning the effect of high continuous voltages upon dielectrics. The reason for this is that it is a relatively easy matter to obtain a suitable supply in the one case, and, till recently, a matter of considerable difficulty in the other. From the account given elsewhere of an important research by a prolific worker in high-voltage engineering—Mr. F. W. PEEK—it will be noticed that continuous voltages up to 150,000 volts were obtained from an alternating supply by means of a Kenotron rectifier in combination with condensers and inductance coils. The workmanlike method adopted by Mr. PEEK is one which can be commended to other investigators, and which is likely to have many applications in the research laboratory. From the research it appears that the dielectric strength of water-free oil is the same for both alternating and continuous voltages, while the puncture voltage of solid insulations in good condition is generally higher with continuous voltages than with the maximum alternating voltages. This seems to indicate a change in the structure of the solid dielectric, and the subject is one which opens up a wide field for further investigation and discussion.

Maintenance of Electric Tramways.

DURING the last few months there has been a regrettable number of serious accidents on electric tramways. For example, accidents to tramcars have occurred at Birmingham, Cricklewood, Harrow, Abbey Wood, Wigan, Woolwich and Croydon, and some of these have been attended with fatal results. As a rule such accidents are due to one of three causes. There is either negligence in taking curves or points at too high a speed, or the car equipment is in such bad condition that proper control of the car is lost, notwithstanding judicious driving, or, lastly, the track becomes so badly worn that normal speeds are no longer safe. Although there is likely to be negligence from time to time, we think that recent accidents have been too frequent for this to be the cause. In that case, the accidents must be due either to defective equipment or excessively worn track. In either case this is probably due to present war conditions. If undue inroads are made on the staff of a tramway undertaking, the car equipment cannot be properly overhauled, and must inevitably become defective as time goes on. The only other course in such cases is to reduce the number of cars in service and for the public to suffer the resulting inconvenience The question of defective track arises from another cause. Here the spending of money is undesirable for public reasons, and apart from this it is extremely difficult to obtain new rails when steel is required on such a large scale for military purposes. Moreover, the labour for such work is not easily obtainable. Under the circumstances we must look forward to a certain amount of defective track, and on that account the public must expect to suffer the inconvenience of lower speeds if safety in travelling is to be assured.

Long-Distance and Cable Telephony.

IN this issue is concluded Messrs. B. S. COHEN and J. G. HILL's important Paper, which was to have been presented two years ago at the International Telegraph and Telephone Engineers' Conference had the latter not been abandoned owing to the outbreak of war. The Paper is characterised by its thoroughness, and is a highly creditable one. We cannot help feeling that the absence of discussion is a loss of some importance to the telephone world, and it is to be hoped that in happier times an opportunity will be made to discuss such a Paper as this. It is evident that the most reliable and effective method of promoting the transmission of speech over considerable distances is by loading of the line, and this furnishes an excellent illustration of the value of theory to industry. In these days it is possible to predict with remarkable accuracy the speaking qualities of a telephone line and to improve such qualities to an extent that is almost startling. The problem is one of the most fascinating in applied mathematics, and is complicated by the fact that the frequency varies over an exceedingly wide range in addition to the superimposition of higher harmonics on a fundamental.

THE effect of the line is two-fold. In the first place, the speech loses its character owing to the displacement and alteration of the amplitudes of the harmonics; and in the

second place, there is a loss of "volume." An instructive exercise is to consider what happens where a sinusoidal alternating-current is sent along a line having resistance, leakance, inductance and capacity, each of the constants being altered in turn. Diagrams and models facilitate the solution of such a problem. Having done this, a further example can be taken in which the transmitted wave consists of a fundamental and a third harmonic in phase with it. Students who take the trouble to master the problems set out above, and such mastery may involve months of work, will be in a position to appreciate what transmission of speech, as distinct from jargon, across a continent really means, and to realise to some extent the amount of work involved in the problems, the solution of which made such transmission possible.

The "Crawling" of Induction Motors.

At one time or another most designers of induction motors will have been annoyed to find that certain of their machines "crawl." The reasons for crawling have been given by many writers, and are now fairly well known. As Dr. F. T. Chapman rightly points out in his article in this issue, the crawling tendency may be reduced by skewing the rotor slots. Such skewing has the further advantage of lessening the liability to humming when the motor is loaded. In the case of an existing motor of normal construction the tendency to crawl may be reduced by cutting through the end rings of the squirrel-cage. This is the method generally adopted. It has the advantage of being easily carried out, and will be found to get rid of the trouble in most cases.

Electric Coupling of Oscillating Circuits. To "La Lumière Electrique" Dr. E. Bellini contributes a Paper on the above. The theory of electric coupling is given and the author examines a number of interesting cases.

Education After the War. The Prime Minister has appointed two Committees to inquire into the position of science and modern languages respectively in the system of education in Great Britain. The terms of reference and constitution of the Science Committee are as follows :—

To inquire into the position occupied by natural science in the educational system of Great Britain, especially in secondary schools and universities, and to advise what measures are needed to promote its study, regard being had to the requirements of a liberal education, to the advancement of pure science, and to the interests of the trades, industries and professions which particularly depend upon applied science.

The members of the Committee are :—

Sir J. J. Thomson, O.M., D.Sc. (chairman), Right Hon. F. D. Acland, M.P., Prof. H. B. Baker, D.Sc., F.R.S., Mr. Graham Balfour, Sir Wm. Beardmore, Bart., Sir G. H. Claughton, Bart., Mr. C. W. Crook, Miss E. R. Gwatkin, Sir Henry Hibbert, M.P., Mr. William Neagle, Mr. F. G. Ogilvie, C.B., Dr. Michael Sadler, C.B., Prof. E. H. Starling, M.D., F.R.S., Mr. W. W. Vaughan.

Mr. F. B. Stead, H.M. Inspector of Schools, will act as secretary.

Committee of the Privy Council for Scientific and Industrial Research. The Report of the Committee of the Privy Council for Scientific and Industrial Research for the year 1915-16 has just been issued. After referring to previous Government action of a kindred nature, the Report describes the present Government scheme and outlines the procedure which the Council decided to adopt. Conferences were held with professional and other societies so as to obtain their views on research, and a register of researches was compiled so as to gain some idea of the directions in which assistance should be given. The view is expressed that research in pure science should be as much a care of the Committee as research in applied science, but it is impossible to do much in this direction during the war. So far, three standing Committees have been set up to deal with special branches of industry, and other standing Committees are in contemplation, so that specialised researches can receive proper consideration. Reference is made to the difficulties experienced in the prosecution of research by British industrial firms and the great necessity for a new outlook on such matters. In conclusion, the Report deals with the possible sphere of research institutes, with research and Government departments, and with research as it affects the Empire as a whole. We hope to deal further with the Report next week.

Commercial Competition After the War.—In a recent issue of the "Frankfurter Zeitung" there appeared an interesting note on a meeting in Frankfurt of the Association for the Advancement of German Economic Interests in Foreign Countries, when Prof. Jastrow, of Berlin, lectured on Germany's future commercial policy.

Taking as his text the Paris Conference, the speaker urged that Germany must be on her guard against being too much influenced by the disgust naturally felt at the declaration of "war after the war." Commercial policy must be determined dispassionately. Germans should bear in mind that, after the war, they will have to work more and enjoy less than before. They must not add to their labours unnecessarily, and, as foreign trade means a more rational division of labour, there must be no idea of giving up foreign trade. It is utterly chimerical to regard Germany as a self-sufficing, self-contained economic unit. The catchwords "Central Europe" and "Hamburg to Bagdad" are all very well, but it should not be forgotten that Germany's exports to the countries allied with her are of no great dimensions: and while in the distant future possibilities will undoubtedly arise in that quarter, for the period immediately in question no great expectations should be entertained. On the other hand, Germany need not fear the paper resolutions of the Paris Conference; already they have called forth opposition in all the *Entente* countries. The truth is that, directly peace is established, the universal hunger for goods will lead to their being bought wherever they can be found. It must, however, be one of the conditions of peace that all boycott of foreign goods is prohibited. The various Governments must be made liable to pay compensation for damage caused by boycott agitations within their borders, whether inspired by statesmen or newspapers. No hindrances must be placed in the way of the reciprocal supply of raw materials. Germany must give up the practice of dumping. It appears, therefore, that the Germans themselves admit some knowledge of dumping, and are beginning to see that such a practice may lead to retaliation.

Resistance of a Sputtered Film.—Miss E. W. Hobbs, B.Sc., contributes a Paper to the "Philosophical Magazine" on "The Change in the Resistance of a Sputtered Film after Deposition." A considerable amount of work has been done by various investigators on the electrical resistance of metallic films obtained by cathodic sputtering. Kohlschütter and Noll published some results in 1912 on thin films of silver deposited in hydrogen, nitrogen and argon. In this case measurements were made *in situ* of the changes of resistance with time when the film was left *in vacuo*, and in various gases after deposition. The present Paper is an account of experiments on thin films of platinum and palladium, carried out on similar lines, and the effect of admitting gas into the discharge vessel was investigated in detail. It is well known that films deposited in this way undergo a process of ageing, entailing a change in the properties of the film. Fawcett in 1898 showed that this change may continue for months, being hastened by rise of temperature. Curves showing the rate of increase of resistance with time are given in the Paper. The effect of admitting air into a vessel containing a film which had been ageing for some time, in each case showed a considerable increase of resistance, rapid at first and gradually diminishing with time. Admitting hydrogen to films of palladium and platinum which had previously been deposited in air, resulted in a small rise at first in resistance, and then a considerable drop in one case and small changes in others. Evidence is given in the Paper that the chief cause is connected with the absorption of gas by the film.

OBITUARY.

Geo. Keith.—Mr. George Keith, whose death occurred at a Nursing Home at Hove on the 22nd inst., following an operation, had for many years been prominently connected with the development of the telegraph and telephone enterprises in the West Indies and South America. He was the fourth son of the late James Keith, of Chapelhall, Ellon, Aberdeenshire, and was born in 1846. He was educated at the Aberdeen Grammar School and Aberdeen University, after which he served as an engineering apprentice and went through the engineering course of study at Glasgow University under the late Prof. Rankine. For several years he was on the staff of Sir Wm. Thomson (afterwards Lord Kelvin) and Prof. Jenkin, consulting engineers for constructing and laying submarine cables on the coast

of Brazil, and received from the Emperor Pedro II. the order of "Cavalliero da Ordin da Rosa." He was afterwards for a considerable time resident in Cuba, where he occupied the position of manager and engineer of the Cuba Submarine Telegraph Co. Since 1892 he had been director and engineer of the company in this country, and latterly its chairman. He was chairman of the Chili Telephone Company, also chairman and managing director of the Amazon Telegraph Co., and a director of the River Plate Telephone Co. He was also a member of the Institution of Electrical Engineers. Mr. Keith married in 1893, Felicie, eldest daughter of the late Charles Alex. Pierce, who survives him, and he also leaves three sons and two daughters. Mr. Keith's genial personality and transparent sincerity had endeared him to all with whom he came in contact, and he will be greatly missed by a large circle of friends and acquaintances.

FREDERICK WM. BROCK.—The death is announced of Mr. Frederick William Brock, director of Messrs. Brunner, Mond & Co., and of the Northwich Electric Supply Co. (Ltd.).

PROF. WM. ESSON.—The death is announced of Prof. William Esson, M.A., F.R.S., Savilian Professor of Geometry, and Fellow of New College, Oxford. The deceased professor was 78 years.

HAROLD BILLE.—We regret to record the death of Mr. Harold Bille, M.I.E.E., joint managing director of Creed, Bille & Co., telegraph instrument makers, of Croydon. Mr. Bille, who was 37 years of age, died on Aug. 19 as the result of a railway accident.

KILLED IN ACTION.—The following deaths in action or as the result of wounds have been reported during the past week :—

Second-Lieut. S. L. Faithfull (R.E.), who was accidentally killed while in action on Aug. 15, was 40 years of age, was trained as an electrical engineer prior to serving in the Boer War. In 1911 he was selected from 200 candidates to be inspector of electrical plant of gold mines on the Rand.

Second-Lieut. Cecil G. Shaddick (Dorset Regt.) was killed in action on Aug. 8. Deceased, who was 23 years of age, was in the service of the Western Telegraph Co. at Cape Verde Islands prior to the war.

Lieut. F. W. R. Turner (R.E.), who was killed in action on Aug. 5, was educated at University College, Cardiff, where he obtained diplomas in the Faculty of Civil and Mechanical Engineering. He joined the Army at the beginning of the war and obtained a commission in May, 1915.

Lieut. O. H. Crowther (R.N.V.R.) was killed while on active service as an aviator on Aug. 20, at the age of 21. He obtained the degree of M.Sc. at Birmingham University when only 19 years of age.

Capt. J. A. Rutherford (M.G.C.) who has been killed in action, was 27 years of age, and held the degree of Master of Engineering of Liverpool University. Prior to the war he was an electrical engineer in the service of the Rangoon Electric Tramway & Supply Co.

PERSONAL.

The Council of the Association of British Chemical Manufacturers has appointed as general secretary Sir Charles H. Bedford, LL.D., D.Sc. The business of the association is temporarily being carried on at the offices of the Society of Chemical Industry, Broadway Chambers, Westminster, S.W.

It is announced that the Distinguished Service Order has been conferred upon Second-Lieut. (temp. Captain) Hubert Conrad Sparks (London Regt.), brother of Mr. C. P. Sparks, for conspicuous gallantry in action during an assault on the enemy's trenches.

ROYAL ENGINEERS (T.F.)—The following appointments have been made :—

London Electrical Engineers : Second-Lieutenant (temp. Lieutenant) B. C. Bayley (from North Mid. Div. Engineers) to be Second-Lieutenant and temp. Lieutenant. Sgt. W. Collins to be Second-Lieutenant (on probation).

Tyne Electrical Engineers : Second-Lieutenants (temp. Lieutenants) W. Hall, R. W. Anderson, M. C. James, K. S. M. Scott, J. F. S. Hunter, A. B. Williamson, F. H. Bowers to be temp. Captains ; Second-Lieutenants W. H. James, J. Lawther, C. A. C. Aitkins (since died of wounds), R. H. Rooksby, H. S. Ripley, J. O. Baird, E. F. Rendell, R. L. Hunter, R. P. Winter, R. P. Findlay, W. G. Edwards, C. Russell, T. W. Crawford, R. G. Ellis, C. W. Erksine, A. G. Dickson, C. G. Huntley, J. A. Power, W. Watson, A. J. L. Plunkett, C. B. Williamson, C. H. R. E. Raven, J. Robinson and E. H. White to be temp. Lieutenants ; Staff-Sergt. H. V. Owen, Company Sgt.-Maj. C. A. Stephens (from H.Q. Signal Co., R.N., Div. Engrs.), Company Sgt.-Maj. A. Howell, Sec. Cpl. R. E. Jardine and Spr. F. S. Corby to be Second-Lieutenants (on probation).

APPOINTMENTS VACANT AND FILLED.

The Western Electric Co. advertise for draughtsmen for their automatic department, 34, Norfolk-street, Strand, London, W.C.

A capable telephone exchange manager is required for service in the East. *See advertisement.*

A firm of consulting engineers require an assistant engineer. Duties to be fulfilled include acting as resident engineer on the construction of power stations, boiler houses, buildings, foundations of all forms of mechanical, electrical and engineering work, also carrying out of tests on plant at makers' works and during operation on site. Salary £200 for first 12 months, with an increase of £25 for second and third respectively in event of applicant proving suitable, in which case the situation would become of a permanent character. *See an advertisement.*

The Governors of the Borough Polytechnic Institute, London, S.E., invite applications for the full-time appointment of an engineer to superintend Herold's Institute, Bermondsey, and to teach general engineering in the Polytechnic's technical school for boys. Salary £250.

A switchboard attendant is wanted at Stoke-on-Trent electricity works for the duration of war. Wages 30s. per week, with 4s. war bonus if married. Applications to the Borough Electrical Engineer, St. Peter's-chambers, Glebe-street, Stoke-on-Trent. *See advertisement.*

The local education authority invite applications for the position of principal of the Barrow Technical School. Salary £400. Particulars from the Director of Education, Town Hall, Barrow-in-Furness, to whom applications by Sept. 2.

Worksop Council has appointed Mr. T. R. Skinner assistant electrical engineer at 30s. per week.

INSTITUTIONS AND SOCIETIES.

Federation of British Industries Association.—Mr. F. Dudley Docker has been appointed president and Sir William Peat chairman of this Association, which has been established as a central organisation of manufacturing interests. Mr. R. T. Nugent, who is stated to be connected with the Trade Department of the Foreign Office, has been appointed director and secretary.

Verband Deutscher Elektrotechniker.—At the recent annual meeting of this Association at Frankfort-on-Main the Secretary, Herr Dettmar, announced that the membership had decreased from 6,011 to 5,867. Seventy members have been killed in the war.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. CLAY, V.D.

Orders for September :—

General Parade.—A general parade will be held on Saturday, Sept. 30, at 2.45, at Headquarters. Uniform.

Lectures.—W. Eyles, Esq. (late R.E.) has kindly consented to give four lectures as follows : Wednesday, Sept. 6 and 13, "Bridging" : Wednesday, Sept. 20 and 27, "Demolitions." Members are requested to take special note that during this month the lectures will be on Wednesdays in place of Tuesdays.

Drills.—Drills will be held under the Sergeant-Major on Tuesday evenings, as during August.

Musketry.—The Range will be open on Thursday evenings, as during August.

Instruction Classes.—Instruction classes at Regency-street will be held as usual for Platoons Nos. 9 and 10.

Entrenching.—Every Sunday at Victoria Station (S.E. & C. Rly.) Booking-office 8.45 a.m. Uniform, haversacks and water bottles. Midday rations to be carried. The importance of a steady continuance of this work cannot be over estimated. It has been pointed out by Major-General Dickie that the work is best done by moderate working parties *every* Sunday. "Half the number on consecutive Sundays is much better than double the number every other Sunday."

The Commandant desires to draw attention to the report on work done on South London Defences in July, 1916, in which the paragraph referring to the Corps says : "The work has been very well done and the task completed," and to express his gratification at the support he has received.

A précis of this report and the General Order recently issued is posted at Headquarters.

Otford Camp.—A most successful Camp was held during the early part of August, and some 20 men are still under canvas.

Special Note.—Ordinary drills will be resumed on and after Sept. 15. Supplementary orders will be issued later.

Corps Meeting.—A general meeting will, if possible, be held at the end of September.

LONG-DISTANCE AND CABLE TELEPHONY (UNDERGROUND AND SUBMARINE).*

BY B. S. COHEN AND J. G. HILL.

(*Concluded from p.* 663.)

Terminal and Transition Effect with Loaded Lines.

98. As is well known, the losses occurring between a terminating instrument and a loaded line of high characteristic impedance and also at the junction of two lines of widely differing impedance may reach a high value. The following curves summarise the results obtained in connection with various loading schemes and laboratory tests, and, whilst being actual measurements, can be confirmed very satisfactorily by theoretical calculation.

99. As the terminal effect is a function of the ratio of the impedances of the speaking apparatus and the line, it is necessary to study the impedance of the former under all the varying conditions of practical usage.

100. A series of curves is given for the effective resistance, inductance and impedance of the Western Electric Co.'s type of common battery instrument much used in Great Britain with solid back transmitter, 60-ohm bell receiver, &c. This instrument is connected to a repeating coil circuit, *see* paragraph 67.

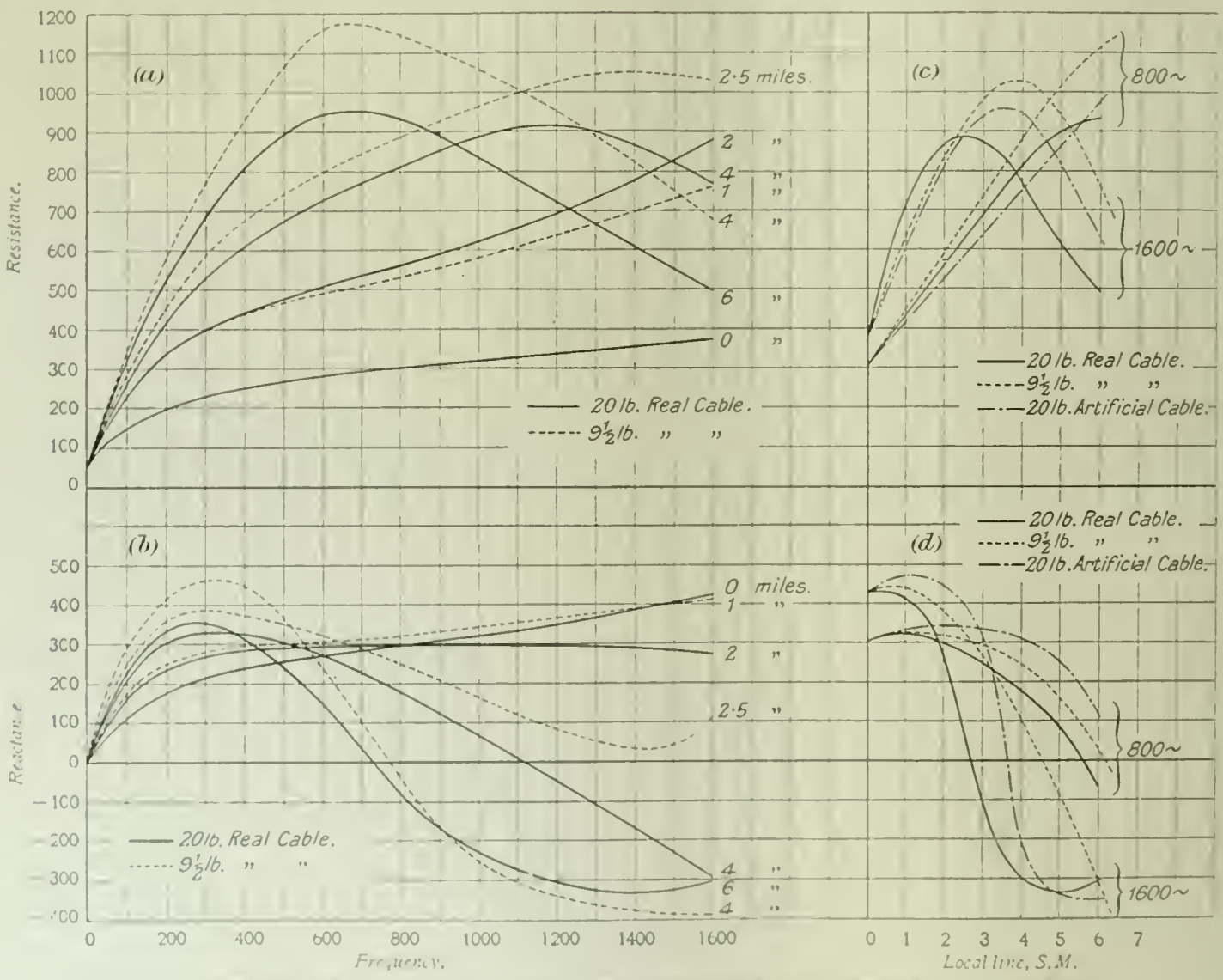


Fig. 11.—Impedance of C.B. Terminal with Repeating Coils and Supervisory Relays for all Values of Alternating Current. (Sept., 1912.)

101. Fig. 11 curves (*a*) show variation in effective resistance for all values of frequency up to 1,600, and for subscribers' local lines from 0 to 2·5 miles long in two types of cable.

102. Curves (*b*) are for corresponding reactance values.

103. Curves (*c*) and (*d*) give the effective resistance and reactance in terms of the equated length of the subscriber's line in miles of standard cable.

104. The polar curves, Fig. 12, give the values of the vector impedance for different frequencies and equated lengths.

105. It will be seen from these curves that under the varying conditions obtainable in practice the vector impedance of the subscriber's terminal C.B. speaking apparatus may vary from 125·46 to 940·5.

106. Taking an average subscriber's line with an equated length of 2 miles of standard cable (0·21), the value is about 650·30. We are now in a position to consider the actual terminal losses when connected to loaded lines of various characteristic impedance values.

107. Fig. 13 gives the actual losses in miles of standard cable for the above type of common battery termination when connected to loaded lines varying in impedance from 800 ohms to 3,000 ohms. It will be observed that the impedance angular values are omitted. This has been found to be quite satisfactory in practice, as these angular values are very small and approximately the same for any type of loaded line. Four curves are given for the common battery termination with local lines of 0, 2, 4, and 6 miles of standard cable respectively.

108. These curves give the losses at both ends of the loaded line, and the value can be halved if only one termination is under consideration. They will be found to apply over a wide range of conditions for loaded cable, and open wire lines. It has been proved to hold for some loaded cable lines with equated lengths as short as 5 miles of standard cable before loading. The curves will also apply if part of the terminal loop is the subscriber's line on the local side of the repeating coil and the remainder is on the loaded line side of the repeater.

109. It will be noticed that reflection is an extremely important factor in the case of fairly heavily loaded lines connected to short subscriber's lines. Thus, the loss at both ends with 1 mile subscriber's lines on a line loaded to 2,000 ohms characteristic impedance is 6·8 miles of standard cable. The problem of reducing these losses becomes in consequence one of great importance.

110. One method for reducing the terminal loss is to use terminal transformers, which are transformers of the kind used in the common battery cord circuits but with windings having impedance of the ratios 1 : 2 or 1 : 4. The effect of inserting such transformers between the terminal apparatus and the ends of loaded lines is to reduce the terminal losses to a considerable extent, and the curves in Fig. 14 show the reduced terminal losses for loaded lines of all values of impedance. The results are obtained with the terminal transformer taking the place of the repeating coil, and if the circuit is such that it is necessary to fit the transformer in addition to the repeating coil, there will be the loss in the transformer to deduct from the improvement; under certain conditions this loss may annul the improvement and there would be no advantage in fitting the transformer. It will be noticed that 6-mile terminal loops with transformers give no terminal losses. The local lines are in standard cable.

111. The curves were obtained by utilising that one of the two

* A Paper prepared for presentation at the International Telegraph and Telephone Engineers' Conference, Berne, Sept., 1914, abandoned owing to the outbreak of war. Reproduced, with permission, from the Post Office Electrical Engineers' "Journal."

types of transformer which gave the best result for the particular combination of terminal loop and characteristic impedance under consideration.

112. It was found that the 1 : 4 type of transformer is the better for lines with impedance of 1,100 ohms and upwards with zero terminal loop and also for lines of 1,300 ohms and upwards with terminal loops up to 2 miles.

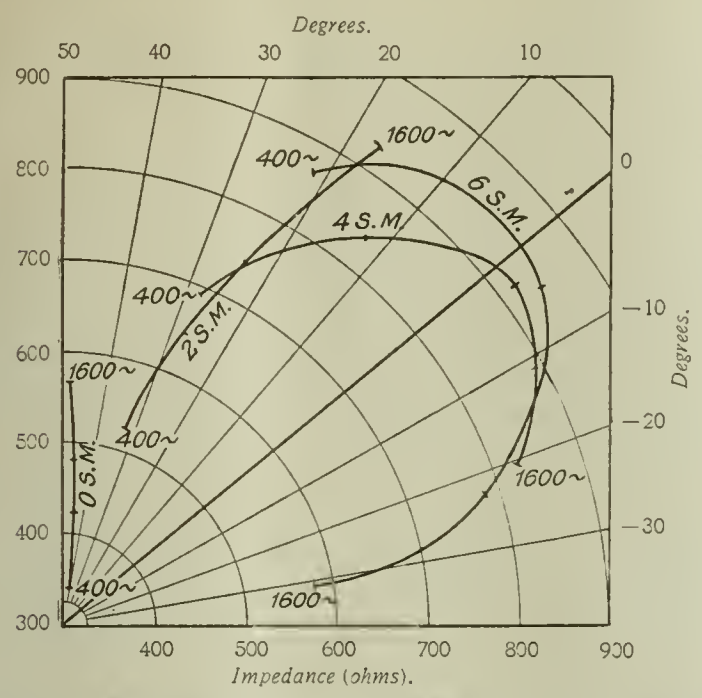


Fig. 12.—Impedance of C.B. Terminal for all Alternating Currents, Points Marked for 400, 800, 1,200 and 1,600 ∼. Local Line, 20 lb. Cable (Sept., 1912).

Terminal Losses Between Loaded and Long Unloaded Cable Lines.

114. The ease of unloaded lines of fair length, say, of the order of 15 miles of standard cable (1·6) in equated length, joined to a loaded line has been investigated, and Fig. 15 gives the results.

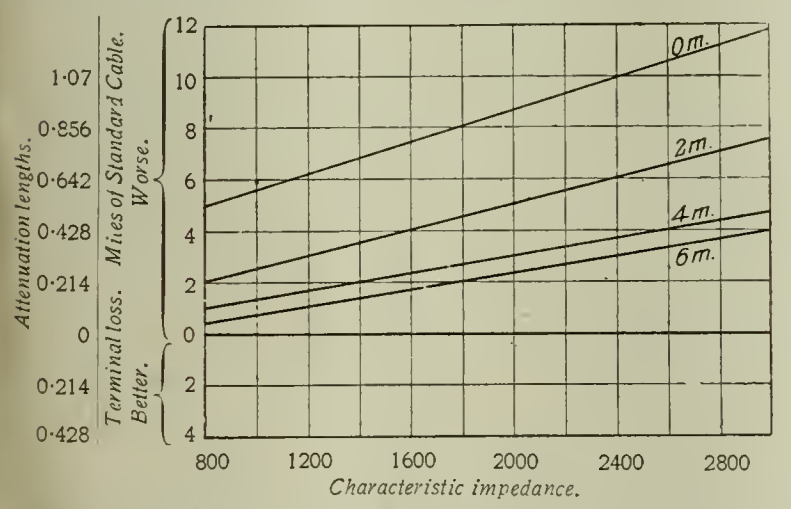


Fig. 13.—Mean C.B. Terminal Loss Curves with Repeaters.

115. The losses at the point of junction are given in miles of standard cable for loaded lines ranging in characteristic impedance from 1,000 ohms up to 2,000 ohms. This curve only applies to unloaded cable lines of the lighter gauge.

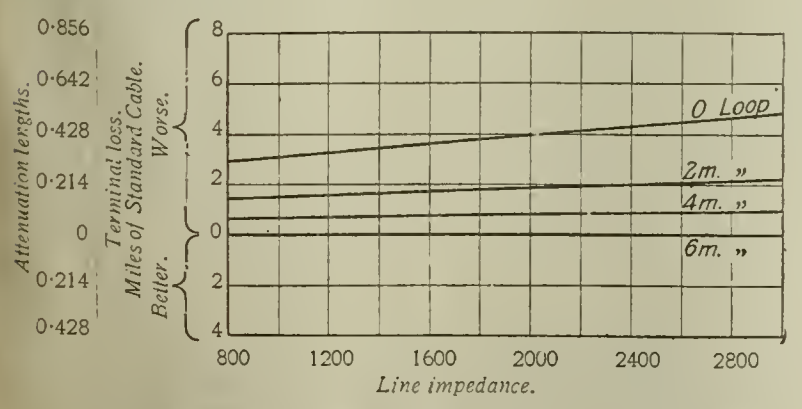


Fig. 14.—Mean Terminal Loss Curves with Terminal Transformer.

116. The transition loss, when passing from a loaded line of one impedance to a loaded line of a different impedance value, has also been investigated, *see* Fig. 16.

117. In this curve the ratio of the characteristic impedance of the two loaded lines is plotted against the loss in miles of standard cable. For example, a loaded line with an impedance value of 800 ohm, when connected to another loaded line of 2,400 ohm impedance, will have a transition loss of 1·2 miles of standard cable (0·18) as the impedance ratio will be 3·0.

Losses in Private Branch Exchange.

118. The apparatus used for signalling and current feeding purposes in connection with subscriber's switchboards is a fruitful source of transmission loss. Many switchboards in general use introduce losses of the order of 4 miles of standard cable (0·43). Generally,

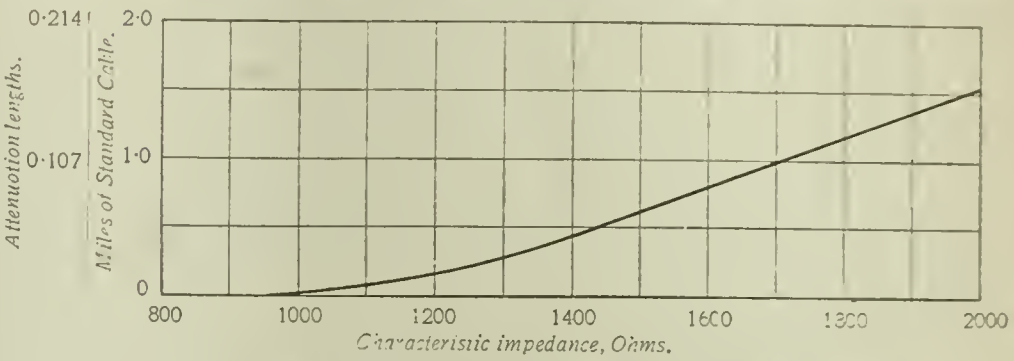


Fig. 15.—Terminal Loss, Loaded Line to Unloaded Trunk.

by a judicious use of condensers to shunt series apparatus and the employment of high impedance low ohmic resistance bridging devices, these losses can be considerably reduced. There are, however, many types of private branch exchange service which it is impossible to provide without the use of apparatus, introducing a loss of the order of 2 miles of standard cable (0·21). When such subscriber's exchanges are used in conjunction with loaded junction lines, it is necessary to study the transmission losses very carefully, particularly in cases where no terminal-reflection-reducing devices are in operation. By combining receiving value local line curve, Fig. 9, with terminal loss curve, Fig. 13, some interesting results are obtained.

119. Fig. 17 shows such a combination. The curves marked *a*, *b* and *c* are resultant curves obtained by adding reflection loss curves for three values of characteristic impedance, viz., 1,000 ohm, 1,600 ohm and 2,000 ohm to the local line reception losses.

120. It will be observed that these resultant curves are practically vertical.

121. The practical application of this is somewhat remarkable. Take a case where the maximum allowable subscriber's line is to be

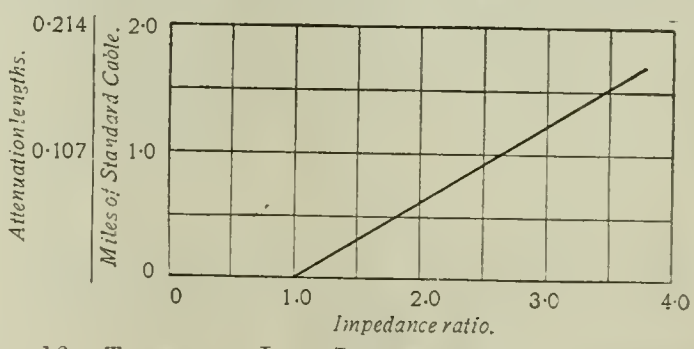


Fig. 16.—Transition Loss, Loaded Lines of Different Impedances.

300 ohms in resistance, in, say, 10 lb. cable. This represents 1·7 miles of this type of cable equalling 2·8 miles of standard cable (0·3).

122. From the curves plotted in Fig. 17 it will be noted that the reception loss for this line is 2·1 miles of standard cable (0·22), or rather less than the equated length.

123. If the heaviest loaded line to which this local line may be connected has a characteristic impedance of, say, 1,600 ohms, then the terminal loss of the line under consideration will be 1·6 miles of standard cable (0·17) and the addition of the receiving and terminal losses give 2·1+1·6=3·7 miles of standard cable (0·4). This value is plotted as a dotted vertical line, Fig. 17. Now, in the ordinary way, if this is the maximum allowable value, any extra losses due to extra apparatus in private branch exchanges, &c., must be compensated for by a reduction in the allowable equated length of the subscriber's line, either by increasing the weight of copper or reducing the permissible length.

124. It will, however, be noted that this dotted line limit is so close to the curve for combined receiving and terminal losses marked (*b*) that we arrive at the important result that *no alteration in type or length of subscriber's local line will compensate for any additional apparatus loss of even such a small amount as half-a-mile of standard cable* (0·05).

125. This is a point worthy of serious consideration, and indicates the necessity of adopting terminal loss reducing devices.

126. The local line receiving loss is the only one considered here, as it will be found on examination that this is the controlling factor in such cases.

Conclusion.

127. In this Paper, the present position of long-distance communication in England is reviewed, and the various factors which make for its improvement, on the one hand, and determine the losses which are at present incidental to it on the other, are examined and illustrated. It is clear that the most reliable and effective method of increasing the range of long-distance telephone communication, whether overhead, underground, or submarine, is by loading. This device has now been tested, and proved to be advantageous and reliable in the leading countries of the world, and its rapid extension is confidently anticipated. Other means of extending the range of communication, notably telephone relays and more efficient transmitting apparatus, are being closely studied and give promising results, but are not in such an advanced stage of development. It is also recognised that the reduction of transmission losses in exchanges, and subscribers' lines and stations, and the elimination of reflection, may be made to play a most important part in the extension of the range of long-distance communication.

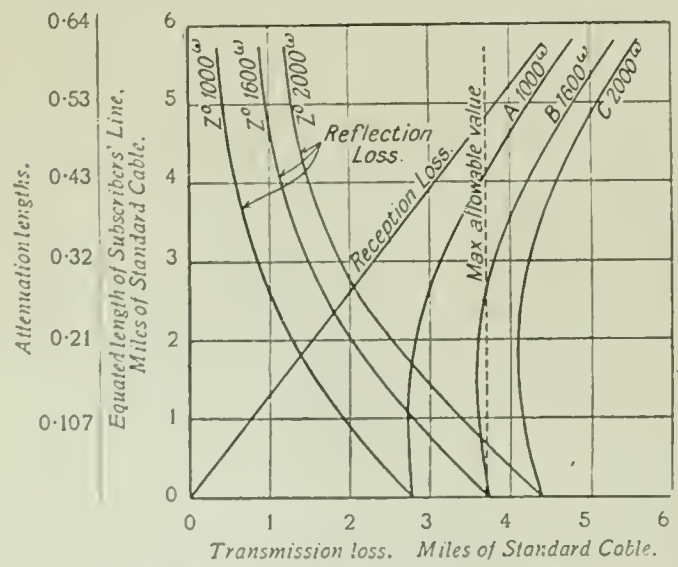


Fig. 17.—Combined Reception and Terminal Loss Curve for Subscribers' Lines.

128. There can be no doubt that the combined effect of the various factors we have reviewed will in the not-distant future result in a material increase in the range of long-distance communication. To achieve that end in Europe, it becomes more and more desirable that the closest co-operation between the various administrations should take place, and that technical terms and standards should, as far as possible, be the same.

AN AUTOMATIC EARTHING PROTECTIVE DEVICE *

BY PAUL THILME.

The breakage of insulators and conductors on overhead high-tension wires may lead to serious disturbances of the supply. Among the many forms these disturbances may take is the arcing between the conductor and the supporting structure. The Americans have for some time used "arcing ground suppressors," of which the following explains the ground idea. If there is an earth on any section this forms a resistance in parallel with one of three transformers, joined together in star with the neutral point connected to earth. The voltage over these, therefore, falls, and a kind of no-voltage relay comes into operation. This works an earthing oil switch, which at once connects the corresponding phase to earth. Further, it can be arranged that this earthing is only momentary, and does not interfere with the continuity of the supply, but if the earth is found not to have disappeared the earthing becomes permanent.

The Allgemeine Elektrizitäts Gesellschaft has worked further on this idea, using only the ground principle, but varying the methods of applying it. The range of action of the apparatus was also extended. If there is an earth on a conductor, the earthing switch is made to close as quickly as possible and then to open again. If the earth has disappeared the switch remains open. The above process is repeated, if, on closing, there is found to be an earth still on the wire. If the arc is found to be still in existence the third time, the switch closes again and remains closed. If there is an earth on several phases at the same time the earthing device comes into operation, but only one of the earthing switches closes, otherwise there would be a "short" on the bus bars. The apparatus is perfectly automatic, and only requires attention when a conductor is permanently earthed. Any operation of the switch is announced by a visible signal. Any marketable apparatus of this kind ought to work 500 times without visible deterioration.

On the opposite page is shown the automatic earthing apparatus for a three-phase network. It consists of single-pole oil switches, S_1, S_2, S_3: they must be suitably insulated and capable of carrying the charging current of the network. They are so arranged that they close under the action of a spring, but are kept open by a catch. A magnet, A, releases the catch, whereupon the switch closes. By means of the contact k, on closing it brings the magnet E into operation, which immediately opens the switch again. Other contacts l, n, and x serve for working signals and facilitating the automatic operation of the apparatus. This arrangement is preferable to the use of motors, in that it acts more quickly. A magnet, which releases a catch, can be worked by a small relay, and acts very quickly, while a magnet which works a large oil switch, requires a considerable time for its excitation; it, moreover, takes so much current that other auxiliary accessories are needed. Motors act still more slowly, as they are geared down to a considerable extent. It is, however, very important that the first closing of the switch should take place very quickly, as this determines the amount of the disturbances. The closing of the switch is a very simple affair.

The second important part of the apparatus is the automatic control. For each phase there is a relay group. This consists of a no-voltage relay, N, an intermediate relay, C, and a permanently-closing relay, Z; there is also an electromagnetically-controlled auxiliary switch, D. In addition there are fuses for the working current of the control, signal lamps, and lever switches for cutting out the various circuits. The no-voltage relay is of the simplest kind. It consists solely of a solenoid in which a tube of iron acts as a core, which on full excitation hangs freely in the solenoid. If the voltage falls the core falls slowly down to a certain point, when it falls suddenly and closes the contact a. The core is adjusted to fall when the voltage decreases to half its normal value. The no-voltage relay is the main part of the apparatus, and the simplicity of its construction is of importance. It will be remembered that in case of a simultaneous disturbance on two or three no-voltage relays, only one earth switch is to be closed. There are, therefore, special intermediate relays, which affect the cut-out coil A of the earthing switch. The intermediate relays C are simple direct-current magnets, the armatures of which are carried by a contact bridge, which in the position of rest keeps the contacts c c closed: when the magnet is excited it opens them, and then closes the contacts b b for the magnet of the earthing switch. A photograph (not here reproduced) shows the details of the apparatus, and other photographs show other parts. All these relays work very quickly. It remains to describe the relay Z for permanently closing the earthing switch. This must, of course, prevent the oil switch from opening again. This is effected as follows: At the right moment, the auxiliary switch D opens, and this cuts off the current to the magnet E. For this purpose the relay Z closes the contact r, which connects the magnet of the auxiliary switch d to the contacts of the intermediate relay C. The relay Z consists of a magnet n, which receives current together with the magnet A of the earthing oil switch. The relay Z comes into operation as soon as one of the earthing oil switches closes, and remains in activity for a certain definite period, determined by the method of its action. If the closing and opening of the earthing switch lasts till the contact r closes, the auxiliary switch D is cut out and the further opening of the earthing switch is prevented. A photograph of the relay Z is given, showing many of the details. The auxiliary switch D is an ordinary direct-current operated switch. Its cut-out coil a is controlled by the relay Z: its cut-in coil is controlled by the press-button d. If the earthing switch is permanently closed, and the auxiliary switch consequently open, then by pressing the button d it can be closed again. The apparatus is then again ready for work.

Let us now describe its method of operation. The no-voltage relay may be supposed to have closed the contacts c_1. The relays N_2 and N_3 have attracted their armatures: the intermediate relays C_2 C_3 have no current, and the contacts c_2 c_3 are therefore closed. Further, the switch D and the contacts l_1 l_2 l_3 are closed, so that current flows from C_1 through D, a_1, c_3, c_2, l_1, l_2, l_3. The contacts c_1 open, and separate the relays C_2 and C_3 from the current. The relays N_2 and N_3 are thus put out of action. The contact b_1 is then closed. Then the coil A_1 of the earthing switch S_1 receives current through D, b_1, m_1, Z_1, l_1, l_2, l_3. The catch V_1 of the earthing switch is set free, and the spring F_1 closes the switch. The beginning of this

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 14, 1916.

movement opens the contact l_1 and stops the current to the three coils A_1, A_2, A_3, and the three intermediate relays C_1, C_2, C_3. From this moment no kind of switching can take place in the other phases. For the proper working of the apparatus the contact l_1 in the earthing switch is of great importance. The no-voltage relay N_1 receives the full pressure when the earthing switch is opened. If there were no contact l_1, then the following would be the course of events: The relay N_1 would be excited, its armature would be lifted and open the contact b, the magnetism in A_1 would disappear, and its armature would be set free, the catch-mechanism V_1 would fall back into the position in which it holds the earth-switch S_1 open. This switch opens so suddenly that the catch would not be ready for a new series of operations. Therefore, the switch would continuously open and close. The function of the contact l_1 is to arrange that the magnet A_1 shall not have current as soon as the earthing switch begins to close, and thus the catch-mechanism is ready for work.

This explains the action of the apparatus very briefly. The author, however, in his original communication, adds many other details and explanations, which are not reproduced here. There are

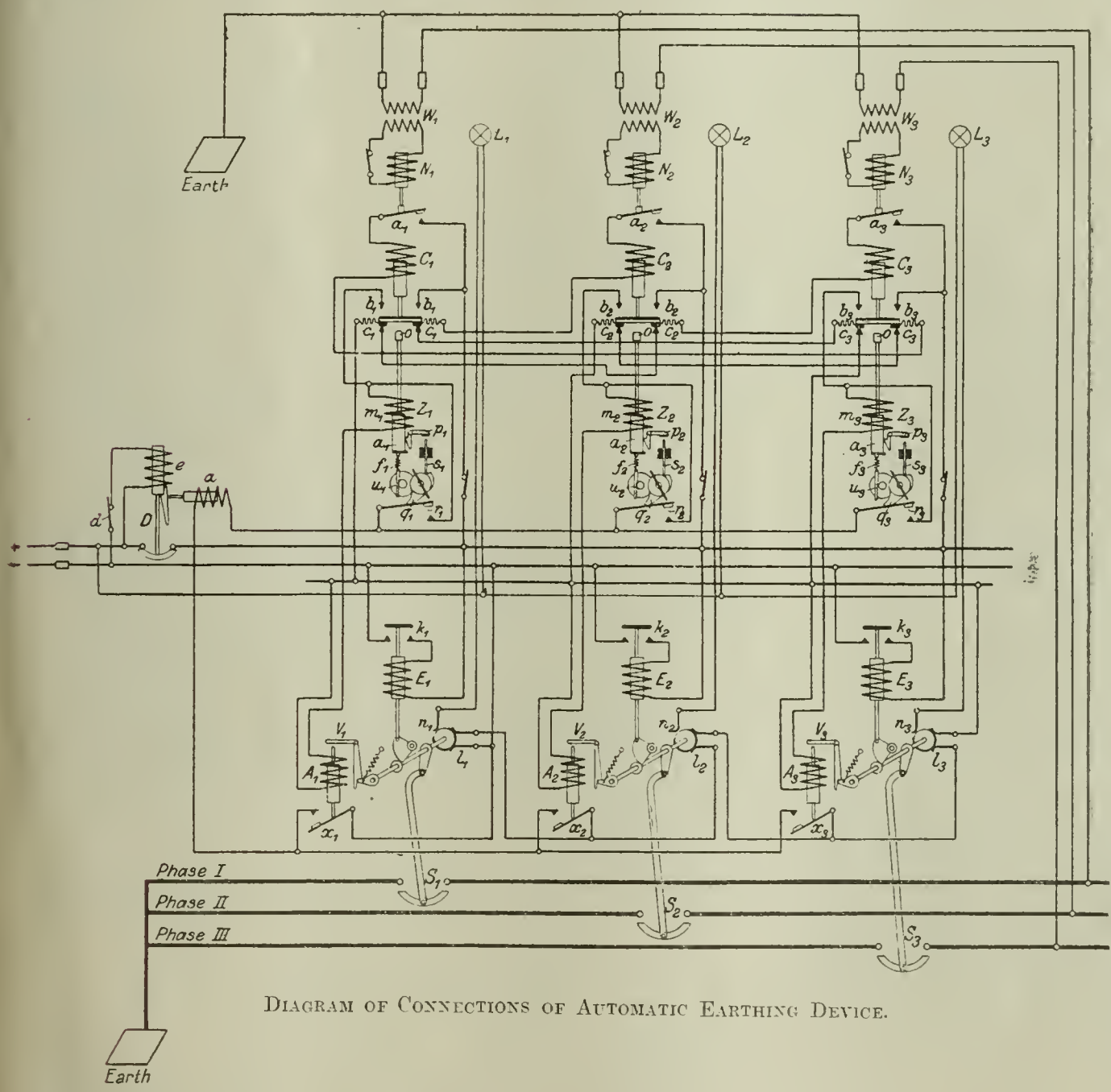


Diagram of Connections of Automatic Earthing Device.

also other sections, dealing with the cases of the suppression of a repeated arcing ground, or of a permanent earth on one phase. The case is also considered of a simultaneous earth on different phases. We cannot find space for the consideration of these cases, and must refer those interested in the matter to the original article.

A few words may be added as to the installation of the apparatus. Most of the connections are already made inside the apparatus, but the author gives a diagram showing the connections to be made in an ordinary case. Direct-current is necessary, preferably at 110 or 220 volts. Higher voltages would need special insulation and precautions against sparking; lower voltages would mean inconveniently heavy currents. This direct-current power can be easily provided in three-phase stations, and is only required occasionally. At the instants when the magnets for opening the earthing oil switches are working, about 20 kw. or 30 kw. are required. The consumption of power by the other accessories is very small. This energy can be taken from a part of a buffer battery without any inequalities resulting. In those rare cases where direct current is not available some sort of a motor-generator must be provided; it should have a considerable flywheel, and a permanent output of about 5 kw. For the no-voltage relays measuring transformers must be provided with 110 volts on the low-tension side. They are to be joined together in star with the neutral point earthed. A simplification of the apparatus is in view, whereby one magnet shall suffice for opening the three oil switches. Seeing that only one switch is opened at a time, this magnet would be of the same size as any one of the three at present provided.

Several pieces of apparatus of the kind already described are in actual service, but as it is called on to work so seldom, it is not easy to report very definitely. Therefore, it is thought that it should be satisfactory if it can be stated that the design is such that after 500 operations of the switch no deterioration is visible. This is the case with the present apparatus. Some tests were made on a line 100 km. long, working at a pressure of 30,000 volts. Here it was found that an artificially-produced arc caused the horn protectors to act in the absence of the earthing apparatus, but there were no discharges between the horns when the apparatus was used. The automatic earthing apparatus is also a protection against surges of a secondary character. Further, the apparatus is very important when a permanent earth arises through an accident on the line. It is to be hoped that this form of protection will justify itself, and that its use on high-tension lines will lead to greater security and continuity in supply.

THE OPEN DELTA CONNECTION FOR TRANSFORMERS.*

BY J. B. GIBBS.

It is well known that two transformers may be connected in open delta to a three-phase system to deliver three-phase power. The characteristics of this connection may be understood by considering

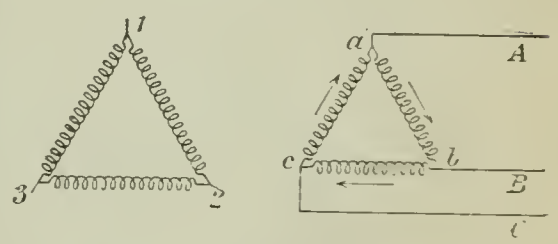


Fig. 1.—Delta Connected Bank of Transformers.

three transformers connected in closed delta and then noting the changes which occur when one of the transformers is disconnected.

Such a bank is shown in Fig. 1, with high-tension delta 1-2-3, low-tension delta a-b-c, and low-tension lines aA, bB and cC. The arrows indicate the positive direction of currents. The vector diagram, Fig. 2, shows the relation of the currents in the windings and lines. The currents in the three transformers are respectively i_{ab}, i_{bc} and i_{ca}, 120 deg. apart. The current in the line aA is the vector sum of the currents flowing from c to a and from b to a, *i.e.*,

$$I_{aA} = i_{ca} + i_{ba} = i_{ca} - i_{ab}.$$

Similarly the line currents I_{bB} and I_{cC} are found as shown.

If the power-factor of the load be assumed as 100 per cent., the voltages from a to b, b to c, and c to a will be respectively in phase with the currents i_{ab}, i_{bc} and i_{ca}, as shown in Fig. 2. That is, the load carried by each transformer has the same power-factor as the load on the bank. It should be noted, however, that the line currents I_{aA}, I_{bB} and I_{cC} are not in phase with the voltages between lines E_{ab}, E_{bc}, and E_{ca}.

Now suppose that the transformer 2-3-b-c is removed, leaving the arrangement shown in Fig. 3. Since the load is unchanged, the line currents and voltages are the same as before, neglecting the effect of the regulation, which will be discussed later. Fig. 4 shows these line currents and voltages, which are the same as in Fig. 2. Now, however, all the current which flows out on the line bB must flow through

* From the "Electric Journal," somewhat abbreviated.

the transformer winding *ab*, and consequently, if the load has a power-factor of unity, the current and voltage in the transformer winding are 30 deg. apart, as shown in Fig. 4, and the transformer is, in effect, operating at 86·6 per cent. power-factor.

In the closed delta bank with a balanced load, the power of each transformer is $i_{ab}E_{ab}$ and the total power of the bank is

$$P=3i_{ab}E_{ab},$$

but $$i_{ab}=I_{bB}/\sqrt{3},$$

and therefore, $$P=3\frac{I_{bB}}{\sqrt{3}}E_{ab}=\sqrt{3}I_{bB}E_{ab},$$

which is the same as the total rating of the three transformers.

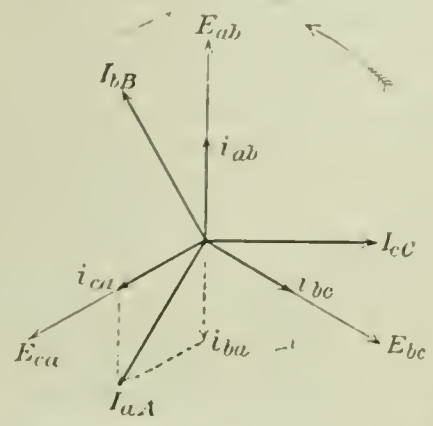


FIG. 2.—VECTOR DIAGRAM OF DELTA CONNECTED BANK.

In the open delta bank, to deliver the same amount of power as before, the size of the transformers must be increased so as to carry the line current I_{bB}, and since there are now two transformers, their combined rating must be total rating$=2I_{bB}E_{ab}$. This is about 15 per cent. greater than the total rating for the equivalent closed delta bank, but, as shown below, this is not necessarily a disadvantage.

Regulation.—The regulation for a closed delta bank carrying a load at unity power-factor is shown in Fig. 5. The no-load voltages are

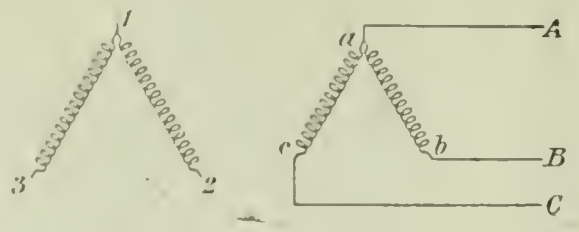


FIG. 3.—OPEN-DELTA CONNECTED BANK OF TRANSFORMERS.

E_{ab}, E_{bc} and E_{ca}, 120 deg. apart, and the drop in each transformer consists of a resistance component, *ir*, in phase with the current and a reactance component, *ix*, perpendicular to the current. These drops subtracted from the no-load voltages give the full-load voltages E'_{ab}, E'_{bc} and E'_{ca}.

The regulation for an open delta bank with a unity power-factor load is shown in Fig. 6. The no-load voltages are E_{ab}, E_{bc} and E_{ca}, as before; the current I_{bB} flows in the line bB and in the transformer

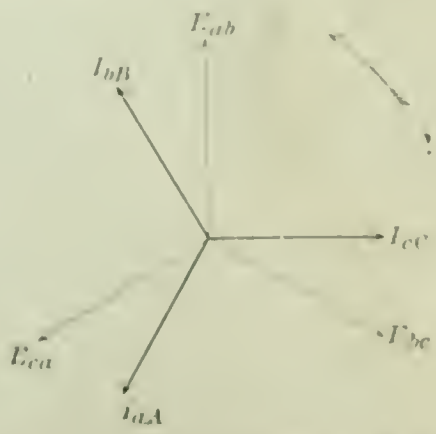


FIG. 4.—VECTOR DIAGRAM OF OPEN-DELTA CONNECTED BANK.

from *a* to *b* (Fig. 3), and the current I_{cC} flows in the line *cC* and in the transformer from *a* to *c*. The drop in the transformer *ab* consists of a resistance component, *ir*, in phase with the current I_{bB} and a reactance component, *ix*, perpendicular to I_{bB}, and this total drop, subtracted from the no-load voltage E_{ab}, gives the full-load voltage E'_{ab}. In the transformer *ca*, the resistance drop is in phase with the current I_{cC}, and the reactance drop is perpendicular to this current, but the resultant drop must be added to the no-load voltage E_{ca} to give the full-load voltage E'_{ca}, because the current I_{cC} flows through the transformer in a negative direction, *i.e.*, opposite to the arrow, Fig. 1, and opposite to the voltage E_{ca}. The full-load voltage, E'_{bc}, is the vector sum of the voltages E'_{ba} and E'_{ac} and is found as indicated in Fig. 6. Thus there is an unbalancing in the full-load voltages of transformers connected in open delta. The unbalance, however, is small in amount and does not introduce practical difficulties.

For the sake of simplicity, the assumption has been made, thus far, that the power-factor of the load is unity. By the same process of reasoning, however, the diagram may be constructed for any power-factor. Thus, Fig. 7 is a diagram for three transformers in delta carrying a load of any power factor. Vectors i_{ab}, i_{bc} and i_{ca}, represent the currents in the windings of the three transformers and they lag behind the full-load voltages in the same windings by the angle θ, whose cosine is the power-factor of the load. The voltage

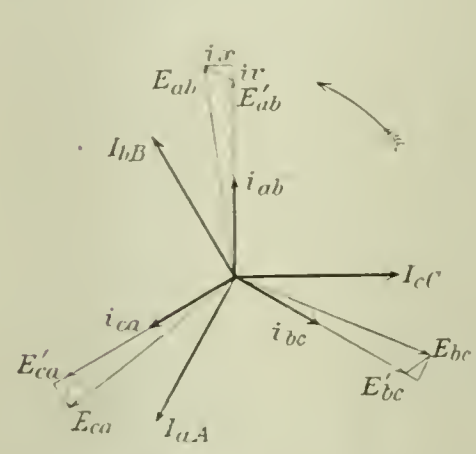


FIG. 5.—REGULATION FOR CLOSED-DELTA BANK.

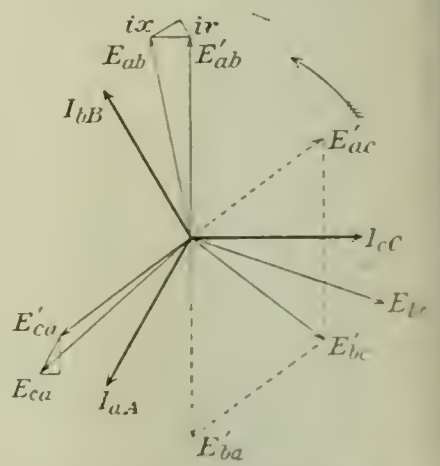


FIG. 6.—REGULATION FOR OPEN DELTA BANK.

drop is each transformer consists of the same triangle as before, Fig. 5, with the resistance component, *ir*, in phase with the current and the reactance component, *ix*, at right angles to the current. The vector sum of these two components, added to the full-load voltages, gives the no-load voltages.

The corresponding diagram for two transformers in open delta is shown in Fig. 8. Since the power-factor of the load is the same as in Fig. 7, the angular relations of the line currents and the full-load voltages will be the same. The voltage drop in the transformer *a-b* is the same triangle as in Fig. 6, with *ir* in phase with the line current I_{bB} and *ix* perpenicular to I_{bB}. Likewise, the voltage drop in the transformer *c-a* consists of *ir* in phase with the current I_{cC} and *ix* perpendicular to I_{cC}; and the full-load voltage E'_b is the resultant of E'_{ba} and E'_{ac}.

It must be understood, of course, that the drops shown in these diagrams are very much magnified. In commercial transformers the resistance drop may be 0·5 to 2 per cent. of the voltage and the

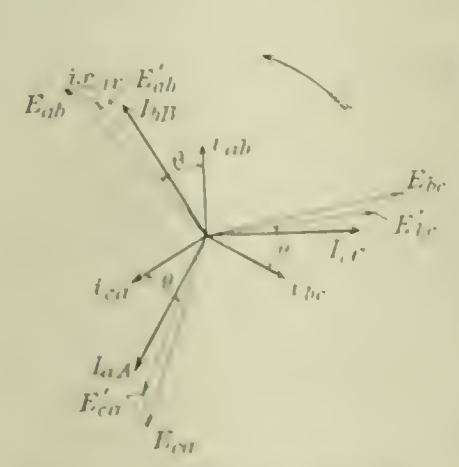


FIG. 7.—VECTOR DIAGRAM OF DELTA BANK, CARRYING LOAD OF ANY POWER-FACTOR.

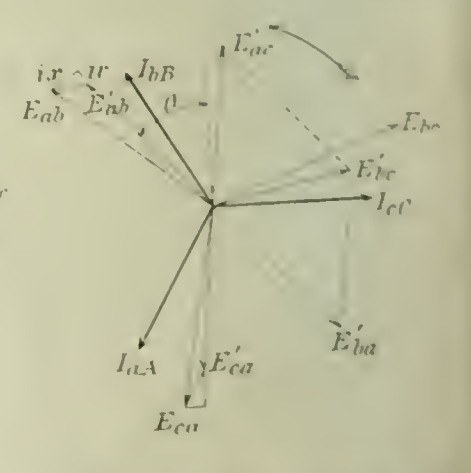


FIG. 8.—VECTOR DIAGRAM OF OPEN-DELTA BANK, CARRYING LOAD OF ANY POWER-FACTOR.

reactance drop, perhaps, 1 to 5 per cent. The vector diagram is not adapted to the graphic solution of problems of this kind, where there is a large difference in the magnitude of the quantities considered, but it is valuable as a guide in working them out either by the symbolic or by the trigonometric method. An example will make this clear.

Example.—Find the full-load voltages for the following case :—

Given :—

Two transformers connected in open delta.	
Transformer rating	5 k.v.a. each
Full-load output of the bank	8·66 k.v.a.
Resistance	1·66 per cent.
Reactance	2·325 per cent.
Power-factor of load	80 per cent.
No-load voltage	100 per cent.

Referring to Fig. 9, the full-load voltage is drawn at an angle θ from the vertical such that cos θ=the power-factor of the load. The current I_{bB} is 30 deg. from the vertical. Therefore $a=\theta-30$ deg., where a is the angle by which the current in the transformer lags behind the voltage. Now the voltage drop in a transformer is

$$\text{Drop}^*=ir\cos a+ix\sin a+(1/200)\,(ix\cos a-ir\sin a)^2.$$

The solution may be simplified, and will give approximately correct results if the last term of the expression for voltage drop be disregarded. This gives drop$=ir\cos a+ix\sin a$. And the resulting full-load voltages are

$$E'_{ab}=98{\cdot}07$$
$$E'_{ca}=97{\cdot}21$$
$$E'_{bc}=95{\cdot}28$$

Table I. shows the full-load voltages of these two transformers for loads of various power-factor.

Table I.—*Two 5 k.v.a. Transformers in Open Delta.*
Resistance=1·66 per cent. Reactance=2·325 per cent.

	Per cent. no-load voltage.	Per cent. full-load voltage.		
		100 per cent. power-factor.	90 per cent. power-factor.	80 per cent. power-factor.
E_{ab}	100	99·68	98·48	98·05
E_{bc}	100	97·09	95·63	95·26
E_{ca}	100	97·36	97·15	97·23

Table II. shows the full-load voltages for three of the above transformers in delta.

Table II.—*Three 5 k.v.a. Transformers in Delta.*
Resistance=1·66 per cent. Reactance=2·325 per cent.

Per cent. no-load voltage.	Per cent. full-load voltage.		
	100 per cent. power-factor.	90 per cent. power-factor.	80 per cent. power-factor.
100	98·31	97·48	97·27

An emergency condition sometimes occurs due to an accident to one transformer of a closed delta bank, and the question arises, how

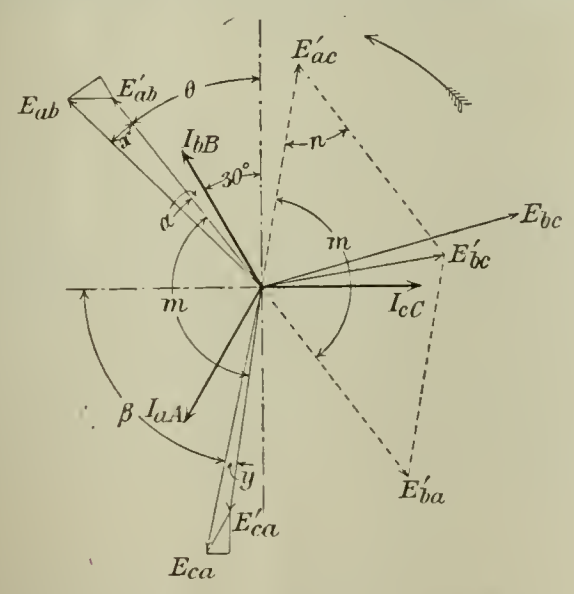


Fig. 9.—Particular Example of General Diagram shown in Fig. 8.

much load the remaining two transformers will be able to carry in open delta. For the same heating, the same current should flow in the transformers as before ; but, as the full-line current now flows through each transformer, the line current must be reduced from its former value in the ratio $1:1/\sqrt{3}$, *i.e.*, the two remaining transformers will carry 58 per cent. of the load of the original bank. An idea of the effect on the regulation may be had by comparing Tables I and II. The actual values in any particular case will, of course, depend on the characteristics of the transformers involved.

* This equation is general if the angle of a lagging current be regarded as positive and the angle of a leading current as negative.

Frequently it is desired to carry a load with two transformers instead of three. In this case transformers of sufficient size are installed and a comparison between the regulations of the open delta bank and the closed delta bank is less unfavourable to the open delta connection than the comparison above, because the larger transformers have, in general, better regulation than the smaller, especially at high power-factors.

Table III. shows the full-load voltages of a closed delta bank of 3 k.v.a. transformers of the same type as the two 5 k.v.a. transformers considered in Table I. A comparison of these two tables gives an idea of the results of the two methods of connection for the same load.

Table III.—*Three 3 k.v.a. Transformers in Delta.*
Resistance=1·99 per cent. Reactance=1·56 per cent.

Per cent. no-load voltage.	Per cent. full-load voltage.		
	100 per cent. power-factor.	90 per cent. power-factor.	80 per cent. power-factor.
100	98·00	97·54	97·48

Table IV.—*Comparison of Closed Delta with Open Delta Connection—Distributing Transformers.*

——	Closed delta Three 3 k.v.a.	Open delta Two 5 k.v.a.
Capacity of bank	9 k.v.a.	8·66 k.v.a.
Losses per k.v.a. per cent.	100	88
Cost per k.v.a. per cent.	100	97½
Weight per k.v.a. per cent.	100	108

Table V.—*Comparison of Closed Delta with Open Delta Connection—Power Transformers.*

——	Closed delta 3·300 k.v.a.	Open delta 2·500 k.v.a.
Capacity of bank	900 k.v.a.	866 k.v.a.
Losses per k.v.a. per cent.	100	101
Cost per k.v.a. per cent.	100	86·3
Weight per k.v.a. per cent.	100	100

Comparing the efficiencies of two V-connected transformers and three delta connected transformers for the same output, it is found that they are practically the same. Thus, the total loss in a bank of three 3 k.v.a. transformers of standard design is 291 watts at full load, or 32 watts per kilovolt-ampere output ; while in a bank of two 5 k.v.a. transformers the total loss is 248 watts, or 28·6 watts per kilovolt-ampere of output. Similarly, in a bank of three 300 k.v.a. transformers the total loss amounts to 16·77 watts per kilovolt-ampere output, while in a bank of two 500 k.v.a. transformers the total loss is 16·98 watts per kilovolt-ampere.

The total cost and weight are also nearly the same for the two schemes. Table IV. shows a comparison of the losses, weights and costs for a bank of small distributing transformers, and Table V. makes the same comparisons for a bank of power transformers.

One advantage of the open delta connection which may be important in some cases is that only two units are required instead of three. This means less floor space, and in the case of distributing transformers mounted on poles it means a neater and simpler arrangement.

Summary.

The foregoing points may be summarised as follows :—

1. The total transformer capacity required for an open delta bank to carry a given load is 15 per cent. greater than for a closed delta. This total capacity is in two units instead of three.
2. The voltage drop in the open delta bank is unsymmetrical, and this causes a slight unbalance in the three full-load voltages. This unbalance is negligible in most cases.
3. When one transformer of a closed delta bank is injured the two remaining transformers will carry 58 per cent. of the load with the same heating, but with a somewhat poorer regulation on two phases.
4. When transformers are chosen for a given load the above advantage of the closed delta connection partially disappears, on account of the larger size of the transformers for the open delta bank.
5. In efficiency and weight the open delta bank is approximately on a bar with the closed delta, while in cost it shows a slight advantage.
6. The open delta connection involves two units instead of three, and requires less floor space than the closed delta arrangement.

THE AIR-GAP FIELD OF THE POLYPHASE INDUCTION MOTOR.

BY F. T. CHAPMAN, D.SC.

(*Continued from page* 708.)

SUMMARY OF CONTENTS.

III.—The Reaction of Rotor Currents on Stator Field (Permeability Constant).
Sections 16 to 18.—Analysis of field due to rotor currents. E.M.F.s induced by these fields in stator windings.
Sections 19 and 20.—The circle diagram, circle coefficient and air-gap dispersion.
Sections 21 and 22.—Superposition of rotor multiple fields on those of stator. The effects in the case of two- or three-phase rotors and of squirrel-cage rotors.
Sections 23 and 24.—"Crawling." Effects of skewed slots.

III. Reaction of Rotor Circuits.—The Circle Diagram.

16. When the rotor circuits are closed, each of the multiple fields produced by the stator currents will induce currents in the rotor windings, the frequency of these currents depending on the number of poles in the multiple field, and on its speed relative to the rotor. The rotor currents of this frequency produce an infinite number of multiple fields corresponding to the analyses already discussed, and each of these induces currents in the stator circuits, which must be regarded as more or less effectively closed by the network to which they are connected. We therefore have an infinite number of actions and reactions between the stator and rotor circuits. The importance of these reactions diminishes rapidly as their remoteness increases, in fact, it is one of the objects of this Paper to show that the only medium of action and reaction between the stator and rotor, which need be considered in practice, is the fundamental or p-pole field; and that, in the case of motors with two or three-phase windings on both members, the action on one member of even the first series of multiple fields produced by the other member may be neglected. In the squirrel-cage motor this is not quite true, but we shall see that its winding tends to diminish the importance of the first series of multiple fields, and hence to simplify the problem still further.

17. *Case (a).—Machine Having Rotors with Two or Three-phase Windings.*—Let P_2 represent the number of phases in the rotor winding. The E.M.F. in one phase due to the c_1th stator field is given by the equation (12), and the E.M.F. in successive phases is obtained by writing $(x_1+\tau/P_2)$, $(x_1+2\tau/P_2)$, &c., for x_1 in this expression. We will also write f_{sc_1} for $(f_1-f_{2c_1})$; thus f_{sc_1} is the frequency of the rotor E.M.F.s induced by the c_1th stator field.

The currents in all the phases will be equal, and will lag behind the impressed E.M.F. by a certain angle ψ_2. The current in the first phase (position as defined in section 8) is

$$i_{2c_1}=-I_{2c_1}\cos\left(2\pi f_{sc_1}t-\frac{c_1\pi x_1}{\tau}-\psi_2\right)$$

$$=I_{2c_1}\sin\left(2\pi f_{sc_1}t-\frac{c_1\pi x_1}{\tau}-\frac{\pi}{2}-\psi_2\right)$$

which may be written for convenience as

$$i_{2c_1}=I_{2c_1}\sin\psi.$$

For succeeding phases we have

$$i_{2c_1}=I_{2c_1}\sin(\psi-c_1\pi\tau/P_2)$$

$$i_{2c_1}=I_{2c_1}\sin(\psi-2c_1\pi\tau/P_2)\text{ and so on.}$$

Let x' be the distance of any point on the rotor surface from the centre of the first phase group; then, proceeding as in sections 3, 4 and 5, we find that these currents give rise to a series of multiple fields, and if the number of poles in any one of these fields be pc_2 the possible values for c_2 are given by

$$c_2=2P_2d_2+c_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (34)$$

where d_2 is any positive or negative integer.

The induction density at any point due to any field is given by

$$y_{c_2c_1}=\frac{2P_2I_{2c_1}T_2PK_{m_2c_2}}{p\pi}\cos\left\{\left(2\pi f_{sc_1}t-\frac{c_1\pi x_1}{\tau}-\frac{c_2\pi x'}{\tau}\right)-\left(\frac{\pi}{2}+\phi_2\right)\right\} \quad . \quad . \quad . \quad . \quad . \quad (35)$$

The velocity of any field is

$$v'_{c_2c_1}=2f_{sc_1}\tau/c_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (36)$$

The speed of one of these fields with respect to the stator windings will be given by

$$v_{c_2c_1}=v'_{c_2c_1}-2f_2\tau$$

$$=2\tau\left(\frac{f_{sc_1}}{c_2}-f_2\right)$$

$$=\frac{2\tau}{c_2}(f_{sc_1}-c_2f_2)$$

$$=\frac{2\tau}{c_2}\{f_1-f_2(c_2-c_1)\} \quad . \quad . \quad . \quad . \quad . \quad (37)$$

The frequency of the E.M.F.s induced by this field in the stator windings is

$$f_1-f_2(c_2-c_1) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (38)$$

If $c_2=c_1$, a condition which equation (34) shows to be possible in every case, except when the rotor phases are star connected (*see* Ex. ii., below), the E.M.F.s induced in the stator are of fundamental frequency.

A few examples will serve to make these relations clearer.

(i.) Suppose both stator and rotor have three-phase windings, *i.e.*, $P_1=P_2=3$.

The possible values of c_1 are $\begin{cases}+1,\ +7,\ +13,\ -17,\ \&c.\\ -5,\ -11,\ -19,\ \&c.\end{cases}$

Consider the effects of the $5p$-pole field on the rotor; the possible values of c_2 are $\begin{cases}1,\ 7,\ 13,\ \&c.\\ -5,\ -11,\ \&c.\end{cases}$

The field for which $c_2=-5$ rotates at the same speed as the stator field which is the prime cause of it. The resultant $5p$-pole field is the combination of the two, and is less than the original stator field; in the limiting case the resultant is the difference between the two.

Over the most important part of the working range of the motor we have $f_2=f_1$ approx., and the frequency of the E.M.F.s induced by the c_2th rotor field in the stator windings is approximately

$$f_{1c_2}=f_1+f_1(c_2-c_1)=f_1(1+c_2-c_1) \quad . \quad . \quad . \quad . \quad . \quad (39)$$

If $c_2=1$ and $c_1=-5$,

$f_{1c_2}=7f_1$.

As the source of supply offers no E.M.F. counter to this, and as the networks to which motors are usually connected have very low impedances, currents of frequency $7f_1$* will be produced in the stator circuits, and their effect is to damp partially the rotor field for which $c_2=1$, and thereby to reduce the total inductance of the rotor windings to currents of frequency f_{sc_1}. The frequency of the rotor currents themselves is $f_1(1-c_1)=6f_1$. On account of the high reactance of the circuits at these frequencies the currents will be small, and the field for which $c_2=-5$ will not affect to any large extent the value of the field for which $c_1=-5$.

Table IIIa.

c_1	c_2	f_{sc_1}	f_{1c_2}
−5	1	$6f_1$	$7f_1$
7	1	$-6f_1$	$-5f_1$
−11	1	$12f_1$	$13f_1$
13	1	$-12f_1$	$-11f_1$

Table IIIa., giving values of f_{sc_1} and f_{1c_2} at synchronism for various values of c_1 and c_2 is interesting. A negative frequency is to be interpreted as indicating that the order in which the currents in successive phases follow each other is opposite to that which was assumed in drawing up the early equations.

* *See* Simons and Vollmer *loc. cit.*

(ii.) Let $P_1=2$, $P_2=3$.

The possible values of c_1 are $\begin{cases} 1, & 5, & 9, & 13, \text{ \&c.} \\ & -3, & -7, & -11, \text{ \&c.} \end{cases}$

The $5p$-pole stator field will give rise to multiple rotor fields for which the following are the possible values of c_2

$$\begin{cases} & 5, & 11, & 17, \text{ \&c.} \\ -1, & -7, & -13, & -19, \text{ \&c.} \end{cases}$$

The $5p$-pole rotor field thus moves forward in this case, and as the stator field does the same, the consequences are similar to those in Ex. (i.). Special relations, which have no counterpart in Ex. (i.), occur when $c_1=-3$, $+9$, &c., for when $c_2=6d_2-3$ the possible values of c_2 are $\begin{cases} 3, & 9, & 15, \text{ \&c.} \\ -3, & -9, & -15, \text{ \&c.} \end{cases}$

corresponding to alternating fields of $3p$, $9p$, &c., poles. It should be noticed, however, that the currents which give rise to these fields can circulate in the rotor windings only when the phases are separately closed or delta-connected, and not when they are star-connected with insulated neutral.

From the results given in later sections of this Paper it will be seen that slightly better performance may be expected from a two-phase motor with delta-connected three-phase rotor, than from the same motor with star connected rotor windings.

(iii.) Another important case occurs when $P_2=1$.

Suppose $c_1=7$, the possible values for c_2 are

$$\begin{cases} 1, & 3, & 5, & 7, & 9, \text{ \&c.} \\ -1, & -3, & -5, & -7, & -9, \text{ \&c.} \end{cases}$$

The same is true for all values of c_1.

A well-known effect is the tendency of a motor with only one closed phase in the rotor to run at half its normal speed. This is due to the fact that if $f_2=\frac{1}{2}f_1$, $c_1=1$ and $c_2=-1$, the value of f_{1c_2} is

$$\begin{aligned} f_{1c_2} &= f_1+\frac{f_1}{2}(c_2-c_1) \\ &= f_1+\frac{f_1}{2}(-1-1) \\ &= 0. \end{aligned}$$

The $-c_2th$ rotor field will produce low frequency stator currents of comparatively large value which give rise to a driving torque or a retarding torque according as the speed is below or above half-speed.

(iv.) In a squirrel-cage motor P_2 is large, and the series of possible values of c_2 is limited in consequence.

Suppose we have, for instance, $p=4$, $G=41$ then $P_2=10{\cdot}25$, and if we assume the formula (34) to be true for fractional values of P_2, we find for $c_1=1$

$$c_2=\begin{cases} 1, & 21{\cdot}5, & 42, \text{ \&c.} \\ & -19{\cdot}5, & -40, \text{ \&c.} \end{cases}$$

and for $c_1=-5$

$$c_2=\begin{cases} & 15{\cdot}5, & 36, \text{ \&c.} \\ -5, & -25{\cdot}5, & -46, \text{ \&c.} \end{cases}$$

It will be seen that this analysis agrees with that of section 14.

18. Examination of the formula (35) shows that the amplitude of the field diminishes rapidly as c_2 increases (*see* Tables X. and XI., giving values of K_{mc}), and in any series the most important field is that one for which $c_2=1$. When the number of phases is small (*i.e.*, 2 or 3) this value of c_2 is always possible, with the single exception that when $P_2=3$ and $c_1=3$, 9, &c., the lowest value of c_2 is 3. But when the number of phases is large, as in squirrel-cage windings, the lowest value of c_2 is equal to c_1 for all values of c_1 less than P_2, *i.e.*, less than G/p; consequently for all the most important values of c_1 the strongest rotor field of the corresponding series is directly opposed to the multiple stator field to which its origin is due. For this reason there is a much greater tendency to the reduction of the stator multiple fields when a squirrel-cage rotor is employed, and it is to this circumstance that the superiority of the squirrel-cage machine is ultimately due.

19. We shall now assume as a first approximation that the stator fields beyond the first one induce negligible currents in the rotor windings, and therefore remain undamped, the same being true of the multiple rotor fields. The two members are thus assumed to act and react on each other through the medium of the fundamental, or p-pole, field only. We shall see later that this assumption may be allowed to stand for motors with two or three-phase windings, but that it requires modification for the squirrel-cage motor.

Under these circumstances the stator winding can be supposed to experience (i.) a self-induced back E.M.F. which is given by equation (12A), or is obtained by the aid of formula (13), and (ii.) an E.M.F. induced by the first rotor field; E.M.F.s (i.) and (ii.) must be balanced by the applied E.M.F. (We shall neglect the resistance of the stator-windings.) In the rotor circuit the self-induced E.M.F.s of equation (12A) must be counterbalanced, and the E.M.F.s necessary to overcome the resistance of the windings must be supplied, through the medium of the first stator field, by induction.

We may thus suppose the stator winding to possess a reactance due to its air-gap fluxes equal to

$$X_1'=2\pi f_1 Q \cdot \frac{T_1^2 \mathrm{P} l\tau}{p}\times 10^{-8} \text{ ohms} \quad . \quad . \quad . \quad (40)$$

and $\lambda_1 X_1'$ due to end winding and slot leakage fluxes; λ_1 is a coefficient which we take for granted in the present Paper. The total reactance per stator phase is thus

$$X_1=X_1'(1+\lambda_1). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (41)$$

If the fractional slip be s the frequency of the rotor currents will be $f_s=sf_1$, and we may write as for the stator circuits the rotor reactance per phase.

$$\begin{aligned} sX_2 &= (1+\lambda_2) \cdot sX_2' \\ &= (1+\lambda_2) \cdot 2\pi s f_1 Q_2 \cdot \frac{T_2^2 \mathrm{P} l\tau}{p}\times 10^{-8} \text{ ohms.} \quad . \quad . \quad (42) \end{aligned}$$

For a squirrel-cage winding the reactance per conductor is

$$sX_2=(1+\lambda_2) \cdot 2\pi s f_1 \mathrm{P} l\tau \left[\frac{P}{G}\cdot \frac{1}{4\sin^2\frac{\pi p}{2G}}\right]\times 10^{-8} \text{ ohms.} \quad . \quad (43)$$

We may further suppose that an effective current A_1 per phase in the stator winding will induce in the rotor an effective E.M.F. per phase, equal to $A_1\gamma_1 s$ through the medium of the first field.

$$\text{Where} \quad Y_1'=\frac{8 f_1 T_1 T_2 P_1 \mathrm{P} K_{m_1} K_{m_2} l\tau}{\pi p}\times 10^{-8} \text{ ohms.} \quad . \quad . \quad (44)$$

(*See* equation (12.)

Similarly an effective rotor current of A_2 amperes per phase induces in the stator winding an E.M.F. $A_2\gamma_2$ where

$$Y_2=\frac{8 f_1 T_1 T_2 P_2 \mathrm{P} K_{m_1} K_{m_2} l\tau}{\pi p}\times 10^{-8} \text{ ohms} \quad . \quad . \quad . \quad (45)$$

For squirrel-cage windings a single conductor is taken to constitute a complete phase, and we have, therefore,

$$Y_1=\frac{4 f_1 T_1 P_1 \mathrm{P} K^{m_1} l\tau}{\pi p}\times 10^{-8} \text{ ohms} \quad . \quad . \quad . \quad . \quad . \quad (46)$$

and

$$Y_2=\frac{4 f_1 G T_1 \mathrm{P} K_{m_1} l\tau}{\pi p}\times 10^{-8} \text{ ohms.} \quad . \quad . \quad . \quad . \quad . \quad (47)$$

Let the resistance of the rotor winding per phase be r_2, the impedance per phase is then

$$Z_2=\sqrt{r_2^2+s^2X_2^2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (48)$$

The rotor current per phase is thus

$$A_2=A_1Y_1 s/Z_2, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (49)$$

and the angle by which this current lags behind the E.M.F. A_1Y_1s is

$$\varphi_2=\tan^{-1}(sX_2/r_2). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (50)$$

In sections 3, 4 and 5, we have seen that a stator current represented by $I_1 \sin 2\pi f_1 t$ produces a p-pole field represented by

$$y=\frac{2I_1T_1\mathrm{P}}{p\pi}\cdot P_1 K_{m_1}\cos\left(2\pi ft-\frac{\pi x}{\tau}\right), \quad . \quad . \quad . \quad (51)$$

and in equation (35) we have an expression for the field produced by the resulting rotor currents. Writing the amplitude of the rotor current per phase as I_2 and replacing $(x_1+x'+2f_2\tau t)$ by x, we see that the value of the first rotor field is

$$y=\frac{2I_2T_2\mathrm{P}}{p\pi}\cdot P_1 K_{m_2}\cos\left\{2\pi ft-\frac{\pi x}{\tau}-\left(\varphi_2+\frac{\pi}{2}\right)\right\}. \quad . \quad (52)$$

Comparing equations (51) and (52) we observe that the stator E.M.F. due to the first rotor field lags behind the self-induced E.M.F. in the same winding by the angle $(\varphi_2+\pi/2)$. We may, therefore, draw for the stator circuits the vector diagram of Fig. 8, the angle between $A_1 X_1$ and $A_2 Y_2$ being $\varphi+\frac{1}{2}\pi$.

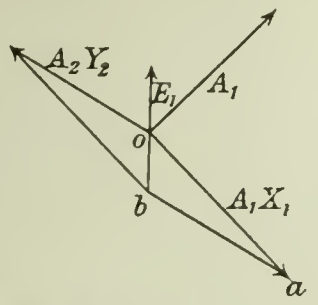


Fig. 8.—Component E.M.F.s, &c., in Primary Windings.

E_1 is the applied E.M.F. per phase and is supposed constant. The triangle Oab is drawn by making ab parallel to $A_2\gamma_2$ and Ob parallel to E_1; Oa being equal to A_1X_1 it follows that ab and bO are respectively equal to $A_2\gamma_2$ and E_1.

If we take this triangle, divide the lengths of all the sides by X_1, redraw it to the current scale, and turn it counter-clockwise through $\pi/2$, we get the new triangle OAB of Fig. 9 in which,

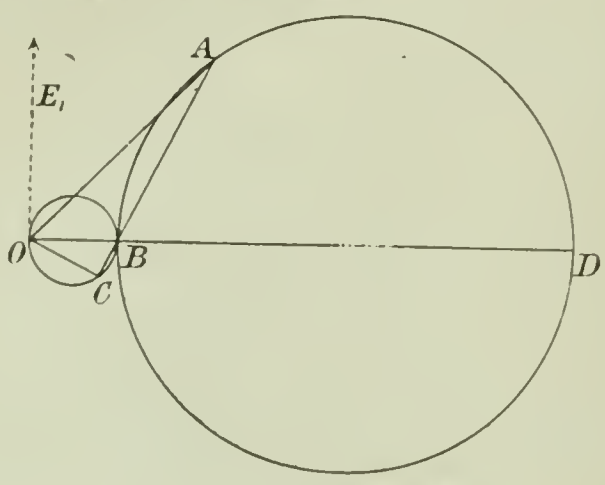


Fig. 9.—Circle Diagram.

OA represents A_1 in magnitude and phase,
AB ,, A_2Y_2/X_1
oB ,, E_1/X_1.

Since E_1 and X_1 are both independent of the load and speed, OB represents a constant current—the no-load or magnetising current.

The angle $O\hat{A}B$ is equal to Oab in Fig. 8, hence

$$O\hat{A}B=\pi/2-\varphi_2.$$

Draw OC perpendicular to AB produced cutting AB in C.

The angle $A\hat{O}C=\varphi_2$,

and $$\overline{AC}=\overline{OA}\cos\varphi_2=\frac{A_1sX_2}{Z_2}.$$

But $$AB=A_2\cdot\frac{Y_2}{X_1}=\frac{A_1sY_1}{Z_2}\cdot\frac{Y_2}{X_1}.$$

$$\therefore\quad \overline{BC}=(\overline{AC}-\overline{AB})=\overline{AB}\left(\frac{\overline{AC}}{\overline{AB}}-1\right)$$

$$=\overline{AB}\left(\frac{X_1X_2}{Y_1Y_2}-1\right).$$

or if we write

$$\frac{X_1X_2}{Y_1Y_2}-1=\sigma, \qquad (53)$$

$$\overline{BC}=\overline{AB}\,.\,\sigma.$$

Now, whatever the conditions may be as to load and slip, the angle at C is a right angle and $\overline{OB}$ is a constant length, hence point C always lies on a circle described on $\overline{OB}$ as diameter, and point A always lies on a circle described on a diameter $\overline{BD}$, where D is a point in OB produced determined by the relation

$$\overline{AB}/\overline{BD}=\sigma.$$

In this way we have derived the usual form of current circle.

20. Let us now examine the expression for σ in formula (53). Substituting for X_1 and X_2, and for Y_1 and Y_2,

$$\sigma=\frac{X_1'X_2'}{Y_1Y_2}(1+\lambda_1)(1+\lambda_2)-1$$

$$=\frac{\pi^4Q_1Q_2}{16P_1P_2K_{m_1}{}^2K^2{}_{m_2}}(1+\lambda_1)(1+\lambda_2)-1.$$

If we write $(1+\lambda_1')$ for $\dfrac{\pi^2Q_1}{4P_1K^2{}_{m_1}}$ (*see* also equation (61) below)

and $(1+\lambda_2')$ for $\dfrac{\pi^2Q_2}{4P_2K^2{}_{m_2}}$ for a wound rotor,

or $(1+\lambda_2')$ for $\left(\dfrac{\frac{\pi p}{2G}}{\sin\frac{\pi p}{2G}}\right)^2$ for a squirrel-cage rotor,

we obtain $\sigma=(1+\lambda_1')(1+\lambda_2')(1+\lambda_1)(1+\lambda_2)-1.$ . . (54)

$(1+\lambda_1')$ is the ratio of the E.M.F. induced in the stator winding by the combined action of all its own multiple fields to the E.M.F. induced by the first field alone. λ_1' is thus a measure of the air-gap dispersion of the stator winding. λ_2' is a similar measure for the rotor winding.

It will be seen that the calculation of these quantities is readily carried out, under the conditions assumed, by means of tables of Q and K, such as those given at the end of Part VI. Since λ_1', &c., are small quantities, equation (54) may be replaced with sufficient accuracy for practical work by

$$\sigma=\lambda_1'+\lambda_2'+\lambda_1+\lambda_2. \qquad (55)$$

21. We are now in a position to examine more closely the reaction of the rotor currents on the multiple fields of the stator. For this purpose we shall neglect the resistance of both stator and rotor windings, and shall regard the network as short-circuiting the stator winding for all E.M.F.s of frequencies other than f_1. In this way we shall obtain a value for the damping which cannot be exceeded in practice.

The c_1th stator field will induce in the rotor an E.M.F. per phase which is given by equation (12). We can regard the rotor circuits as primaries with this E.M.F. impressed on them while the stator circuits act as short-circuited secondaries. The value for σ is the same as for the main currents and E.M.F.s. The slip is very great, and may be either positive or negative, according to the value of c_1.

If we call the E.M.F. E_{c_1}, the reactance of the rotor circuits at the frequency of E_{c_1} would be

$$X_2\times\frac{f_1-f_2c}{f_1},$$

and, were it not for the action of the short-circuited stator winding, the current would be

$$\frac{E_{c_1}f_1}{X_2(f_1-f_2c)}.$$

But we know from the theory of the circle diagram that the effective reactance of the primary circuit is reduced in the ratio $\overline{OB}\,\overline{OD}$ (Fig. 9) when the secondary circuits are closed and the slip is large.

The ratio $$\frac{\overline{OB}}{\overline{OD}}=\frac{\sigma}{1+\sigma}.$$

The actual rotor current is therefore

$$\frac{1+\sigma}{\sigma}\cdot\frac{E_{c_1}f_1}{X_2(f_1-f_2c)}=\frac{1+\sigma}{\sigma(1+\lambda_2)}\cdot\frac{E_{c_1}f_1}{X_2'(f_1-f_2c)}.$$

The instantaneous value of the current is obtained by writing e_{c_1} of equation (12) in place of E_{c_1} and changing the phase angle by $-\pi/2$. Substituting for X'_2 at the same time we obtain

$$i_{2c_1}=\frac{1+\sigma}{\sigma(1+\lambda_2)}\cdot\frac{4I_1T_1P_1K_{m_1c_1}K_{m_2c_2}}{\pi^2Q_2T_2}\cdot\sin\left\{2\pi(f_1-f_2c)t-\frac{c\pi x_1}{\tau}\right\}. \qquad (56)$$

The value of the c_1th field due to this current is obtained by substituting the amplitude of i_{2c_1} in the last equation for I_{2c_1} in equation (35) and at the same time inserting $\varphi_2=\pi/_2$ and $x=x_1+x'+2f_2\tau$.

We thus obtain

$$y_{c_1c_1}=-\frac{8I_1P_1P_2T_1\mathrm{P}K_{m_1c_1}K^2_{m_2c_1}}{p\pi^3Q_2}\cdot\frac{1+\sigma}{\sigma(1+\lambda_2)}\cdot\cos\left(2\pi f_1t-\frac{c\pi x}{\tau}\right).$$

The c_1th field due directly to the stator current I_1 is given by equation (6), and is

$$=y_{c_1}\frac{2I_1P_1T_1\mathrm{P}K_{m_1c_1}}{p\pi}\cdot\cos\left(2\pi f_1t-c\pi\frac{x}{\tau}\right).$$

It is clear that the sum of y_{c_1} and $y_{c_1c_1}$ is less than y_{c_1}. The ratio between the strength of the two fields is

$$\frac{y_{c_1c_1}}{y_{c_1}}=-\frac{4P_2K^2_{m_2c_1}}{\pi^2Q_2}\cdot\frac{1+\sigma}{\sigma(1+\lambda_2)}.$$

For example, let $P_2=3$, $m_2=4$, $\sigma=0{\cdot}07$, $\lambda_2=0{\cdot}02$, values often met with in practice. Consider the reaction of such a rotor winding on the 5th stator field ; we shall have

$$K_{m_2c_1}=0{\cdot}041, \text{ and } Q_2=1{\cdot}125, \text{ hence}$$

$$\frac{y_{5_15}}{y_5}=-\frac{4\times3\times(0{\cdot}041)^2}{\pi^2\times1{\cdot}125}\times\frac{1{\cdot}07}{0{\cdot}07\times1{\cdot}02}$$

$$=-0{\cdot}0276.$$

The ratio in the case of higher multiple fields is still smaller. We may safely conclude that, *in machines with two or three-phase rotors the reaction of the rotor on the multiple fields of the stator, and of the stator on the multiple fields of the rotor may be neglected, for purposes of practical calculation.* In other words, the air-gap dispersion is correctly accounted for by the co-efficient λ_1' and λ_2' as defined in section 20.

22. The case of the squirrel cage machine differs somewhat from the last.

Let the stator multiple field to be considered be represented by

$$y_{c_1}=P_1WK_{m_1c_1}\cos\left(2\pi f_1t-\frac{c_1\pi x}{\tau}\right), \quad . \quad . \quad . \quad (57)$$

as in equation (6).

The linear velocity of the rotor conductors being $2f_2\tau$ the velocity of this field with respect to them is

$$\frac{2f_1\tau}{c_1}-2f_2\tau=\frac{2\tau}{c_1}(f_1-f_2c_1),$$

and the E.M.F. per conductor at any point x will be

$$e=-\frac{2l\tau}{c_1}(f_1-f_2c_1)P_1WK_{m_1c_1}\cos\left(2\pi f_1t-\frac{c_1\pi x}{\tau}\right)\times10^{-8}.$$

If x_1 is the position of the conductor at time $t=0$, $x=x_1+2f_2\tau t$ and

$$e=-\frac{2l\tau}{c_1}(f_1-f_2c)P_1WK_{m_1c_1}\cos\left\{2\pi(f_1-f_2c_1)t-\frac{c_1\pi x_1}{\tau}\right\}\times10^{-8}$$

The reactance per bar will be

$$(1+\lambda_2)\cdot2\pi(f_1-f_2c_1)l\frac{\tau}{c_1}\mathrm{P}\left[\frac{c_1p}{G}\cdot\frac{1}{4\sin^2(c_1p\pi/2G)}\right]\times10^{-8}\text{ ohms},$$

see equation (33), where $p_1=c_1p$ and $\tau_1=\tau/c_1$.

The current per conductor will be—

$$i_{2c_1}=-\frac{P_1WK_{m_1c_1}}{(1+\lambda_2)\pi\mathrm{P}}\left[\frac{G}{c_1p}\cdot4\sin^2\frac{c_1\pi p}{2G}\right]\cos\left\{2\pi(f_1-f_2c_1)t-\frac{c_1\pi x_1}{\tau}-\frac{\pi}{2}\right\}$$

$$=-\frac{P_1WK_{m_1c_1}}{(1+\lambda_2)\pi\mathrm{P}}\left[\frac{G}{c_1p}\cdot4\sin^2\frac{c_1\pi p}{2G}\right]\sin\left\{2\pi(f_1-f_2c_1)t-\frac{c_1\pi x_1}{\tau}\right\}.$$

Consideration of the series for c_2, given in section 14, shows that the short-circuited stator winding will not have a damping effect, tending to reduce the reactance of the rotor windings in this case, such as exists when the rotor has a two or three-phase winding. Equation (32) gives the value of the cth field produced by a current per bar equal to

$$I_G\sin(2\pi f_st-\varphi).$$

The density due to the first field produced by the current i_{2c_1} is therefore

$$y_{c_1G}=-\frac{P_1WK_{m_1c_1}}{(1+\lambda_2)\pi\mathrm{P}}\left[\frac{G}{c_1p}\cdot4\sin^2\frac{c_1\pi p}{2G}\right]\cdot\frac{\mathrm{P}G}{\pi c_1p}$$

$$\times\cos\left\{2\pi(f_1-f_2c)t-\frac{c_1\pi x_1}{\tau}-\frac{c_1\pi x'}{\tau}\right\}.$$

(In section 14 the number of poles in the impressed field was p_1 which must now be replaced by c_1p, and the pole-pitch τ_1 in that section must be replaced by τ/c_1. Also the cth field in that section has cp_1 poles ; for our present purpose, therefore, $c=1$.)

Writing $x=x'+x_1+2f_2\tau$ we have

$$y_{c_1G}=-\frac{P_1WK_{m_1c_1}}{1+\lambda_2}\left[\frac{2G}{c_1p\pi}\cdot\sin\frac{c_1p\pi}{2G}\right]^2\cos\left(2\pi f_1t-\frac{c_1\pi x}{\tau}\right). \quad (58)$$

The ratio between y_{c_1G} and y_{c_1} is

$$\frac{y_{c_1G}}{y_{c_1}}=-\frac{1}{1+\lambda_2}\left[\frac{2G}{c_1p\pi}\cdot\sin\frac{c_1p\pi}{2G}\right]^2. \quad . \quad . \quad . \quad (59)$$

The ratio between the resultant field $y_{c_1G}+y_{c_1}$, and y_{c_1} is

$$\frac{y_{c_1G}+y_{c_1}}{y_{c_1}}=1-\frac{1}{1+\lambda_2}\left[\frac{2G}{c_1p\pi}\sin\frac{c_1p\pi}{2G}\right]^2. \quad . \quad . \quad . \quad (60)$$

The following table (IV.) gives values of these two ratios for $G/p=10{\cdot}25$, representing a four-pole rotor with 41 slots or an 8-pole rotor with 82, neglecting λ_2

On comparing equation (12A) with equation (13) it will be seen that

$$1+\lambda_1'=\frac{\pi^2Q_1}{4P_1K^2_{m_1^1}}=\frac{\Sigma K^2_{m_1c_1}}{K^2_{m_1^1}} \quad . \quad . \quad . \quad . \quad (61)$$

$$\text{or} \quad \lambda_1'=\frac{\Sigma K^2_{m_1c_1}-K^2_{m_1^1}}{K^2_{m_1^1}} \quad . \quad . \quad . \quad . \quad . \quad (62)$$

To investigate the effect of the squirrel-cage winding on the value of λ_1' we must consider its effect on the separate multiple fields. The value of the c_1th field and of the E.M.F. it produces in the stator winding, is reduced by a fraction of its own value, equal to y_{c_1G}/y_{c_1}. This is equivalent to a reduction of the corresponding term in the series $\Sigma K^2_{m_1c}$ by the same proportion. Table V. gives the values of the second to the eleventh terms of this series for three-phase windings with three, four and five slots per pole per phase, and also the values of the reduction caused by a squirrel-cage winding with 10·25 slots per pole. The totals of these and the values of $(\Sigma K^2_{m_1c})-K^2_{m_1}$ are given for comparison.

It may be doubted whether it is legitimate to carry these calculations as far as the thirty-first field, especially as the effects of resistance and slot and end-ring-leakage are neglected ; it certainly is not advisable to take them beyond this point.

Table IV.

C_1	$\frac{y_{c_1G}}{y_{c_1}}$	$\frac{y_{c_1G}+y_{c_1}}{y_{c_1}}$	C_1	$\frac{y_{c_1G}}{y_{c_1}}$	$\frac{y_{c_1G}+y_{c_1}}{y_{c_1}}$
3	0·932	0·078	19	0·006	0·994
5	0·82	0·180	21	0·0053	0·995
7	0·68	0·320	23	0·0133	0·987
9	0·51	0·490	25	0 0276	0·972
11	0·35	0·650	27	0·0413	0·969
13	0·21	0·790	29	0·0472	0·953
15	0·102	0·898	31	0·0442	0·956
17	0·039	0·961			

Consideration of Tables IV. and V. shows that a larger number of rotor conductors would have produced a more favourable reduction in all three cases, but especially in the first one. Unfortunately, however, the more favourably a winding reacts on the multiple fields the more trouble these fields will give during the starting period, it is therefore a better policy to reduce the multiple fields by other means such as the employment of fractional-pitch windings, where practicable, and a large number of slots per pole.

Where the stator slot openings are important the effects of the reaction of squirrel-cage windings are not easy to predict, but they are unquestionably less than where the slot openings are negligible. At the same time, the tendency to "crawl" will be greater on account of the accentuation of the multiple fields of the orders $2q \pm 1$.

23. A good method of reducing the crawling tendency, and one which is adopted by many manufacturers, is to skew the rotor slots. The amount of the skewing is usually such that the projection of a rotor conductor on a plane perpendicular to the axis of rotation extends over an arc equivalent to the pitch of the stator teeth. Incidentally, this construction lessens the liability to humming when the machine is loaded.

The value of the inductance per bar is not changed by this arrangement of the conductors, but Y_1 and Y_2 are both reduced, and σ is therefore slightly increased. The series of values for $y_{c_1}G/y_{c_1}$ is also considerably modified.

Let γ be the angle through which the slots are skewed reckoning the normal pole pitch as 180 deg. As regards the mutual actions between stator and rotor currents, the rotor current in each bar may be supposed to be uniformly distributed over the angle γ, and the E.M.F. induced in it by the c_1th field is the mean value taken over the angle $c_1\gamma$, while the E.M.F. which one of its own fields would produce in any stator conductor is reduced by the same ratio.

As is well known, the value of this ratio is $\frac{2 \sin c_1\gamma}{c_1\gamma}$. To modify Table IV. to meet this case the ratio $y_{c_1}G/y_{c_1}$ must be multiplied by the appropriate value of $\frac{2 \sin \frac{c_1\gamma}{2}}{c_1\gamma}$. This has been done for the case of $\gamma=15$ deg., and $G/p=10{\cdot}25$, and the results are given in Table VI.; it will be seen that the rotor has now no appreciable reaction on the stator multiple fields of higher order than the thirteenth. It is not necessary, however, to modify the deductions made from Table V. on this account.

24. Skewed slots are sometimes employed with wound rotors in order to avoid humming, and in this case, as in the case of squirrel-cage motors, Y_1 and Y_2 are reduced in value in the ratio $\frac{2}{\gamma} \sin \frac{\gamma}{2}$. Hence where skewed slots are employed we must write for the stator winding

$$(1+\lambda_1') = \frac{\pi^2 Q_1}{4 P_1 K^2_{m_1 1}} \cdot \frac{2}{\gamma} \sin \frac{\gamma}{2}, \quad \ldots\ldots \quad (63)$$

for a wound rotor

$$(1+\lambda_2') = \frac{\pi^2 Q_2}{4 P_2 K^2_{m_2 1}} \cdot \frac{2}{\gamma} \sin \frac{\gamma}{2}, \quad \ldots\ldots \quad (64)$$

for a squirrel cage rotor

$$(1+\lambda_2') = \left(\frac{\frac{\pi p}{2G}}{\sin \frac{\pi p}{2G}} \right)^2 \frac{2}{\gamma} \sin \frac{\gamma}{2}. \quad \ldots\ldots \quad (65)$$

(To be continued.)

Table V.

No. of slots per pole per phase =	3		4		5	
Order of multiple field.	$K^2_{m_1 c_1}$	$K^2_{m_1 c_1} \times \frac{y_{c_1} G}{y_{c_1}}$	$K^2_{m_1 c_1}$	$K^2_{m_1 c_1} \times \frac{y_{c_1} G}{y_{c_1}}$	K^2_{mc}	$K^2_{m_1 c_1} \times \frac{y_c G}{y_{c_1}}$
5	$1{,}850 \times 10^{-6}$	$1{,}516 \times 10^{-6}$	$1{,}680 \times 10^{-6}$	$1{,}377 \times 10^{-6}$	$1{,}600 \times 10^{-6}$	$1{,}312 \times 10^{-6}$
7	640×10^{-6}	445×10^{-6}	510×10^{-6}	347×10^{-6}	453×10^{-6}	308×10^{-6}
11	259×10^{-6}	91×10^{-6}	131×10^{-6}	46×10^{-6}	81×10^{-6}	28×10^{-6}
13	281×10^{-6}	59×10^{-6}	97×10^{-6}	20×10^{-6}	61×10^{-6}	13×10^{-6}
17	$3{,}190 \times 10^{-6}$	125×10^{-6}	86×10^{-6}	3×10^{-6}	36×10^{-6}	1×10^{-6}
19	$2{,}550 \times 10^{-6}$	15×10^{-6}	117×10^{-6}	1×10^{-6}	33×10^{-6}	0×10^{-6}
23	89×10^{-6}	1×10^{-6}	$1{,}750 \times 10^{-6}$	23×10^{-6}	51×10^{-6}	1×10^{-6}
25	50×10^{-6}	1×10^{-6}	$1{,}483 \times 10^{-6}$	41×10^{-6}	64×10^{-6}	2×10^{-6}
29	37×10^{-6}	2×10^{-6}	50×10^{-6}	2×10^{-6}	$1{,}087 \times 10^{-6}$	51×10^{-6}
31	51×10^{-6}	2×10^{-6}	26×10^{-6}	1×10^{-6}	950×10^{-6}	42×10^{-6}
Totals.....	$8{,}997 \times 10^{-6}$	$2{,}257 \times 10^{-6}$	$5{,}930 \times 10^{-6}$	$1{,}861 \times 10^{-6}$	$4{,}416 \times 10^{-6}$	$1{,}758 \times 10^{-6}$
$(\Sigma K^2_{m_1 c_1}) - K^2_{m_1 1}$	$13{,}000 \times 10^{-6}$		$8{,}170 \times 10^{-6}$		$5{,}960 \times 10^{-6}$	

Table VI.

c_1.	$\frac{2}{c_1\gamma} \cdot \sin \frac{c_1\gamma}{2}$	$y_{c_1}G/y_{c_1} \frac{2}{c_1\gamma} \cdot \sin \frac{c_1\gamma}{2}$
1	0·996	..
3	0·975	0·909
5	0·936	0·762
7	0·866	0·589
9	0·784	0·400
11	0·688	0·241
13	0·583	0·122
15	0·470	0·048
17	0·357	0·014
19	0·245	0·001
21	0·139	0·001
23	0·043	0·000
25	0·043	0·001

THE EFFECT OF HIGH CONTINUOUS VOLTAGES ON AIR, OIL AND SOLID INSULATIONS.*

BY F. W. PEEK, JUN.

Summary.—The dielectric strength of air, oil and solid insulations was determined for direct-current voltages up to 150 kv. The direct-current visual corona voltage is equal to the maximum alternating-current corona voltage for wires varying in radius from 0·013 cm. to the largest sizes. The spark-over of gaps is the same on alternating current and direct-current for equal maximum voltages when the gap is such that spark-over precedes corona. When corona precedes spark-over there is generally a difference in alternating-current and direct-current spark-over voltages. Insulators spark-over at the lowest voltage when the cap, or electrode surrounded by the denser field, is (+). The direct-current spark-over voltages in oil generally correspond closely to the maximum alternating-current spark-over voltages. In wet oil the direct-current spark-over voltage is lower than the alternating current. The direct-current breakdown voltages of solid insulations in good condition are generally higher than the maximum alternating-current voltages. When the insulation is moist, the direct-current and maximum alternating-current breakdown voltages are generally approximately the same. It appears that high-voltage direct current would be useful in certain high voltage cable testing.

High continuous- or "direct-current" voltages were obtained from the 60 cycles alternating by means of a kenotron rectifier in combination with condensers and inductance coils. A sketch of the connections used is given in Fig. 1. The condensers are charged up to the maximum of the alternating voltage wave. They remain at this voltage if there is no leakage, and no power is being taken at A. If current flows at A the condensers become partly discharged between the maximums of two waves, and there is a double frequency ripple on top of the "direct-current" voltage across A. With a given current taken at A the amplitude of this ripple decreases with increasing condenser capacity and increasing inductance. With a given capacity and inductance the ripple decreases with decreasing current at A. With a given condenser and inductance the amplitude of the ripple decreases with increasing supply frequency. The variation is less for connection 1*a* than 1*b*. Since in the following tests, the current flowing up to breakdown was practically negligible, there was no appreciable ripple on the voltage wave. Voltage was first measured with a static voltmeter, and by maximum of the wave on the voltmeter coil. When no power was taken the static voltmeter checked with the maximum of the alternating wave, and later, with sphere gap measurements.

* Abstract of Paper read before the American Institute of Electrical Engineers.

Air.

Sphere Gaps.—Sphere-gap curves were taken on 6·25 cm. and 12·5 cm. spheres. The continuous, or direct-current, voltage required to spark over a given gap was found to be $\sqrt{2}$ times the required effective sine wave alternating or alternating-current voltage—that is, the direct-current spark-over voltage and the alternating-current maximum voltage are equal (*see* Fig. 2). This is true for various air densities as shown in Fig. 3. The direct-current spark-over voltage curve of a sphere may, therefore, be calculated from the formula already given for alternating-current voltages.

$$e=gx/f.$$

Where $g=27{\cdot}2\delta\{1+(0{\cdot}54/\sqrt{\delta R})\}$, x=spacing in centimetres, $\delta=3{\cdot}92b/(273+t)$, b=barometric pressure in centimetres, t=temperature, deg. Centigrade R=sphere radius in centimetres, $f=\varphi(x/R)$. This voltage may also be found by multiplying voltage value in standard curve by $\sqrt{2}$.

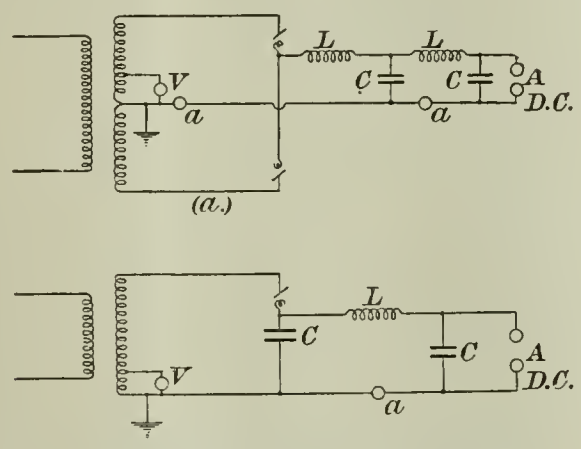


Fig. 1.—Condenser Capacity=0·064 mfd.

Needle Gaps.—The direct-current needle gap spark-over voltage corresponds approximately to the maximum alternating-current spark-over voltage over a considerable range. At the higher values the continuous spark-over voltage seems to be less than the maximum alternating.

Table I.—*Alternating-current and Direct-current Spark-over Voltages of 2/0 Needles in Air.*

Spacing, centimetres.	Kilovolts, 60-cycle (max.).	Kilovolts, direct current.
5·1	51·0	52·0
7·6	62·5	63·0
10·2	76·5	73·5
12·7	88·3	82·5
15·3	98·3	90·5

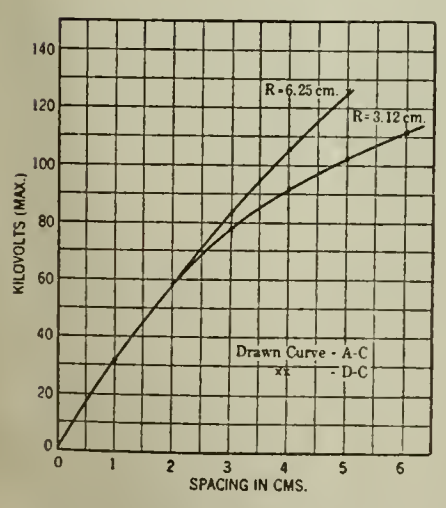


Fig. 2.—Alternating-current and Direct-current Spark-over Voltages for Spheres.

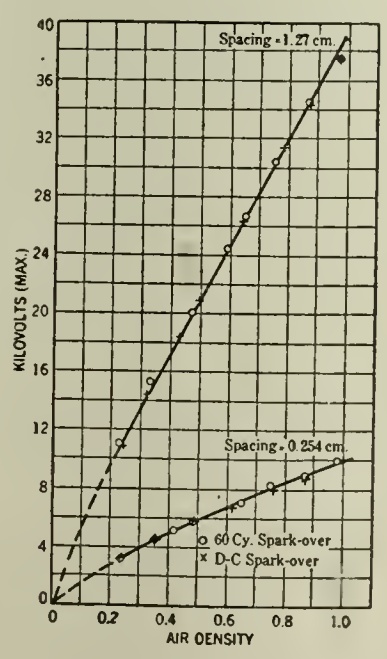


Fig. 3.—Spark-over Voltages of 2·54 cm. Spheres at Various Air Densities.

Corona.—Visual corona and spark-over tests were made on concentric cylinders. Typical data are plotted in Fig. 4. In this test the outer cylinder was 3·81 cm. in radius. The polished inner cylinders or wires and tubes varied from 0·0038 cm. to 1·11 cm. radii.

The data shows that the maximum alternating-current and the direct-current corona voltages are equal for wires over a large range of sizes. The spark-over voltages are equal when $R/r<\epsilon$, or where corona does not precede spark-over. Where corona precedes spark-over the direct-current voltage is higher than the alternating-current. The direct-current spark-over voltage is higher when the wire or conductor of the greatest field intensity is (−). This is shown in Fig. 4.

Effect of Air Density on Corona and Spark-over of Wires.—The visual corona and spark-over voltages were measured for concentric cylinders at various air densities. An outer cylinder of glass coated with the foil was used for these tests. The air was exhausted and the corona and spark-over voltages measured at different air

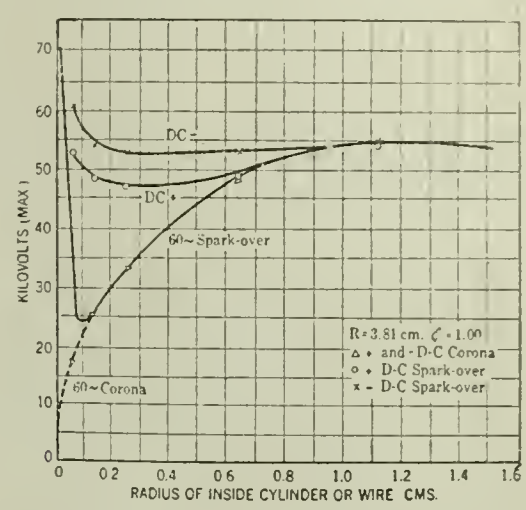


Fig. 4.—Alternating-current and Direct-current Corona and Spark-over for Various Sizes of Wire (Concentric Cylinders at Normal Air Density).

pressures. The apparatus was the same as that used in alternating-current tests and already described. Some results are plotted in Fig. 5.

The data shows that the maximum alternating-current and the direct-current visual corona voltages correspond down to $\delta=0{\cdot}3$. The difference is not great even at $\delta=0{\cdot}08$. The difference at the lower values of δ may be due to the difficulty in determining the exact starting point in these cases. A table of spark-over data is given in the Paper.

At the higher values of δ the positive spark-over voltage is lower than the negative and closely follows the maximum alternating current. The positive seems to be slightly higher than the negative for very low values of δ.

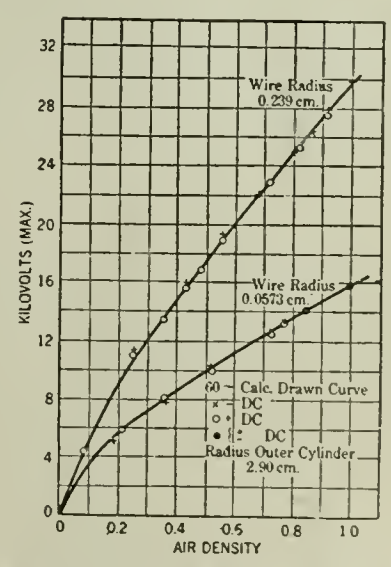


Fig. 5.—Variation of Alternating-current and Direct-current Visual Corona Voltages with Air Density.

The tests show that the formula already given for alternating current corona may also be used for direct-current corona over a wide range of wire diameter, air density, &c. The direct-current corona voltage is equal to the maximum alternating-current corona voltage.

The direct-current visual corona voltage in kilovolts is $e_v=g_v r\log_\epsilon(R/r)$ wire in a cylinder, $e_v=2g_v r\log_\epsilon(R/r)$ parallel wires.

Where $g_v=g_0\delta\{1+(0{\cdot}3/\sqrt{\delta r})\}$ kv. per centimetre, where $g_0=31$ (concentric cylinders), $g_0=30$ (parallel wires), $\delta=3{\cdot}92b/(273+t)$, b=barometric pressure centimetres, t=degrees Centigrade.

Surface Spark-over of Insulators.—Spark-over tests were made on several standard insulators. The results are plotted in Table II. The spark-over voltage is highest when the cap or electrode around

which the field intensity is highest is (−). This checks with the impulse tests. When the cap is (+) the direct-current spark-over voltage generally very nearly coincides with the maximum alternating-current spark-over.

Table II.—*Surface Spark-over of Suspension Insulators.*

Insulator number.	60-cycle, kilovolts (max.).	Direct-current, kilovolts.	
		Cap+.	Cap−.
1	116·0	117·5	127·5
2	99·0	99·0	106·0
3	126·0	132·0	139·0
4	111·5	128·0	135·0
5	119·0	128·0	135·0

Oil.

The "corona" and spark-over characteristics of oil are very similar to those of air. Practically the same laws are followed for

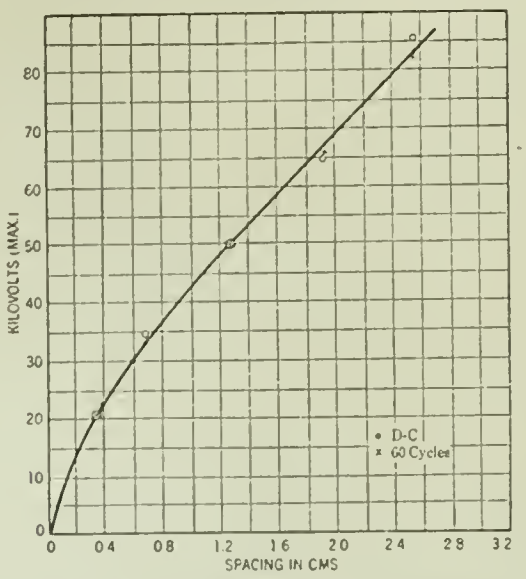


Fig. 6.—Alternating-current and Direct-current Spark-over Voltages of 2/0 Needles in No. 8 Transil Oil at 25°C.

alternating-current voltages in both oil and air. This apparently also holds for direct current.

Needle gap spark-over voltages for oil are given in Table III. The direct-current voltages correspond to the alternating-current maximum.

Table III.—*Direct-current and Alternating-current Spark-over Tests on 2/0 Needles in No. 8 Transil Oil at 25°C.*

Needle gap, centimetres.	60-cycle, kilovolts (max.).	Direct-current, kilovolts (max.).
0·317	21·2	21·7
0·635	34·7	33·5
1·27	50·5	50·2
1·91	65·0	66·0
2·54	86·5	82·5

The effect of moisture on the strength of oil for alternating-current and direct-current voltages is plotted in Fig. 7.

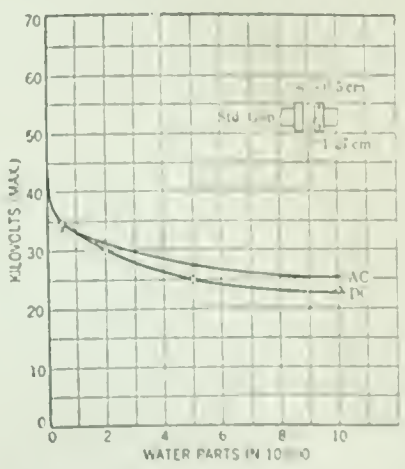


Fig. 7.—Effect of Moisture on Disruptive Strength of No. 8 Transil Oil at 25°C.

When the oil is wet the direct-current breakdown voltage is lower than the alternating-current breakdown voltage. This is probably due to lining up of water particles under direct current.

Solid Insulations.

In air and in oil there is no appreciable loss until local breakdown occurs in the form of corona or brushes. In solid insulations loss starts as soon as voltage is applied and generally increases as the square of the voltage. The heating which results increases the loss and weakens the insulation. Practically all solid insulations absorb moisture. The interstices in the non-homogeneous structure become filled with moisture and gases. This makes, in effect, not only a complicated arrangement of resistances, but also of resistances and capacities in series throughout the material. Where the conducting paths extend through from terminal to terminal, either alternating or direct current can flow. But where the conducting paths extend partly through the structure they are, in effect, resistances in series with capacities; only alternating current can flow through these paths. The effective resistances as measured by alternating current and by direct current are quite different except in those solid insulations in which the "conducting" paths are arranged from terminal to terminal. The voltage distribution, heating, &c., will generally not be the same for alternating-current and direct-current voltages.

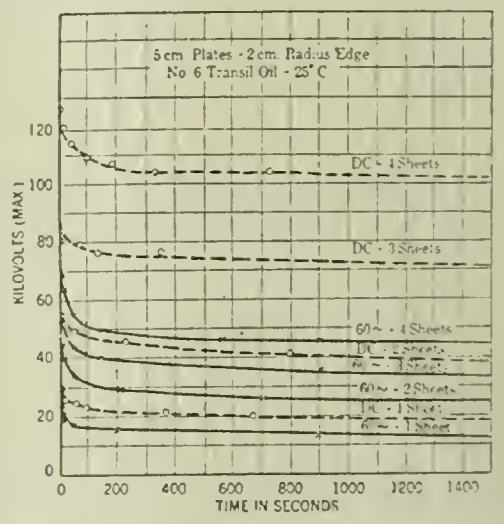


Fig. 8.—Variation of Direct-current and Alternating-current Puncture Voltages with Time of Application—Varnished Cambric.

In the homogeneous materials, air and oil, direct-current breakdown voltages correspond to the maximum 60-cycle alternating-current breakdown voltages. In most solid insulations relatively higher direct-current values should be expected, especially in insulations where the alternating-current and direct-current "resistances" are decidedly different.

Varnished Cambric.—Because of the effects of heating due to losses, voltage-time curves are necessary in order to compare the strengths of solid insulations. Alternating-current and direct-current voltage-time curves were taken on varnished cambric. The insulation under test was placed in transil oil between 5 cm. diameter brass plates with rounded edges. A given voltage was applied and

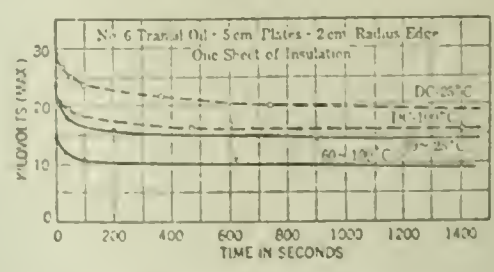


Fig. 9.—Effect of Temperature on the Alternating-current and Direct-current Disruptive Strength of Varnished Cambric.

time noted until breakdown occurred. The break-down voltages for various thicknesses of varnished cambric in the approximately uniform field between parallel plates is plotted in Figs. 8 and 9.

Fig. 8 shows that the direct-current puncture voltage for a given thickness of cambric and for a given time of application is higher than the maximum alternating-current puncture voltage. Fig. 9 shows that both the alternating-current and direct-current puncture voltages decrease with increasing temperature. (The temperature referred to is that of the oil bath in which the insulation is immersed.)

The curves between puncture voltage and time are closely approximated by the equation—

$$e = e_0 \{1 + (a \sqrt[4]{T})\} \text{ kilovolts.}$$

or the unit strength by

$$g = g_0 \{1 + (a \sqrt[4]{T})\} \text{ kilovolts per millimetre.}$$

Where e=puncture voltage in time T, kilovolts (max.); T=time in seconds; e_0=puncture voltage for $T=\infty$, kilovolts (max.); g=breakdown gradient in time T, kilovolts per millimetre; g_0=breakdown gradient in $T=\infty$, kilovolts per millimetre; a=depends upon the kind and thickness of the insulation and frequency.

This equation seems to hold well for a range of time between $T=1$ and $T=\infty$. The breakdown voltage is plotted with $1/\sqrt{T}$ in Fig. 10. The result is a straight line from which the above relation is obtained.

In Fig. 11 the alternating-current and direct-current breakdown voltages of varnished cambric for the time, $T=\infty$, are plotted with thickness. As $T=\infty$, this is the highest voltage that the insulation

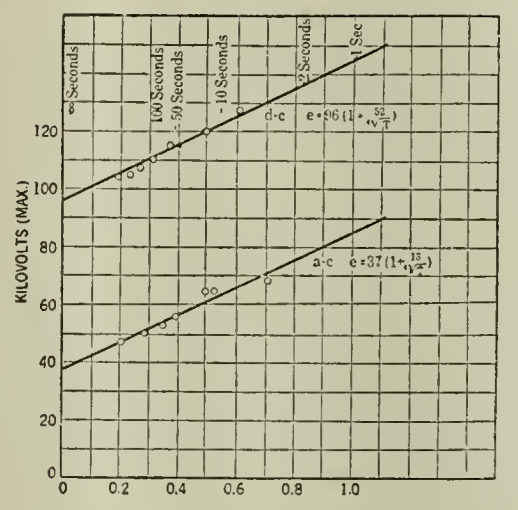


Fig. 10.—Variation of Alternating-current and Direct-current Puncture Voltages with Time.

4 sheets (1·20 mm.) Varnished Cambric Voltage plotted with $1/\sqrt{T}$.

will withstand indefinitely without puncture. For this material, at thicknesses from 0·3 mm. to 1·2 mm., the puncture voltage increases directly with the thickness—that is, the direct-current unit breakdown strength or gradient is constant. The unit strength of solid insulations under alternating-current voltages decreases with increasing thickness. For alternating-current voltages—

$$g=g_0\{1+(a/\sqrt{t})\},$$

or,

$$e=g_0t\{1+(a/\sqrt{t})\}.$$

For direct-current voltages apparently $g=g_0$ and $e=g_0t$, where e=breakdown voltages of thickness t; t=thickness in millimetres; g=unit strength for thickness t, in kilovolts per millimetre; g_0=constant; a=depends upon the kind of insulation, time and frequency.

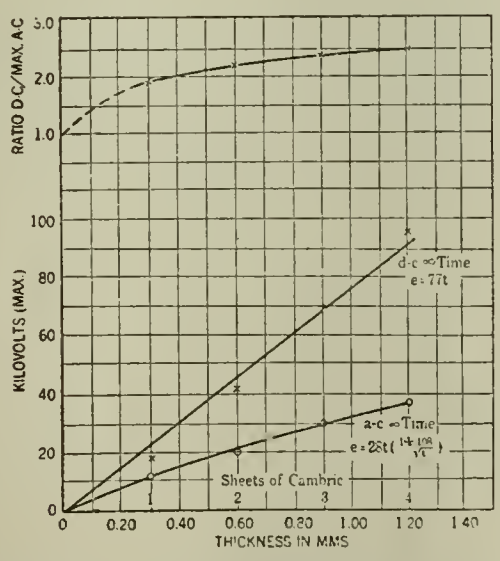


Fig. 11.—Variation of Alternating-current and Direct-current Breakdown Voltage with Constant Time.

The curves in Fig. 12 correspond to those in Fig. 11 for $T=2$ seconds.

It can be seen from the above relations that the ratio between the direct-current and alternating-current puncture voltages for solid insulations cannot be constant, but must increase with increasing thickness of insulation, especially where the time of application is long. This is shown graphically in the ratio curves in Figs. 11 and 12. Thus, in Fig. 12, where the time is 2 seconds, or relatively short, the direct-current puncture voltage very nearly corresponds to the alternating-current maximum puncture voltage where the thickness is not great. In Fig. 11, where the time is a maximum, the direct-current puncture voltage is 2·5 times the alternating-current maximum puncture voltage or 3·5 times the alternating-current effective voltage for a thickness of 1·2 mm.

Some of the direct-current puncture values for single sheets of cambric apparently have a lower unit strength than a greater number of sheets. This is undoubtedly due to a greater probability of weak spots on a single sheet. Results of the same consistency cannot be expected or obtained on solid insulations as on gaseous and liquid insulations.

The thickness range of the insulation in the above tests was not great; it was limited by the available voltage (150 kv. direct current). It is *possible* that the direct-current unit strength will not remain approximately constant over a wide range.

Wet Insulations.—Some 2·4 mm. (3/32 in.) treated pressboard was soaked in water and then partly dried out. Alternating-current and direct-current tests were made on this poor insulation.

5 kv. was thrown on the insulation, after the first minute the voltage was increased to 7·5, then to 10, &c., until breakdown occurred. If breakdown occurred before the end of the minute the time was recorded in seconds. For example, in the first alternating-current test, insulation No. 6 withstood 60 seconds at 5 kv., 60 seconds at 7·5 kv. and 5 seconds at 10 kv. when breakdown occurred. It will be noted that the direct-current and alternating-current maximum breakdown voltage average about the same in this insulation which was conducting from terminal to terminal. In some of the tests, in

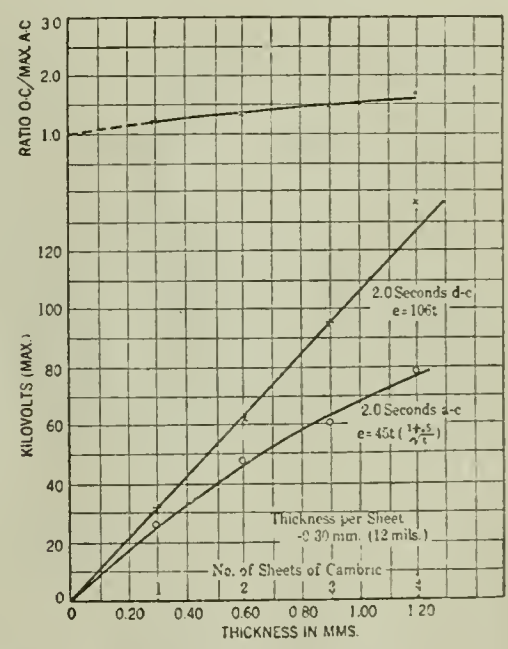


Fig. 12.—Variation of Alternating-current and Direct-current Breakdown Voltage with Constant Time.

fact, breakdown takes place at a lower voltage on direct current than alternating current. This is, perhaps, due to a better lining up of moisture by direct current. Some of this insulation, dry and in perfectly good condition, was then tested in the same way. Starting at 5 kv. the voltage was increased every 60 seconds in 2·5 kv. steps until breakdown occurred; breakdown resulted on alternating-current when 70 kv. (max.) was reached; on direct current when 130 kv. was reached.

Similar tests were made on sections of paper-insulated cables that had absorbed varying amounts of moisture. In those sections in the worst condition as indicated by low puncture voltages, the direct-current and alternating-current maximum puncture voltages averaged about the same. In the sections in the best condition the direct-current puncture voltage was somewhat higher than the maximum alternating-current voltage.

There is considerable difficulty in practice in making alternating-current voltage tests on long lengths of cables, due to the size of the apparatus, which is necessarily large on account of charging current. The necessary kilovolt-amperes often amount to several hundred. The wave shape is often distorted by the leading current, the apparatus is difficult to move about, &c. Direct-current tests would eliminate these difficulties, as very small apparatus would be required, providing such tests would detect faulty sections, &c. It cannot be said that a given direct-current voltage is equivalent to a given alternating-current voltage. The above tests indicate, however, that faulty sections of cable could be as equally well located by direct-current tests as by alternating-current tests.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury, court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential and a World wide circulation.** *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d.; Canada and India, 2s.; Australasia and South Africa, 3s.; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preparation.*

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

SUBMARINE CABLE LAYING AND REPAIRING. By H. D. Wilkinson. M.I.E.E. *New Edition in preparation.*

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

ELECTRIC BLASTING APPARATUS AND EXPLOSIVES: With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.

THE SHOT-FIRER'S GUIDE: A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.

THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.

THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*

LIGHT, RADIATION AND ILLUMINATION. From the German of Paul Hogner, translated by Justus Eck. Price 6s. nett, post free 6s. 6d.

ELEMENTARY THEORY OF ALTERNATE-CURRENT WORKING. By Capt. G. L. Hall, R.E. 3s. 6d. nett.

COMMON BATTERY TELEPHONY SIMPLIFIED. By W. Atkins. *Third issue* 3s. nett., postage 3d.

ELECTROMAGNETIC THEORY. By Oliver Heaviside. Vol. I. Price 12s. 6d. Vol. II Price 12s 6d. Vol. III. 21s. nett.

ELECTRIC CRANES: THEIR DESIGN, CONSTRUCTION AND APPLICATION. By H. H. Broughton, M.I.E.E. Price 25s. nett, postage 9d. (abroad, 1s. 8d.)

ELECTRICAL TESTING FOR TELEGRAPH ENGINEERS. By J. Elton Young. Price 10s. 6d. nett, post free 11s

STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Price 7s. 6d nett.

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie, A.M.Inst.C.E. *New Edition in preparation.*

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM): A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d. each, post free. Hanging Cards: 1/- each post free. Pocket Books, complete in envelope, 2s. 6d., post free

Now Ready.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E.

FIRST EDITION: Price **15s.** nett, post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.
Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s.; post free, 2s. 4d.

THE LAY PRESS AND TECHNICAL EDUCATION.

Till such time as the meaning and purpose of higher technical education is better understood and more highly appreciated by the lay Press it is doubtful whether live and intelligent interest will be shown by those who are most likely to benefit by such education.

The truth of this was brought home to us recently in the course of correspondence with the editor of an old-established provincial weekly. It appears that an important success was secured by the local technical college, and, apparently, the only space available for recording this success—a success of which any town really interested in technical education might well be proud—was that required by a four-line note. To show his appreciation, the editor allowed the note to be sandwiched between "Police News" and "Hints on Jam Making," the latter being one of the humorous compositions we are beginning to expect from the Board of Agriculture in reply to requests by the people of the country for bread and meat. It warned people against using benzoate of soda as a substitute for sugar in the making of jam, and in passing we would observe that anyone sufficiently foolish to use the abomination named for the manufacture of anything as homely as jam deserves to learn by personal experience.

A brief protest brought forth an article of some length, which was characterised not so much by the knowledge it imparted as by the abuse it contained. Further correspondence, in which it was suggested that had the student committed a petty theft prominence would have been given to the fact without any prompting by the person whom he had robbed, brought more abuse of a kind bordering on the vulgar, and which gave one the idea that the editor was angry with his correspondent for directing his attention to a matter of national importance, which he, intent on praising the parish pump, had overlooked.

If local opinion be influenced, as it should be influenced, by the local Press, we are of the opinion that something more than attendance at prize distributions and annual sports, to say nothing of reports of education committee meetings and four-line paragraphs recording important successes, are necessary before newspapers can claim to speak with authority on the subject of technical education.

No wonder our people are ignorant when the food provided by the lay Press for the consumption of the rising generation consists for the most part of accounts of theatrical performances, kinema shows and music-hall entertainments (with accompanying advertisements in another column), together with a goodly supply of information concerning the evil that men do. It is not to be wondered at, we say, that our traders fear foreign competition when a football match, a boxing contest or a race meeting receives fuller treatment at the hands of the lay Press than does an epoch making discovery, which, as a rule, is written-up by some badly informed journalist.

Notwithstanding the big and ever-increasing demand for technologists, we ask: "Is it a matter for surprise to find that the institutions in which such men are trained are practically empty at the present time, seeing that the lay Press sounded no warning note." Such is the support they give to technical education that one finds in their columns articles in which encouragement is given to ill-considered

schemes for the training of war workers. We say deliberately that, as a result of this encouragement, the State allows public money to be spent unwisely by many of our colleges at the present time.

Vitally important as higher technical education is to us if we wish to maintain our position in the struggle for industrial supremacy, there is another and, in many respects, equally important side. In the words of Herbert Spencer, whose essay on "Education," by the way, has a special significance at the present time, "Sad indeed it is to see that men occupy themselves with trivialities, and are indifferent to the grandest phenomena; care not to understand the architecture of the heavens, but are deeply interested in some contemptible controversy about the intrigues of Mary Queen of Scots; are learnedly critical over a Greek ode and pass, without a glance, that grand epic written by the finger of God on the strata of the earth."

REVIEWS.

Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free, on receipt of published price, adding 3d. for books published under 2s. Add 10 per cent. for abroad or for foreign books.]

An Intermediate Text Book of Magnetism and Electricity. By G. F. WOODHOUSE. (Sedbergh: Jackson & Son.) Pp. x.+264. 6s. net.

The only novelty possessed by this book is that it appears to have been written for nobody in particular. We have searched through the three parts—namely, Magnetism, Electricity and Electrostatics—for new features and have found none.

If the author really feels that, "since electricity plays so important a part in everyday life, a student should know something of the technical side of it," and if he hopes that his treatment of "dynamos, telegraphs, &c.," is sufficient to arouse a student's interest and to encourage him to further study, his feelings agree with our own; but his hopes and ours are very different, and for close upon a quarter of a century we have been studying and teaching electrical engineering. During this time we have found that by scrapping tangent galvanometers and Daniell cells, by telling students nothing of right and left-hand rules, and forgetting about men swimming with currents, by throwing all cat-skins into the dust bin, by making the most of simple apparatus and looking at the subject from an engineering, and therefore scientific, standpoint the subject can be made *electrical* in its interest.

We are strongly of the opinion that the spending of a certain period in the works and in the test room should be one of the conditions of the appointment of any man who is expected to teach magnetism and electricity. If this were done, motor starters of the kind depicted in this book would gradually disappear from text books, and laboratory work would be practical and workmanlike.

Speaking of the rotating field, the author states that "This is turned to account in the construction of . . . the squirrel-cage motor." This, of course, is strictly in accordance with fact; but in the brief description of this motor we are told that "The rotor consists of two discs or rings mounted on a shaft a short distance apart. Many bars of copper are fixed across from one circumference to the other. The stator is similar to that in Fig. 148, but has many more poles." In these words is one of the greatest discoveries of our time described. The illustration referred to is a spider-line diagram, which we do not pretend to understand. On p. 143 the student is recommended to construct a commutator, of which drawings are given. Our advice to the author is that he should endeavour to construct a commutator to the same drawings.

We have little space at our disposal to notice the many other instances, such as "These (arc) lamps are very efficient, and give about 1 c.p. per watt"; and the example on p. 109, in which, in drawing a comparison between continuous-current and alternating-current transmission, the author shows that the latter is a "much more economical arrangement" by spending ten times as much on copper for the alternating-current line as need be spent. The subject-matter on the pure magnetism and electricity side is no better than that to be found in a large number of books, and the author's treatment on the technology side could not easily be worse than it is. To two students credit is given for the diagrams, "which form an important feature of the work." One of these men is a good draughtsman.

Alternating Currents: Their Elements Explained, and their Calculation Effected without the Use of Hyperbolic Functions. By H. R. KEMPE. (London: Crosby Lockwood & Son.) Pp. v'ii.+83. 3s. 6d. net.

This useful and well got up little book, by a man who knows his subject, will be welcomed by those for whom the book has been written, namely, those who wish to know by what processes formulæ given in existing text-books are obtained.

Of the nine chapters, the first is introductory. The next four deal with the effects of inductance and capacity; effect of angle of lag; joint resistances and elementary combinations of resistance, inductance and capacity. Telephonic transmission is considered in Chapters VI. and VII., and brief notes on reflection and alternating current measurements are given in the remaining chapters.

We are of the opinion that in places the author unduly lengthens the elementary algebra, and we do not like his use of the word resistance for the combined effect of R and L. In some respects, however, the setting out at length of algebraic transformations is helpful to the student working without a teacher, and it is possible that the author had these men in view in compiling the sections to which we have referred. Students of telephony will be grateful for the well-written chapters dealing with telephonic transmission, and those who wish to know how elementary diagrams should be drawn and lettered, and how mathematics should be set up in type cannot turn to a better authority than this book.

Every Boy's Book of Electricity. (Percival, Marshall & Co.) 63 pages. Price 1d.

This pamphlet contains definitions, descriptions of primary and other batteries, dynamos and motors, electric lighting, "X" rays, wireless telegraphy, besides information on how to become an electrical engineer, with details of salaries paid according to the post. The figures showing a storage cell and a bichromate battery, apparently short-circuited through an electromagnet, might be improved. The latter, for instance, has a large number of quite unnecessary spirals of connecting wire. The pamphlet will probably serve as a popular introduction to more detailed works.

THE APPLICATION OF TELEPHONE TRANSMISSION FORMULÆ TO SKIN-EFFECT PROBLEMS.*

BY PROF. G. W. O. HOWE, D.SC.

Summary.—The problem of the distribution of current, and depth of penetration, is regarded more from an engineering point of view to that generally adopted.

In the introduction it is pointed out that inside the material, of which the wire is made, there is a transmission of energy at right angles to the direction of the main transmission, and governed by the same laws.

A transmission line has four fundamental properties, viz., resistance, inductance, capacity and leakance, the values of which per unit length may be represented by R, L, C and G respectively. If Z is the impedance of unit length of the line, $Z=R+j\omega L$, where $j=\sqrt{-1}$ and $\omega=2\pi f$; similarly if Y is the admittance of unit length, $Y=G+j\omega C$. If the transmission line is so long, or the losses so great, that the values of the current and P.D. at any point are not affected by reflection from the receiving end when an alternating P.D. is maintained at the sending end, then the P.D. or current at a point distant x from the sending end is equal to that at the sending end multiplied by e^{-ax}, where $a^2=ZY$.

* Abstract of a Paper in the "Journal" of the Institution of Electrical Engineers.

$ZY=(R+j\omega L)(G+j\omega C)$ and is a complex or vector quantity, and e^{-ax} gives both the amplitude and the phase of the current or P.D. at the given point. If the complex quantity $\sqrt{(ZY)}$ be split up into its real and imaginary parts, we have $\sqrt{(ZY)}=\beta+j\alpha$, and $e^{-ax}=e^{-\beta x}\times e^{-j\alpha x}$. Now $e^{-\beta x}$ is a proper fraction and gives the amplitude of the current or voltage at the point x in terms of the amplitude at the sending end, while $e^{-j\alpha x}$, which is equal to $\cos ax-j\sin ax$, represents a vector of unit length rotated through an angle $-ax$. At a distance x from the sending end, the phase of the P.D. or current lags behind that at the sending end by the angle ax.

The problem of "the slabs" dealt with in "Recent Researches," p. 296 is reconsidered, and it is shown that

$$t=\frac{1}{2\pi}\sqrt{\left(\frac{10^9\rho}{f\mu}\right)},$$

where ρ is resistivity, f is frequency, μ permeability, and t the depth which, with uniform distribution, would give equal losses. Another method of arriving at the same result is also given.

Conductors in which the Current is confined to a Thin Surface Layer.

The same formula can be applied to any conductor, not too near the return lead, if the value of t is small compared with the minimum dimension of the cross-section. If, however, the penetration is comparable with this minimum dimension, the formula no longer holds, because the inductance and leakance of our fictitious transmission line into the material change as the centre of the wire is approached.

If in a round wire the penetration is small, the ratio of the effective to the total cross-section is

$$\frac{2\pi(r-\frac{1}{2}t)t}{\pi r^2}=\frac{2\beta r-1}{\beta^2 r^2}.$$

Therefore

$$\frac{R_f}{R_0}=\frac{\beta^2r^2}{2\beta r-1}=\frac{\beta^2r^2(2\beta r+1)}{4\beta^3r^3-1},$$

where R_0 is the resistance to steady currents, and R_f the resistance to high-frequency currents.

If the penetration is small, as we have assumed, $4\beta^3r^3$ will be very large compared with unity, so that we have approximately,

$$\left.\begin{aligned}R_f/R_0&=\tfrac{1}{2}\beta r+0{\cdot}25\\&=\pi r\sqrt{\left(\frac{f\mu}{10^9}\right)}+0{\cdot}25\end{aligned}\right\}.$$

This formula is usually given without the constant term 0·25, and is referred to as Lord Rayleigh's formula for very high frequencies. As given here it can be safely used if the value of R_f/R_0, calculated by it, exceeds 1·75, the error in that case not exceeding 1 per cent.

Example 1.—For copper at a frequency of 10^6, we have

$$t=\frac{1}{\beta}=\frac{1}{2\pi\sqrt{\left(\frac{10^9\times1{\cdot}7}{10^6\times10^6}\right)}}=\frac{1}{152}\text{ cm.}=0{\cdot}066\text{ mm.}$$

$$R_f/R_0=\tfrac{1}{2}\beta r+0{\cdot}25=\tfrac{1}{2}(152r)+0{\cdot}25=76r+0{\cdot}25,$$

where r = radius of wire in centimetre.

The formula is applicable at this frequency to any copper wire with a diameter exceeding $\frac{1}{4}$ mm.

Example 2.—Steel rails, $f=50$, $\rho=20\times10^{-6}$ ohms per centimetre cube. Assuming $\mu=1{,}000$,

$$\alpha=\beta=2\pi\sqrt{\left(\frac{f\mu}{10^9\rho}\right)}=2\pi\sqrt{\left(\frac{50\times1{,}000}{10^9\times20\times10^{-6}}\right)}=10.$$

$$t=1/\beta=0{\cdot}1\text{ cm.}$$

Knowing the equivalent depth of penetration and the periphery, the effective resistance can be calculated. If the frequency be reduced to 25, t becomes 1·4 mm., since it is inversely proportional to the square root of the frequency.

Round Wires in which the Current is not Confined to a Thin Surface Layer.

In this case the characteristics, *i.e.*, the inductance and leakance per centimetre of the fictitious transmission lines into the conductor, are not constant but vary with the distance from the centre, and the ordinary telephone transmission formulæ are no longer applicable. The fictitious lines of infinite conductivity are now two parallel discs, 1 cm. apart, carrying radial currents, while the magnetic flux is concentric about the axis. The inductance of the "line" in henries per radial centimetre is

$$\frac{2}{10^9x^{\mu}},$$

or l/x where $l=(2/10^9)$, and x is the distance from the receiving end, that is, from the centre of the wire. The leakance per radial centimetre is gx, where $g=2\pi/\rho$. For the loss of current due to leakance we have

$$\frac{di}{dx}=v\cdot gx,$$

and for the drop of voltage along the "line" we have

$$\frac{dv}{dx}=\frac{l}{x}\cdot\frac{di}{dt}=j\omega\frac{l}{x}i,$$

assuming that the current is a sine function of the time.

Hence $$\frac{d^2v}{dx^2}+\frac{1}{x}\cdot\frac{dv}{dx}-k^2v=0,$$

where $$k^2=-j\omega lg=-j\omega4\pi\mu/10^9\rho,$$

and $$k=\sqrt{-j}\sqrt{\left(\frac{8\pi^2f\mu}{10^9\rho}\right)}=(1-j)\beta,$$

where $$\beta=2\pi\sqrt{(f\mu/10^9\rho)}.$$

Hence $$k=\sqrt{2}\beta\angle45°.$$

The current density at any point in the wire is equal to the potential difference between the two parallel discs at that point divided by the specific resistance of the material, that is, to v_x/ρ.

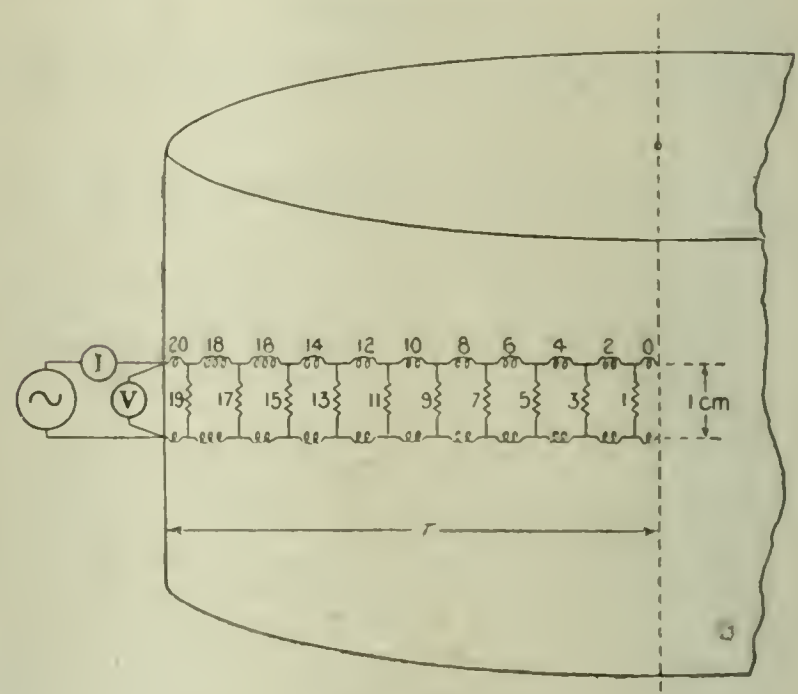


Fig. 1.

The problem can be solved for any particular case without employing higher mathematics, by applying the graphical method so commonly employed in telephone transmission problems. The line

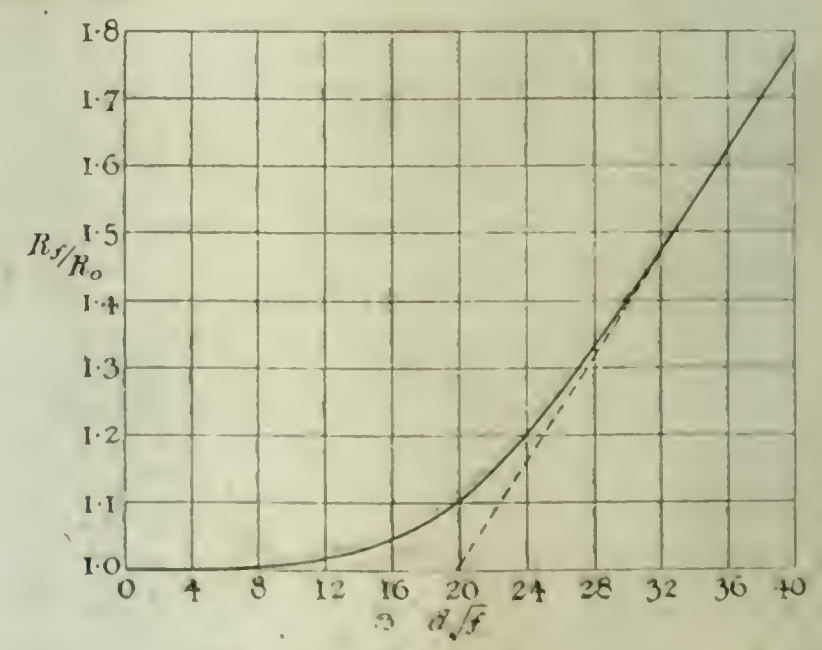


Fig. 2.

Resistance to alternating current for straight round copper wire.
Resistance to continuous current

If $d\sqrt{f}$ exceeds 32; $R_f/R_0=0{\cdot}038\,d\sqrt{f}+0{\cdot}25$.

is divided into a definite number of sections by assuming its leakage and capacity to be concentrated at a number of equidistant points. The current and potential difference at the receiving end are assumed,

and those at any part of the line determined by constructing a vector diagram section by section, commencing at the receiving end and gradually working back along the line. The accuracy will depend on the fineness of the assumed subdivision of the line.

Several graphical constructions are then given.

Although of interest in showing clearly the variation in current density and phase throughout the conductor, the graphical construction is quite unnecessary for the determination of R_f/R_0 for such large values of $d\sqrt{f}$. One would not apply the method to each individual problem as it arose, but merely to three or four typical cases lying between $d\sqrt{f}=10$ and $d\sqrt{f}=40$; the results could then be plotted and the curve used to find the value of R_f/R_0 for any other value of $d\sqrt{f}$. This curve is shown in Fig. 2.

Coiled Conductors.

As a further illustration of the application of the method, we shall now consider the case of a solenoid, closely wound with a single layer of rectangular wire. If the wire is of small radial thickness, or the frequency comparatively low, or the specific resistance high, the current may extend with varying density throughout the whole cross-section. From the point of view of the transmission of energy normally into the conductor, it is analogous to a transmission line of definite length, open at the far end, the far end in this case being the outer surface of the conductor, and the length of the transmission line the radial depth of the wire with which the coil is wound. If, as we are now assuming, the electromagnetic energy is not entirely

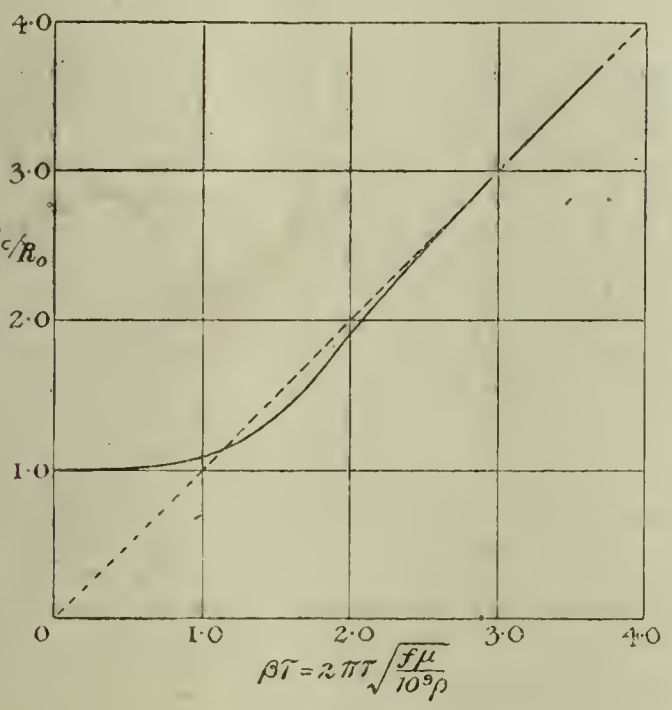


Fig. 3.

dissipated before reaching the end of the line, the electromagnetic wave is reflected and gives rise to a wave travelling back along the line, *i.e.*, radially inwards in our coiled conductor, this reflected wave being superposed upon the forward or outward wave.

The formulæ for this case are well known to telephone engineers and those concerned with long-distance power transmission. The remainder of the Paper deals with this calculation and alternative method, the final result for copper being written

$$R_c/R_0=1+47{\cdot}5\times10^{-6}(\tau\sqrt{f})^4.$$

Equivalent formulæ have been obtained by Wien and Sommerfeld by other methods.

The values of R_c/R_0 calculated from the accurate formula $R_c/R_0=\beta\tau/\gamma$ for different values of $\beta\tau$ are plotted in Fig. 3. These results are not only applicable to single-layer solenoids closely wound with rectangular wire, but also to hollow tubular straight conductors with a radial thickness τ not exceeding about one-third of the radius. They are also applicable to the case first considered, viz., two wide parallel strips or slabs, if the penetration is such that the current is distributed throughout the whole thickness of the strips.

Protective Relays. In a recent issue of the "Electric Journal" there is an article by Mr. N. N. Crichton on the "Use of Protective Relays on Alternating-current Transmission Systems." The subject was discussed under the following headings: The Sectionalising of Transmission Lines; Calculation of the Short-circuit Current; Relay Accuracy; Effect of Unbalanced Short-circuits; Protection of Apparatus; and Details of Relay Construction.

ON A METHOD OF MEASURING THE PRESSURE OF LIGHT BY MEANS OF THIN METAL FOIL.*

BY GILBERT D. WEST, B.SC.

In a Paper to the Physical Society I described the measurement of the pressure of light by a method requiring few of the elaborate precautions generally necessary in such experiments. The essential feature of the apparatus was a strip of gold leaf suspended in the middle of a test tube containing air or hydrogen at reduced pressure. Radiation from a 32 c.p. carbon filament lamp, impinging directly on one side of the strip, was sufficient to cause a microscopically measureable deflection of the end.

The pressure of normally incident radiation on a perfectly reflecting surface has been shown by Maxwell and others to be numerically equal to twice the energy content of the radiation per unit volume, and hence, if this quantity be measured in the way described below, a check on the original observations can be made. A mean of the results of several successive experiments with the deflected strips gave a value for the pressure of radiation which only differed from that calculated from the energy density by a small per cent. The accuracy and constancy of the final results seemed to preclude their being seriously affected by gas action; but, as gas action had to be taken into consideration, the present research was undertaken with a view to its fuller investigation, and if possible to its complete elimination.

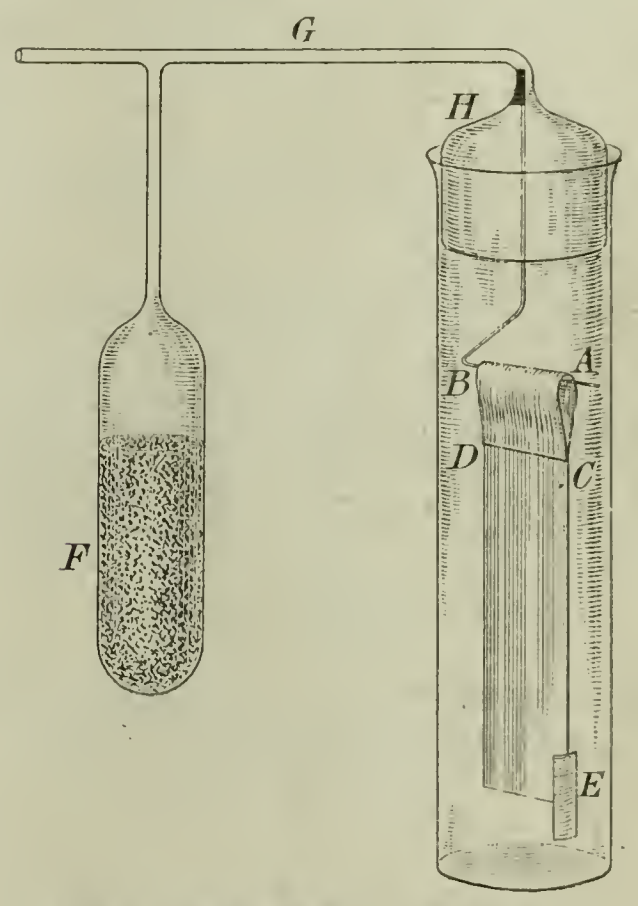


Fig. 1.—Arrangement of Apparatus.

H is hollow stopper, E is cover glass cemented to tube, F contains pith charcoal, G is tube which may be connected to Galde pump.

Measurement of the Energy Density.—The method used was similar to that described in the previous Paper. The initial rate of rise of temperature of a blackened copper plate enclosed in the tube was measured by means of an attached copper eureka thermo-junction. Due allowance was made for cooling corrections, and the lamp black was again assumed to absorb 95 per cent. of the incident radiation. The cold junction was immersed in oil contained in a vacuum flask, and during an experiment a delicate indicating thermometer in the oil only showed negligible variations. The calibration of the thermo-junction was carried out in the usual way, and a number of minor matters received fuller consideration than was previously given.

When from the measurements thus taken the energy reaching 1 sq. cm. in one second is known, the energy per 1 c.c. can be calculated from a knowledge of the velocity of light.

The 32 c.p. lamp was enclosed in a metal box whose front face had been replaced by a glass screen covered with a few thin wires. Inasmuch as it is required that the radiation should be normally incident, the lamp was not brought too close to the tube, a calculation of the limiting approach having been previously made. The current passing through the lamp was kept at the same value throughout all the experiments. The reflecting and transmitting powers of the foils

* Abstract of Paper read before the Physical Society of London.

used were then tested. Gold and aluminium reflected 90 per cent. of incident radiation.

Calculation of the Deflection of the Strip.—Since the foil reflects 90 per cent. of the incident radiation, and since 7 per cent. is reflected from the glass of the tube, the total pressure of the radiation is given by

$$E(1+0{\cdot}07/0{\cdot}9)(1+0{\cdot}9) \text{ or } 2{\cdot}04E,$$

where E is the energy density of the incident beam.

A certain amount of radiation, however, strikes the back of the glass tube, and some of this is reflected to the back of the strip. For a strip three-quarters the width of the tube it is estimated that the normal component of this radiation is about 1 per cent. of all that is incident on the strip. It is, therefore, necessary to substitute $2{\cdot}02E$ for $2{\cdot}04E$.

It can be shown that a uniform flexible strip when deflected by a small uniform pressure still remains straight. To a close degree of approximation, therefore, we may calculate the deflection of a strip such as that represented in Fig. 1 by taking moments about the axis of rotation. The details of apparatus used are then given, the expansion of strip due to rise of temperature is examined, as well as the thermo-kinetic reaction. A series of results taken in succession is given below.

GOLD STRIP.

Liquid air vacuum. Energy density of radiation when lamp 10·5 cm. distant $=1{\cdot}95\times10^{-5}$ ergs/c.c. Length of strip $=7{\cdot}10$ cm. Length of folded part AC $=1{\cdot}02$. Mass of 1 sq. cm. of gold leaf $=1{\cdot}82\times10^{-4}$ gm.

Distance of source.	Deflections from lamp.			Deflections calculated from energy density.
	Lamp on left side.	Lamp on right side.	Mean.	
10·5 cm.	$2{\cdot}5/10^{-1}$ cm.	$3{\cdot}2\times10^{-3}$ cm.	$2{\cdot}8\times10^{-3}$ cm.	$1{\cdot}6\times10^{-3}$ cm.
11·5 cm.	1·9	2·7	2·3	1·4
12·5 cm.	1·7	2·2	2·0	1·2

The reason why all the preceding results are too high has not been explained, and it is proposed to undertake further investigations on the matter. Other results obtained with the gold strip were also too high, but better results were obtained with the aluminium strip.

Experiments on the pressure of light may be advantageously carried out as far below the maximum as possible, or as far above the maximum as convection currents will permit. The latter alternative is the easier, and appears to give more consistent results.

THE CHARACTERISTICS OF TUNGSTEN FILAMENTS AS FUNCTIONS OF TEMPERATURE.*

BY IRVING LANGMUIR.

Summary.—The author discusses various functions for estimating the temperature of filaments. The question of specific resistance and total emissivity are dealt with, and the intrinsic brilliancy of a black body as a function of the temperature is calculated by means of Planck's equation. This is then compared with the values obtained by Nernst and Pirani.

Several years ago a detailed study of the characteristics of tungsten filaments as functions of the dimensions and temperature, was undertaken in this laboratory. The data thus obtained have been in continual use ever since, and have served as the basis for the calculation of temperatures in several investigations which have been published.

More recently, in connection with a redetermination of the melting-point of tungsten, an optical pyrometer was set up, suitable for measuring the true temperatures of filaments with considerable accuracy. With this instrument a new study of the characteristics of filaments has been made, and the results are now felt to be of sufficient accuracy to warrant their publication.

GENERAL THEORETICAL CONSIDERATIONS.

Any property of a filament which varies with the temperature may be used, after proper calibration, as a means of estimating the filament temperature. For example, the energy radiated per unit area might be adopted for a filament in vacuum, but would be very unsatisfactory if the filament were surrounded by a gas.

The various properties (or methods) that may be utilised to estimate the temperature of filaments may be divided into four groups according to the knowledge of filament dimensions required, as follows*:—

1. Requiring no dimensions: (*a*) Intrinsic brilliancy; (*b*) colour of light emitted; (*c*) ratio of "hot" to "cold" resistance; (*d*) watts per candle (W/C).

2. Requiring both length and diameter: (*e*) Resistance, $R'=Rd^2/l$; (*f*) Power radiated $W'=W/ld$; (*g*) candle-power $C'=C/ld$; (*h*) voltage $V'=V\sqrt{(d)}$, $l=\sqrt{(W'R')}$; (*i*) electron emission $i'=i/ld$.

3. Requiring diameter only: (*j*) Current $A'=A/d^2=\sqrt{(W'/R')}$; (*k*) $C/Vd^2=C'/V'$; (*l*) $1/d\sqrt[3]{(C/R)}=\sqrt[3]{(C'/R')}$; (*m*) candle-power (using slit) C/d.

4. Requiring length only: (*n*) $V\sqrt[3]{(A)}/l=\sqrt[3]{(W^2R)}/l=\sqrt[3]{((W')^2R')}$; (*o*) $\sqrt[3]{(CV^2)}/l=\sqrt[3]{(C'(V')^2)}$; (*p*) $C/A^{\frac{2}{3}}l=C'/(A')^{\frac{2}{3}}$; (*q*) $\sqrt[3]{(C^2R)}/l=\sqrt[3]{((C')^2R)}$; (*r*) thermal expansion $\Delta l/l$.

(*a*) *Intrinsic Brilliancy.*—This is the property utilised in the Holborn-Kurlbaum pyrometer for the measurement of temperature. The use of intrinsic brilliancy for this purpose has the particular advantages: (1) That measurement can be made at any point on a surface; (2) extremely rapid increase with temperature; (3) variation with temperature follows known laws.

Only relative measurements of intrinsic brilliancy are involved in the use of a pyrometer. Since it has been shown that the emissivity of tungsten does not change appreciably with the temperature, the variation of the intrinsic brilliancy of tungsten with the temperature is given accurately by Wien's law ($C_2=1{\cdot}4392$):

$$\log_{10}\frac{E}{E_0}=\frac{-0{\cdot}62503}{\lambda}\left(\frac{1}{T_0}-\frac{1}{T}\right).$$

(*b*) *Colour of Light Emitted.*—The colour of the light emitted by an incandescent body may be used to estimate its temperature. This method is a very old one, but has only recently been used for accurate pyrometry. Hyde states, in fact, that the colour match method which he developed "is perhaps more sensitive than the spectrophotometric method, and yields results in close agreement with the latter. It is conceivable, of course, that two lamps might have the same colour, and yet show different spectral distributions. Such a case has not yet been observed. On the other hand, it has been found that in certain cases, *e.g.*, with the osmium *versus* the carbon lamp, it is impossible to obtain exact colour matches, although the spectrophotometric curves differ by an amount so small that the differences might well be ascribed to experimental error." Hyde showed that a filament could be set at definite temperature as accurately by the colour-match method as the usual pyrometric methods.

The colour-match method has been used for several years in this laboratory for estimating the temperatures of filaments. It has proved to be of great practical value, and appears to be of more universal applicability than any other pyrometric method. The relation between the true temperature of a filament and that of a black body which matches it in colour has only recently been the subject of study.

We shall see, from experiments to be described later, that there is a distinct difference in temperature between tungsten and a black body which matches it in colour, and that this difference is in the direction predicted by Hyde.

(*c*) *Ratio of "Hot" to "Cold" Resistance.*—Ratio of the resistance at the temperature T to that at 0°C. or at room temperature has often been used for estimating temperature (v. Pirani, Corbino, Somerville).

This ratio affords the simplest and most convenient estimation of the temperature of filaments, and has the advantage that it can be used when the filament is surrounded by gas, or even when its surface is tarnished by oxidation. In practice, however, the method proves to be one of the least accurate methods of estimating temperatures for the following reasons:—

1. The resistance increases relatively slowly with the temperature as compared with most other properties used for temperature estimation.

2. The resistance and its temperature coefficient are very sensitive to traces of impurities (carbon).

3. At room temperature the resistance of the filament is often so low that uncertainties in the lead and contact resistances are apt to play a large part.

(*d*) *Watts per Candle.*—This function has been used more than any other for the rating of tungsten lamps, and is thus used as the basis of an arbitrary temperature scale. Pirani has published† tables giving watts per candle as a function of the temperature. Considerable confusion arises from the fact that the candle-power may be measured in several ways. For our purpose we shall measure the candle-power of straight filaments in a direction perpendicular to

* Abstract of an article in the "Physical Review."

* l—length, d—diameter, V—volts, A—amperes, W—watts, R—resistance (ohms), C—candle-power (measured perpendicular to axis of filament); C is thus equal to the total lumens divided by π^2 or to the mean spherical candle-power multiplied by 4π; V', A', &c., specific properties defined above.

† Verh. d. D. Phys. Ges., 14, 213 (1912), and *ibid.*, 14, 681 (1912).

their lengths. This corresponds most nearly to watts per mean horizontal candle-power.

The advantages in the use of watts per candle are: (1) It requires no knowledge of the dimensions of the filament; (2) the function increases much more rapidly with temperature than does resistance, and is not so greatly affected by impurities in the metal.

The disadvantages are: (1) Unless the mean spherical candle power is measured the results will depend on the geometrical configuration of the filament; (2) the watts per candle do not increase nearly as rapidly with the temperature as the intrinsic brilliancy or the candle-power; (3) watts per candle cannot be used for estimating temperature when the filament is surrounded by a gas.

(*e*) *Resistance.*—If ρ be the resistivity of tungsten at the temperature T, then the resistance of a filament heated electrically to T will be $R=4\rho l/\pi d^2$. For convenience let us place $R'=4\rho/\pi$. This equation then becomes $R'=Rd^2/l$, where R' is a function of the temperature only and is numerically equal to the resistance of a filament of unit length and unit diameter.

(*f*) *Power Radiated.*—Since the energy radiated is proportional to the surface we may place for a filament in a vacuum $W'=W/ld$, where W' is numerically equal to the power (watts) radiated from a filament of unit diameter and unit length.

From a tungsten surface the power radiated per cm.^{2} will be $E\sigma T^4$, where E, the "total emissivity," is also a function of the temperature. We may thus place $W'=\pi E\sigma T^4$.

(*g*) *Candle-power.*—If C is the candle-power of a filament measured in a direction perpendicular to the axis of the filament, then we may place $C'=C/ld$, where C' (a function of the temperature only) is the total intrinsic brilliancy of the filament. This property differs, however, from (*a*), the intrinsic brilliancy, in being the calculated (mean) intrinsic brilliancy for the entire filament rather than the observed brilliancy of a small part of the filament.

The quantity C' can be theoretically calculated from the Planck equation, visibility function, emissivity of tungsten, and mechanical equivalent of light.

The power radiated from a black body per square centimetre is

$$J_\lambda=\frac{C_1\lambda^{-5}}{e^{\frac{c_2}{\lambda T}}-1}.$$

If E_λ is the emissivity of tungsten for the wave-length λ then $E_\lambda J_\lambda$ will be the energy of wave-length λ, radiated from tungsten per square centimetre. The total light expressed in watts is then

$$L_W=\int_0^\infty V_\lambda E_\lambda J_\lambda d\lambda.$$

By dividing this by M, the mechanical equivalent of light (in watts per lumen) we obtain the total lumens per square centimetre radiated by tungsten. To convert this to candles per square centimetre the value in lumens per square centimetre should be divided by π. Thus $C'=L_W/\pi M$.

The function C' serves as a very convenient measure of temperature. In common with the pyrometer method it possesses the advantage of being applicable to filaments surrounded by gas.

(*h*) *Voltage.*—If we take the square root of the product of W' and R' we obtain for a filament in vacuum

$$V'=\sqrt{(W'R')}=V\sqrt{(d)}/l.$$

Thus we see that the voltage drop per centimetre along a heated filament in vacuum is inversely proportional to the square root of the diameter. This relation is useful in determining what the length of a filament should be in order that it may be heated to a given temperature by a given applied voltage.

(*i*) *Electron Emission.*—The use of electron emission to measure temperature was suggested by Richardson, but has apparently not been practically applied.

(*j*) *Current.*—By taking the square root of the quotient of W' by R' we obtain

$$A'=\sqrt{(W'/R')}=A\sqrt{d}.$$

In other words, the current necessary to heat a filament in vacuum to a given temperature varies with the 3/2 power of the diameter. This function is especially convenient for estimating the temperature of filaments in experimental work, but unfortunately it cannot be used when the filament is surrounded by gas.

(*k*) *and* (*l*) The two functions $C/(Vd^{\frac{3}{2}})$ and $\sqrt[3]{(C/R)}/d$ can be used to measure the temperature of filaments of unknown length, but in most cases (*j*) will be found more convenient. However, when the filament is surrounded by a gas (*j*) is not applicable, and in this case $\sqrt[3]{(C/R)}/d$ could be profitably used to measure temperature.

(*n*) $(V\sqrt[3]{(A)})/l$. This function proves very useful in estimating the temperature of filaments of varying diameter. For example, if it is desired to measure the rate of evaporation of a filament, or the rate of attack by a gas at very low pressure, the filament can be maintained at constant temperature by maintaining $V\sqrt[3]{(A)}$ constant, even when the diameter changes considerably. This function is not applicable to filaments surrounded by gas.

(*o*) *and* (*p*) $(\sqrt[3]{(CV^2)})/l$, $C/(A^{\frac{2}{3}}l)$. These functions have as yet not found any application.

(*q*) $(\sqrt[3]{(C^2R)})/l$. This function can be used in place of $(V\sqrt[3]{(A)})/l$ for filaments of varying diameter when surrounded by a gas at relatively high pressure. It may also be used for measuring the temperature of filaments (not helically wound) of unknown diameter in gases.

(*r*) *Thermal Expansion.*—This function can be used as an approximate measure of temperature. The change of length of a single loop filament can be determined fairly accurately by a cathetometer, so that the temperature may be readily found within 30–50 deg. at 2,500 deg.

Experimental Measurement of Characteristics.

Specially constructed lamps with carefully measured long single loop filaments were thoroughly aged by running the filaments at 2,400°K. for 24 hours after which they were set up in front of a Holborn-Kurlbaum pyrometer. The volts and amperes were thus obtained as functions of the temperature. The lamps were then measured on the photometer, and the candle power per centimetre of length was determined by photometering through a measured horizontal slit. From these data V', A' and C' were calculated as functions of the temperature and from these R', W' and W/C were obtained.

Lamps Used.—About 20 special lamps were constructed having cylindrical bulbs 7–9 cm. in diameter. The leads were of very large size (0·05 cm. platinum for the smaller filaments, and 0·08 cm. tungsten for the larger sizes) so that the total lead resistance, obtained by subsequently welding together the two leads, averaged only 0·017 ohm. The filaments, in the form of single hair-pin loops, were electrically welded to the leads in such a way that the filament close to the lead was straight.

Tungsten Wires.—Twelve different samples of tungsten wire were used. Of these, six were regular samples of commercial wire, used in the manufacture of lamps. Four out of these six contained thorium (thoriated tungsten).

The remaining six samples were special experimental lots of wire drawn down from three different rods.

The diameter of the wires ranged from 0·0028 cm. to 0·0252 cm.

Measurement of Diameters.—Experience with many ways of measuring diameter has finally resulted in the adoption of calculation from the density and weight per unit length. The diameter in centimetre is thus given by the formula (w=mg. per centimetre).

$$d=0{\cdot}008186\sqrt{(w)}.$$

The diameters obtained this way for wires which have been run in lamps agree within the experimental error.

Pyrometer.—The pyrometer was the same as that described in connection with the determination of the melting-point of tungsten. Before undertaking the study of the characteristics of tungsten filaments the pyrometer was carefully recalibrated.

Photometer Measurements.—A Lummer-Brodhun constant illumination photometer was used. In most of the work an illumination of 57 candle meters was used, but with filament temperatures below 1,900°K. it was necessary to use lower illuminations. The transmission coefficient for this screen was determined in this laboratory by the use of a flicker photometer. It was also calibrated for us through the kindness of Dr. Ives, by the use of his physical photometer. The results by the two methods were practically identical.

The object of the photometer measurements was primarily to determine the intrinsic brilliancy of the filaments in candles per square centimetre. To avoid uncertain corrections due to the cooling effects of the leads, a slit, usually 2·5 cm. wide, was placed horizontally in front of and close to the lamp to be photometered. Corrections were made for instrument calibration and cooling of leads to filaments.

Preliminary Treatment of Filaments.—While the lamps were being exhausted the filaments were heated for one minute to a temperature of about 1,500 deg. This treatment causes the evolution of an amount of gas (mostly carbon monoxide) which measured at atmospheric pressure is usually about three to six times the volume of the filament. After sealing off from the pump, the characteristics of the lamps were studied and the temperatures were determined by the pyrometer. The filaments were then heated to 2,400°K. for 24 hours before studying the characteristics. This heating produced a slight further decrease in emissivity and a slight (2 to 4 per cent.) decrease in resistance. The time of 24 hours was chosen for the heat treatment in these experiments, because if the time is extended beyond this

the changes due to the evaporation of tungsten and the resulting darkening of the bulb, are liable to more than offset the changes in resistance due to the elimination of minute traces of impurities.

Experimental Results.

Volt-Ampere Characteristics.—With each lamp tested the readings of volts and amperes for about 30 to 50 pyrometer settings from 1,050°K. up to 3,540°K. were obtained. Up to temperatures of about 3,000°K. the changes in the filament and the blackening of the bulb occurred so slowly that readings could be taken without haste. For higher temperatures than this the readings were taken at greater intervals (usually about 100 deg. apart), and were made as quickly as possible, and after each reading the volts and amperes were redetermined at one or two lower temperatures (about 2,400°K. and 2,600°K.) From these data it was possible to calculate the change in diameter of the filament (due to evaporation) and the amount of absorption of light by the bulb. This calculation was made by the aid of the function $V^2/(A^2 l)$. Knowing the bulb absorption it was then possible to determine the true temperature when the filament was subsequently raised again to a temperature above 3,000°K.

It was found practicable to study the characteristics of the filaments in vacuum right up to the melting-point of the filaments. Although in some cases corrections as large as 250 deg. (at 3,500 deg.) needed to be applied for the effect of bulb absorption, yet it is felt that the accuracy with which such corrections could be made was so high that the uncertainty in the final result was not over 30 deg. to 40 deg. (at 3,540°K.)

From the observed values of volts and amperes the values of the functions V' and A' were found from the known lengths and diameters. The logarithms of these functions were then plotted on a large scale against log T. The points from all the lamps tested were found to lie very closely along a smooth curve. The average deviation of the points from the smooth curve was found to be about 0·2 per cent. in temperature. For filament temperatures above 1,200°K. the maximum departure of any of the observations was 1·2 per cent. in temperature. The small deviations which did occur were not all irregular, for certain lamps tended to give low values while others gave consistently high values (within the above-mentioned limits).

Candle-power Data. To determine the relation between candle-power per square centimetre and temperature, three lamps were studied. Two of these were nitrogen-filled lamps with large (0·6 mm. diameter) single loop, straight (not helically wound) filaments, and the third was a vacuum lamp with a single loop filament, 0·25 mm. diameter.

At low filament temperatures irregularities occur in the convection losses from the filaments of gas-filled lamps. It was to avoid these, and to find whether the nitrogen exerted any effect on the emissivity that the vacuum lamp was studied.

The values of log C' obtained from the three lamps were plotted against $1/T$. A smooth curve (not far from a straight line) was passed as nearly as possible through the points.

The values of C' taken from the smooth curve for every hundred degrees from 1,400 deg. to 3,100 deg. give an average of 262·7 for the ratio C'/L_B.

Discussion of Experimental Data.

It will be of interest to compare the results of the above experiments with the data of other investigators. The ratio of hot to cold resistance for tungsten filaments has been determined by Somerville, Pirani and Corbino. From these data it is possible to calculate R', provided we know the specific resistance of tungsten at room temperature.

Specific Resistance of Tungsten. Fink has given the specific resistance of tungsten at 25° C. as $5{\cdot}0 \times 10^{-6}$ ohm-cm. units, and its temperature coefficient between 0 deg. and 170 deg. as 0·0051. Thus at 0° C., according to Fink, the specific resistance would be $4{\cdot}43 \times 10^{-6}$ ohm-cm. More recent measurements made in this laboratory of the specific resistance of well-aged tungsten filaments have given at 0 deg., $5{\cdot}0 \times 10^{-6}$ ohm-cm. The temperature coefficient from 0 deg. to 300 deg. is found to agree well with Fink's value, *i.e.*, 0·0051. We have seen that the function R' is equal to $4\rho\pi$ so that we may place at 0° C. $R' = 6{\cdot}37 \times 10^{-6}$.

At higher temperatures we may now calculate R' from Somerville's, Pirani's and Corbino's data by simply multiplying their values of the ratio of hot to cold (0° C.) resistance by the above value for R' at 0° C.

In our own experiments on the characteristics of tungsten filaments we have measured R' from 1,300° K. up to 3,540° K. and from 273° K. to 600° K. The agreement with Somerville's results at low temperatures is excellent, while at high temperatures the results agree with Pirani's. At lower temperatures Pirani's values appear to be too low. Corbino's results above 1,700 deg. are too low, probably due, as Pirani has pointed out, to failure to correct for the cooling effect of the leads.

Total Emissivity.—Planck's law (equation 7) gives J_λ the energy of wave-length λ radiated from a black body. The total energy W' radiated from a tungsten filament 1 cm. in diameter and 1 cm. long is then

$$W' = \pi \int_0^\infty E_\lambda J_\lambda d\lambda.$$

On the other hand, by the Stephen-Boltzman law we may place $W' = \pi E \sigma T^4$, where E is the *total emissivity* and the constant σ is equal to $5{\cdot}633 \times 10^{-12}$ watts per square centimetre. The values of E, above 1,200 deg. have been calculated from the corresponding values of W' by means of this equation. For the lower temperatures (up to 600°K.) the value of E has been calculated by a formula given by Foote, namely, $E = 0{\cdot}5736\sqrt{(\rho T)}$, where ρ is the resistivity of ohm-cm. The results obtained from this equation for the higher temperatures do not agree at all well with the values found from our experiments.

Rubens, by a study of the emissivity of platinum, platinum-rhodium, nickel and constantan at different temperatures, concludes that for wave-lengths below 2μ the temperature coefficient of the emissivity is negligible or at least very small, whereas for wave-lengths greater than 6μ the emissivity may be calculated accurately by the Hagen-Rubens formula,

$$E_\lambda = 0{\cdot}365\sqrt{(\rho\ \lambda)}.$$

For these longer wave-lengths the temperature coefficient of the emissivity is thus one-half that of the electrical resistivity.

From the data on the total emissivity the values of W' for temperatures below 1,200 deg. were calculated by means of equation $W' = \pi E_\sigma T^4$. At the lower temperatures, however, "back radiation" was taken into account so that W' was actually calculated from the equation,

$$W' = \pi\sigma(ET^4 - E_0 T_0^4).$$

Here T_0 is room temperature which is taken to be 20° C. ($T_0 = 293$).

E_0 is the total absorption coefficient of a filament at a temperature T for energy radiated by a black body at T_0, that is, at 293 deg. Since the wave-length of the energy radiated at room temperature is longer than 6μ Hagen and Ruben's formula should apply, and we may therefore consider that E_0 increases in proportion to $\sqrt{(\rho)}$. For $T = 293$ we may place $E_0 = E$ and may thus calculate E_0 from Foote's formula,

$$E_0 = 0{\cdot}0230\sqrt{(\rho/\rho_0)},$$

where ρ_0 is the resistivity at 293 deg.

Total Intrinsic Brilliancy.—It will be of interest to compare the experimentally determined candles per square centimetre with the results of the calculation of this quantity from the Planck equation and visibility function according to equation (8). For this purpose we take the constants of the Planck equation to be $C_1 = 3{\cdot}721 \times 10^{-12}$ watts per square centimetre, $C_2 = 1{\cdot}4392$ cm.

These values, according to Planck's theory, correspond to the following values of the fundamental constants h, N and σ: $h = 6{\cdot}580 \times 10^{-27}$ ergs. second, $N = 6{\cdot}062 \times 10^{23}$, $\sigma = 5{\cdot}633 \times 10^{-12}$ watts per square centimetre.

Nutting's visibility data has been chosen since Ives considers this more accurate than his own. From these data the light (in watts per square centimetre) radiated from a black body has been calculated by the equation,

$$L_B = \int_0^\infty V_\lambda J_\lambda d\lambda.$$

The integration was performed by the aid of Simpson's one-third rule, using 35 ordinates at each temperature. The calculations were carried out to four significant figures and the results should be accurate to 0·2 per cent. The values of L_B obtained in this way are given in the following table:—

Light Radiated from a Black Body and from Tungsten in Watts/cm. Calculated from the Planck equation and Nutting's visibility data.

T K.	L_B Black body.	L_W Tungsten.
1,000	0·000000109	0·000000532
1,200	0·000269	0·000132
1,500	0·00329	0·001615
1,750	0·03429	0·01687
2,000	0·2000	0·0986
2,500	2·458	1·216
3,000	13·26	6·580
3,500	44·98	22·34

Similar calculations of the light radiated from tungsten were then made by the same method. For this purpose the emissivity of tungsten E_λ was taken to be 0·46 for $\lambda = 0{\cdot}66\mu$ and 0·50 for $\lambda = 0{\cdot}55$, while for other wave-lengths in the visible spectrum the emissivity

was obtained by linear interpolation or extrapolation from these values. Thus the light radiated from tungsten was obtained by the equation,

$$L_W=\int_0 E_\lambda V_\lambda J_\lambda d\lambda.$$

The values of L_W have been recorded in the table above.

The quantity L_W should be proportional to C' the candles per square centimetre found by experiment. It is seen that at temperatures above 1,900 deg. the ratio is very nearly constant. The absence of any systematic error is an excellent confirmation of the correctness of the pyrometric measurements. At temperatures below 1,900 deg. the ratio of C' to L_W decreases considerably. The average of the remaining values of the ratio gives

$$C'/L_W=262{\cdot}7.$$

The mechanical equivalent of light may be obtained from this ratio; thus $M=L_W/\pi C'=0{\cdot}00121$ watt per lumen. This value is considerably lower than the latest value of this constant given by Ives and Kingsbury, namely, 0·00159. Nutting gives the value 66·2 candles per watt, which corresponds to 0·00120 lumen per watt.

It should be noted that the value 0·00121 obtained from the experiments described in this Paper does not depend to any great extent upon assumptions as to the emissivity of tungsten.

In a recent publication Pirani calculates the intrinsic brilliancy by a similar method to that which we have used. At low temperatures Pirani's values for the brilliancy are 10 to 20 per cent. *higher*, and at high temperatures as much as 15 per cent. *lower* than those we have calculated. The discrepancy cannot be accounted for by the slightly different values chosen for the constant C_2, nor does the fact that Pirani chose the Ives instead of the Nutting visibility curve account for the difference.

The difference between the Pirani and Langmuir values for C_B' would seem to be caused by insufficient accuracy in the graphical methods used by Pirani in determining the area of his curves.

Nernst has given the following relation between the temperature and the brilliancy of a black body :—

$$T=\frac{11{,}230}{5{\cdot}367-\log_{10}K},$$

where K is the brilliancy in Hefnerkerzen per square millimetre. If we express the brilliancy in international candles per square centimetre this becomes

$$T=\frac{11{,}230}{7{\cdot}321-\log_{10}C_B'}.$$

Colour of Light Radiated by Tungsten.

A series of experiments was undertaken to determine whether the light radiated from tungsten differs materially in colour from that radiated by a black body. A helix was formed by winding a tungsten wire on a mandrel. This filament was sealed into a bulb which was then filled with nitrogen. A very much enlarged image of the heated filament was thrown on a white screen, and by means of a Weber portable photometer the intensity and colour of various parts of the image were determined.

The intensity of the light coming from the interior of the helix was from 1·5 to 1·8 times as great as that coming from the outer portions. The colour of the light from the interior was distinctly redder than that from the outside. By first colour-matching the interior of the helix against the photometer lamp and then increasing the current through the helix until the outer portions gave a colour-match with the photometer, it was possible to determine the difference in colour quantitatively.

If we take the emissivity of tungsten for white light to be 0·50 and assume that the inner portion radiates like a black body, then the ratio of the brilliancy of the inner and outer portions should be 2·0. Actually the observed ratio as found by the photometer was less than this (1·5 to 1·8) showing that strictly black-body conditions did not obtain. The observed difference in colour between the inner and outer portions was therefore corrected for this lack of blackness as measured by the ratio of brilliances.

Two methods of making this correction are then referred to.

Tungsten, even in the visible region of the spectrum, is a selective radiator giving a larger proportion of blue light than a black body. The energy distribution in the visible spectrum of a black body is given by Wien's equation. If E_λ be the emissivity of tungsten for the wave-length λ, the energy distribution of the light emitted by a tungsten filament will, therefore, be

$$J_W=C_1E_\lambda\lambda^{-5}e^{-\frac{C_2}{\lambda T_W}},$$

where T_W is the true temperature of the tungsten.

Experimentally it has been found that the colour of the light emitted by tungsten is the same as that emitted by a black body at a slightly different temperature T_B. The energy distribution from the black body is

$$J_B=C_1\lambda^{-5}e^{-\frac{C_2}{\lambda T_B}}.$$

Since the tungsten filament and the black body are of the same colour, although not of the same brilliancy, the ratio of J_W to J_B must be constant for all wave-lengths in the visible spectrum. It is thus possible to obtain from the two preceding equations the relation

$$\frac{d(lnE_\lambda)}{d\lambda}=\frac{C_2}{\lambda^2}\left(\frac{1}{T_B}-\frac{1}{T_W}\right).$$

We have seen that T_B-T_W is small compared to T_W, so that we may place approximately

$$\frac{dlnE_\lambda}{d\lambda}=\frac{C_2(T_W-T_B)}{\lambda^2T^2}.$$

From this equation, with the data of the Paper we may calculate the emissivity of tungsten for one wave-length if we know it for another wave-length. Let us place $C_2=1{\cdot}439$, $\lambda=550\times10^{-7}$ cm. and take T_W-T_B.

Since this quantity varies with the temperature it must follow that the emissivity of tungsten varies with the temperature. How large must this variation be in order to account for the figures obtained ? If we assume that $E_\lambda=0{\cdot}46$ for $\lambda=0{\cdot}664\ \mu$ at 2,400°K., then we may calculate the value of E_λ at 2,400°K. for other wave-lengths by integrating (29).

It is probable from Rubens' work that the variation of the emissivity with temperature occurs mostly in the region of longer wave-lengths ; so that we may safely consider that the temperature coefficient of E_λ for $\lambda=0{\cdot}4$ micron is negligible. We thus obtain $E_\lambda=0{\cdot}525$ at $\lambda=0{\cdot}4$ for all temperatures. Then by (29) we may calculate E_λ at these temperatures for other wave-lengths.

The change in emissivity with wave-length is in fairly good accord with the measurements of Coblentz.

The variation of E_λ with temperature indicated in the table is so slight that it does not materially affect our temperature scale, which has been based on the assumption of constant emissivity. Finally, a formula is given for the thermal expansion of tungsten.

LEGAL INTELLIGENCE.

Prize Court Case.

In the Prize Court, on Aug. 23, the President (Sir S. Evans) had before him a suit by the Crown asking for condemnation of a case of "hardware" on the ground that it belonged to enemies of this country.

Mr. M. W. Slade, for the Crown, said that the goods consisted of a case of electrical meters and other machinery, and were shipped on board the s.s. "Michigan" by Isaria (Ltd.), a company incorporated in this country, to customers in Canada, shortly before the war. They were rejected by the customers in Canada, and were seized on their return to Liverpool as being enemy property. Isaria (Ltd.), who claimed the goods, stated that they were manufactured in Bavaria, the order for them being placed in April, 1914. Accepting their statements, counsel asked for condemnation on the ground that Isaria (Ltd.) was an enemy firm. The facts with regard to Isaria (Ltd.) were set out in his lordship's judgment in May of last year in the case of the s.s. "Poona." His lordship had decided that Isaria (Ltd.) must be taken to be a British firm, but, following upon the decision of the House of Lords in the Continental Tyre case, the company must be regarded as an enemy firm.

The President, in giving judgment, said that that case of hardware, consisting of certain electrical machinery or parts of machinery, was seized in this country upon its return from Canada, where its reception had been refused by the people to whom it was sent. The foundation of the Crown's claim was that the goods belonged at all material times to Isaria (Ltd.), a company formerly registered in London, but whose shareholders were all foreigners. There was not a single British shareholder in the company. In the case of the "Poona," he described exactly the construction of the company, and he need not repeat what he there said. The company had not put forward any claim to the goods in these proceedings, although they sent a letter to the Procurator-General alleging that they were the owners, and that as a company registered in this country they were entitled to have the goods released to them, as they were in the case of the "Poona." In that case he (the President) said that if the judgment of the Court of Appeal in the Continental Tyre Co.'s case was unsound, it must be so pronounced by the House of Lords. It had been pronounced to be unsound by the House of Lords, and following that decision and his own inclination, as already expressed in the "Poona" case, he must hold that Isaria (Ltd.), for all purposes affecting this case, must be regarded as an enemy company, although carrying on business here, and accordingly the goods in question must be condemned as enemy property.

Wm. Cook v. W. A. Jennings.

At Leicester County Court last week plaintiff sued defendant, the principal shareholder of the Evington Cinema, for £5. 5s. for professional advice given.

Plaintiff stated that when he asked defendant to be allowed to tender for the electrical installation of the new cinema he was referred to the architect (Mr. Smith), who asked plaintiff to prepare a general scheme for the installation. Plaintiff replied that if he did that he would expect to be paid. He had several interviews with the Corporation officials and with defendant at the latter's request. He also drew up a scheme, which was not in accordance with his tender, and his charge of £5. 5s. was reasonable.

DEFENDANT said plaintiff, a stranger, asked about tendering for the electrical supply, and saw him at various times. Whatever plaintiff did was done on his own initiative, and not at defendant's request.

Mr. ERNEST HY. SMITH, architect for the cinema, denied that plaintiff told him that if he prepared a scheme he should expect payment. He treated plaintiff in the same way as the other engineers who were seeking information for tendering.

Mr. HILTON JOHNSON, electrical engineer, who contracted for the electrical installation, stated that he had a number of interviews with the architect on the same question as plaintiff in order to give him the necessary information for tendering.

His HONOUR said defendant was the managing director of a limited company, against whom there was no case, as the action ought to have been taken against the company, and dismissed the action, with costs.

Trading With the Enemy.

At the Mansion House, London, on the 24th ult. Geo. De G. Hill & Co. were summoned for (on July 25) offering and proposing to trade with Joseph de Poorter, of Rotterdam, a person mentioned in the statutory list published in accordance with the Trading with the Enemy (Extension of Powers) Act, 1915, and the Trading with the Enemy (Neutral Countries) Proclamation, 1916.

Counsel for the Director of Public Prosecutions said that the proclamation issued on Feb. 29 last announced that it was desirable to place all the persons mentioned in a list attached to it in the position of enemies, and that from that moment it became illegal to trade, in any of the wide senses in which the word was used in the Trading With the Enemy Act, with any person whose name appeared in the statutory list. He said that on the first list appeared the name of Mr. Joseph de Poorter, of Rotterdam. Mr. Hill wrote a letter to Mr. de Poorter, on July 25, in which he invited him to trade, offering freight on a particular steamer. The letter was stopped by the Censor and forwarded to the War Trade Intelligence Department, who thereupon wrote to defendants. The latter replied that they were not aware that Mr. de Poorter's name had been placed in the list, otherwise they would not have attempted to communicate with him.

After hearing the defence, Ald. Sir GEO. TRUSCOTT said as it was merely an act of negligence he should take a very lenient view of the case. He fined defendants £25 and £10. 10s. costs.

EDUCATIONAL.

University College, University of London.—We have received a copy of the handbook of the Faculty of Engineering of this College, which gives particulars of the courses of instruction in civil, mechanical, electrical and municipal engineering, chemistry, mathematics, &c. The courses lead to the degree B.Sc. (Eng.) of the University. The dean of the Faculty is Prof. E. G. Coker, and the vice dean is Prof. J. A. Fleming, who is also the Pender Professor of Electrical Engineering. The laboratories are well appointed, and good facilities are provided for practical work. The pamphlet, which contains details of the fees, classes, examinations, &c., can be obtained from the Secretary, Gower-street, W.C.

University of Manchester.—The session will begin on Oct. 5. Complete theoretical and practical training is provided for students preparing for the higher positions in the electrical engineering profession. At the end of a three years' course students may obtain either an ordinary or an honours degree of B.Sc. in electrical engineering. A special course, also extending over three years, prepares for a certificate in electrical engineering. The John Hopkinson Laboratories are fitted with modern electrical machinery and testing appliances, and excellent facilities are offered for educational and research work. Particulars may be obtained from the Registrar.

University of Bristol.—In the faculty of engineering complete courses of instruction are provided in civil, mechanical, electrical and automobile engineering.

The autumn term commences on Sept. 3, but in the faculties of arts, science and medicine it begins on Oct. 3. There are also complete courses of instruction in the evening classes. Particulars from the registrar, Mr. James Rafter, M.A.

University College of North Wales (Bangor).—The new session will commence in October, when a systematic course of instruction will be given in electrical measurement, and practical electricity for students proposing to enter the profession of electrical engineer will be commenced. The physical laboratory is well equipped for practical work. Prospectus and further information from Mr. J. E. Lloyd, M.A., Secretary and Registrar.

Armstrong College (University of Durham) Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanica marine, civil and electrical engineering, naval architecture, m ing, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

Royal Technical College, Glasgow.—The session 1916-17 begins on Sept. 26.

The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, &c. There are also full courses of instruction in the schools of navigation and wireless telegraphy, and both day and evening classes are held. The diploma courses extend over three or four sessions, and the average fee is £12. 12s. per session. The college is affiliated to the University of Glasgow, and the degrees of the university in engineering and applied chemistry are open to its students. Prospectuses may be obtained from the Director, and the calendar is published at 1s. (post free 1s. 4d.).

Northampton Polytechnic, London.—In the day engineering college full-day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

South-Western Polytechnic.—This Polytechnic will reopen on Sept. 25 for day and evening classes. The Engineering Courses include lectures in electrical and mechanical engineering, physics, chemistry and mathematics, and practical instruction in the laboratories. There is a complete three years' day course (leading to a diploma or University Degree in electrical engineering), and also a four years' evening course suitable for electrical engineering and wiremen's examinations of the City and Guilds Institute.

Students are prepared by recognised teachers of the University of London for the B.Sc. degree in engineering, for the examinations at the Engineering Institutions and of the City and Guilds of London Institute. The evening courses also include classes in electric wiring and other trade subjects. In the electric wiring department an advanced course has been arranged for the preparation of candidates for the final wiremen's examination of the City and Guilds of London Institute. Arrangements have been made for placing students who have passed satisfactorily through the three years' day course in positions with large engineering firms, and hitherto such firms have offered more vacancies than the Institute has been able to fill with its students. Prospectuses may be obtained from the Secretary, Manresa-road, Chelsea, London, S.W.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914 SPECIFICATION.

15,690 Bing. Electromagnetic friction clutches.

1915 SPECIFICATIONS.

6,408 B T-H Co. (G E Co.) Driving and regulating of talking machines.

8,537 Kerr. Electric heaters. (7.12.15.)

11,321 B T-H Co. & Whitaker. Starting and synchronising of dynamo-electric machines.

Comprises an arrangement for starting and self-synchronising a synchronous dynamo-electric machine by means of a starting motor mechanically coupled to the shaft on which the starting motor has a salient pole or equivalent rotor and two primary windings, the number of poles and poles of one primary winding being equal in number to the poles of the main machine, and the poles of the other primary winding being equal in number to the poles of the main machine when both machines are mounted on the same shaft, a corresponding relation in the pole numbers being provided in accordance with the speed ratio when the two machines are coupled by gearing.

11,976 Lucas. (Universal Hand-Power Telephone Co.) Telephone transmitters.

13,934 Railing & Garrard. Operating rotary converters and other alternating machines. (Patent of addition not granted.)

Consists in connecting the armature of the rotary to the alternating current supply through the primary of a transformer or equivalent as soon as the excitation of the rotary has commenced and not waiting until full speed, or approximately synchronous speed, is attained.

14,293 Cowan. Magneto-electric machines for ignition in internal-combustion engines.

15,873 Ireland. Spring arrangements for electric ignition devices.

1916 SPECIFICATIONS.

100,974 Beaver, C. J. & Casemore, E. A. Systems for the protection of electric cables in the event of external damage. (Addition to 6,674/15.) (3,707.)

100,987 Pemberton, E. A. Telephone instruments. (5,061.)

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	747	The Electric in the Daily Papers	160
Imports and Exports of Electrical Manufactures	748	"A Question of Origin." Illustrated	162
Business Notices	748		
Bankruptcies, Liquidations, &c.	748	Miscellaneous Notes	751
Electricity Supply	748	Tenders Invited	751
Traction Notes	749	Tenders Received & Accepted	752
Telegraph and Telephone Notes	749	Municipal Accounts	752
Empire Notes	749	Companies' Meetings and Reports	753
Foreign Notes	750	New Companies, &c.	753
		City Notes	754
The Round Table	157	Electrical Companies' Share List	754
To Help Sales. Illustrated	158		

COMMERCIAL TOPICS.

Enemy Goods and Trade-marks in Australia. It is announced that Mr. Mahon, the Commonwealth Minister of External Affairs, has ordered the suspension of an additional 300 enemy trade-marks.

The Commonwealth Government has decided that after Sept. 30 wholesale houses must not sell enemy goods which were imported before the war and retail houses must not sell such goods after Nov. 30 next.

* * * *

British Capital in Ontario. Of late there has been a revival of criticism of the Government of Ontario in regard to its attitude towards certain electric power companies in which much British capital has been invested.

The present controversy, however, goes back for at least 13 years, when the Executive Government entered into agreements with certain electrical companies which permitted them to take specified quantities of water from the Niagara or Welland rivers at certain rentals, payable to the Hydro-electric Commissioners, the latter binding themselves not to lease similar powers to any other company or persons at less rentals than those payable under the agreements by the companies in question. On the faith of these agreements, funds were obtained, largely from investors in this country, to carry out the enterprises. Scarcely, however, had the promoters begun to carry out their scheme of distribution when there arose an agitation amongst the municipalities of Ontario for cheap electric power, and ever since there has been a growing disposition on the part of the province to interpret the contract with these private concerns in a manner very different from that which was understood when the capital was raised in this country. Of course, it is open to the Ontario Government to adopt whatever arrangements it considers best with regard to the obtaining of electrical power of every kind in the country, always so long as it observes, both in the letter and in the spirit, its agreement with the power companies from whom it accepted payment in consideration of certain concessions; but there must be no question of infringing the rights which have been acquired by private enterprises for valuable consideration, and it is on that point that a clear statement is desired. It is also stated that not only is the Hydro-Electric Commission endowed with authority to put a stop to the generation of power by companies holding licences from the Government, but its power is almost unassailable by reason of the fact that it has been specially provided that the Commission is to be immune from process by law, excepting through a fiat of the Provincial Attorney-General. The statements call for some explanation from the Government of Ontario, as its good faith and credit are at stake.

* * * *

The British Consular Service. On the 22nd ult. a number of questions were asked in the House of Commons as to the nationality of British consular officials, &c.

Lord Robert Cecil, who replied, stated that all salaried consular officials were British-born subjects. A considerable number of the unsalaried consuls and vice-consuls were foreigners, but he feared that was to some extent inevitable if we were to have representatives in towns where there were few or no suitable British residents. It was entirely misleading to discuss salaried and unsalaried posts together. Unsalaried consuls of foreign nationality were, as a rule, appointed where it was a choice of having an unsalaried foreign consular officer or none at all, and not where there was a possibility of having an efficient British consular officer. The subject was exhaustively examined by the Royal Commission that reported after full consideration: "Upon a full consideration of the facts, we think that no criticism can be passed upon the policy now pursued by the Foreign Office in respect to the whole question. We think the appointment of whole-time salaried officers is not only unnecessary and extravagant, but would prove actually prejudicial. On the other hand, we have received a considerable amount of evidence testifying to the value of the services which unpaid consuls of foreign nationality can render to British trade."

Lord R. Cecil added that the whole matter was being carefully considered, but no foreigner would be appointed in future to any consular office without the express authority of the Foreign Office.

* * * *

American Output of Electrical Machinery. A summary of the census of products of the electrical machinery industry of the United States has been issued. In this summary it is stated

The total value increased by about 50 per cent. between 1909 and 1914. The number of establishments decreased from 1,151 to 1,121; but, eliminating these which make electrical machinery as a subsidiary product, the total number of establishments engaged primarily in that industry increased by 21. The values in dollars of the products of the electrical machinery industry in 1909 and 1914 respectively were as under:

Dynamos	$17,231,804	...	$23,233,437
Transformers	8,801,019	...	13,120,065
Motors	32,087,482	...	44,176,235
Batteries (parts and supplies)	10,612,470	...	23,402,455
Carbons (furnace, lighting, brushes, battery, &c.)	1,934,864	...	3,602,741
Arc lamps	1,706,959	...	742,142
Searchlights, projectors and focussing lamps	935,874	...	2,081,545
Incandescent lamps	15,714,809	...	17,350,385
Sockets, receptacles, bases, &c.	4,521,729	...	5,512,609
Electric lighting fixtures	2,200,668	...	3,383,955
Telegraph apparatus	1,957,432	...	2,248,375
Telephone apparatus	14,259,357	...	22,815,640
Electric heating apparatus	1,954,112	...	4,034,436
Electric measuring instruments	7,800,010	...	8,786,506
Insulated wire and cables	51,624,737	...	69,505,573
Other products	66,694,153	...	115,416,577
Total	$240,037,479		$359,412,676

Under the head of dynamos are included dynamotors, motor generators, boosters, rotary converters, double current generators, &c. (8,393 in number) of an aggregate capacity of 780,009 kw., and valued at $5,367,895, representing increases of 266·3 per cent. in number, 164·3 per cent. in capacity and 70·2 per cent. in value, compared with 1909. Under d.c. dynamos there were reported 208,548 small dynamos and automobile starter generator sets of the value of $5,933,273, but some of these devices are also included under the heading motors for automobiles, &c. There were 115,843 transformers manufactured in 1914 of 2,644,794 kw., and valued at $13,120,065, increases of 51, 61·7 and 49·1 per cent., respectively. The output of motors for industrial power and railway use was 417,992 of an aggregate capacity of 2,882,795 h.p., and of $32,286,149 in value, increases of 62·5, 19·6 and 31·2 per cent. over 1909. The value of switchboards, panel boards and cut-out cabinets was $8,989,111, an increase of 50·5 per cent. over 1909. The increase in the value of the output of primary and storage batteries was 120·5 per cent., of incandescent lamps 10·4 per cent., and of arc lamps, &c., 6·8 per cent. In telegraph (including wireless telegraph) apparatus, the increase was 14·9 per cent., and in telephones 60 per cent., while there was an advance of 106·5 per cent. in the output of electric heaters, cooking devices, flat irons and welding apparatus, an increase of 12·6 per cent. in electric measuring instruments, and of 34·6 per cent. in insulated wires and cables; but electric conduits decreased by 4·4 per cent. There was a record increase of 265·4 per cent. in the value of magneto-ignition apparatus, spark plugs, coils, &c. ($22,260,847), electro therapeutic apparatus ($2,653,098) showed the substantial increase of 139·5 per cent., and carbons 86·2 per cent. There were also substantial increases in the values of the output of electric clocks, signals and attachments, electric lighting fixtures, &c. There were 900 electric locomotives (of $3,720,914) under unclassified electrical machinery, &c.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From Aug. 19, 1916, *to* Aug. 25, 1916.

IMPORTS.

FOLKESTONE.—*France:* Elec. carbons, 35 pkgs.; unenumerated, 9 cases.
GRIMSBY. *France:* Unenumerated, 10 cases.
LIVERPOOL. *U.S.A.:* Electrodes, 51 cases; elec. light carbons, 26 cases.
HULL. *Sweden:* Elec. machinery, 98 cases.
LONDON. *U.S.A.:* Insulated wire, 18 brls., 33 cases; carbon candles, 405 pkgs.; wire and cable, £99; telephone material, £44; unenumerated, £4,834 657 cases. *Holland:* Elec. lamps, £3,676 433 pkgs.; elec. glow lamps, £2,371; unenumerated, £680. *Japan:* Unenumerated, £685. *France:* Unenumerated, £52 4 cases. *Switzerland:* Unenumerated, £331. *Denmark:* Unenumerated, £22. *Italy:* Elec. wire, 40 cases; wire and cable, £1,107.
SOUTHAMPTON. *France:* Elec. lamps, 4 pkgs.; elec. cable, £20; insulators, 2 cases; unenumerated, 35 pkgs.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Unenumerated, £749. *Melbourne:* Wire and cable, £109; elec. machinery, £118; unenumerated, £904. *Sydney:* Elec. lamps, 1,000 n.o.; telegraph material, £190; unenumerated, £752. *Wellington:* Elec. machinery, £200; wire and cable, £44; unenumerated, £866. *Lyttelton:* Wire and cable, £42; unenumerated, £37. *Dunedin:* Wire and cable, £122; unenumerated, £26. *Adelaide:* Unenumerated, £43. *Christchurch:* Elec. machinery, £23; unenumerated, £40. *Perth:* Wire and cable, £121; unenumerated, £168. *Hobart:* Unenumerated, £764. *Fremantle:* Unenumerated, £146. *Banff:* Elec. machinery, £1,050.
AFRICA. *Durban:* Elec. machinery, £791; wire and cable, £4,446; glow lamps, £702; unenumerated, £2,387. *Cape Town:* Wire and cable, £2,379; unenumerated, £1,263. *Port Elizabeth:* Elec. machinery, £35; wire cable, £1,727; unenumerated, £305. *East London:* Wire and cable, £13; unenumerated, £81. *Delagoa Bay:* Elec. machinery, £150; unenumerated, £172. *Beira:* Unenumerated, £75. *St. Helena:* Telegraph material, £40.
EGYPT.—*Alexandria:* Wire and cable, £46; elec. machinery, £45; unenumerated, £1,202. *Port Sudan:* Wire and cable, £49; unenumerated, £212. *Suez:* Telegraph material, £25.
ADEN. Telegraph material, £110; unenumerated, £65.
INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Wire and cable £3,009, elec. machinery, £3,147; unenumerated, £905. *Singapore:* Wire and cable, £55; elec. machinery, £516; unenumerated, £333. *Calcutta:* Wire and cable, £584; elec. machinery £24 unenumerated, £1,588. *Madras:* Elec. machinery, £321; unenumerated, £301. *Colombo:* Unenumerated, £350. *Port Swettenham:* Unenumerated, £21. *Penang:* Wire and cable, £197; telegraph material, £18; unenumerated, £33 *Bankok:* Elec. machinery, £159; unenumerated, £288. *Saigon:* Unenumerated, £38.
CHINA. *Hong Kong:* Wire and cable, £980; elec. machinery, £550; unenumerated, £331. *Shanghai:* Wire and cable, £621, telegraph material, £24; unenumerated, £1,470. *Tientsin:* Wire and cable, £300.
CANADA. *Toronto:* Unenumerated £21
U.S.A. *New York:* Wire and cable, £20; elec. machinery, £174; unenumerated, £374
SOUTH AND CENTRAL AMERICA. *Talcal:* Wire and cable, £76. *Valparaiso:* Wire and cable, £2,336; unenumerated, 129. *Buenos Ayres:* Telegraph material, £261; unenumerated, £111. *Monte Video:* Unenumerated, £170. *Antofagasta:* Unenumerated, £56.
JAPAN. *Yokohama:* Elec. machinery, £785. *Osaka:* Unenumerated, £90. *Tokio:* Unenumerated, £1,509.
EAST INDIES.—*Sumatra:* Unenumerated, £50.
WEST INDIES. *Demerara:* Unenumerated, £20. *Trinidad:* Unenumerated, £20. *Barbados:* Unenumerated, £11.
HOLLAND. *Amsterdam:* Wire and cable, £3,631; unenumerated, £310. *Rotterdam:* Elec. machinery, £14; wire and cable, £248; unenumerated, £92.
RUSSIA. *Vladivostock:* Unenumerated, £12; *Archangel:* Wire and cable, £86; *Petrograd:* Elec. machinery, £749
FRANCE. *Dieppe:* Elec. machinery, £160, unenumerated, £189. *Paris:* Wire and cable, £29; telegraph material £480; unenumerated, £439. *Boulogne:* Unenumerated, £19. *Bordeaux:* Unenumerated, £29. *Marseilles:* Unenumerated, £34.
GIBRALTAR. Unenumerated, £111.
MALTA. Telegraph material, £34, elec. machinery, £278; unenumerated, £117.
SWEDEN.—*Nyköping:* Telegraph material, £35.
PORTUGAL. *Lisbon:* Wire and cable, £578.
SPAIN. *Barcelona:* Unenumerated, £745.

FOREIGN GOODS (duty paid and free).

Sydney: Elec. lamps, 1,000 n.o. Melbourne, unenumerated, £34. *Colombo:* Unenumerated, £29. *Petrograd:* Unenumerated, £286. *Philadelphia:* Unenumerated, £120. *New York* Unenumerated, £116. *Marseilles:* Unenumerated, £30. *Malta:* Unenumerated, £36 *Tokio* Unenumerated, £223. *Dieppe* Unenumerated, £17. *Hong Kong* Unenumerated £150 *Durban* Unenumerated, £24 *Port Sudan:* Unenumerated, £44 *Cape Town* Unenumerated, £37 *Kuri:* Unenumerated, £61. *Port Elizabeth* Unenumerated, £58 *Alexandria* Unenumerated £20 *Auckland.* Unenumerated, £104 *Amsterdam* Unenumerated, £40 *Shanghai* Elec. lamps, 9,482 n.o. *Rotterdam* Elec. cable, £350 *Baroda* Unenumerated, £23. *Bombay:* Unenumerated, £12 *Brisbane* Unenumerated, £37 *Boulogne* Unenumerated, £45.

NOTE.—**The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."**

BUSINESS NOTICES.

The partnership between Arthur C. Heap and W. Pollard Digby, carried on at 18, Westminster Palace-gardens, Victoria-street, S.W., terminated on Aug. 31. Mr. A. C. Heap has accepted an important appointment which compels him to relinquish all private consulting and inspecting work. Mr. W. P. Digby will continue to carry on the professional work hitherto entrusted to Heap & Digby, and will be joined by Mr. Walter Ryley, who has been with the firm for several years. The title of the new firm will be Digby & Ryley.

It is stated that the shares of the British Mannesmann Tube Co. (Ltd.) have been sold by the Public Trustee to a British group, including Sir Hugh Bell, Mr. A. J. Dorman, Messrs. Balfour, Williamson & Co. and Messrs. Higginson & Co., all German interest in the company being thus eliminated. The concern owns large works at Swansea, and it is intended to erect additional mills at Newport (Mon), while other developments are also proposed.

Arc Lamps for Sale. Messrs. Thos. Broadbent & Sons (Ltd.), Central Iron Works, Huddersfield, advertise some Excello arc lamps for sale.

Application for Restoration of Lapsed Patent.—John Conrad Bedford Ingleby has applied for the restoration of the Patent (No. 13,719 of 1908), granted to him for "Improvements in or relating to squirrel-cage rotors for induction motors or alternators," which expired on June 29, 1915.

BANKRUPTCIES, LIQUIDATIONS, &c.

Mr. E. A. Radford, 3, York-street, Manchester, has been appointed trustee in the bankruptcy of Jas. Fredk. Coates (trading as J. F. Coates & Co., electric motor manufacturers, &c.), 52, King William-street, London, E.C., and 64, Mosley-street, Manchester.

A meeting of the creditors of the Resisto-Electrical Mfg. Co. (Ltd.) will be held at the offices of Messrs. Lowe, Bingham & Matthews, 167, Fenchurch-street, London, E.C., on Sept. 6.

A first and final dividend of 2s. 8½d. will be payable on Sept. 4 at 30, Mosley-street, Newcastle-on-Tyne, to creditors of Wm. D. Birkett, factor of electrical goods, Arnside, Windsor-avenue, Whitley Bay, Northumberland.

A meeting to receive an account of the winding up of the Phœnix Electric Heating Co., 1914 (Ltd.), will be held at 8, Staple Inn, London, W.C., on Oct. 2.

ELECTRICITY SUPPLY.

GENERAL.

Bradford-Shipley Linking-up Scheme.—At the meeting of Shipley Urban Council on Tuesday it was reported that the sub-committee authorised to deal with the proposal to link-up the Bradford and Shipley electricity systems had had before them the detailed report of the engineer, who found that only a comparatively small saving in coal would be effected, but considered that there were serious disadvantages in the scheme.

The sub-committee directed that a communication be addressed to Bradford Corporation suggesting that before a definite statement was submitted to the Board of Trade there should be a further interview between the two authorities.

Mr. T. F. DOYLE urged that it would have been better from the outset to have had nothing to do with the scheme. Any benefit arising out of it must be at a sacrifice to Shipley. He could not imagine Bradford Corporation shutting down any of their generating plant for the convenience of Shipley. Bradford could supply the district much cheaper than Shipley.

Mr. E. REYNOLDS, chairman of the Electricity Committee, pointed out that in conferring with Bradford Corporation they had only been obeying the behest of the Board of Trade. It had been agreed that each authority should have a report from its engineer before proceeding further.

The recommendation to attend a further conference was then approved.

Residents of Baildon having applied for a supply of electricity, the committee had directed that the applicants be informed that the supply could only be granted through Baildon District Council.

Amesbury.—The Rural Council have received a letter from Mr. Hamilton Fulton in regard to a prospective electric supply scheme.

Inquiries showed that the War Office would be willing to grant a supply of electricity from their power station on terms which were considered reasonable, but before proceeding to carry out a scheme as a private undertaking the promoters wished to ascertain whether the Council would undertake it, or, if they decided not to do so, whether they would give the private undertaking the facilities necessary for placing poles and overhead wires.

The Council decided to ask for plans showing the positions of the poles, and to inquire whether Mr. Fulton had obtained the consent of the County Council.

Dublin.—The electric supply department are substituting metallic filament lamps for arc lamps for street lighting. The alteration has already been made in Merrion-square with very satisfactory results.

Glasgow.—The question of coal purchases by the Electricity Committee was considered at last week's meeting of the Corporation.

A member said that as supplies could not be got from coal owners the Committee had to make purchases from middlemen whose charges were above the rates fixed by the Prices of Coal (Limitation) Act. It had been discovered that the middlemen were exempt from the Act, and an agreement, he alleged, had been come to between owners and merchants whereby a portion of the Corporation's supplies had to come through the latter.

Bailie HANNAY said that the increased cost was entirely due to the longer distance some of the coal had to be transported.

Hinckley.—The Rural Council has given permission to the Leicestershire & Warwickshire Electric Power Co. to lay mains to Burbage House.

Morecambe.—The Board of Trade have made an order under sec. 6 of the Electric Lighting Act, 1909, authorising the Corporation to supply electrical energy to premises in Heysham.

Ormskirk.—On the recommendation of the Building & Electricity Committee the Board of Guardians have accepted the offer of the Ormskirk Electric Supply Co. to supply electrical energy for both lighting and power.

Reigate.—At a meeting of the Guardians last week a report was considered from a L.G. Board inspector on the proposed laundry extension.

In his report the inspector said, with regard to motive power for new appliances, that he did not regard the installation of electricity as an economical system, seeing that steam power was already in service, although that the steam pressure was stated to be insufficient for driving laundry machinery. Though the provision of further boiler power would involve a larger initial outlay than the introduction of electric power, the current expenses would be less unless very favourable terms could be obtained for the supply of electric current. He thought the Guardians would well advise to call in an independent consulting engineer to report as to the working economy of steam compared with electricity.

The views of the Guardians' architects (Messrs. T. R. & V. Hooper) differed from those of the L.G. Board inspector. They thought electricity should be the motive power and the cost on installation would be far less.

The matter was ultimately referred to the Works Committee.

Rochdale.—The works Sub-committee is considering a report recommending the Corporation to apply for sanction to borrow £50,000 for electricity supply extensions.

Stalybridge.—The Stalybridge, Hyde, Mossley & Dukinfield Tramways and Electricity Board have agreed to give a supply of electric current to a number of consumers outside the present area of supply.

Stirling.—The Council have decided to install an electric elevator in the new municipal buildings in Corn Exchange-road at an estimated cost of £427. 10s.

Worksop.—At the meeting of the Council on Monday the Lighting Committee recommended the appointment of Mr. T. R. Skinner as general assistant electrical engineer at a salary of 30s. a week.

Coun. SAXTON, who moved an amendment that the appointment be not confirmed, said that the Council allowed Mr. J. P. Crowther to join H.M. forces and agreed to pay him half his salary, and was given to understand that the acting engineer (Mr. Fletcher), whose salary was increased at the time, would be able to manage without extra assistance.

Coun. HARTLAND remarked that if the staff was depleted, the demands on the works were decreased.

The CHAIRMAN said that Mr. Crowther had personally told him that if the Council would let him go they could manage with Mr. Fletcher without further assistance.

Despite considerable opposition, the recommendation was eventually agreed to.

TRACTION NOTES.

Croydon.—Two tramcars collided at interlacing lines on Monday, resulting in injuries to 11 persons.

Glasgow.—The Tramways Committee propose to curtail the tramcar service at night by an hour, owing to scarcity of labour and the consequent strain on the department. At present nearly 600 of the traffic staff are working seven days per week.

TELEGRAPH AND TELEPHONE NOTES.

Australian Wireless Service.—The "Australian Mining Standard" says the proposal of the Australian Commonwealth Government to reorganise its wireless telegraph service on naval lines has caused a flutter in the staff.

The Minister for the Navy (Mr. J. A. Jensen) assured a deputation recently that the men could rely upon being treated fairly, and that he believed the department would be generous and reasonable. The impression seemed to have been formed that wireless operators had only signed on for three years, and that when the war was over those on duty on coastal stations would be dismissed, men on the warships taking their places. Nothing like that was intended.

Swiss Government Telegraphs and Telephones.—The report on the working of the Swiss State telegraph and telephone department for 1915 contains the following information :—

The number of telephone subscribers is 79,709 (decrease 3·44 per cent.). Telegrams to and from prisoners of war in Austria-Hungary and Italy were 7,381 outward (from Switzerland) and 1,187 inward. The total number of telegrams transmitted was 17,301,728, including 3,181,285 inland, 3,621,945 international, 310,021 official, 244,383 military, and 944,094 inland and international combined (counted double). Telephone conversations of all kinds numbered 73,739,221 (decrease 2,777,246). Income was 21,878,385 fr. (against 23,314,102 fr. in 1914), and expenditure 18,993,192 fr. (against 20,509,153 fr.); surplus 2,885,192 fr. 2,804,948 fr.).

EMPIRE NOTES.

Australasia.—The "Australian Mining Standard" says it is proposed to light Warragul, Gippsland (Victoria), by electricity, utilising the waterpower of the Tanjil River (36 miles distant) for generating purposes. It is calculated that current could be supplied at 1d. a unit. A company is being formed for carrying out the scheme, the promoters being Messrs. H. Copeland, S. J. Gay and V. J. Crowley.

Sir Joseph Ward, Postmaster-General for New Zealand, expressed the hope at a recent meeting that after the war the post office departments of Australia and New Zealand would direct their combined energies to secure the ideal of 6d. per word cablegrams to Great Britain.

Edison & Swan meters are to be used on consumers' premises in connection with Nunawading (Victoria) Shire Council's electricity scheme.

A fairly successful trial was made recently of a generator to be installed on the "dummy" of the Melbourne cable tramways for generating electrical energy for lighting the cars. The dynamo is chain driven from one wheel of the "dummy," and a storage battery is provided to supply light when the car is stationary.

The Hawthorn (Victoria) Tramways Trust having sought the sanction of the State Government to a Bill extending its borrowing powers to enable it to borrow £50,000 for extensions, the Cabinet has decided that, while the general question of tramway control is under consideration, it cannot agree to the proposal so far as it affects extension of lines, but it has approved a Bill authorising the Trust to raise money for additional cars and equipment.

On June 30 the lease under which the Melbourne cable tramways were controlled by the Melbourne Tramway and Omnibus Co. expired, the system came under the control of the Tramway Board appointed by the Government for that purpose, under the temporary Act passed last December. The Act will remain in force until the end of 1917, but it may be terminated earlier if an agreement is arrived at between the Government and the municipalities interested as to the constitution of a single authority to take control of the whole of the city and suburban tramways. The new board consists of Mr. Colin Templeton (chairman), Sir David Hennessy and Sir Henry Weedon (Melbourne City Council), Mr. A. Renfrew (Fitzroy City Council), and Mr. F. T. Hickford (Brunswick City Council). The board is empowered to obtain a bank overdraft not exceeding £500,000, and it may borrow £500,000, the Government guaranteeing repayment of the money overdrawn or borrowed, and it may advance the board sums not exceeding £500,000. Mr. Justice Cussen will act as assessor in fixing the valuation at which such of the company's assets as may be required shall be purchased. Mr. H. A. Wilcox, managing director of the company, will continue to act as general manager under the board, and will be paid £2,500 a year, or £500 more than he formerly received.

Canada.—The introduction of machinery in Ontario is proceeding apace and is revolutionising farm labour.

For many years span ploughs, harrows and cultivators, reaping, binding and threshing machines and other labour-savers have been employed, but of late electric motors and other machinery have been rapidly coming into use.

South Africa.—The final Government estimates of expenditure on the South African railways and harbours for the year ending March 31, 1917, include £55,099 for telegraphs and telephones, and £27,624 for signals.

The following are items of expenditure from Loan Funds for which provision is made in the estimates of the South African Government for 1917:—Additions to telegraph and telephone systems and new works, £150,000; telephone exchange buildings, £14,800.

Johannesburg Municipal Council contemplate an extraordinary expenditure of about £100,000 per annum on certain remunerative and unremunerative undertakings until such time as they have reached completion. The works include electric power supply, tramways and water supply.

Water Power of Canada.—The potential water power of Canada, as at present known, is estimated at 17,000,000 H.P., of which only 1,590,500 H.P. is developed. The outstanding feature of the power situation in Canada is that, close to all present commercial centres, with the exception of some of those in the Middle Prairies, there is abundance of dependable water power.

Within 70 miles of Winnipeg there is about 500,000 H.P. available energy, of which 60,000 H.P. is now developed. Within 50 miles of Calgary there is 48,100 of dependable 24-hour horse-power, of which 15,000 continuous horse-power is now utilised. The Western Canada Power Co. is developing at its plant on Slave River (35 miles from Vancouver) 25,000 H.P., which is transmitted for use in the coast district. This company's present plant and a further power site on the same river can be increased to allow of a maximum development of 100,000 H.P. The presence of so much available water power means much for the young industries of the Dominion.

FOREIGN NOTES.

Argentina.—Statistics of imports which have been prepared by the Director-General of Commerce and Industry of the Argentine Ministry of Agriculture include the following; the figures being in each case for 1913, 1914 and 1915 respectively:—

Steel Rails: Total imports, $6,263,680, $3,397,440, $535,640; from the United Kingdom, $1,995,720, $1,734,360, $90,320; Germany, $1,856,280, $726,680, $114,760; U.S.A., $1,640,080, $623,320, $330,560. *Machinery:* Total, $6,210,438, $3,470, $1,445,126; Germany, $2,886,625, $1,252,070, $153,984; U.K., 1,355,353, $959,195, $450,017. *Railway Material:* Total, $5,041,415, $1,116,622, $1,690,786; U.K., $3,638,864, $3,238,370, $1,513,574; Germany, $536,788, $500,323, nil; U.S.A., $265,118, $224,906, $131,206. *Electric Wires and Cables:* Total, $1,945,631, $3,394,481, $1,689,251; Germany, $2,308,394, $1,558,673, nil; U.K., $2,023,900, $903,339, $860,256; U.S.A., $120,789, $52,107, $241,253. *Spare Parts of Machinery:* Total, $2,734,468, $1,670,147, $1,222,300; U.S.A., $796,673, $440,873, $131,439; Germany, $698,671, $396,187, $83,396; U.K., $593,787, $431,048, $421,680. *Gal. Iron Wire:* Total, $2,125,538, $1,227,144, $617,515; Germany, $1,311,544, $894,596, nil; U.S.A., $495,807, $109,378, $582,427; U.K., $234,481, $128,160, nil.

The electric suburban service of the Central Argentine Railway between Retiro and Tigre has been commenced.

The Inspeccion General de Rentas has been authorised to make arrangements with the Luz y Fuerza and Anglo-Argentina Companies for the supply of electric light at the ports and dependencies of Paraná and Concepcion del Uruguay respectively. The monthly cost of the supply at each of these ports will not exceed $750 paper, whereas the official estimate of the Ministry of Public Works involved an expenditure of $2,500 monthly.

It was expected that the electricity supply at Bahia Blanca would cease on July 16 owing to lack of coal. The company owning the works was unable to procure petroleum from the Ministry of Agriculture at the current price, and trials of wood fuel had not given satisfactory results.

The "Review of the River Plate" states that owing to a dispute with the Municipality as to payments for services and the difficulty of getting coal supplies, the Rosario Gas Company suspended its public service on July 15. The Municipal Intendent at once ordered electric lighting installations to be put in the streets where the gas had been suspended and his action has since been enthusiastically confirmed by the city council and by the inhabitants of the streets affected. $25,000 m/n. is to be spent upon the purchase of electrical material for the purpose. Subsequently, however, the electric supply company made it plain that although it was glad of the new business, it would have to become the subject of a formal and binding contract, and profiting by the sad experience of its gas rival it is asking that certain municipal revenues should be specifically affected to the payment of the current it is to supply.

Colombia.—The Municipal Council of Urrao, Department of Antioquia, has been authorised to borrow 40,000 pesos (£8,000) for electric lighting and aqueduct works, and the municipality of Amaga, Department of Antioquia, has been authorised to borrow an amount not exceeding 6,000 pesos (£1,200) for electric power plant.

Electric Traction in Argentina. The first electric railway in Argentina was officially inaugurated on Friday by President Plaza, when the Central Argentine Co.'s route from Buenos Ayres to Tigre was opened. The work of electrification was carried out by British contractors.

Iceland.—The De Forende Igeniorkontorer, of Christiania, is preparing plans for electricity supply works for Reykjavik Municipal Council.

Lyons Municipal Contracts.—H.M. Consul at Lyons reports that the Lyons Municipal Council have decided that, in future, contracts for supplies required by the town should be concluded only with firms participating in the annual Lyons Fair.

Melilla (N. Africa).—A concession for the construction and working of an electric tramway in Melilla, for which tenders were invited in April last, has been granted to Don Ramon Prendes Rodriguez. Construction work must be completed within two years.

Patents in Austria-Hungary.—The Austro Hungarian Government has issued a regulation regarding retaliatory measures for the protection of trade against French, British and Russian subjects, and regarding patents and trade marks against Italian subjects.

The regulation decides that patents and trade-marks of subjects of France and Great Britain can, on request, be restricted or abolished in the public interest by the Minister of Public Works or charged with royalties, but patents of Russian subjects can be restricted or abolished without regard to the public interest.

Applications for patents and trade marks by subjects of enemy States will be accepted, but not granted.

Russia. The Russian Minister of Commerce has issued a Decree dated July 5 (June 22, O.S.) giving a list of machines, apparatus, &c., which are to be admitted, for 10 years, free of customs duties, for the requirements of the Siberian and Ural gold-mining industries.

These include dredges, with all machines, boilers, engines, &c.; dynamos, electric motors for driving electric dredges, with cables and distributing arrangements; protecting and measuring appliances; transformers; and everything necessary for the fitting up of the station for supply current for same. Parts of dredges; electrical equipment for electrical dredges; electric stations on the bank or on a barge for serving the dredge (engines, dynamos, switchboards, &c.); excavators complete with boilers, washing arrangements, electric and steam locomotives, and parts of same; appurtenances and mechanism for prospecting dredging areas (drilling apparatus—steam, electric, &c., with accessories); and parts of same; apparatus, machines, &c., for crushing gold ores and extracting from them gold by chemical processes (including vacuum pumps, motors and appurtenances for smelting residues); and parts of same.

The Acting British Consul-General at Odessa reports that electric lamps and appliances, formerly supplied by Germany to the local market, are now being supplied in large quantities by Japan. Japan is also supplying many classes of rubber goods in large quantities.

During 1915, the import and export trade of the Odessa district was dependent on extremely limited and uncertain transport by way of Vladivostock and Archangel. In normal times Odessa is the emporium for multitudinous commodities brought from Southern and Western Europe, and is one of the great centres of Russian foreign trade. Immense quantities of agricultural machinery and implements of all sorts are annually imported from the United Kingdom, Germany, Canada and America. Under the conditions imposed by the European war, and more particularly by the war with Turkey, the discussion of general trade is of small interest.

It will be of more advantage to insist once again on the almost limitless potentialities of the Russian market, and on the imperative necessity for the British merchant to avail himself without delay of the unique opportunity now offered him for supplanting the German in Russian trade. The sympathies of the Russian people are sincerely British, and British goods will, whenever possible, be given a preference. But it would be puerile, and even suicidal, to foster the idea that after the war the Russian merchant will purchase British goods for the simple reason that they are British. After the conclusion of peace the German will make a desperate effort to regain his footing in the Russian market, and in so doing will no doubt be well backed by his Government and banks, and the methods adopted will be well thought out, and the campaign well organised. Co-operation in the matter of organisation and in the plan of campaign to be adopted is necessary. A group of firms of allied trades, the demand for the products of each of which does not justify a separate organisation, could join together to form an agency or branch in Russia, and of far greater and more general importance is the co-operation of all British merchants trading with Russia. By means of this a standard of terms of credit and conditions could be set up, and a system of reliable information as to the financial standing and commercial morality of Russian traders could be established, and a trading bank founded in which British merchants engaged in Russian trade might be mutually interested. Some financial institutions must also specialise in the Russian trade, and be willing to give facilities to merchants so as to enable them to grant the four to six months' credit required. It has come to light how German trade in Russia was financed through London. These facilities must in the future be withdrawn from the Germans, and extended to British merchants. The giving of credit is necessary, but no credit should be given without inquiry. Such inquiries can only be made on the spot.

The usual British condition of cash against documents is an effective bar to business with Russia in normal times. The general custom is to give from four to six months' credit, and unless the British merchant complies with this custom, he will have great difficulty in selling his goods. The Russian merchants of good standing are very honest. In order to get at these, however, a knowledge of the Russian language is generally necessary. As regards agents, many of the so-called agents who write extremely plausible letters to British firms offering to represent them are not desirable representatives. British firms must be locally represented either by resident agents or by travellers chosen for their business capacity, and for tact and ability to adapt themselves to clients' requirements. The agent should make himself agreeable to his prospective client, and try to make a personal friend of him. Establish good personal relations, and good business will follow. It is futile to endeavour to establish a trade by correspondence only, and to run the business direct from the United Kingdom. Whatever correspondence is necessary should be conducted, and all catalogues and circulars printed, in the Russian language. Prices should be given in roubles, and quoted c.i.f. at a Russian port or even the buyer's railway station. The weights and measures should be Russian. When quoting, if the price c.i.f. is not inclusive of Russian Customs duties, then the British exporter should give his buyer an estimate, as nearly approximate as possible, of the amount of the duties to be paid. In the case of goods of doubtful Customs assessment, the agents would do well to get an authoritative ruling on a sample from the Customs Department at Petrograd. German firms gave this great facility, and Russian merchants are accustomed to it. Goods should be well and carefully packed, so that they arrive undamaged. It is important that no time be lost in entering into business relations with Russia. The initial spade work should be done now. As it is probable that not many men can be found at the present time with an adequate knowledge of Russian, it would be well to send such as have some knowledge of other European languages. The great handicap to be overcome at the outset by British traders will be the language difficulty.

The supply of British subjects who at present know Russian, will not be equal to the demand. Until this necessary link is forged, British trade cannot be properly pushed. However honest a Russian merchant may be, he cannot have the same interest as the British merchant in furthering the interests of British trade as opposed to that of other nations. Agents should be appointed in Petrograd, Moscow, Warsaw, Kiev, Odessa, Kharkov and Rostov, each with his defined sphere. From these centres the districts dependent upon them could be properly organised and controlled. The necessary corollary of a British export trade to Russia is an import trade from Russia into the United Kingdom. This would naturally consist for the most part in agricultural products, timber, and ore. As regards the grain export trade of Russia, before the war Germany was by far the largest buyer. British importers fought shy of Russian grain on account of the uncertain quality and often of the quantity they might receive, whereas German importers were less particular.

Prof. M. Lauwick, of Ghent, in an article in "The Times" Russian Section, mentions that in 1913 Russia imported from German physical and chemical instruments valued at £440,000 and telegraph and telephone apparatus valued at £23,000.

Switzerland.—*Prohibition of Exports.*—The exportation of various articles from Switzerland, including electrodes (mounted or otherwise), and insulating tubes of paper with sheet-iron envelopes, is prohibited as from July 28.

MISCELLANEOUS NOTES.

Alien Enemy Patent.—The application of the Suffolk Electricity Supply Co. (Ltd.) for a licence under Aust's patent No. 4,908 of 1909, relating to the fitting of subsidiary pumps to the cylinders of Diesel engines, has not been proceeded with. The proceedings before the Comptroller-General of Patents were reported in our issue of July 21.

British Firms in Germany.—As a reprisal for the liquidation of German businesses the Federal Council has empowered the Imperial Chancellor to arrange for the compulsory liquidation of businesses, the capital of which is mainly in the hands of British subjects or which are managed or supervised from British territory.

Already 11 companies or firms, including the Imperial Continental Gas Association, which owns several Continental gas and electricity works, have been ordered to be wound up.

Enemy Firms Wound Up.—The Board of Trade has ordered the winding up of 330 businesses controlled by alien enemies. The latest list includes the British Pyrophor Metal Co., G.m.b.H., 39, Victoria-street, London, S.W., production and sale of cerium iron stones (avermetal). (Controller: F. J. Saffery, 14, Old Jewry-chambers, E.C.)

Engineering School for Boys.—On the initiative of the Leyton Higher Education Committee Essex County Council are opening this month a new engineering and trade school in Leyton for boys between 13 and 16 years of age.

A practical engineer with a first-class London degree has been appointed headmaster, and a training is to be given suitable for lads who wish to enter engineering or chemical industries at the age of 16. The Draper's Company have voted £100 a year for three years in aid of the Scheme. Applications for admission to the new school should be addressed to the Town Hall, Leyton.

Exports to China.—The "London Gazette" contains a further list of firms and persons in China to whom goods may be consigned from the United Kingdom, including the Yunnanfu Electric Light Co.

Military Tribunal Case.—At Newport (Mon) last week the borough electrical engineer (Mr. A. Nichols Moore) applied for the exemption of nine men in his department.

Mr. Moore explained that his department was down to its minimum. The men included men from the permanent-way department, night car repairer, brake fitters, coach-builder, motor tramways inspector, overhead linesman, &c. All the men were absolutely necessary.

Three months' exemption in each case was granted.

Munitions Tribunal Case.—At Newport (Mon) recently Reginald Victor Powell complained that Newport Corporation tramways department unreasonably refused to issue a certificate in his favour on July 31.

Powell alleged that he had been superseded as senior switchman by a man who had only been in the Corporation's employment about three weeks, whereas he was a capable man, and had been a servant of the Corporation for about 18 months. His application was based wholly upon the fact that the new man had been described as "senior switchboard attendant."

Mr. A. Nichols Moore, borough electrical engineer, said that the explanation was that both men were senior switchboard attendants.

The application was refused.

Royal Assent.—On Aug. 23 the Royal Assent was read to new Acts of Parliament, including the Telegraph (Construction) and the Shropshire, Worcestershire and Staffordshire Electric Power Acts.

Secretaries' Association.—We have received a copy of Vol. VII. of the lectures delivered before the members of this association during the session 1915-16.

Verbatim reports of the lectures, together with a resumé of the most interesting points in the discussion, are given. The lectures were, with one exception, on topical commercial subjects, and as they were delivered by experts on the particular subjects treated, the volume possesses considerable interest, not only for secretaries of companies, but for all engaged in trade or commerce. The lectures were: "The Secretary and his Directors," by Herbert W. Jordan; "The War: Its Effect on Commerce and Finance," by Emil Davies; "National Health Insurance: Its Present and Future," by Frank G. Harris; "Foreign Exchanges, the Part they Play in International Trade," by A. Lester Boddington; "Curious Cases in Company Law," by R. R. Formoy; "An Ancient Order of Chivalry" (The Order of the Hospital of St. John of Jerusalem), by H. W. Fincham. The volume is published at 1s. net, and can be obtained from the Association at 70A, Basinghall-street, London, E.C.

TENDERS INVITED.

Turbo-Alternator, Condenser, &c.

The Town Clerk, Invercargill (N.Z.) will receive tenders until 4 p.m. on Sept. 28 for the supply and erection of a Steam Turbo-Alternator, with Condenser, Fittings, &c. (Contract No. 40). Specification, &c., from the Town Clerk.

C.I. Pipes, &c.

Sheffield Electric Supply Committee require tenders by 10 a.m. Sept. 11 for the supply and laying of 48 in. c.i. Water Pipe and Construction of Chambers.

Tramway Material.

The Madrid "Gaceta" of Aug. 4 notifies that tenders will be opened on Oct. 7 for the Construction and Working of an Electric Tramway in Barcelona, an extension to Sans of the lines of the Cia Nacional de Tranvias de Barcelona, which holds an option on the proposed concession. Minimum rolling stock required will be Two Motor Tramcars and Two Trailers.

Tenders will be opened on Oct. 11 for Construction and Working an Electric Tramway in Madrid, from the Calle de Alcala to the Calle de Diego de Leon. Minimum rolling stock required will be Four Cars.

In both cases construction work must be commenced within three months and completed within 10 months and a year respectively from dates of concession. An option on the concession is held by the Sociedad Tranvia del Este, Madrid.

Carriage Lighting.

The Great Northern Railway Co. (Ireland) require tenders by 10 a.m. Sept. 6 for Electric Battery Materials for Carriage Lighting. Specification from the Secretary.

Electrical Goods, Fittings, &c.

The directors of the Powell Duffryn Steam Coal Co. require tenders for Stores (including Electrical Goods, Indiarubber, &c.) from Oct. 1. Particulars from Stores Manager, Aberaman Offices, near Aberdare, and tenders to the directors of the company, 101, Leadenhall-street, London, E.C., by Sept. 6.

Edmonton Guardians invite tenders (by Sept. 20) for six months' supply of Electric Lamps. Tenders to the Clerk, Lower Edmonton, London, N.

West Ham Guardians require tenders by 10 a.m. Sept. 14 for three months' supply of Electrical Fittings, Oils, &c. Forms of tender from the Clerk, Union-road, Leytonstone, N.E.

Tenders are required for the manufacture and supply of Electric Light Fittings for Australia House, London. Forms of tender, &c., from Mr. H. H. Turner, 48, Broadway, Westminster, S.W.

Crane Gantry and Roofing.

Wolverhampton Corporation require tenders by Sept. 8 for a Steel Crane Gantry and Steel Roofing for the electricity department.

Telephone and Telegraph Material, Instruments, &c.

Tenders are invited for the supply to the Postmaster-General's Dept., State of South Australia, of Telephone Material in accordance with schedule No. 428, and tenders are invited (up to Oct. 4) for the supply to the Postmaster-General's Dept., State of Western Australia, of Telephone and Telegraph Instruments in accordance with schedule No. 501. Tenders are also invited (up to Nov. 15) for the supply and erection at the telephone exchanges of Glenelg and Brighton, State of South Australia, of Automatic Switchboards and all associated apparatus (as per schedule No. 426). Tender forms, specifications, &c., may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, Perth, requires tenders by 3 p.m. Oct. 4 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts for the Australian Commonwealth Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General, Perth, W.A.

Tenders are invited by the Deputy Postmaster-General, Adelaide, for the supply and delivery of Telephones, Telephone Material, Instruments and Parts. (Schedule Nos. 429 to 437). Specifications, &c., and sealed patterns may be inspected at the Office of the High Commissioner in London for the Commonwealth, 72, Victoria-street, S.W. Tenders by 2 p.m. Sept. 27.

The Departamento de Fomento de la Mancommunidad de Cataluna, Barcelona, require tenders by noon Sept. 11 for the provision of a telephone system for the towns of Lerida, Balaguer, Tremp and Sort at an estimated cost of £5,000.

Tramway Track Work, &c.

Manchester Tramways Committee invite tenders for the supply of Permanent Way Special Track Work, Point Tongues and Crossings. Specifications from Mr. J. M. McElroy, general manager, and tenders to the chairman of the Tramways Committee, 55, Piccadilly, Manchester, by 10 a.m. Sept. 12.

Electric Crane, Air Compressor, Crane Motors, &c.

The Victorian Railway Commissioners, Spencer-street, Melbourne, require tenders by 11 a.m. Sept. 6 for the supply of 12 Three-phase Crane Motors and Controllers and 11 One-phase Workshop Motors and Starters (Contract No. 30,110). Specifications from the offices of the Commissioners.

The New South Wales Government Railways & Tramways Department require tenders by noon Sept. 20 for the supply and erection of an Electric Overhead Travelling 50-ton Crane (specification 474); and by noon Oct. 11 for a motor-driven Air Compressor (specification 480) for Zarra-street power house. Specifications, &c., from the Electrical Engineer, 61, Hunter-street, Sydney.

Electric Time-releasing Mechanisms.

The Victorian Railway Commissioners, Spencer-street, Melbourne, invite tenders (by 11 a.m. Oct. 18) for the supply and delivery of Electric Time-releasing Mechanisms (100 with two normal and two reverse contacts, and 50 with four normal and four reverse contacts) for automatic signalling. Specifications from the Commissioners, Spencer-street, Melbourne.

Aerial Ropeway, Power Plant, &c.

The N.S.W. Department of Public Works require tenders by 2 p.m. Sept. 18 for Power Plant, Transmission Line and Aerial Ropeway for Chichester River Storage Reservoir. Specification, &c., from the offices of the Department, Sydney.

TENDERS RECEIVED AND ACCEPTED.

Walthamstow.—The Council have accepted the following tenders:—

British Thomson-Houston Co., e.h.t. switchgear, £984; General Electric Co., l.t. switchgear, £135; Bruce Peebles & Co., motor converter, £1,825.

Aberdeen.—The Tramways Committee has accepted the tender of the British Thomson-Houston Co. for two traction motors at £115 each.

Melbourne (Victoria).—The City Council has accepted the tenders of Beacon Carbons (Ltd.) for carbons, £2,040; Edison Swan Electric Co. for metal filament lamps, £642; and the Reason Mfg. Co., and British Westinghouse Electric & Mfg. Co. for meters.

Sydney (N.S.W.)—The Electric Supply Committee has recommended the Council to accept the following tenders in connection with the laying of a cable across Darling Harbour:—

W. T. Henley's Telegraph Works Co., cable, £4,124 (based on copper at £85, and lead at £22. 10s. per ton); Australian General Electric Co., two 1,000 k.v.a. transformers, £1,680, and 12 10,000 volt switches and expulsion fuses, £560; and W. G. Watson & Co., 20 three-pole disconnecting switches and fuses, £420.

Government Contracts. The following tenders were accepted by the British Government departments during July:—

War Office.—A. E. Dean, X-ray apparatus; Liverpool Elec. Cable Co. and Siemens Bros. & Co., elec. cable; British L.M. Ericsson Mfg. Co. and Siemens Bros. & Co., lighting dischargers and parts; General Electric Co., elec. light and power sundries; Aster Engineering Co., Day Motor Co., W. H. Dorman & Co., Fyfe, Wilson & Co., Morris, Henty & Gardners, and Petters (Ltd.), electric lighting sets; Butters Bros. & Co., electric gantry cranes; W. H. Dorman & Co., generating sets; British Thomson-Houston Co. and City Electrical Co., electric generators and motors and parts; Lodge Sparking Plug Co., sparking plugs; General Electric Co., rotary converter at Woolwich.

India Office.—Peel-Conner Telephone Works, carbon cups; General Electric Co., cells; Automatic Telephone Mfg. Co., extension of switchboard.

Post Office.—Automatic Telephone Mfg. Co., telegraph apparatus; British L.M. Ericsson Mfg. Co. and Western Elec. Co., telephone apparatus; Craigpark Elec. Cable Co., W. T. Henley's Telegraph Works Co., India Rubber, Gutta Percha & Telegraph Works Co., and Telegraph Construction & Maintenance Co., telegraph cable; British Insulated & Helsby Cables, Fuller's Wire & Cable Co., London Electric Wire Co. & Smith's, Siemens Bros' & Co., Union Cable Co., and Western Electric Co., telephone cable; India Rubber, Gutta Percha & Telegraph Works Co., porous cells; London Electric Wire Co. & Smith's, Peel-Conner Telephone Works, and Phœnix Telephone & Electric Works, telephone cords; Edison & Swan United Electric Light Co., W. G. Pye & Co., and Record Electrical Co., galvanometers; Telegraph Construction & Maintenance Co., tackle for cable ship; Western Elec. Co., telephones; Siemens Bros. & Co., telephone exchange equipment extension at Leeds.

Meter Contracts.—Messrs. Chamberlain & Hookham have secured contracts for the supply of electricity meters from Cardiff and Manchester Corporations for the ensuing 12 months.

Monometer Furnaces.—The Monometer Mfg. Co. (Ltd.), Aston, Birmingham, have received a number of orders for monometer tilting, white metal and other furnaces.

Among the firms ordering are:—The Daimler Co., Birmingham Small Arms Co., Wolseley Motors (Ltd.) (repeat order), India Rubber, Gutta Percha & Telegraph Works Co. (for France and London), Waltham Iron Works, Sir Douglas Fox & Partners, Martindales & Co., Sutcliffe, Speakman & Co., Blackwell's Metallurgical Works, Brit. Bronze (Ltd.), Cheswright & Nicholls, Jas. Hinks & Co., Tozer, Kelmsley & Fisher, Charles Francis Press (New York), London Electric Wire Co., &c.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Aberdeen. The accounts of the Corporation tramways department for the year ended May 31 show total capital expenditure £368,769 (increase £2,436), and the total amount of sinking fund is £57,199, of depreciation and renewals fund £106,795 and of reserve fund £13,270.

Revenue was £94,328 (compared with £88,002 in previous year), and working expenses were £58,197 (£51,525), leaving gross profit £36,130 (£36,477). Interest required £4,230 (£4,788) and sinking fund £5,519 (£5,378), and of the balance £13,799 (£13,626) has been placed to depreciation and renewals fund, £2,883 (£1,626) devoted to special expenditure, £6,464 (£7,590) placed to reserve, £2,000 (as in previous year) contributed to common good, and £1,232 (£1,666) to city improvements. The net profit for the year was £9,697. Units used were 2,481,384 (2,317,204) and the car mileage was 1,968,615 (1,909,009). The total number of tickets sold was 25,289,869 (22,866,761), passengers carried being 26,593,730. Total revenue per car-mile was 11·5d. and working expenses were 7·09d.

Greenock. The Corporation recently adopted the past year's accounts of the electric supply department.

The chairman of the Electricity Committee (Mr. M'Callum) stated that the net surplus was £6,998. When the new machinery was installed the department hoped to be able to cope with all reasonable demands for a number of years.

The Provost, on behalf of the other members, congratulated the con-

vener, the manager and Committee on the very handsome result. The difficulties of the department, especially as to the price of coal, had been well known, and it was therefore wonderful how they had been able to come out with such a balance.

King's Lynn.—The electricity works accounts for the year ended March 31 show total capital expenditure £57,190 (increase £427), of which £36,321 has been redeemed.

Revenue was £8,068 (compared with £7,992 in previous year) and working expenses were £4,025 (£3,489), attendance and renewals of street lamps required £55 (£209), interest £820 (£853), sinking fund £2,017 (£2,017) and war service allowances £118 (£66), the net profit being £1,018 (£1,350). Average price obtained was 2·75d. (2·76d.) per unit. Coal cost 0·735d. (0·543d.) per unit, total works cost was 1·824d. (1·358d.) and total, including capital charges, war allowances, &c., 3·194d. (2·587d.). Units generated were 572,333 (656,340) and sold 529,610 (615,803). Maximum supply demanded was 396 kw. (515 kw.) and load factor 16·93 (14·55) per cent.

Southwark.—At March 31 the gross capital expended on the supply department was £152,018, of which £107,278 was outstanding.

The total revenue for the year ended March was £22,174 (against £21,753), including £21,542 (£21,105) net from sale of electricity meter rents, &c. Working expenses were £17,859 (£17,750) and war allowances £681 (£228), leaving gross profit of £3,684 (against £3,755). Interest required £4,391 (£3,908) and repayment of loans £6,052 (£5,526), leaving a net deficit of £6,679, an increase of £208 over 1915. Units generated were 3,653,043 (against 3,346,280), and sold 2,661,966 (2,657,345). There are 197 (197) arc and 182 (84) public incandescent lamps.

Winchester.—The accounts of the electricity department for the year ended March 31 show gross capital expenditure £103,287 (increase £1,385), of which £5,010 has been repaid.

Revenue was £14,408 (compared with £14,649 in previous year), working expenses were £8,582 (£8,047), leaving gross profit £5,826 (£6,601). Loan redemption and interest on loans required £5,015 (£5,015), and bank interest, depreciation of stock and expenditure in the nature of capital (£50) accounted for £235, leaving net profit £575 (£1,317). Coal cost 0·575d. (0·415d.) per unit and total costs, including special charges, were 1·715d. (1·523d.). Units generated were 1,307,030 (1,221,470) and sold 988,366 (965,622). Maximum load was 616 kw. (639 kw.)

COMPANIES' MEETINGS AND REPORTS.

ALDERSHOT GAS, WATER & DISTRICT LIGHTING CO.—At the recent half-yearly meeting the chairman (Mr. W. T. Robertson) said the open fire was doomed, and he was confident that the day was not far off when coal gas would form the staple lighting and heating agent in the majority of houses. At their Farnborough electric light works gas was the motive power for the generation of electricity. All three departments of their business—gas, water and electricity—were progressing satisfactorily, in spite of the difficulty of obtaining raw materials.

BOMBAY ELECTRIC SUPPLY & TRAMWAYS CO. (LTD.)—The annual general meeting of this company was held on July 19 at Bombay. The chairman (Sir Sassoon David), in moving the adoption of the report, said that was the first occasion upon which a general meeting of the company had been held at Bombay. After meeting all fixed charges and defraying all operating expenses and maintenance charges and making various appropriations, the net profit justified them in recommending the declaration of a dividend at rate of 7 per cent. per annum on the ordinary shares. That would leave £9,602 to be carried forward, against £8,326 brought forward. The creation of the Indian board was the result of the action recently taken by a very large majority of the shareholders to so change its constitution as to free it from liability to pay English income tax in addition to the Indian income tax. The price of materials had in many cases doubled or trebled, and there were great difficulties in obtaining many articles on any terms whatever. For example, they were anxious to place an additional 20 two-car trains on the lines, but it was quite impossible to say when they would obtain that portion of the material for the construction of that rolling stock which was on order from England.

HAVANA ELECTRIC RAILWAY, LIGHT & POWER CO. (LTD.)—During 1915 the output was 42,186,102 units against 39,668,427 in 1914. Earnings increased 15½ per cent., but operating expenses decreased 11½ per cent., so that net earnings advanced 26·8 per cent. The growth of the number of private consumers of electricity had been accompanied by a decrease in the number of gas meters in use, but though gross receipts from gas fell, the decline was exceeded by the reduction in working expenses, and net earnings rose 10·6 per cent. The electric railway undertaking has felt the deleterious effects of the European war, which has greatly depressed the tobacco trade, many of the workers in that industry being out of employment. The number of passengers and gross earnings fell 2·84 per cent., but operating expenses dropped 8·11 per cent. Net earnings improved $98,000. The gross earnings of the whole undertaking for 1915 were $5,541,302, compared with $5,396,713 in 1914; net income was $3,203,796, against $2,801,392. After paying dividend of 5½ per cent. on the common stock, transferring $101,535 to sinking fund reserve, and applying $178,000 to redemption of the Havana Electric Railway Co. consolidated mortgage bonds, the surplus is $234,560.

MALACCA ELECTRIC LIGHTING CO. (LTD.)—At the recent meeting, Mr P. M. Robinson, who presided, stated that after making provision for depreciation, writing off $1,000 from the consideration to vendors, and preliminary expenses amounting to $2,058.88 which would not recur, also the debit balance brought forward ($3,868.09), in all a total of $19,779.06, the directors were able to recommend a dividend of 5 per cent., and that notwithstanding that the price of fuel during the past year had risen very considerably. They were informed last year that in order to deal with the increasing demand for electricity the directors had decided to instal another 140 B.H.P. engine and dynamo. That plant was duly installed and had proved of considerable benefit. At the close of the year the total length of streets along which mains were erected was 8,059 yds. against 6,117 yds. In some cases extensions were delayed owing to unavoidable delay in obtaining material from Europe. A new feeder was installed during the year on account of the largely increased load and another would be installed during the next few months. Further extensions would be carried out during the current year as conditions permitted. On March 31, 1916, they had 628 consumers against 367 in 1915), and the consumers were now 701. One of the most satisfactory features of the past year's business had been the great increase in the units sold for power, and the directors hoped that the revised rates under contemplation for power supplied during non-peak hours would lead to a still further increase in the day load and enable electric motors to be used throughout their area in place of engines. The directors also hoped that in course of time the use of electricity for cooking and heating purposes, heating flat irons, &c., would increase, and they were prepared to consider special terms for large installations of that kind. Their consumers had proved for themselves that electricity provided the cheapest light obtainable in Malacca and many consumers had told them that previously their monthly bill for oil for lighting only was greater than their present monthly bill for electricity, notwithstanding that now they also had fans installed throughout their premises. In order to avoid having to refuse business the directors had recently decided to purchase locally a 140 B.H.P. engine which was offered to them, and they were fortunate in getting the promise of quick delivery of a new dynamo from the makers in England, and latest advices indicate that it would be delivered by the time promised. The building extensions had been completed, and the engine foundations were ready. They might expect to have the new plant running at an early date. They believed they had a good business which, with good management, should yield satisfactory returns.

NEW COMPANIES, MORTGAGES & CHARGES.

NEW COMPANIES.

FELLOWS MAGNETO CO. (LTD.) (144,665).—Reg. Aug. 23, capital £75,000 in 50,000 preferred shares of £1 each and 50,000 ordinary shares of 10s. each, to carry on the business of manufacturers and repairers of and dealers in machinery and plant, tools, motor cars, airships, aeroplanes, dynamos, magnetos, accumulators, coils, carburetters, &c.; mechanical and electrical engineers, machinists, &c. First directors are V. L. Fellows, D. V. L. Fellows, S. L. Fellows and H. M. Alleyn (vendors to company). Reg. office: Cumberland-avenue, Park Royal, Willesden.

HADON (LTD.) (144,685).—Reg. Aug. 25, capital £500 in £1 shares, to take over an invention for electrically-operated clocks, to carry on the business of clock manufacturers, dealers and importers, &c., and to enter into an agreement with W. Alldis. Private company.

HILL BROS. MAGNETOS (LTD.) (144,612.)—Reg. Aug. 15, capital £50,000 in £1 shares (20,000 6 per cent. cumulative preferred) to take over the business carried on by W. A. Hill at Bedminster, Bristol, as Hill Bros., and to carry on the business of manufacturers of and dealers in magnetos, engineers, electricians, machinists, manufacturers of electrical or other machinery, smiths, wire drawers, metallurgists, &c. Private company.

INTERNATIONAL M.P. SUPERHEATER CO. (LTD.) (144,687).—Reg. Aug. 25, capital £400,000 in £1 shares, to acquire any patents, rights, licences and concessions relating to the manufacture or construction of superheaters, locomotives, engines or other similar apparatus; to carry on the business of engineers, machinists, manufacturers of superheaters or other apparatus for heating water or air, locomotives, engines, &c.; and to adopt an agreement with Miecislas Pokrzywnicki. First directors are Pol Mouton and E. Petersson. Reg. office: 14-15, Coleman-st., E.C.

MORTGAGES AND CHARGES.

BARFORD ELECTRIC SUPPLY CO. (LTD.)—Debenture dated Aug. 11, 1916, to secure £700, charged on company's undertaking and property, including uncalled capital, has been registered. Holders, J. B. Carslake, Major G. W. Richard, and H. D. Smith-Ryland.

BRILLIANT ARC LAMP & ENGINEERING CO. (LTD.)—Memorandum of satisfaction to extent of £40 on Aug. 12, 1916, of debenture dated June 22, 1915, securing £90, has been filed.

HOLSWORTHY GAS & ELECTRIC SUPPLY CO. (LTD.)—Particulars of £750 debentures, created July 22, 1916, have been filed, amount of present issue being £500. Property charged: Co.'s undertaking and property, subject to certain prior mortgages and debentures. No trustees.

NEW PETO & RADFORD ACCUMULATOR CO. (LTD.)—Mortgage on Victoria Works and Greville Works, Ashtead, to secure £2,000. Holders: C. G. Howard and C. R. Mayo.

RESISTO ELECTRIC MFG. CO. (LTD.)—Issue on Aug. 4, 1916, of £1,900 debentures, part of a series of which particulars have already been filed.

RECEIVERSHIP.

BROWN & PARSONS (1913) (LTD.)—A. E. Mason, 193, Wolverhampton-street, Dudley, ceased to act as receiver or manager on Aug. 18, 1916.

CITY NOTES.

MEMORANDA (Aug. 30).—Bank rate 6 per cent. (since July 13, 1916). Consols 59⅛. Consols Pay Day, Sept. 1. Stocks and Shares Ticket Days, Sept. 13 and 28. Pay Days, Sept. 14 and 29. Price of silver, 32.

BRITISH EMPIRE TRUST CO. (LTD.)—The report for the year to April 29 states that of the investments at the end of the year over 79 per cent. were in railways, electric railways, electric light, gas or water power companies.

BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)—An interim dividend at rate of 8 per cent. per annum (1s. per share) has been declared on the ordinary shares for the past half-year.

CLYDE VALLEY ELECTRICAL CO.—The directors have declared a dividend of 1¼ per cent., tax free.

DAVIS & TIMMINS (LTD.)—Interim dividend at rate of 6 per cent. per annum (tax free) has been declared on the ordinary shares for the past half-year.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units sold to consumers during the five weeks ended June 30, amounted to 2,354,014, compared with 2,355,478 units in the corresponding five weeks of 1915.

KALGOORLIE ELECTRIC TRAMWAYS (LTD.)—The accounts for 1915, after including debit balance of £12,520 brought forward and charging £1,060 for depreciation and £9,206 for debenture service, show a debit balance of £18,520 to be carried forward.

NEWCASTLE-ON-TYNE ELECTRIC SUPPLY CO. (LTD.)—The directors have decided to pay an interim dividend of 2½ per cent. on the preference and ordinary shares respectively on the 29th inst., less tax.

OXFORD ELECTRIC CO. (LTD.)—An interim dividend at rate of 5 per cent. per annum (2s. 6d. per share) has been declared on the ordinary shares for the past half-year.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date Aug. 29, the following as the present basis prices of—

New Metals.	per lb.		Per ton.
Solid Drawn Brass Tubes	15½d.	English Lead	£31 10 0
Solid Drawn Copper Tubes	18½d.	Antimony	Nominal.
Brazed Copper Tubes	18½d.	Old Metals.	Per ton.
Brazed Brass Tubes	17½d.	Clean Copper Scrap	£99 0 0
Brass Wire	14½d.	Clean Brass Scrap	62 0 0
Copper Wire	18d.	Brazery Copper Scrap	86 0 0
Rolled Brass	14½d.	Old Lead	25 10 0
Brass Sheets	15½d.	Old Zinc	38 0 0
	Per ton.	Hollow Pewter	120 0 0
Copper Sheets	£150 0 0	Black Pewter	80 0 0
Spelter	58 0 0	Gun Metal	80 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date Aug. 29, the following approximate prices of Scrap Metals:—

	Per ton.		Per ton.
Aluminium Cuttings	£110 0 0	Old Lead	£3 15. under English lead price
Clean Mixed Brass	64 0 0		
Clean Copper	98 0 0	Old Zinc	42 0 0
Brazery Copper	84 0 0	Hollow Pewter	130 0 0
Gun Metal	85 0 0	Shaped Black Pewter	90 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80. Commercial Tinman's Solder, £97. Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

We give below the latest prices at which actual transactions took place on or before Tuesday, Aug. 29.

Shrs.	Last Dividend	Name.	Price, Tues., Aug. 29	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	8¼†	6 19 2	Mar., Sept.
10	4½%	Do. 4½% Cum. Pref.	8⅜†	5 11 8	Feb., Aug.
10	6%	Do. 6% Cum. 2nd Pref.	9⅛	6 2 4	Feb., Aug.
10	10%	Brompton & Kensington Ord.	6⅛	7 6 9	Mar., Sept
5	7%	Do. 7% Pref.	7⅛	5 0 2	Mar., Aug
St.	4%	Central Elec. Supply G. Deb. St.	80	5 0 0	..
St.	4%	Charing Cross, West End & City Debs.	79½	5 0 8	Jan., July
	2/3	Do. 4½ Pref.	3⅛	6 10 11	..
5	5%	Do. Ord.	3⅛†	6 17 7	Aug., Feb
5	4½%	Do. City Pref.	3⅛	6 18 6	Jun., Dec
5	4%	Chelsea Elec. Supply Co. Ord.	3¼	7 5 5	Mar., Sept
St.	4½%	Do. do. Deb.	85	5 5 11	Jan., July
10	8%	City of London Elec. Lt. Ord.	12⅞	6 9 4	Feb., Aug
10	6%	Do. 6% Pref.	10⅜	5 14 3	Mar., July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun., Dec
St.	4½%	Do. 4½ Debs.	89	5 2 6	Jun., Dec
10	7%	County of London Ord.	11	6 7 3	Mar., Sept
10	6%	Do. 6% Pref.	10⅝	5 13 7	Feb., Aug.
St.	4½%	Do. 1st Deb.	94⅛	5 4 0	Jan., July
St.	4½%	Do. 2nd Deb.	83	5 8 5	May, Nov
St.	4½%	Edmundsen's Elec. Supply 4½% Debs.	92½	5 18 10	July
5	7%	Kensington & Knightsbridge Ord.	9⅜	6 11 9	Feb., Aug
St.	4%	Do. Deb. St.	78½	5 1 0	Jan., July
5	6%	London Elec. Supply 6% Pref.	8⅜	6 11 6	..
St.	4%	Do. 4% Mort. Debs.	80½	4 15 7	Jan., July
5	3%	Metropolitan E. Supp. Ord.	3⅛†	6 6 4	Mar., Aug
St.	4½%	Do. 1st Mort. Deb.	90	5 11 6	Jan., July
St.	5%	Midland Elec. Corp. 1st Mort. Deb.	99	5 1 0	Jan., July
..	6%	Newcastle & Dist. E.L. 6% 2nd Debs.	79½	6 0 4	Mar., Sept
St.	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St.	92	5 8 8	Mar., Sept
1	6%	North Metropolitan E.P. Supply 6% Pref.	9⅛	6 3 10	Apl., Oct
4	5%	South London E.S. Ord.	2⅜	6 16 2	Mar., Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price Tues., Aug. 29	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	6⅜	6 5 6	Feb, Aug
5	7%	Do. do. Pref.	5⅞	5 19 2	Feb, Aug
St.	3½%	Do. do. Debs	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	73	6 3 3	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations	1⅝	6 11 3	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6⅛	5 12 7	Mar, Sept
5	4½%	Do. 4½ Cum. Pref.	4⅞	5 4 1	Jan, July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	84½	5 18 4	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	80⅜	7 8 8	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	74¼	5 7 1	..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	..
St.	4½%	Do. 4½% Pref.	81½	5 10 5	Jan, July
St.	4%	Do. 4% Deb. St.	75½	5 6 0	Jan, July
St.	4%	City & S. London Deb.	74¼	6 7 0	May, Nov
St.	5%	Do. Pref. 1896	70½	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2¼	5 11 1	Jan, July
St.	4%	Do. 4% Pref.	66½	6 0 4	Mar, Sept
St.	4%	Do. 4% Debs.	76¼	5 4 11	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	24⅛	4 1 6	Feb, Aug
St.	3½%	Do. 3½% Pref.	62	5 12 11	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	59⅞	5 16 11	Feb, Aug
St.	3½%	Do. 3½% A Debs.	68½	5 2 9	Jan, July
St.	3½%	Do. 3½% Debs.	69½	5 1 1	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 4	May, Nov
St.	4½%	Do. 4½ First Pref.	73½	6 2 5	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	108½	5 10 8	Jan, July
St.	4%	Do. 4% Debs.	73	5 9 7	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	78	5 2 7	Jan, July
St.	4%	Do. 4% Guar. Stock	70	5 14 4	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	3⅝	4 15 1	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1 1/16	5 6 8	Mar
100	5%	Do. Prior Lien Debs.	93½	5 6 11	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12⅜	7 1 5	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅜	5 15 8	Jan. July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	⅛	6 8 0	Mar, Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2 1/16	6 3 1	April
100	6%	Do. 6% Prior Lien Debs.	102	5 17 8	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	67½	5 18 6	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅜	8 1 7	Jan, July
5	5%	Do. 5% Pref.	4⅛	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	June, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅞	6 17 2	Sept.
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	¼	..	Feb, Aug
St.	4%	Do. 4% Deb.	59½	6 13 11	Jun, Dec
1	7½%	Elec. Construction Ord.	⅞	8 5 8	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	68	5 17 8	Jan, July
10	10%	General Electric Ord.	13⅜	7 6 9	July
10	6%	Do. 6% Pref.	9⅜	6 0 5	June, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	16½	6 3 0	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4	5 12 6	..
St.	4½%	Do. 4½% Db.	87½	5 2 9	Jun, Dec
10	10%	India Rubber, G.P. &c., Ord.	12⅜	8 5 4	Feb, Aug
10	5%	Do. Pref.	8	6 3 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39	6 3 1	Mar, July
100	4%	Do. 4% Debs.	95¼	4 4 1	Jan, July
1	7½%	Vickers Ord.	1 1/16	4 2 9	May, Aug
1	6d.	Do. 5% Pref.	⅝	5 10 4	May, Aug
St.	4%	Do. 1st Debs.	81½	4 18 0	June, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 5	June, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	40½	10 3 8	..
St.	4%	Do. 1st Mt. Deb. St.	56½	7 1 0	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	104	5 15 5	Feb, My, Aug, N
St.	1½%	Do. Def. Ord.	23 1/16	6 16 9	Feb, My, Aug, N
St.	4%	Commercial Cable 4% Debs.	70⅜	5 12 10	Ja, Ap, Jly, O
10	5%	Cuba Submarine Ord.	8½	5 17 8	May, Nov
10	10%	Do. 10% Pref.	13½	7 5 5	..
5	5/0	Direct Spanish 10% Pref.	7⅛	6 13 4	..
10	4%	Direct United States	6 1/16	1 19 8	Ja, Ap, Jly, O
St.	8%	Eastern Tel. Co. Ord.	148½	5 7 11	Ja, My, Jly, O
St.	3½%	Do. 3½% Pref.	67	5 4 6	Ja, My, Jly, O
St.	4%	Do. 4% Debs.	78½	5 1 10	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78	5 2 7	Feb, Aug
10	8%	Do. Ord.	14⅜	5 8 6	Ja, Ap, Jly, O
10	22%	Gt. Northern Tel. Co. With Coup. 11	42½	5 3 6	Ja, My, Jly
25	13%	Indo-European	47½	6 16 1	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3⅛	3 3 4	April
1	7%	Do. 7% Pref.	2⅛	2 13 4	July
10	1%	West India & Panama Ord.	11	8 14 5	May, Nov
10	6%	Do. 1st Pref.	7⅞	7 12 5	May, Nov
10	8%	Western Telegh. Co.	15	5 6 8	Mar, Jly, O, Dec
St.	4%	Do. 4% Deb. St.	77	5 3 11	June, Dec
..	4½%	Western Union 50-yr. Bds.	99⅛	4 10 10	May, Nov
		Telephones.			
1	7/1	Monte Video Telegh. Ord.	⅜	7 13 7	Nov
1	1/0	Oriental Telephone Ord.	2⅞	4 18 6	Apl, Oct
St.	4%	Do. Deb. St.	79	5 1 3	Jan, July
St.	4½%	Telegh. Constr. Egypt Db. St.	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6⅜	5 16 11	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4⅛	5 6 8	Jan, July
St.	4½%	Do. Deb. Stk.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Cable Telegh. & Trust	12⅜	4 13 2	Sp, Dc, Mr, Jn
10	6%	Do. 6% Pf.	10⅛	5 12 11	Sp, Dc, Mr, Jn
100	5%	Mackay Companies' Common	85½	5 17 6	Ja, Apl, Jly, O
..	4%	Do. $100 Pref.	70½	5 13 6	Ja, Apl, Jly, O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, & c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	5	6 0 0	Mar, Sept
St.	..	Do. 5% Debs.	94½	5 5 10	Jun, Dec
10	6/0	Bombay E.S. & T. 6% Pref.	10⅛	5 15 8	..
St.	4½%	Do. 4½% Debs.	83	5 8 5	Jan, July
5	7%	Calcutta E.S. Corp. Ord.	6⅛	7 1 2	May, Nov.
5	5%	Do. 5% Pref.	4⅛	5 15 1	Mar, Sept

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 1,999. [Vol. LXXVII. No. 23.] **FRIDAY, SEPTEMBER 8, 1916.** PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents. or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 755
Arrangements for the Week.. 757
The Hydroelectric Station on the Pescara River. Illus... 758
The Calculation of the Capacity of Radiotelegraph Antennæ, Including the Effects of Masts and Buildings. By Prof. G. W. O. Howe, D.Sc., M.I.E.E. Illustrated 761
Electric Water Heating as Applied to Domestic Service. By C. W. Crosbie. Illustrated 762
Power Generation for Electric Railways. By Henry G. Stott. Illustrated..... 766
Report of the Committee of the Privy Council for Scientific and Industrial Research 768
The Connection of Armature Coils to Commutator Segments. By Rudolf Knoll. Illustrated 770
THE PRIVY COUNCIL AND RESEARCH..... 772
Mr. Gerald Stoney's Address to the Engineering Section of the British Association 773
The Influence of Pressure on the Electrical Ignition of Methane. By W. M. Thornton, D.Sc., D.Eng. Illustrated 775
LEGAL INTELLIGENCE 779
Educational 779
The "Electrician" Commercial and Industrial Section .. 781–788

NOTES.

"Justice Needs That Both Be Heard."

IT is seldom one finds such a fearless and unbiassed statement of unpleasant truths in a Presidential Address as that contained in Mr. GERALD STONEY'S address on Wednesday last to the Engineering Section of the British Association. Such truths in plenty have been given in the past from the point of view either of the employer or employé, but not to our knowledge have both sides of the question been considered in the same address. Our readers will remember the great outcry against the policy of "Ca'canny" by several large employers and by the politicians. Less has been heard of the point-blank refusal by many of the armament firms to allow hundreds of firms anxious and willing to do so to help in the production of munitions. "And when," says Mr. STONEY, "under pressure from the Government, the Ring accepted outside help, in many cases the conditions imposed on the sub-contractors were unfair in the extreme, apparently the whole idea of the Ring being to make all the profit they could out of the troubles of the Empire." This serves to support our contention that justice needs that both sides be heard before passing judgment. We have never understood the real motive for the vilifying of a large section of the community, since such methods tend rather to retard than to accelerate the rate of production. The engaging of vast numbers of unskilled workers were to little purpose unless those most likely to suffer made a sacrifice by agreeing to "Dilution of Labour." Little has been written concerning the difficulty of effecting what Mr. STONEY aptly terms "Dilution of Works." It is of interest to note that Mr. STONEY, himself a hard worker, is of the opinion (and does not hesitate to express it) that laziness is inherent in man, irrespective of his station, and that men work because they are compelled to do so, the best work being done when the inducement is greatest. If to this be added the accepted fact that the more a man has the more does he wish to have, we get a good idea of things as they are. The address, which is a review of some errors committed in the past in the engineering and allied industries, can be recommended to all sorts and conditions of men, and the appeal for combination and unity in the future is one which we heartily endorse.

German Plant.

THE condition of affairs at Shanghai Electricity Works is far from satisfactory, and must cause much anxiety to the engineer, Mr. T. U. H. ALDRIDGE. On June 17th last a 5,000 kw. turbo-alternator by the A.E.G. broke down. It appears that the insulation of the stator conductors failed, with the result that there was a serious arc to earth, the copper conductors and the iron laminations being fused into one mass and the insulation of the end windings being entirely destroyed. It need scarcely be remarked that a breakdown of this kind at the present time introduces many difficulties. Local facilities are insufficient to deal with serious repairs to a large machine, and, of course, communication with the makers is out of the question. This, however, is not the only difficulty. One of the other 5,000 kw. machines is incapable of giving its full output owing to trouble with the turbine. This does not seem to have been the first experience of the kind, as serious defects developed in both the 2,000 kw. turbines and in one of the smaller alternators supplied by the A.E.G. In his report, Mr. ALDRIDGE remarks that the electricity department equipped the station with 14,000 kw. of A.E.G. turbine machinery, with results which can only be described as unfortunate. So much has been said in the past in regard to the excellence and the superiority of German plant that it is interesting to note that such plant, even by the A.E.G., is not always what it might be.

"Unto Him That Hath Shall Be Given."

THAT low salaries are not peculiar to the servants of Education Committees is evident from the following:—

> Clerk required immediately, must possess good knowledge of shorthand, typewriting and modern office routine, as well as keeping of store and cash books; previous experience with an electricity works an advantage. Salary £80 per annum. Application, in candidate's own handwriting, stating age, experience and qualifications, together with copies of not less than two recent testimonials, to the Electrical Engineer and Manager, Electricity Works . . .

In commenting on this, the "Municipal Journal" rightly points out that a clerk really fulfilling the qualifications enumerated in the advertisement is undoubtedly worth more than £80 a year to his employers, and clinches the matter by observing that people who are prepared to pay £80 for a clerk *deserve* an £80 clerk. Were the above an isolated example one could leave the electrical engineer and manager to sweat the man foolish enough to work under him, but last week a discussion of some length on the appointment of general assistant electrical engineer at a salary of 30s. per week was

indulged in by the Worksop Council. We have neither the time nor the inclination to ascertain what manner of man it is that sits on the august body referred to, but we will take a leaf from the book of our contemporary, and observe that we sincerely hope the Worksop Council will succeed in obtaining a general assistant electrical engineer *worth* 30s. per week. To our knowledge, wages of 10s. to 60s. per week are being offered at the present time for supervisers of country-house lighting plants. Our advice to general assistant electrical engineers in search of employment is "Beware of Worksop."

Standard Radio Sets.—In an informative Paper read by Mr. C. H. Shoemaker before the Institute of Radio Engineers, the most recent standard 2 kw. and ½ kw. sets of the Marconi Company are described fully. Details are given of the design of the switchboards, gaps, condensers, radiation thermo-ammeter, motor-generator, transformer, automatic starter, overload relay, wave-changer and receiver. The adjustment of these sets is carefully considered.

Detectors in Wireless Telegraphy.—A Paper by Mr. W. D. Bancroft on this subject appeared recently in the "Journal of Physical Chemistry." The author discussed the mechanism by which the electrolytic detectors, crystal rectifiers and coherers are operated, and expressed the opinion that the fundamental feature in all three cases is an absorbed gas film on the surface. The action of the three detectors when subject to waves is due to the fact that electrical stress decreases the thickness of the absorbed gas film, and, therefore, decreases its resistance.

Economical Load of Boilers.—In an article in "Power" Mr. H. O'Neill discussed, with curves plotted from the results of numerous experiments, the relationship of boiler efficiency and rate of evaporation. The losses were grouped as "no load" and "load" losses, the latter including those which increase with rate of evaporation. It was deduced that, generally, the advantage of working boilers above the builders' rating is in saving capital cost of new plant required to deal with increased load; but for working efficiency the best result is obtained at, or slightly under, the builders' rating.

Protected Thermo Elements.—In a Scientific Paper on this subject by Mr. A. W. Gray, a detailed description is given of a convenient mounting for protecting laboratory thermo-elements from damage by contamination or by mechanical strains. This mounting was developed in the Thermal Expansion Laboratory of the Bureau of Standards, and has long been in regular use there. Since thermo-elements are so useful in determining temperatures the Paper ought to be useful both to physicists and chemists. Those interested in the subject may obtain a copy free by addressing a request to the Bureau of Standards.

Arc Oscillations in Coupled Circuits. An informative Paper dealing with the above subject was read early in the year before the Institute of Radio Engineers by Prof. H. Yagi. The following is a summary:

1. When a secondary circuit is closely coupled, its reaction causes variation in the primary oscillations and consequently in the secondary oscillations themselves.

2. The cyclic current diagrams afford a means of studying the variation of current with time which cannot be easily done by the dynamic characteristics.

3. There are favourable conditions for maximum current effect in the secondary. They depend on the ratio of the frequency of the separate discharges to that of the secondary oscillation.

4. A spark creates more powerful oscillations than an arc of the same current strength, though the former are not quite so steady, owing to the necessarily higher discharge potential.

These principles are fully illustrated by a number of experimentally obtained dynamic characteristics and cyclic current diagrams.

Prime Movers.—Extracts from the Report of the Committee on Prime Movers to the National Electric Light Association were given recently in the "Electric Light Journal." The outstanding feature is the phenomenal increase in the size of turbines and condensers and the large number ordered. The General Electric Co., of America, are constructing turbines for steam pressures of 300 lb. gauge, and plans are being considered for using 500 lb. pressure. A single-flow turbine and single generator of 50,000 kw. output is on order. Any practical requirements as to size is made by the Westinghouse Co., by dividing the set into two or more elements, and a 60,000 kw. three-cylinder two-stage turbine set with three generators is being built for the Interborough Co., of New York. Typical designs of condensers and auxiliary plant are reviewed. For condenser tubes the Detroit Edison Co. has found the best life is to be obtained from the following mixture: Copper, 70 per cent.; zinc, 30 per cent.; tin, none; lead, under 0·01 per cent.; and iron, under 0·075 per cent. The size and pressure of boilers is increasing, and the Babcock & Wilcox Co. are constructing large boilers for 350 lb. working pressure and 250 deg. superheat.

Bakelite Gear Wheels.—Entitled "Bakelite Micarta-D Gears and Pinions," an article by Messrs. T. D. Lynch and R. E. Talley appears in the current issue of the "Electric Journal." The material is a product of heavy duck bonded together with Bakelite by heating while under heavy pressure. It is said to be as strong as cast-iron, unaffected by atmospheric changes, vermin proof and may be stored indefinitely without shrinkage or without deterioration. The following are the physical properties of the material:—

1. Tensile strength, parallel to laminations, 10,000 lb. per square inch.
2. Compression strength, perpendicular to laminations, 35,000 lb. per square inch.
3. Compression strength, parallel to laminations, 17,000 lb. per square inch.
4. Transverse strength, maximum fibre stress parallel to laminations, 17,000 lb. per square inch.
5. Transverse strength, maximum fibre stress perpendicular to laminations, 17,000 lb. per square inch.
6. Coefficient of expansion per inch per degree Centigrade, 0·00002 in. in the direction parallel to the laminations and 0·00085 in. in the direction perpendicular to the laminations.
7. Specific gravity, 1·4.
8. Weight per cubic inch, 0·05 lb.
9. Shrinkage is practically zero up to a temperature of 100° C.
10. Oil absorption, practically zero.
11. Water absorption, 0·25 to 2 per cent. by weight depending on the relative amount of edge surface exposed (with 50 hours' immersion in water at 21° C.).

Corrosion Investigation.—The need for accurate scientific work on the corrosion of condenser tubes has long been recognised by engineers, and it resulted six years ago in the establishment of the Corrosion Research Committee of the Institute of Metals. Good work has been done under the committee's guidance, and three reports have been issued, the experimental plant meanwhile remaining installed in the University of Liverpool. Recently a change of venue became possible as a result, first, of the action of the Government Research Council in making a substantial grant in aid of the corrosion research: and, secondly, because of the offer made by the Brighton Corporation at the instigation of Mr. John Christie, the municipal electrical engineer, to give house room and other facilities to the Corrosion Research Committee within the Southwick power station.

In effect we shall now have a State-aided corrosion research station working under almost ideal conditions as regards supplies of water and power, and atmosphere. The action of the Brighton authorities in thus associating themselves with this work should set an example to municipal and other bodies of the possibility of assisting in that co-ordination of scientific and industrial research that it is one of the main functions of the Research Council to effect.

Further co-operation in the work is being arranged with the Imperial College of Science and Technology, South Kensington, where certain scientific aspects of the corrosion problem will be able to be investigated with every facility at hand. The work, both at Brighton and South Kensington, will be in the charge of Capt. G. D. Bengough, D.Sc., the Investigator to the Corrosion Research Committee, who has been temporarily relieved of his military duties in order to devote himself to this extremely important national problem. As assistant he will have the well known metallurgist, Dr. O. F. Hudson, who has just relinquished his position as lecturer in metallurgy in the University of Birmingham, in order to join forces with Capt. Bengough. With these two highly-qualified investigators working under the direction of a reorganised committee, which includes representatives of the various Government departments, public bodies, scientific and technical institutions interested in corrosion, and working further, under such ideal conditions as regards research stations the outlook may be regarded as very promising for the eventual solution of those mysterious corrosion problems that have baffled generations of engineers.

Feeder Voltage Regulators.—Messrs. E. E. Lehr and I. C. Minick contribute to a recent number of the "Electric Journal" an illustrated article on "Feeder Voltage Regulators of the Induction Type," and discuss their advantages and methods of operation. The latest regulators are automatically controlled by means of a voltage-regulating primary relay and an electrically-operated motor switch, commonly called an auxiliary or secondary relay. The line-type compensator, with the necessary current transformer and a voltage transformer for reducing the line voltage to a value suitable for the primary relay, are normally required for automatic operation. Several diagrams of connections of automatic regulators are given.

OBITUARY.

KILLED IN ACTION.—The following deaths in action or as the result of wounds are reported :—

Capt. W. A. Douglas (Royal Scots), who has been killed, was 26 years of age, was an electrical engineer and a partner in James Gray & Sons, Edinburgh.

Sec.-Lieut. A. J. Brockman (Royal Lancaster Regt.) was in the service of the Eastern Telegraph Co. abroad prior to the war.

Capt. H. G. Baker (Gloucester Regt.), who was killed on Aug. 16, was in his 22nd year. He was an old student of the City and Guilds College, Finsbury, and was in the service of the British Westinghouse Co. until the outbreak of the war.

Lieut. Jas. D. Simpson (Canadian R.E.), killed in action, was 28 years of age. He had served an apprenticeship as an electrical engineer with Messrs. Mavor & Coulson.

Lieut. F. G. D. Stoney (R.E.), who died of wounds on Aug. 25, earned the diploma of the City and Guilds Engineering College and the B.Sc. (Lond.) with honours in 1913. He was in the service of Messrs. Ransomes & Rapier when the war commenced.

The following are also reported killed : Pte. B. Jephcott (Australian Imperial Infantry) was an electrical engineer in Sydney prior to the war. Pte. R. Massey (1st County of London), aged 19, who was employed by the Electrical Apparatus Co. prior to enlisting. Lance-Corp. Wood (Loyal North Lancs.), who was formerly a Bolton tramway employé. Pte. Cecil Lloyd (K.R.R.), aged 21, who was in the employ of the Birmingham and Midland Tramways Joint Committee at their power station, Smethwick.

PERSONAL.

Mr. E. J. Fox is resigning the position of London manager of Messrs. Stewarts & Lloyds (Ltd.) in order to take up the position of general manager of the Stanton Iron Works Co. (Ltd.), near Nottingham, with a seat on the board as managing director. Mr. Fox succeeds in March next Mr. J. A. Longden, whose services will, however, be available to the company, as he remains a member of the board of directors.

Mr. J. N. Stephens, manager of the wiring supplies department of the British Thomson-Houston Co., has joined the Royal Flying Corps as second lieutenant (Asst. Equipment Officer).

Senor John Antonio Ibargaray has been appointed chief of the Argentine State Telegraph Department.

ROYAL ENGINEERS (T.F.).—The following appointments have been made :—

London Electrical Engineers : Sergt. C. S. Knight (R.E.), Spr. P. Foulger and Pte. W. C. Anderson (from Inns of Court O.T.C.) to be second lieutenants (on probation).

Tyne Electrical Engineers : Gunner H. J. Ingman (R.G.A.) to be second lieutenant (on probation). Sec.-Lieut. (temp. lieutenant) J. R. Abbott to be temp. captain.

APPOINTMENTS VACANT AND FILLED.

An assistant master in electrical engineering is required at the Polytechnic (Regent-street, London, W.) for part or whole of next session. Applications to the Director of Education. *See an advertisement.*

An advertiser requires a telegraph engineer for service in the East.

A switchboard attendant is wanted at Stoke-on-Trent electricity works for the duration of war. Wages 30s. per week, with 4s. war bonus if married. Applications to Borough Electrical Engineer, St. Peter's-chambers, Glebe-street, Stoke-on-Trent. *See advertisement*

The Governors of the Borough Polytechnic Institute, London, S.E., invite applications for the full-time appointment of an engineer to superintend Herold's Institute, Bermondsey, and to teach general engineering in the Polytechnic's technical school for boys. Salary £250.

The Western Electric Co. advertise for draughtsmen for their automatic department, 34, Norfolk-street, Strand, London, W.C.

Mr. D. H. Davies, chief assistant electrical engineer at Stockton-on-Tees, has been appointed electrical engineer and tramways manager to Heywood Corporation, at £200 per annum. There were about 50 applicants.

Mr. E. Grimes, generating engineer of Hackney electricity works, has been appointed station superintendent of the Barking works.

Mr. Mark Whittle, of Horwich, has been appointed assistant electrical engineer at Aylesbury.

Consequent upon rearrangements, the following appointments have been made in Bolton Tramways Dept. : Chief clerk C. Ormrod, to be chief traffic assistant ; Inspector Salkeld, to be depot inspector ; Inspector Burney to be timekeeper; and Inspector Hade to be special inspector.

INSTITUTIONS AND SOCIETIES.

Birmingham and District Electric Club.—The next monthly meeting will be held at the Swan Hotel, New-street, Birmingham, on Saturday evening, September 9, 1916, at 7 p.m. The chair will be taken by the president, Mr. W. G. L. Riddle, and a Paper on "Sand Blasting and Sand Blast Machinery" will be read by Mr. J. J. Richardson.

Institute of Metals.—The annual autumn meeting of the Institute of Metals will be held on Wednesday, September 20th, commencing at 4 p.m., in the rooms of the Chemical Society, Burlington House, Piccadilly, London. Sir George T. Beilby, F.R.S., LL.D., will preside, and a number of important metallurgical Papers will be presented and discussed. The Government Research Council having made a grant of £1,000 per annum towards the cost of carrying on the research inaugurated by the Institute of Metals Corrosion Committee into the causes of the corrosion of marine condenser tubes, it has been found possible by the Corrosion Research Committee, which has recently been reconstituted so as to include representatives of all bodies interested in the subject, greatly to extend their sphere of activities.

Nottingham Society of Engineers.—The first meeting of the session will be held at the Welbeck Hotel on Wednesday, October 18th, at 7.30 p.m. The council have appointed, subject to the confirmation of the society, Mr. J. F. Chambers to the post of secretary, rendered vacant by the resignation of Mr. H. G. Price, and all communications, subscriptions, &c., should be forwarded to Mr. Chambers, The Elms, Daybrook, Nottingham.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.
Officer Commanding, Lieut.-Col. C. B. CLAY, V.D.

Orders for September :—

General Parade.—A general parade will be held on Saturday, Sept. 30, at 2.45, at Headquarters. Uniform.

Lectures.—W. Eyles, Esq. (late R.E.) has kindly consented to give four lectures as follows : Wednesday, Sept. 6 and 13, "Bridging" : Wednesday, Sept. 20 and 27, "Demolitions." Members are requested to take special note that during this month the lectures will be on Wednesdays in place of Tuesdays.

Drills.—Drills will be held under the Sergeant-Major on Tuesday evenings, as during August.

Musketry.—The Range will be open on Thursday evenings, as during August.

Instruction Classes.—Instruction classes at Regency-street will be held as usual for Platoons Nos. 9 and 10.

Entrenching.—Every Sunday at Victoria Station (S.E. & C. Rly.) Booking-office 8.45 a.m. Uniform, haversacks and water bottles. Midday rations to be carried. The importance of a steady continuance of this work cannot be over estimated. It has been pointed out by Major-General Dickie that the work is best done by moderate working parties *every* Sunday. "Half the number on consecutive Sundays is much better than double the number every other Sunday."

The Commandant desires to draw attention to the report on work done on South London Defences in July, 1916, in which the paragraph referring to the Corps says : "The work has been very well done and the task completed," and to express his gratification at the support he has received.

A précis of this report and the General Order recently issued is posted at Headquarters.

Otford Camp.—A most successful Camp was held during the early part of August, and some 20 men are still under canvas.

Special Note.—Ordinary drills will be resumed on and after Sept. 15. Supplementary orders will be issued later.

Corps Meeting.—A general meeting will, if possible, be held at the end of September.

THE HYDROELECTRIC STATION ON THE PESCARA RIVER.*

There are two hydroelectric stations on the River Pescara, which are used for electrochemical purposes. Of these, one, which utilises a fall of 76 metres in height, is described in the present article, the minimum flow being 30 cubic metres per second. The power is transmitted to Naples, a distance of 385 km., at 88,000 volts, and amounts to about 18,500 kw. The arrangements are such that a flow of 40 cubic metres can be utilised, which gives another 6,000 kw. The water is not taken directly from the river, but is led, partly through a tunnel and partly through an open channel, from the site of the other power station. The total length of this connection is about 9 km., of which about 3·5 km. are through tunnels and 5·5 km. is through open channels. The open channel is of trapeze-shaped section, and is 2·7 metres broad at the bottom. There is a small depression in the reservoir before the water passes to the intake pipes, and here the solid matter in suspension is collected. The pressure pipes are built up out of sections 1·5 metres long; their diameter in the upper portions is 2·3 metres, and in the lower portion 2·1 metres.

The wall-thickness increases correspondingly from 5 mm. to 14 mm. At the lower end there is a conical piece, tapering from a diameter of 2·1 metres to one of 1·75 metres. The gradient of the first section is 21·4 per cent., of the second 14·4 per cent., and of the conical piece 50·5 per cent. In order to allow for the effects of temperature, there is an expansion piece at the top of each length of pressure tube at a point near the reservoir, and there is a second expansion piece lower down at the point on each tube where the gradient changes. The power station is somewhat sunk into the ground, and the level of the generator room is 7·1 metres below that of the surrounding soil. Beneath the floor of the generator room are two passages, one of which is used for cables and the other for turbine piping and connections.

The switch room is constructed on three floors. The ground floor is divided into four parallel sections. Two of these contain the switching apparatus and the low-tension 'bus-bars; the other two are set apart to uses in connection with the transformers, and contain the oil pumps, cooling coils, &c. On the first floor, the transformers are arranged in 15 cellular compartments, and behind them are placed the respective switches. Nine transformers are at present in position, and six will be added later. The second floor contains the high-tension wires; the middle portion is divided into two passages. One of these adjoins the generator room, and has the lightning protectors; on the other side are placed the oil switches and 'bus-bars for 88,000 volts. These two passages end in two rooms in which the earthing devices are placed. There is a flat roof overhead, in which there are two towers, 15 metres high; these contain the terminals from which the overhead wires start with a voltage of 88,000. There is also a connection to the railway of normal gauge with a gradient of 13 per cent. It is possible to draw railway trucks up this incline by an electrically-operated capstan, and in this way machinery or parts of the same can be brought directly from the railwey into the power house.

The generator room contains four turbines, each directly connected to a generator with a capacity of 6,650 kw. There are two exciting sets, each of 140 kw., and nine single phase transformers, each with a capacity of 3,600 k.v.a. The turbines are double Francis turbines, capable of utilising a fall of 76 metres. Their speed is 420 revs. per min.; an overload of 7,360 kw. can be dealt with. They are electrically controlled from the switchboard by means of oil pressure regulators. The exciter sets are driven by two simple Francis turbines at speeds of 630 revs. per min. The efficiency of the large turbines at full load (6,400 kw.) is 87 per cent. The controlling apparatus is so designed that the speed increases by 3 per cent. if the load is suddenly reduced from full to three-quarters load, by 5 or 6 per cent. if it falls to half-load, and by 10 or 12 per cent. if the whole of the load is suddenly removed. In the entire absence of controlling regulators the speed would rise to 750 revs. per min. if the full load were suddenly switched off. The efficiency of the smaller turbines at full load is about 79 per cent. The alternators have an output of 7,200 k.v.a. with a power factor of 0·8, at 6,000 to 6,600 volts, with a frequency of 42. Fig. 1 gives drawings showing the construction of the machines. Fig. 2 gives the characteristics. It was guaranteed by the makers that the temperature rise should not exceed 35° C., with a room temperature of 30° C. If the machine were run continuously with a load of 6,500 kw. the temperature rise was not to exceed 40° C., if it was run continuously with a load of 6,800 kw. the temperature rise was not to exceed 45°C., if it was run for two hours with a load of 7,360 kw. the temperature rise was not to exceed 50°C. The efficiency at full load with a power factor of unity was guaranteed to be 97 per cent. The voltage drop with a power factor of unity was 10 per cent., and with a power factor of 0·8 was 25 per cent. The machines can deliver the short-circuit current for two minutes without damage. The exciters furnish 400 kw. at 200 volts.

The transformers are of the single-phase type, and are cooled by oil. The voltage is transformed from 6,000 to 46,200 volts, the frequency being 42. The transformers are grouped in sets of three, the primaries being joined in delta and the secondaries in star. The neutral point of the star is not earthed. For cooling purposes, oil has been chosen instead of water, partly because the cooling by oil is more effective and partly because the risk to the insulation of the transformer by leaky coils is avoided. The oil is circulated by a small pump, and the warm oil is cooled by passing the coil through flowing water: very small quantities of water are required. If the circulation of the oil is stopped and the transformer is worked at full load, the temperature rise will be 40°C. above the normal at the end of four hours, and this is well within permissible limits. Thus any accident to the pump is not of vital importance, as there is a considerable interval within which to effect repairs. Fig. 3 gives the details of the construction of the transformer.

The switches are arranged in cellular chambers for 6,000 volts, but this principle is not applied to the 80,000-volt system, because the distance between the conductors is in itself a sufficient safeguard. The design has been so arranged that everything shall be as simple as possible and easily open to inspection: signal lamps are used for

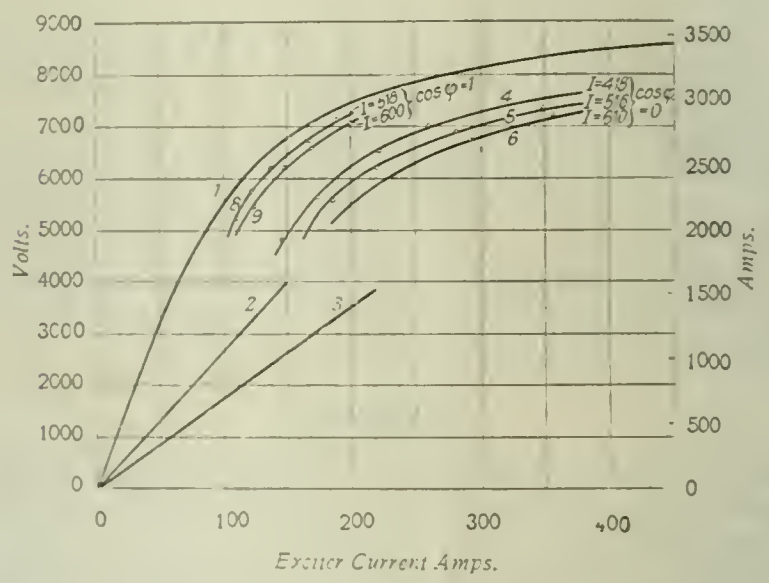


FIG. 2.—CHARACTERISTIC CURVES OF THE POLYPHASE GENERATOR SHOWN IN FIG. 1.

1=No-load curve. 2=Short-circuit current (single-phase).
3=Short-circuit current (three-phase).
4, 5 and 6=Characteristics for cos Φ=0. 8 and 9=Characteristics for cos φ=1.

switches that are operated from a distance. The instruments are arranged on two separate boards: the one set is connected to the main generators and exciters, and the other to the transformers and 6,000-volt connections. The switches are worked at 200 volts with the direct current given by the exciters: there is also another 6 kw. dynamo that can be used in an emergency.

The bare copper conductors, connected to the machines, are led to a ring 'bus-bar, on which are the connections to the transformers and 6,000-volt conductors. A second group of 'bus-bars is provided, to which test connections can be made without interfering with the working of the station. An artificial liquid resistance, capable of absorbing 10,000 kw., is provided in the station. The transformers have no switches on the 88,000-volt side: the board contains instruments showing the state of the load, and controlling the output by automatic protective devices. The best protection against surges and atmospheric discharges consists in the use of horn arresters and water earthing devices. Each outgoing conductor has two separate groups of horn arresters, the one in the towers and the other in the 88,000-volt room. The water earthing devices are connected to the 88,000-volt loses. Each outgoing conductor has six choking coils for 200 amperes, three water resistances for the horn arresters (not earthed), and there are also devices in connection with the arresters to protect against slight surges.

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 21, 1916.

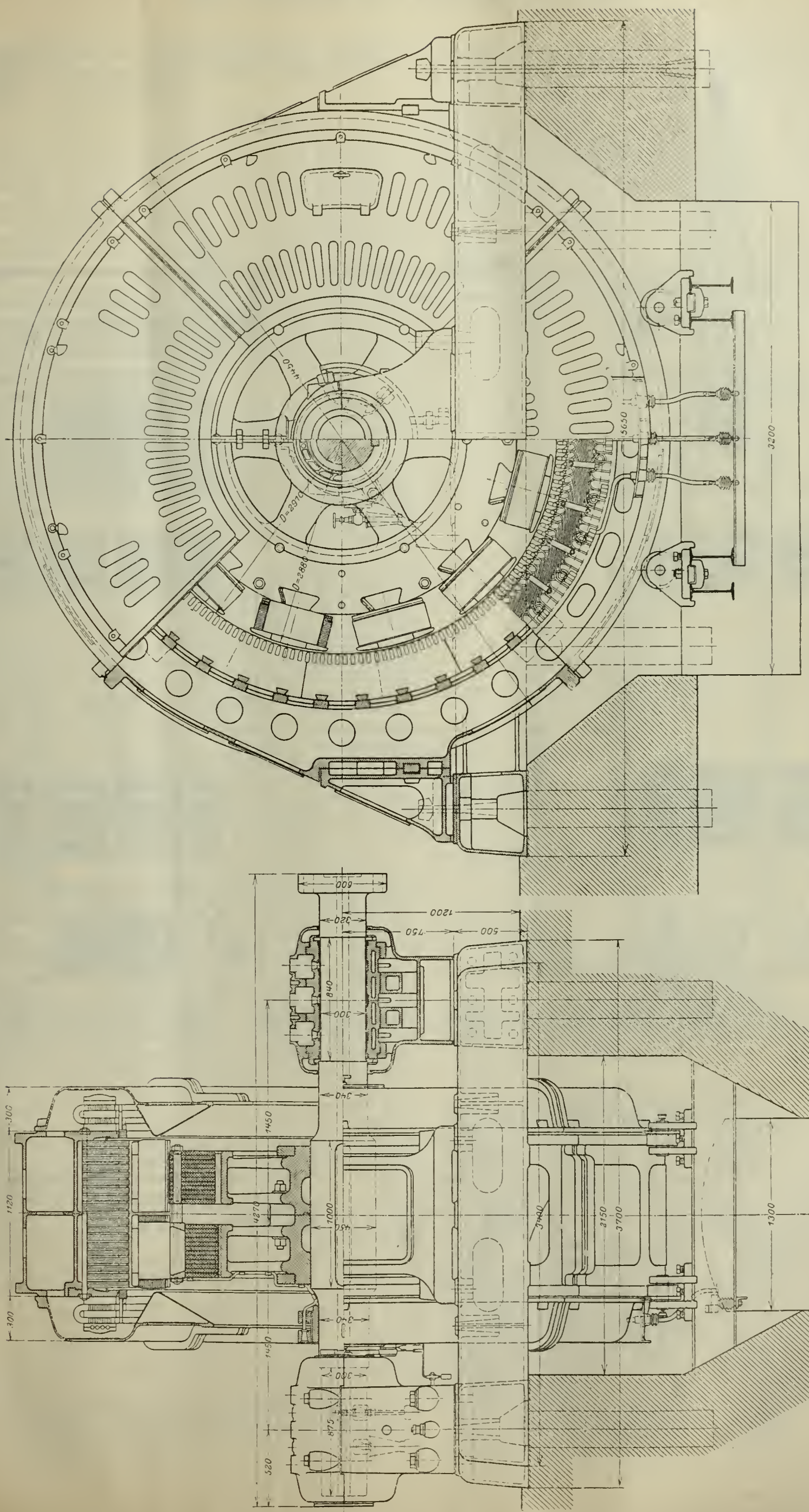


FIG. 1.—SECTIONAL ELEVATIONS OF POLYPHASE GENERATOR IN THE PESCARA POWER STATION. 7,200 K.V.A., 6,600 VOLTS, 42 ~.

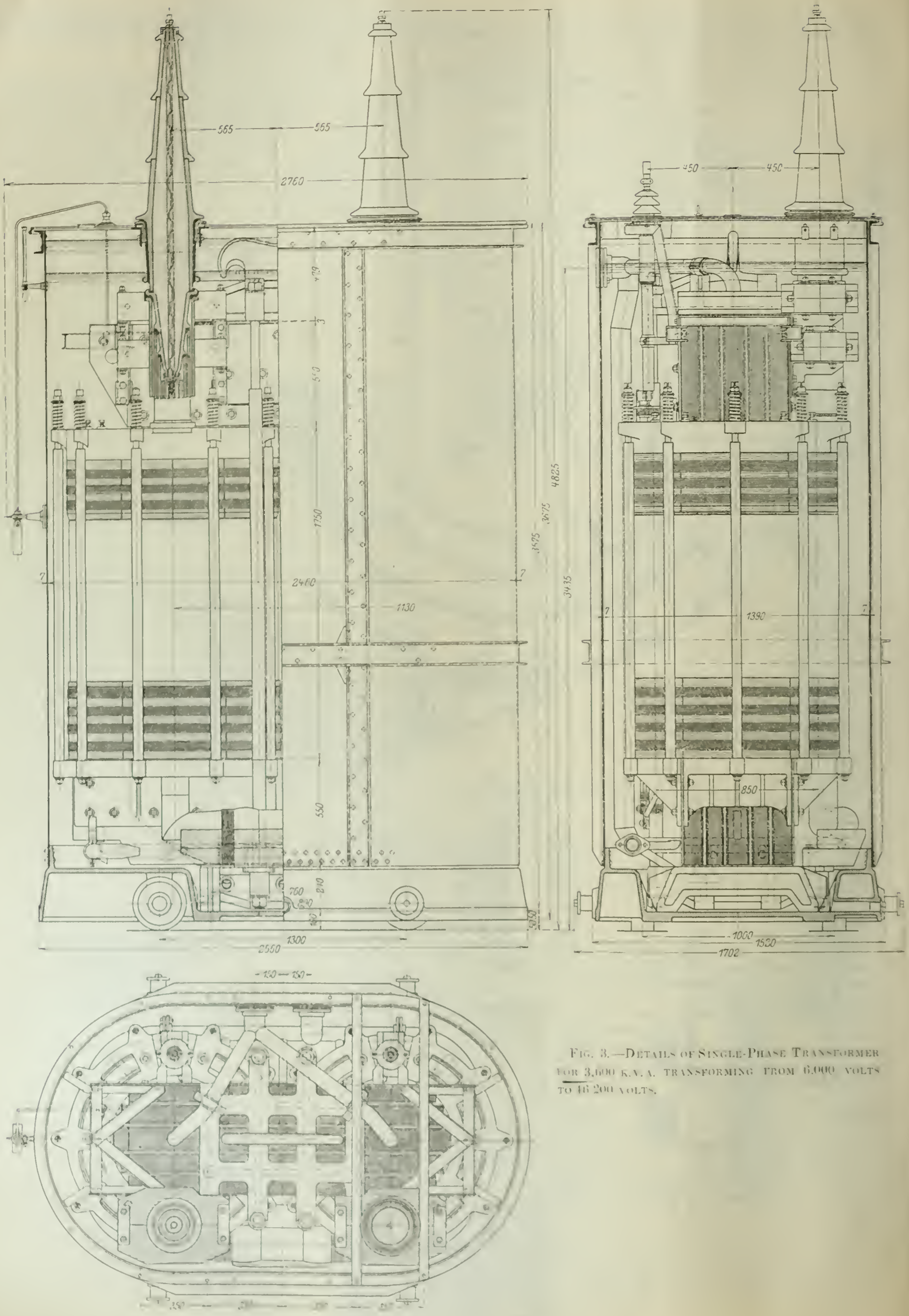


FIG. 3.—DETAILS OF SINGLE-PHASE TRANSFORMER FOR 3,600 K.V.A. TRANSFORMING FROM 6,000 VOLTS TO 16,200 VOLTS.

THE CALCULATION OF THE CAPACITY OF RADIO-TELEGRAPH ANTENNÆ, INCLUDING THE EFFECTS OF MASTS AND BUILDINGS.*

BY PROF. G. W. O. HOWE, D.SC., M.I.E.E.

Until quite recently the calculation of the capacity of radio-telegraph antennæ, except in the simplest cases, was looked upon as an impossibility, and one of the leading text-books on the subject stated that, "In the case of multiple-wire aerials, the only way to determine the capacity is to measure it." This is no longer the case, however, and it is shown in this Paper that, even for aerials of complicated design, it is a relatively simple matter to pre-determine the capacity and to calculate the effects of the earth, the masts and anything else in close proximity to the aerial. The accuracy obtainable is more than sufficient for all practical purposes.

The principle of the method employed by the author has already been described,† and in the present Paper the method is extended and applied to a number of concrete examples. Some tests are also described, the results of which indicate the accuracy of the calculated values.

The principle of the method is briefly as follows: It is assumed that the charge is uniformly distributed over the surface of the whole antenna, and the average potential of the antenna under this fictitious condition is then calculated. Formulæ have been worked out by means of which the average potential can be easily determined even in the case of complicated antennæ. The assumption is then made that this average potential differs but little from the actual potential which the antenna would have at every point if the same total charge were no longer uniformly distributed, but allowed to have its own natural distribution.

In the original Paper, read before the British Association at Sydney, formulæ and curves were given for flat multiple-wire antennæ with any number of wires from 1 to 12, and also for four-wire aerials with the four wires at the corners of a square. Formulæ and curves were given for wires meeting at various angles, and it was shown that two equal wires meeting at an acute angle, like the sides of a letter V, have the same average effect on each other as if they were parallel at a distance equal to 0·36 of the perpendicular dropped on one wire from the end of the other. The effect of the earth on both horizontal and vertical wires was considered, and some numerical examples of the application of the method to actual antennæ were given. It was shown that, when applied to an example quoted by Dr. Louis Cohen (THE ELECTRICIAN, February 21, 1913), the method gave results in good agreement with the measured value, whereas the method described by Cohen himself gave an error of 20 per cent. In September, 1915, the author published formulæ and curves by means of which aerials of the umbrella type can be readily calculated.

In his "Principles of Electric Wave Telegraphy," Prof. Fleming gives a number of measured capacities of actual aerials of various types to serve as a guide in estimating the capacity of any other aerial. Some of these measured values agree fairly well with the calculated values, but others show a wide divergence; it was in seeking to explain these discrepancies that the author was led to devise a method of calculating the effect of masts and buildings. Although the data given with regard to the method of supporting the aerials are too meagre in most cases to allow of accurate calculation, it will be seen that the assumption of probable data leads in some cases to calculated results differing but little from the measured values. The discrepancies are most marked when the aerial consists of a very large number of wires; for instance, "25 vertical (?) wires 0·1 in. diameter, 200 ft. long, arranged fan shape with top ends about 2 ft. apart=1,640 micro-microfarads." Now, this is considerably greater than the calculated value, even if the wires were everywhere 2 ft. apart and not brought together at the lower end. Unless there is some error in the data, this can only be due to masts or buildings, or some factor which is not mentioned.

In the original Paper the curves and formulæ were not carried beyond 12 wires, and we shall now extend them so as to include this multiple antenna of 25 wires. It was shown on page 859 of THE ELECTRICIAN (September 4, 1914) that the capacity of a multiple-wire antenna with n parallel wires in one plane is given by the formula,

$$C=\frac{16\cdot94n}{n\left(\log_e\frac{l}{d}-0\cdot31\right)+\log_e\frac{d}{r}-B}\times10^{-6}\text{ mfd. per foot,}$$

where l is the length of the antenna, d the distance between adjacent wires and r the radius of the wire. The constant B is the average value of $\log_e(\lfloor n-m\rfloor m-1)$ for all values of m from 1 to n. The work of finding this average value is considerably lightened by remembering that $\log\lfloor x$ is equal to $\log\Gamma(x+1)$, the values of which are tabulated in Dale's Mathematical Tables, p. 77. For $n=25$ we get $B=44\cdot75$. The values of B for any number of wires up to 25 can be read off the curve (Fig. 1), which is an extension of Fig. 6 in the original Paper. For any value of n greater than 15 it is seen that $B=2\cdot44\ (n-6\cdot7)$. If, instead of the capacity, we wish to find the

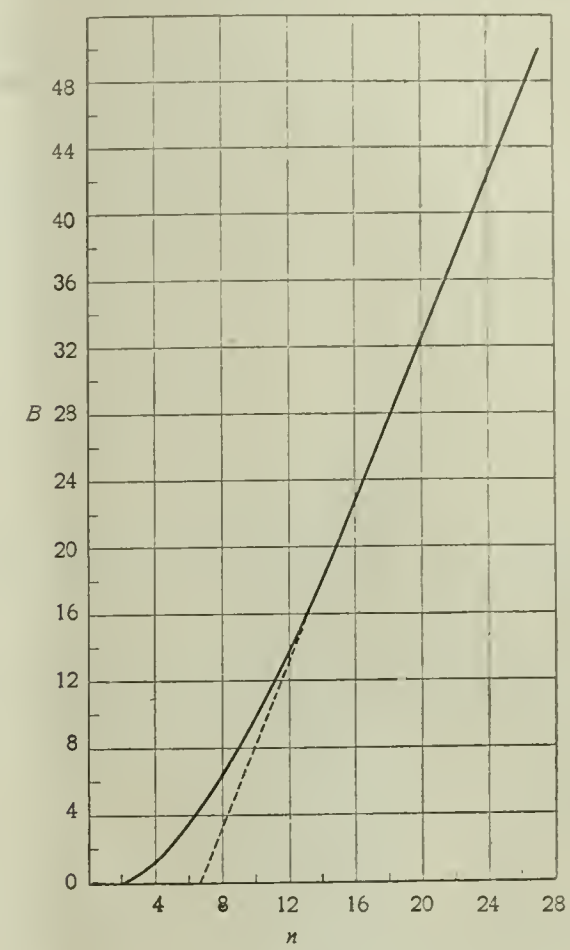


FIG. 1.

average potential of the antenna when uniformly charged with unit quantity per centimetre of wire, we have

$$V_{\text{av.}}=2n\left(\log_e\frac{l}{d}-0\cdot31\right)+2\log_e\frac{d}{r}-2B,$$

or if n is greater than 15

$$V_{\text{av.}}=2n\left(\log_e\frac{l}{d}-0\cdot31\right)+2\log_e\frac{d}{r}-4\cdot88(n-6\cdot7).$$

Now, in the example quoted above, if the 25 wires had been parallel and 2 ft. apart, we should have

$$\frac{l}{d}=\frac{200}{2};\quad\log\frac{l}{d}=4\cdot6;\quad\frac{d}{r}=\frac{24}{0\cdot05};\quad\log\frac{d}{r}=6\cdot16.$$

$V_{\text{av.}}$ due to its own charge $=214\cdot5+12\cdot3-89\cdot5=137\cdot3$. The total charge is $25\times200\times30\cdot5=152{,}500$, and were it not for the earth the capacity would be $1{,}234\times10^{-6}$ mfd. The negative potential of the aerial due to its image in the earth will be approximately $\frac{152{,}500}{200\times30\cdot5}=25$, thus lowering its resultant potential from 137·3 to 112·3, and increasing the capacity to $1{,}510\times10^{-6}$ mfd.

It was shown in the original Paper that fan-shaped aerials could be calculated as parallel wires with a value of d equal to 0·365 of the actual distance at the widest point (strictly, of the perpendicular dropped from the end of one wire on to the other); hence $l\ d$ and $d\ r$ should be taken as 274 and 175 respectively. Repeating the calculation with these values, we get a resultant capacity of $1{,}054\times10^{-6}$ mfd. whereas that given as the measured value is $1{,}640\times10^{-6}$ mfd.

Another actual example for which the measured capacity is given is that of "160 wires, each 0·1 in. diameter and 100 ft. long, arranged conically with bottom ends together 10 ft. above the ground, and top ends 2 ft. apart=2,685 micro-microfarads." The circumference of the circle formed by the upper ends of the wires is 320 ft., giving a radius of 51 ft., and since each wire is 100 ft. long it must make an angle of 30 deg. with the vertical. If we assume each wire to have unit charge per centimetre of length, the average potential of any wire

due to its own charge = 19·55
" the next wire = 9·3
" the 40th wire = 2·695
" the opposite wire = 2·2

* Abstract of a Paper read before Section G of the British Association at Newcastle.

† The capacity of radiotelegraphic Antennæ," Brit. Assoc., Sydney; THE ELECTRICIAN, Vol. LXXIII., p. 829, 1914. "The Capacity of Aerials of the Umbrella Type," Brit. Assoc., Manchester; THE ELECTRICIAN, Vol. LXXV., p. 870, 1915.

By plotting these values, the potential due to any wire can be found, and thus the average value, which is found to be 3·28. Hence, the potential

due to its own charge	=	19·55
,, the other wires	=	321 (=159 × 3·28)
,, the earth image	=	−160 (approx.)
The total potential	=	381

Hence

$$C=\frac{160\times100\times30{\cdot}5}{381\times0{\cdot}9}=1.423\times10^{-6}\text{ mfd.}$$

which is only 0·53 of the measured value given for this antenna.

It has been assumed that each wire is insulated at its upper end. This is improbable, and it is interesting to consider the effect on the capacity of supporting the 160 wires from a horizontal cable of, say, 0·5 in. diameter. This cable will form a circle with a circumference of 320 ft., and since it has five times the diameter of the antenna wires, and is more advantageously placed, it will require a much greater charge per centimetre of length to raise it to the same potential. We shall assume that it has a charge of 12 units per centimetre.

It is necessary now to find the potential of this cable due to the various charges.

1. The Potential of a Circle of Wire Due to Its Own Charge of 1 Unit per Centimetre.

The potential at any point P on the axis of the wire is due (a) to the charge on the wire in its immediate vicinity which may be considered linear, and (b) to the charge on the remainder of the circle.

(a) This may be confined to the wire subtending a small angle θ_1 on each side of P (*see* Fig. 5), and may be calculated as a cylindrical conductor of length $l=2\theta_1 R$. In the present example $R=51$ ft., and if θ_1 be taken as 4 deg., $l/r=342$. The potential at the mid-point $P=2\log_e l/r=11{\cdot}67$.

(b) The potential at P due to the remainder of the circle

$$=2\int_{\theta_1}^{\pi}\frac{Rd\theta}{2R\sin\theta/2}=2\left[\log\tan\frac{\theta}{4}\right]_{\theta_1}^{\pi}=-2\log\tan\frac{\theta_1}{4}$$

$$=-2\log\tan1^\circ=8{\cdot}1.$$

Hence the total potential at P due to the charge on the ring $=11{\cdot}67+8{\cdot}1=19{\cdot}77$. This applies to any circle with $R/r=2450$, and a charge of 1 unit per centimetre. It is interesting to note that if this wire were straight its average potential would be 6 per cent. lower, so that its capacity is decreased this amount by being bent into a circle.

In our example, with a charge of 12 units per centimetre, the potential will be 237.

2. The Average Potential of the Horizontal Suspension Wire Due to the Antenna Wires.

From Fig. 24 in the original Paper it is found that the potential at F, due to the diametrically opposite wire OP of the cone, is 1·0, at E 1·05, at D 1·2, at C 1·7; thus the average over EF is 1·025, over DE 1·12, CD 1·4, while from Fig. 23, the average over $PC=2{\cdot}6$. Hence the average potential over the whole circle due to the charge on one antenna wire = 1·54, and that due to the whole 160 wires, 246.

Hence the potential of the suspension wire

due to its own charge	=	237
,, antenna wires	=	246
,, its own image	=	−20
,, image of 160 wires	=	−106
Total	=	357

The potential previously calculated for the 160 antenna wires will be modified by the presence of the charge on the suspension wire.

We will here make use of an important theorem: The average potential over a surface of area A, due to a charge uniformly distributed over another surface of area B, is equal to the average potential over the second surface due to the same charge uniformly distributed over the first surface. If the charges are not equal in the two cases, the potentials vary in direct proportion to the charge. To prove this theorem let l be the distance between two elements δA and δB of the surfaces: then if the area B have a uniform density σ_1, the potential of the element δA will be $\sigma_1\int\frac{dB}{l}$, and the average potential over the whole of the surface A will be obtained by integrating over the surface and dividing by its area thus $(\sigma_b/A)\int\int\frac{dBdA}{l}=\frac{Q_b}{AB}\int\int\frac{dBdA}{l}$ where Q_b is the total charge on the area B. Similarly the average potential of B, due to the charge on $A=\sigma_a/B\int\int\frac{dAdB}{l}=\frac{Q_a}{AB}\int\int\frac{dAdB}{l}$.

If $Q_a=Q_b$, the average potentials are equal.

Now since we have calculated the average potential of the circular cable, due to one wire of the cone, we can write down at once the potential of the latter due to the charge on the former. It is

$$1{\cdot}54\times\frac{320\times12}{100}=59.$$

The average potential of any wire of the cone which was previously calculated to be 381, will therefore be increased to 381+59 by the presence of the charged suspension cable; the earth image of the latter will, however, reduce this by 25, giving a resultant of 415.

On the cone we have $16{,}000\times30{\cdot}5$ units at a potential of 415, and on the suspension cable $3{,}840\times30{\cdot}5$ units at a potential of 357, giving a total charge of $19{,}840\times30{\cdot}5$ units at an average potential of 404.

$$\text{The capacity}=\frac{19{,}840\times30{\cdot}5}{404}=1{,}500\text{ cm.}$$

$$=1{,}670\times10^{-6}\text{ mfd.}$$

This is an increase of 17 per cent. due to the suspension cable, but the actual increase will be greater, since, the calculated potential of the cable being less than that of the wires of the cone, it is evident that the density on the cable is greater than has been assumed. All faulty assumptions as to the distribution of the charge give values below the true capacity. A recalculation shows that to give the same potential in all the wires, the charge on the cable should be 16 units per centimetre of length, and not 12, as has been assumed; this increases the capacity to $1{,}680\times10^{-6}$ mfd., which is 18 per cent greater than that calculated without the suspension cable.

Again, another example consists of "four vertical parallel wires 110 ft. long and 0·1 in. diameter, spaced 6 ft. apart at the angles of a square=583 micro-microfarads." This type of antenna was considered in the original Paper (*see* Fig. 18), and since $l/D=18{\cdot}3$ and $d/r=1{,}440$, the capacity will be about 3·85 per foot, or 424×10^{-6} mfd. in total. This neglects the effect of the earth, which is determined as follows: The potential of the antenna

due to its own charge	=	35·2
,, its earth image	=	− 4·0 approx.
The resultant potential	=	31·2

Hence the capacity will be increased in the ratio of 35·2 to 31·2—*i.e.*, 13 per cent.—which gives a total capacity of 478 micro-microfarads, which is only 82 per cent of the measured value. That these discrepancies are due to such disturbing factors as masts and buildings, particulars of which are not given, is proved by the fact that the calculated and measured values agree very well even in the case of very complex arrangements of wires, if the disturbing factors are carefully eliminated or calculated and allowed for.

(*To be continued.*)

ELECTRIC WATER HEATING AS APPLIED TO DOMESTIC SERVICE.

BY C. W. CROSBIE.

Summary.—A description is given of some of the systems that have been developed for supplying domestic hot water electrically. The load-factor and the consumption of energy are discussed in the light of the author's experience.

Hot water in these days is considered a common necessity, and the problem of providing it to meet the requirements of domestic supply, by electrical means, assumes an importance not yet fully realised by engineers. There is no doubt that a more extensive adoption of electric hot water apparatus will considerably strengthen the position of electric cooking and heating, to say nothing of the material benefits which must accrue to supply authorities from this source, consequent upon the improvement of the load-factor and reduction in generating costs. This will readily be appreciated when it is considered that the domestic consumer is the greatest potential user of electricity, and at present the average annual consumption

per head of population, including the supply of power, is extremely low, *i.e.*, approximately 36 units ; while in the case of purely residential districts, where power for industrial purposes is more or less non-existent, the average consumption probably would not exceed 18 units per annum.

Unfortunately the solution of the problem is not entirely dependent on the apparatus available, much of which has already attained a degree of conversion efficiency hitherto unapproached by other methods. Electric supply undertakings have it in their power, if only they will view the problem broadly and attack it boldly, by the framing of suitable tariffs. It is purely a question of competition and economics : competition so far as the consumer is concerned as regards price, convenience, and the service of his existing system ; and of economics from the point of view of electric supply.

The author is convinced both propositions can be satisfied by the adoption of a constant load thermal storage system. Before entering into the matter fully it would be as well to make a brief survey of the systems that are available. These are numerous and interesting, both as regards design and the means by which a solution of the problem is sought. To name at random but a few : Belenus boiler, Belling geyser, British electric geyser, Cooper water heater, Ferranti water heater, Losles water heater, and Therol water heater; and these may be classified under one or other of the three main headings :—

1. Boilers,
2. Geysers, and
3. Thermal storage systems.

1. *Boilers.*—The term is applied to apparatus used for heating water in bulk, such as urns and so-called rapid boilers, generally consisting of utensils fitted with heating elements partially or wholly immersed. For domestic purposes other than for kitchen use they are not to be recommended for the following reasons : (*a*) they are independent, self-contained

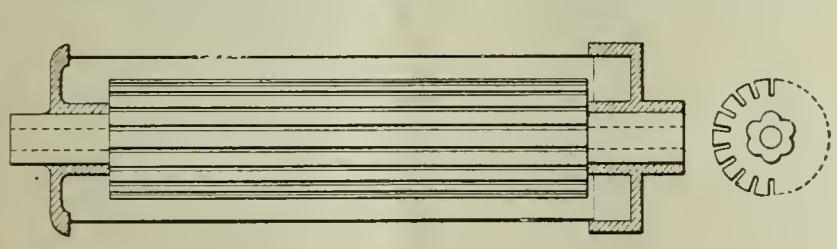


Fig. 1.—Belenus Electric Boiler.

and usually bulky and not being connected to the service, require to be filled by hand and the water carried to the point at which it is to be used ; (*b*) for large quantities of water the time required to bring it to the requisite temperature is too long ; (*c*) the maximum demand heavy and, in consequence (*d*) a bad load-factor is given prohibiting the supply of electricity on the most favourable terms.

The Belenus is not a boiler in the above sense, but is probably so-called by reason of the fact that it is arranged to take the place of the ordinary saddle-back boiler fitted to kitchen ranges and is installed in a like manner. It consists of a cast-iron cylinder having a longitudinally corrugated bore to furnish as large a heating surface in contact with the water as possible. The exterior is slotted for the reception of the heating elements. Each slot takes a 500-watt element; and there are 18 such elements which may be connected in any desired combination. For heat control four or five switches are provided, making possible a variation from $\frac{1}{2}$ kw. to 9 kw. This heater suffers under the same disadvantage enumerated above under (*c*) and (*d*), but when connected to the water system of the house and a storage tank, would in every way meet the requirements of the domestic consumer. This boiler is shown in Fig. 1.

2. *Geysers.*—These are designed for a rapid production of hot water, and their chief advantage is that a supply is instantly available on the operation of the control handle. They have serious drawbacks, inasmuch (*a*) as it is necessary to install one at every point at which water is to be used; (*b*) the loading being kept down from considerations of the demand on the mains does not allow of a sufficiently rapid flow of water to fill, say, a bath in a reasonable time; (*c*) the maximum demand is exceedingly high; and (*d*) the poorest of load-factors conceivable is given.

The Belling consists of a cast-iron body in which are embedded the heating elements, the water flowing through a system of passages in the iron and taking up the heat on its way. It is provided with a switch interlocked with the water tap so that the electric current cannot be switched on before the water, or the water turned off, without first switching off the current. It is loaded to 10 kw. and has an efficiency of 98 per cent.

The British Electric Geyser may be described in greater detail in view of its novel construction, and the claims which are made for it in regard to the filtration and sterilisation of the water in its passage through the heater. It consists of a porcelain tube packed with carbon granules through which the water passes, and which also constitutes the heating element. The heater is provided, as in the case of the Belling, with an interlocked switch and tap. The water in its passage through the carbon is sterilised by the electrochemical action set up, and delivered pure at the nozzle. Hot or cold water may be drawn at will according to the position of the control handle, and for any length of time; the cold water being filtered by the carbon granules. Geysers on this principle are built for

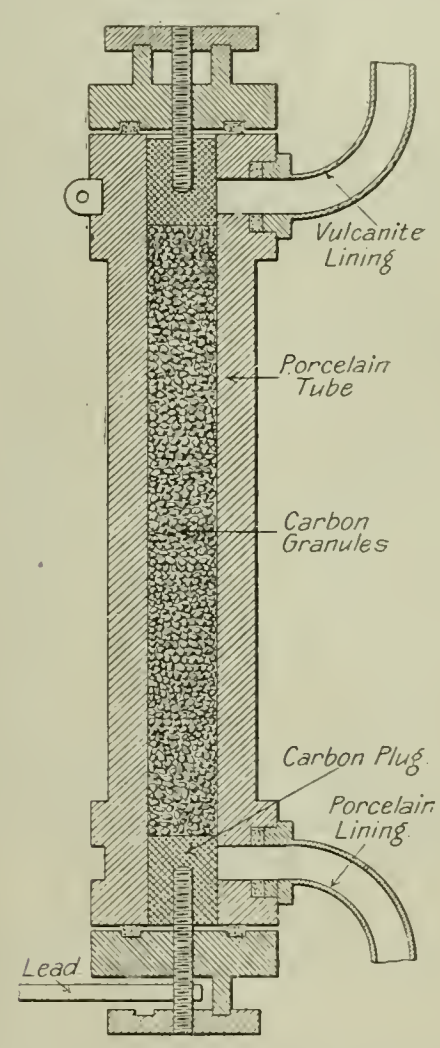


Fig. 2.—British Electric Geyser.

a delivery of from 22 to 40 gallons of water per hour with a rise in temperature of 60°F. to 100°F., the consumption being approximately 200 watts per gallon. The usual loading is about $7\frac{1}{2}$ kw. for lavatory basins, and for baths two such heaters are connected hydraulically and electrically in parallel, the loading then being 15 kw. The efficiency of the apparatus is about 98 per cent. at the nozzle. Fig. 2 shows the general arrangement.

3. *Thermal Storage Systems.*—No one, more than the electrical engineer, realises the handicap and disadvantage under which he labours for the want of a cheap and reliable method of storage in his business of electrical supply, and it is for this reason that the thermal storage of water will appeal to him, offering as it does the only solution to what is and always has been the greatest difficulty he has had to contend with, in the matter of meeting irregular and variable demands for energy. Even were it practicable for electrical storage, on a commercially large scale, at the source of generation, it would not entirely overcome the difficulty of maximum demands; for there still

remains the question of copper in his distributors; while storage in some form on the consumer's premises would greatly reduce his difficulties.

Arguments are sometimes advanced against thermal storage on the score that it is inefficient because of the retention of the storage tank and long lengths of piping, but it must be borne in mind that the losses thus incurred are insignificant in comparison with the material advantages to be gained in the low maximum demand and high load-factors which become possible on its adoption. Moreover, these losses are not so high as is imagined in a properly lagged system. Apart from the consideration of electrical supply there is, also, the consumer's point of view; namely, his ability to obtain hot water at all points where he has become accustomed to use it.

Thermal storage systems may be designed by the application of accelerators or thermostatic control, or both, to meet almost any conceivable demand. Thus, in the case of a service where the demand is likely to be irregular due to the temporary increase in the household by the visit of friends and relations, the provision of a secondary heater or accelerator with hand or thermostatic control would meet the requirements. These secondary heaters or accelerators can be arranged with any number of varying heats; and the thermostatic control arranged to bring them into operation, either by the fall in temperature of the water; or when any given predetermined minimum quantity of hot water, is reached in the cistern. The load-factor will necessarily vary with the loading and arrangement of the system.

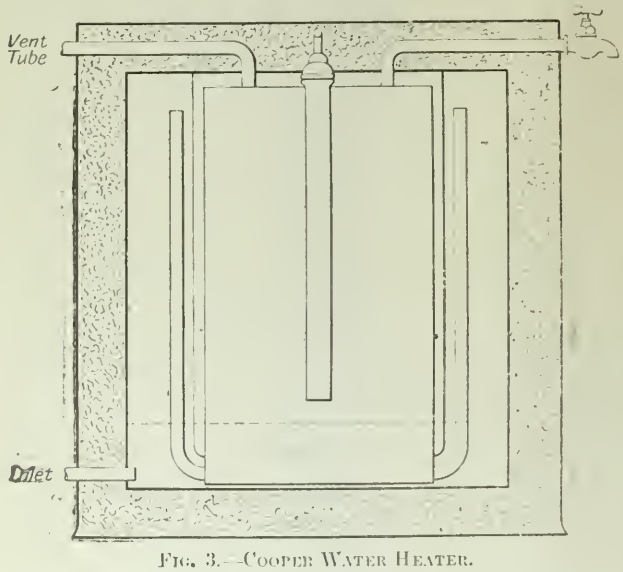


Fig. 3.—Cooper Water Heater.

In the following description four examples of apparatus working on the thermal storage principle are given:—

The Cooper Water Heater consists of a water-tank within a water-tank, the essential feature being that only a portion of the water contained is heated directly by the immersion element, the remainder being heated indirectly. The immersion heater is fitted to the inner or small tank by insertion from the top. The inner tank draws in water at the bottom through two tubes which project into the water jacket, and are carried up nearly to the top. The cold water supply is connected to the bottom of the water jacket, and the draw-off connection at the top of the inner or heating chamber. Thus the water (about one-third of the total contents) in the heating chamber is rapidly raised in temperature and with its rise, heat is transmitted, across the small annular air space, at an increasingly greater rate to the water jacket. In this manner it will be seen that when hot water is drawn from the apparatus, the heating chamber is supplied with water from the jacket at a considerably higher temperature than would have been the case had the cold supply been connected thereto. The object of this construction is to obtain a small quantity of water rapidly raised to temperature, and further, to allow for additional heat storage in the surrounding water jacket when no demand is made on the apparatus. The heater is rated at 750 watts and is capable of heating, daily, 100 gallons of water from 60°F. to 110°F., and being left on circuit continuously has a load-factor of 100 per cent. and efficiency of 80 to 87 per cent. The construction is shown in Fig. 3.

The Ferranti Water Heater is probably the simplest of the thermal storage systems; consisting of a cylindrical storage tank similar to those used with kitchen ranges, a pipe connection being made at the bottom of the tank, carried up and re-inserted at the top. This circulating pipe connection carries the heater consisting of a cast-iron tube with heating elements clamped thereto. The whole apparatus is thoroughly lagged to prevent loss by radiation. The chief and most important feature of this apparatus consists in its ability to supply a small quantity of water at a high temperature within a short period of switching on the current, or of drawing off the whole of the contents of the storage tank of the heated water. This is attained by the utilisation of the low thermal conductivity of water, for, when heat is supplied at the upper surfaces of a liquid, the flow of heat downwards is exceedingly slow, and thus when the water in the circulator has been heated it is thrown into the top of the tank where it lies ready to be drawn off; this process continues so long as the electric current is on, fresh cold water being taken from the bottom, heated, and thrown on the top, until the whole contents of the storage tank is heated throughout. In this respect it has a great advantage over systems wherein immersion heaters are introduced directly into the mass of water, particularly if these be at the bottom, for it is well known that when the lower strata of a liquid are heated portions of the liquid rise to the surface while the colder portions sink to the bottom, and in this manner convection currents are set up which transport heat from one part of a liquid to another and tend to bring about a uniformity of temperature throughout the mass, such temperature directly depending upon the mass of water and the quantity and duration of heat applied. The rating is 350, 500 or 750 watts on continuous load according to size and requirements of household. The maximum demand is low, efficiency about 85 per cent. and load-factor 100 per cent.

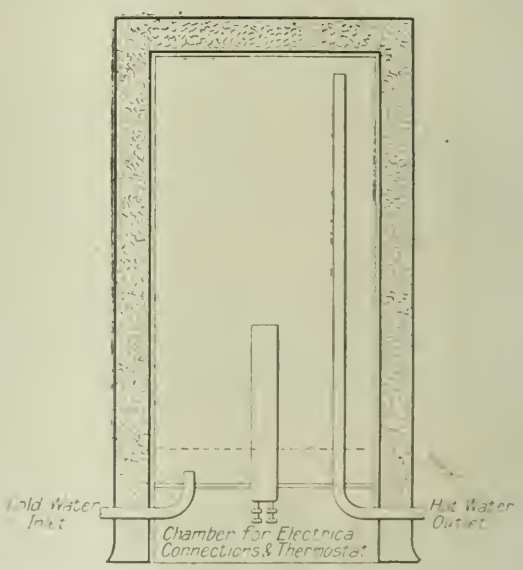


Fig. 4.—Losles Water Heater.

The Therol Water Heater was the first of the thermal storage systems to be placed on the market and consists of a lagged tank in which, separated by a jacket, is a block of cast-iron housing the heating elements. The iron block is pierced by a number of tubes which communicate with the water in the surrounding jacket. Upon first switching on the current the temperature of the whole mass of iron is gradually raised to about 500°F., and as soon as the water is admitted to the block from the surrounding jacket it is heated instantaneously and

vaporised. The temperature of the water is controlled by a three-way tap by the admixture of cold water with the steam, or boiling water, produced in the heating block. With a rating of 200 watts on continuous load from 20 to 30 gallons of water can be produced per day, at a temperature of 110°F. The maximum demand is low and the load-factor 100 per cent.

The Losles Water Heater consists of a lagged cylindrical tank with an immersion heater introduced through the bottom of the tank (Fig. 4). A thermostat is fitted to the apparatus for the purpose of controlling the heater and maintaining the water at a prescribed temperature; when this temperature is reached the heater is automatically switched off, and as soon as the temperature of the water falls a few degrees due to the withdrawal of hot water or the cumulative effect of radiation, the thermostat puts the heater again into action and it remains in circuit until the predetermined temperature is again reached, when it is switched off. The cold water supply and the hot water draw-off connections are made at the bottom of the tank, the latter rising through the mass of water and terminating very near the top of the tank with a view to reducing the losses to a minimum. The apparatus is rated at 1,000 watts for a storage capacity of 10 gallons of water and is capable of providing 84 gallons of water per 24 hours raised through 38°F., or 20 gallons per 24 hours through 150°F. The maximum demand is higher than that of a continuously-rated heater of the same thermal storage capacity and the load being intermittent the load-factor is approximately 50 per cent., and the efficiency from 87 per cent. to 90 per cent.

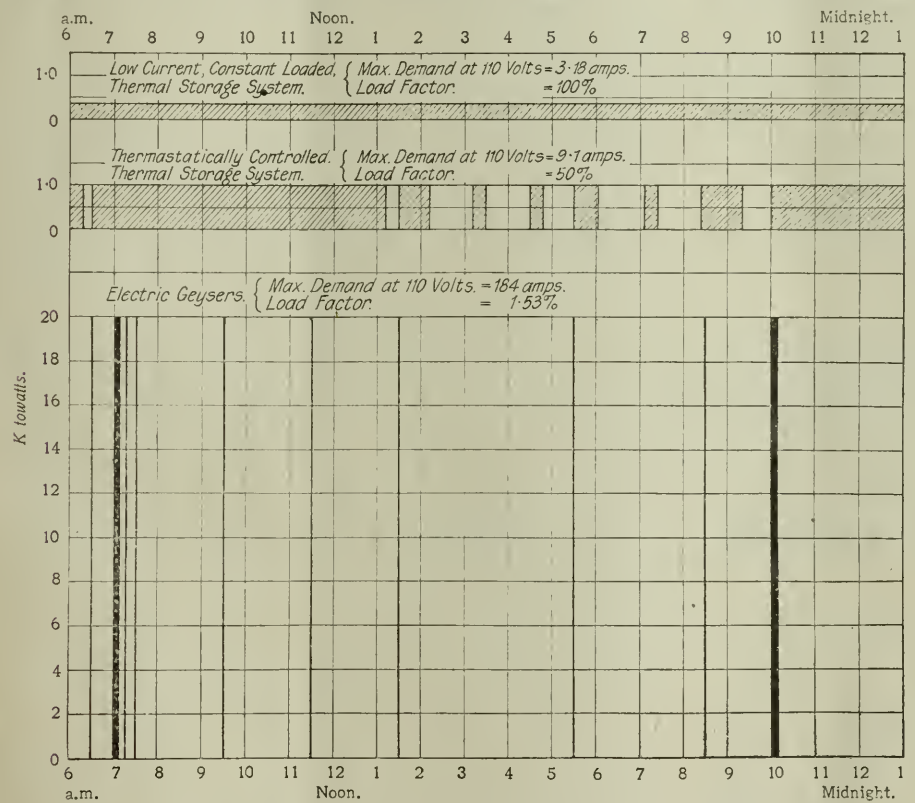


Fig. 5.—Diagram showing Loads from the Three Systems of Water Heating.

Having discussed the details of various heaters, our next consideration will be the actual requirements of domestic service and the manner in which this can be met by the application of the three classes of heaters and showing their effect on the problem of electrical supply. Quite erroneous ideas are prevalent as to the quantity of water required; generally it will be found that no consideration has been given as to the temperature at which such water is to be used. We have found from actual experience that an allowance of 7½ gallons at an average temperature of 110°F. per person per day to be ample for families of four persons and under, and for a larger number of persons an allowance of 5 gallons would probably meet all requirements. The following figures have been tabulated from actual measurements with a meter in the cold water supply:—

Time.	Water drawn from heater. Quantity in galls.	Temp. °F.	Purpose.	Equivalent quantity in galls. at 110 °F	Electrical equivalent in Kelvins at 100% efficiency.
6.30 a.m.	2·00	110	Washing passages, door-steps, &c.	2·00	0·352
7 ,,	20·00	85	Tepid bath	13·60	2·395
7.15 ,,	0·50	110	Shaving washbasins, &c.	0·50	0·088
7.30 ,,	0·50	110	,, ,,	0·50	0·088
9.30 ,,	1·76	132	Breakfast washup	2·18	0·384
11.30,,	0·50	110	Washing sundries.....	0·50	0·088
1.30 p.m.	1·76	132	Lunch washup	2·18	0·384
5.30 ,,	0·88	132	Tea ,, ...	1·09	0·192
8.30 ,,	1·76	132	Dinner ,, ...	2·18	0·384
10 ,,	20·00	95	Warm bath	16·15	2·840
			Total.....	40·88	7·195

The last column of the Table gives the energy demand for the quantity of water raised through 60°F., the sum of these demands divided by the efficiency of any particular water heater gives the daily consumption of that heater. On this basis and an equivalent water service the characteristic load curves and load-factors in Fig. 5 have been calculated for the low current constant loaded thermal storage, thermostatically-controlled thermal storage and geyser systems as being representative of their respective kinds and are as therein shown.

A few words of explanation may here be added with respect to the loading of the geyser. This is determined by the time required to furnish the largest quantity of water drawn, and if we were to base this on the rate of flow through the taps ordinarily provided on baths, *i.e.*, 25 gallons in 10 minutes, or 150 gallons per hour, we should have to provide for nothing less than 20 kw., and thus in the case of some electric geysers they would apparently require four heaters, due to the limitation in loading of a single unit on 110 volts and under; and since it would obviously be unfair to the storage systems not to take their equivalent in the rate of filling a bath, we have taken for the purpose of a true electrical comparison the loading above determined; and the ordinates in the load curve are drawn to half scale with respect to the other two. The following Table summarises the load curves:—

Heater.	Maximum demand.	Load-factor.
Constant loaded thermal storage.....	0·35 kw.	100 per cent.
Thermostatically-controlled thermal storage .	1·00 kw.	50 ,,
Electric geysers	20·00 kw.	1·53 ,,

It is obvious from a consideration of the above Table and curves that the thermal storage system is the only one which can seriously be considered on a large scale; the maximum demand is so low as not to aggravate the difficulty of mains; further, the storage taking place on the consumer's premises furnishes an ideal system in respect to distribution excelling even that of water and gas supply; and the best possible load-factor, *i.e.*, 100 per cent., should enable electric undertakings to offer current at ¼d. per unit for this purpose with excellent financial results to themselves, as will be seen from the following

Table which is the result of actual experience in a town furnishing power and light in the proportions and rates indicated :—

Domestic Service in an Individual House.

Service.	Units per annum	Price per unit.	Annual Load-factor.
Lighting	97	5d.	5·28 per cent.
Cooking and heating.....	3,834	1d.	6·78 ,,
Water heating	3,066	£11. 10s. per kw. per annum.	100·00 ,,
Total service	6,997	0·756d.	11·40 ,,

Characteristics of Electric Supply in which Above House is Situated.

Service.	Percentage of total units sold.	Average price per unit.		Annual load-factor of total supply.
		Particular supply.	Total supply.	
Power	69	1·09d.	2·02d.	16·9 per cent.
Private lighting	22	5·03d.		
Public lighting.....	9	3·74d.		

It has been a matter of considerable surprise to find engineers fighting shy of low tariffs for loads of 100 per cent. power-factor, and in the face of the above figures it is difficult to see wherein lies their justification, particularly in cases where the districts are purely residential, bearing in mind the fact that the average price per unit for total domestic supply, *i.e.*, 0·756d. per unit, at 11·4 per cent. load-factor for an individual house, is exceedingly good when due consideration is given to the improvement of the load-factor at the consumer's terminals, to the fact that nearly half of the total consumption is taken at an unvarying load-factor of 100 per cent. throughout the year; and that approximately 95 per cent. of the total energy consumed is taken during the off-peak periods.

In conclusion, the writer hopes the results here shown will attract the attention of central station engineers and induce them to give the matter closer consideration with a view to bringing about an all-electric service for domestic purposes and the realisation of a universal adoption of electricity in the home.

POWER GENERATION FOR ELECTRIC RAILWAYS.*

BY HENRY G. STOTT.

The subject of power generation is a very broad one which must be studied from both the financial and economic viewpoints. A proposition can be perfectly successful from an engineering point of view, but be quite foolish from an economic one.

The first question which arises in any power generation problem is the cost of power, which is made up of two main items, fixed charges and operating charges. These, in many cases, are very nearly equal for steam plants. Fixed charges comprise interest on capital, amortisation of capital, functional depreciation, taxes and a portion of administration expenses or running expenses. Operation and maintenance costs include all costs involved in operating the plant and in maintaining it at original efficiency. Unfortunately the element of fixed charges is often neglected or ignored in computing and comparing the cost of power.

The first item to be determined in fixed charges is what the money will cost, considering interest and providing for the return of the money to the owners. The latter is called an amortisation charge and is usually included in with interest, resulting in a total cost for the money of about 6 per cent. Taxes form a larger percentage of the total cost of power than is often realised, amounting to 3·5 per cent. on the total investment on the average, and varying between 2 per cent. and 5 per cent. When all the items in fixed charges are included the total cost of the money invested will be found to be not less than 10 per cent. and probably 12 per cent. or more.

In hydraulic plants the operating charges are so small as to be negligible, while the fixed charges are very high.

Some Power-cost Graphics.—The diagrams reproduced herewith illustrate many points regarding the cost of power. Fig. 7 shows typical railway load curves, the lower one being the summer curve and the upper one the winter curve. Due to the heating load and the heavier schedule run, the winter load goes up to about 100,000 kw. and down, with a corresponding peak in the summer, to about 55,000 kw. The heating load in this particular case is about 20 per cent. of the schedule load.

Fig. 1 is based upon Fig. 7, and illustrates the varying cost of power during 24 hours, and with varying amounts of power, supplied from a hydraulic plant, and a steam plant respectively. The total load is divided between the hydraulic plant and the steam plant, as indicated by the scales.

Figs. 2 and 3 show the costs with different sources of power. In all cases the cost of power during the small hours of the morning when the load is light, goes up to a high figure. The difference between the cost at 3 a.m. and 9 a.m. is very marked.

The first curve, A, is for hydroelectric power only. It shows how the cost is prohibitive at light loads. Curve B is for 75 per cent. hydroelectric power and 25 per cent. steam power, curve C is for half of each, and curve D is for all steam power. A combination of steam and hydroelectric power for certain load curves almost invariably provides a lower cost of power for railway work than power from either a straight steam or hydroelectric plant.

Fig. 4 shows the variation of cost of power with load factor, in a plant costing $60 per kilowatt. The lower curve plotted below the zero line shows the operating and maintenance costs, and the first curve above the zero line shows the fixed charges or investment costs. The latter curve indicates how important these charges become at light load. As the load factor increases the fixed charges become less, and there is also a decrease in operation and maintenance cost. At any load factor the total cost of power can be obtained by adding the two ordinates, as is done in the upper curve above the zero line. This curve indicates the importance of building up the load factor in any plant. Fig. 5 gives similar data for a plant costing $80 per kilowatt. Referring to the upper curve it will be seen that at 50 per cent. load factor the total cost of power is about one-half of what it is at 20 per cent. load factor.

In Fig. 6 the curves of Figs. 4 and 5 are superimposed to emphasise the difference in costs of plants A and B (*see* Fig. 8) when operating at 45 per cent. and 25 per cent. load factors.

Diversity Factor or Time Differential.—Fig. 8 shows a typical load curve with a load curve of a small plant added for purposes of comparison. Let us assume that a small direct-current station is shut down and that its load is added to that of another plant which already had a fairly large load. This introduces another factor, which is sometimes called the "diversity factor." I do not think that this name describes the factor very well. "Time differential" is a better description. It simply means that if one can find a load to add on to his other load, in which the peak load or high point does not come at the same time as it does in the other load, then the second load can be carried with advantage without adding much to the capacity of the plant. In other words, the fixed charges will not be increased by adding the load in the valleys shown in Fig. 8, as long as it is not added also to the higher peak. The difference between the broken line and combined curve at the peak in this figure represents the time differential, and 5,000 kw. in the total capacity of the plant would be saved by having this small load added.

The question of disposing of small plants and installing a new central plant is purely an economic problem. The question arises as to the money borrowed for the old plants, and whether it has been written off in the shape of depreciated capital. It is very important that the new plant with high-tension transmission should make up in higher efficiency for any loss in capital and at the same time show a net gain and superior operation over the previous installation.

In all probability the service from the central plant with long-distance high-tension transmission will not be as reliable as that from the small plant on account of lightning disturbances, which break the insulators and disrupt the transformers. That is, the "reliability factor" will not be as great. However, this objection is at present not very grave because the apparatus is being improved and made more capable of withstanding lightning shock.

Power Costs in Large Plants.—The size of plant has quite an appreciable effect on the cost of power. Below certain sizes, say, below 1,000 kw., the efficiency of the steam turbine goes down very rapidly with the size. In plants where such sizes of unit are needed it would be better to buy reciprocating engines direct-connected to the generators than to put in turbines. As the size goes up, however, the turbine shows considerable improvement over what the reciprocating engine can do, and in units of 30,000 kw. capacity or more there is a very marked improvement. The unit purchased not long ago by the Interborough Rapid Transit Company is to generate 70,000 kw. on 10·5 lb. of steam per kilowatt-hour.

Further, there must be a certain number of men to operate stations: engineers, firemen, oilers, &c. A man can take charge of a large unit as easily as a small one, so that the cost of labour does

* Abstract of an address before the American Electric Railway Association; and from the "Electric Railway Journal" of New York.

not go up in proportion to the size of the plant. That is another factor which makes a large plant cheaper proportionately. In a very large plant, however, the cost of these items is almost negligible, whereas the costs of coal and water are very important items, especially the former.

For illustration, when we started developing power for the electrification of the Manhattan Elevated Railroad system in New York, about 15 years ago, it took almost 3 lb. of coal per kilowatt-hour, and to-day we are using but 1·5 lb. with modern turbines. When the

The flatter the load curve the cheaper the power. That is the main incentive for the general power company to get loads from all sources, various kinds of loads, and especially night loads. If the railway can build up a load factor as good as the power company can, then there is no reason why the railroad company should not make the power and sell some of it to someone else. If the power company can build up a better load factor than the railway can, for any reason, then the railway can make power cheaper than the power company can make it.

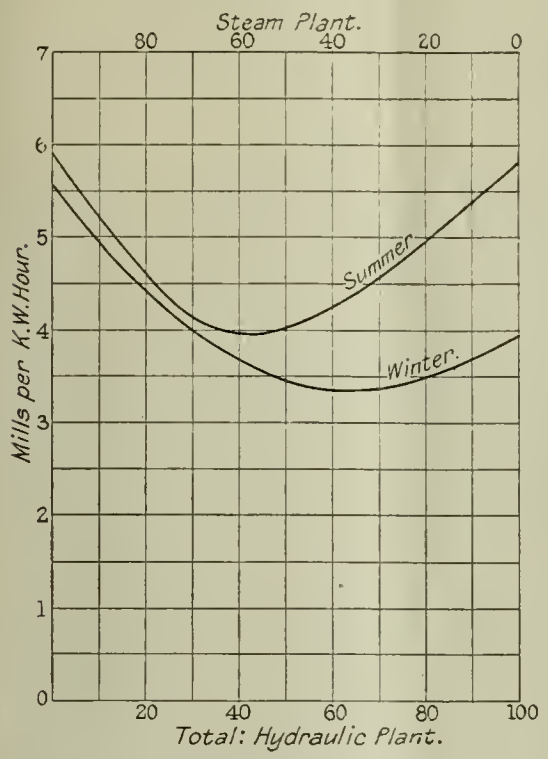


Fig. 1.—Daily Average Cost of Power, Steam and Hydraulic Plant—Typical City Load.

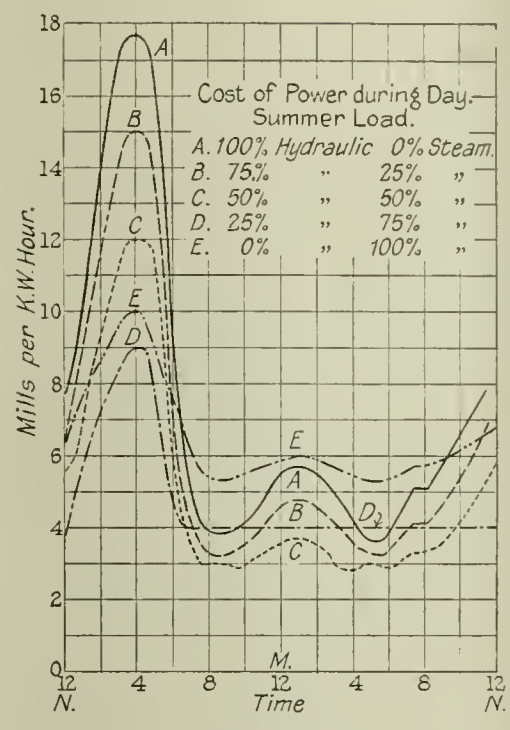


Fig. 2.—Cost of Power during Day—Summer Load.

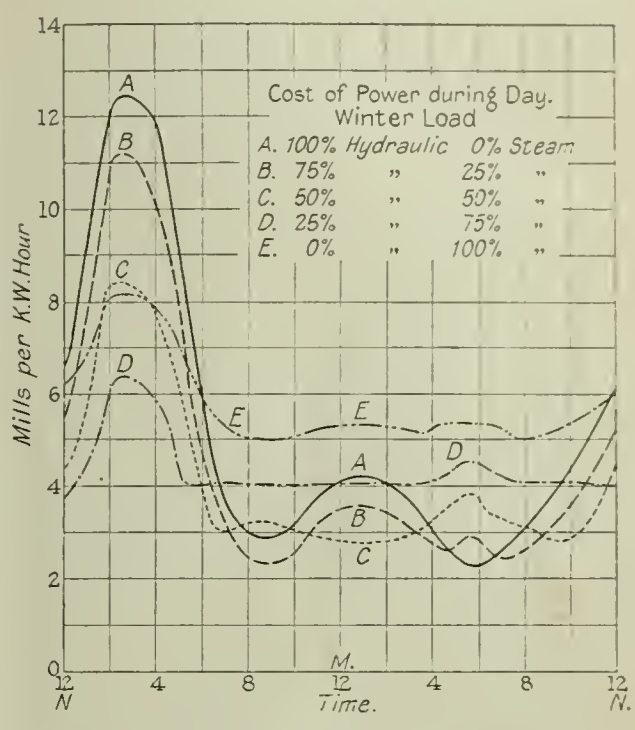


Fig. 3.—Cost of Power during Day—Winter Load.

older units were put in they were the finest ever built, and cost about £50,000 each. But owing to the progress of the steam turbine it seemed advisable to take out the engines and replace them with turbines, although their scrap value was only about £2,000 each. The problem of writing off this difference is a real one. It touches the question of what we might call the effect of obsolescence upon economy of production.

Shall Railways Generate or Purchase Power ?—The general question as to whether the railway company should manufacture its own power or buy it is a very interesting one. If we look at the question in its broadest aspect there is no reason why a railroad company cannot

Steam versus Water Power.—In the hydroelectric plant the first cost is probably two to three times what it would be for a first-class modern steam plant. The average installation of hydroelectric plants at the present time in first cost will amount to not less than £30 per kilowatt of capacity. A first-class steam plant can be put up to-day for an amount varying from about £11 to £15 per kilowatt of capacity depending on the size. If a big dam must be built for a large water storage, then the hydroelectric plant may run from £40 to £50 per kilowatt of capacity.

Another difficulty with the hydroelectric plant is that there are usually certain dry seasons when the hydroelectric power will be cut

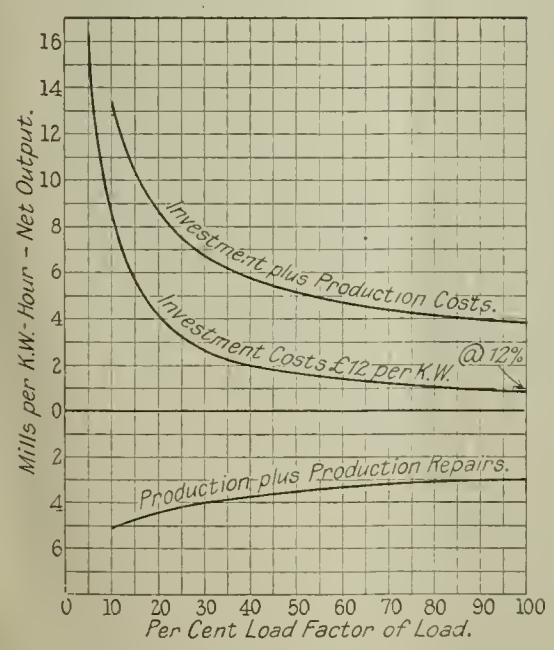


Fig. 4.—Variation in Cost of Power with Load Factor in Plant Costing £12 per Kilowatt.

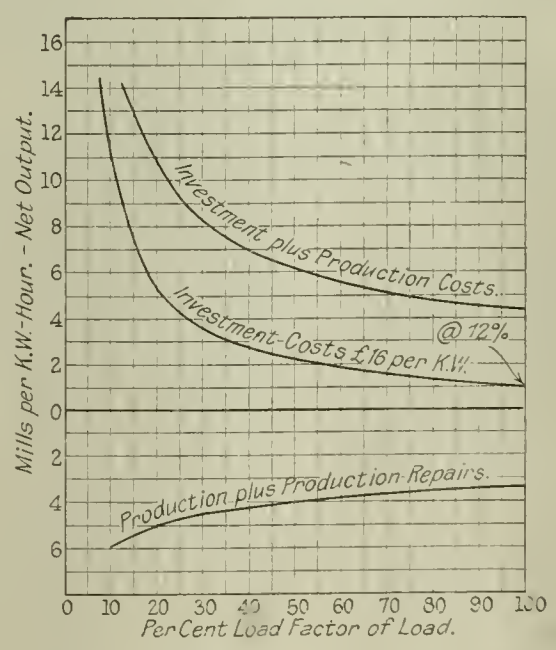


Fig. 5.—Variation of Cost of Power with Load Factor in Plant Costing £16 per Kilowatt.

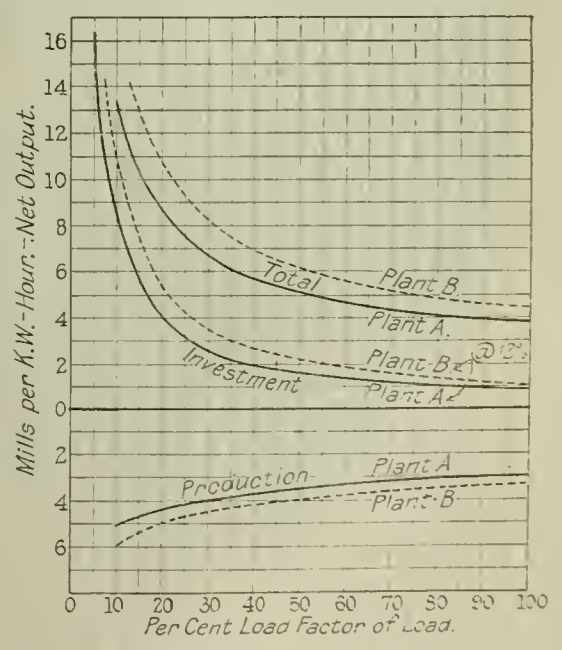


Fig. 6.—Showing Curves in Figs. 4 and 5 Superimposed.

build just as economical plants as any power company can build. The only difference is the one pointed out in Fig. 8, that is in the time differential. Suppose that there was a capacity of 50,000 kw. which the railway required only at certain times. If power could be sold to some consumer who would come in and fill up the "valley" in the railway load, power could be sold for practically nothing but the operating cost. It would, at the same time, cut down the cost to the railway, which would certainly expect to make a profit on what was sold.

down largely, if not stopped altogether. The water supply is very uncertain unless enormous expense for dams and storage is incurred.

The financial question exists even in such water supplies as that furnished by the Niagara River. Some months ago in a consulting capacity I came in contact with a case where a large company, not very far from the Falls, was confronted by two conditions. First of all, it was not allowed to get any more power from the Falls. The Governments of the United States and Canada had established a

certain maximum number of cubic feet per second which they would allow to be diverted from the Falls, in order to preserve its scenic beauty. That point has now been reached. After making a thorough investigation of the shape of the load curve, and an analysis of the whole situation, and taking into consideration what power is costing now, it developed that the company could afford to put in a large steam plant of its own and make power at least as cheaply as it could buy power at Niagara Falls. That, of course, is conditioned on the load factor. If the full load would continue more than 12 hours a day the hydroelectric power would be cheaper. This company is now building a plant which will cost £800,000 so as to make the greater part of its own power.

If such a condition exists at Niagara Falls, one can imagine what the condition is in the average water-power plant, which runs dry half the time. When we talk of cheap hydroelectric power, there is a string attached to it. It is cheap, of course, when you consider only the cost of operating the water-power plant. But, as pointed out before, the money spent in building the plant must be paid for. Instead of paying for coal or other supplies as in a steam power plant, interest, &c., must be paid for the money in this case. For practically all cases where the load is that of a lighting or railway company, which means that its load factor is not more than 50 per cent. at the very outside (and in some cases it goes down to 30 per cent.) water power is a very questionable investment.

In connection with the operation of combined water-power and steam plants the following point should be noted. In order to make a hydroelectric proposition pay, and at the same time sell power at a low cost, the power must be used for a considerable number of hours in a day, or otherwise it must be sold at a high price or it will not be a paying proposition. The steam power plant, with its low fixed charges for a short number of hours per day (10 or 12, as the case may be), and for even a shorter time over the peak load, helps out by cutting down the fixed charges on the hydroelectric power, and in allowing these fixed charges to be distributed over 24 hours instead of six or seven.

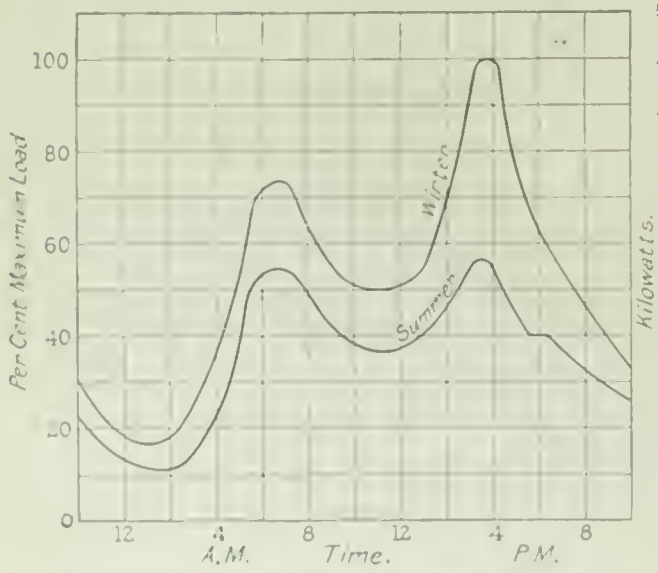


Fig. 7.—Typical Railway Load Curves.

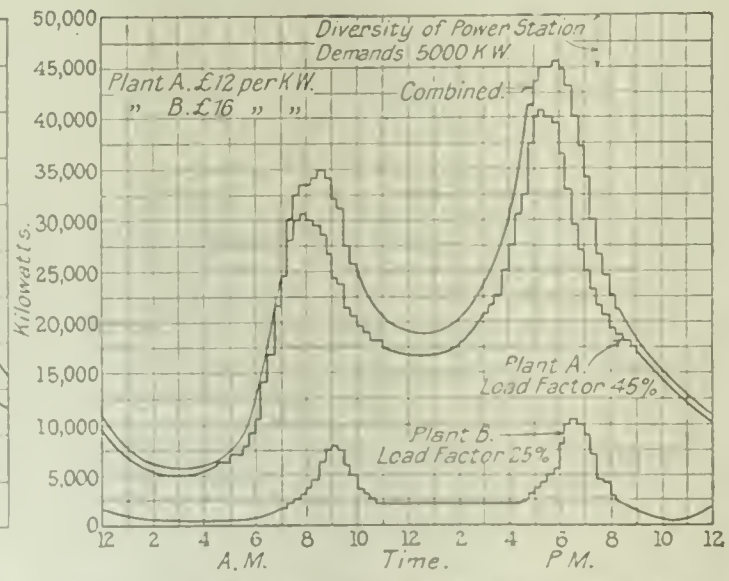


Fig. 8.—Combined Load Curves for Large and Small Stations.

Direct or Alternating Current.—Among other questions involved in the subject of power for electric railways is that as to whether it is better to operate a number of isolated plants or to give up the direct-current system, and extend with the alternating-current generation system, in turn, converting the alternating current by means of rotary converters into direct current. The answer to that question, it seems to me, would necessarily depend to a very large extent on the size of the plant and the amount of load. This comes back again to the question of cost of power production.

The high-tension alternating current is cheaper to make, as a rule, but if the location of an existing power plant is far away and the load is small, then in all probability direct-current power is as cheap as alternating-current power. When new units are to be put in, however, it would in general be a mistake to buy any more direct-current units, unless it may be simply a small addition, the reason being that it is necessary in practically every case to have engine-driven units for the small sizes. As already pointed out, if the units are small, better economy will be obtained from the engine, for in small sizes the economy of the steam turbine is poor. Again, the turbine requires a large amount of condensing water in order to get a good vacuum, and in some cases this may be not obtainable. On the other hand, if a new plant is being built then, where the transmission distance is not too great, it will probably pay to put in one central power plant to generate alternating current and transmit it at the required high tension.

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

As mentioned briefly in our last issue, the report of the Committee of the Privy Council for Scientific and Industrial Research has been issued for the year 1915-16. The report of the Committee itself occupies merely a single page, and states that of the £25,000 placed at their disposal by Parliament in the financial year 1915-16, £12,241, including a special grant of £4,250 to the Royal Society, was expended in the last months of that year. For the current financial year the vote was £40,000.

The report of the Committee is followed by the report of the Advisory Council, covering 40 pages. Further, the names of members of the Standing Committees are given, and at the end of the pamphlet are a number of appendixes. Appendix I. is the Order in Council, Appendix II. gives the scheme for the organisation and development of scientific and industrial research, which was issued last year. Appendix III. gives a list of researches aided by the Committee. Appendix IV. is a report of the Committee of the Privy Council for Canada, and Appendix V. is a memorandum of the Committee of the Council on the proposed extension of the research scheme to the Empire as a whole. In what follows we give an abstract of the report of the Advisory Council.

The first few pages of the report deal with previous Government action in the support of science, such as the creation of the National Physical Laboratory. In regard to the present scheme, it was felt by the Government that the encouragement of scientific work could not be left until after the war, but existing conditions render it difficult to deal effectively with purely scientific matters. Accordingly, the Council decided to give science in its application to industry precedence over pure science in their deliberations. Inquiry showed that there were certain researches already being conducted or directed by professional associations in the period preceding the war which stood in grave jeopardy of enforced abandonment. The Council decided, therefore, to save as many of these derelict researches as possible. Many conferences have been held with scientific and engineering societies throughout the country, and Prof. McClelland has had similar interviews with corresponding associations in Ireland. A register of researches which were, or are, being carried out at universities or technical colleges has been made, and a survey is being made of the arrangements for such researches. It is hoped that the register will enable suitable workers to be rapidly found when the proposal for special lines of inquiry come before the Council. The Council is also considering the possibility of inducing firms to assist the progress of research by stating, in confidence, the problems they have in hand or in contemplation. There are indications of a change of view among certain firms which would render co-operation of this kind more possible. A spirit of co-operation is growing up and a willingness to accept the suggestions of the Council for the initiation of research for the benefit of trade as a whole. The depletion of the staff and students of universities and technical colleges has cut down research to a minimum, with a result that the Council have only been able to recommend grants to some 40 individuals at such institutions, the total sum so appropriated not exceeding £6,000. It is the view of the Council that research in pure science should be as much their care as applied science, and the Council hope to come into such close contact with universities and higher technical colleges as to be able to call the attention of both students and teachers to many interesting problems in industrial research. It is hoped also to encourage interchange of information.

In the remainder of this abstract we shall adopt the wording of the report.

Formation of Standing Committees.—A number of researches bearing on industrial engineering problems was already in progress before the establishment of the Council, and a considerable number of applications for aid to new researches was received immediately we got into touch with the professional bodies connected with these great trades. These facts and the representations of the societies urging the establishment of stronger machinery for dealing with the manifold aspects of engineering research convinced the Council at an early date that they must proceed at once in accordance with paragraph 8 of the White Paper to set

up a series of strong Standing Committees to assist them in surveying the field of research, in constructing panels of referees, and in dealing with applications for grants. The five great engineering societies—the Institutions of Civil, Mechanical and Electrical Engineers, the Iron and Steel Institute and the Institution of Naval Architects—submitted a petition to the Privy Council, and were later received by the Lord President in deputation, urging that the Advisory Council should be enlarged by the inclusion of representatives of the several branches of engineering ; but steps had already been taken to establish the Standing Committees referred to, and the Lord President suggested in his reply that the present small Council, with a number of strong representative committees grouped round and supporting it, should be given a fair trial. The societies thereupon submitted their nominations to the Advisory Council, and we desire to express our recognition of the promptitude and zeal with which all the societies concerned have set themselves to making the new Standing Committees a success.

Three Standing Committees have already been set up (Metallurgy, Engineering and Mining). Each of these consists of about 15 members, of whom approximately half have been nominated by the professional societies concerned, the remainder being appointed directly by the Council.

The Council hope, with the assistance of their Standing Committees, the professional societies, the Home Office and the Board of Trade gradually to construct panels of names which will enable them to obtain the very best advice on the different aspects of the problems they are called upon to solve. The advice they need may be commercial, economic, financial or scientific. The best opinion in all these spheres will, it is hoped, be available on the panels for the guidance of the Council and their Standing Committees, and will ensure the confidence of the industries concerned that the steps proposed have been considered in all their aspects.

The Council realise that the number and scope of the Standing Committees will need extension from time to time, but the absence of strong professional societies working in conjunction with the other scientific industries in this country makes it inadvisable to proceed hastily in so important a matter. In particular, the organisation of the Council's machinery for the manifold chemical industries needs cautious handling in the first instance. Up to the present we have dealt with such questions as we have been able to approach by means of small special committees of the Council itself, which have been empowered to consult other persons as occasion arose ; but at best this must be a temporary expedient. It seems unlikely that a single chemical committee, with the large number of special sections that would be necessary, could usefully be established at the present moment, and we are disposed to think that a series of standing committees dealing with particular branches of the chemical trades may be the better manner of proceeding. A standing committee on fuel may be necessary ; possibly another for rubber, and a third for the chemistry of cotton and paper. A standing committee for textiles, with special sections for cotton, wool and silk, is also likely to be needed before long. The amount of progress it will be possible to make in the actual initiation of researches must be severely limited during the war, but this is not altogether a disadvantage, for it will give more opportunity and time than would otherwise be possible for thinking out a co-ordinated plan of campaign and taking steps to secure co-operation and prevent overlapping. It is not often in our history that the nation has found time to think. Now, by a curious paradox, while the flower of her youth and strength are fighting for her freedom and her life, the others have a chance of thinking out the best use to which that life and freedom can be put when they are safe once more.

Parallel Movements in the World of Science and Industry.—Indeed, at the present time activity is as marked in the field of ideas as it is in the field of war. The useful work which the Royal Society has done for the Government during the war by means of a series of special committees, and the attempts of societies such as the Chemical Society and the Society of Chemical Industry, to arouse an interest in the application of science to industry and the importance of organised effort, led the Royal Society to establish a board of scientific societies. The British Science Guild, which has done much in recent years to impress upon the nation the necessity for scientific organisation, has put forth an emphatic manifesto on the importance of science and the need of educational reform. The movement has not been confined to professors and to scientific men ; the practical man of business, the manufacturer and the trader have been as anxious and interested as any. It is not to be wondered at, for they were the first upon whom the significance of a state of war was forced. In the early months of the war the great steel manufacturers were in grave danger from the possible exhaustion of the supply of chemical glass necessary for the testing of their materials and products. The pottery manufacturers were hit in another way. The supply of seger cones necessary as a guide to the firing of their china and earthenware was cut off by the war, and they were threatened with closure from this and other causes ; but Dr. Mellor, the principal of the Stoke Pottery School, was able rapidly to supply the need and to manufacture sufficient cones for the whole pottery trade. The Stoke local education authorities appealed to the Board of Education in June, 1915, to assist them by a special grant for the erection of research laboratories and workshops in connection with the Stoke school. Ultimately the Council decided to recommend a grant for the erection of the necessary buildings and equipment, and an annual grant towards the maintenance expenditure, which is estimated at some £2,000 a year. The necessary land adjoining the Pottery school has been found by the authorities of the school, an annual subscription towards the cost of the investigation has been guaranteed locally, and the governors of the School of Pottery have placed Dr. Mellor's services at the disposal of a joint research committee of the manufacturers and the governors. The research will be carried out by Dr. Mellor and Mr. Bernard Moore.

The Movement towards Trade Association.—It is clear, we think, from these examples that we may expect in growing measure to have the help and sympathy of the manufacturers in the work that lies ahead. The Council have found that many scientific industries are completely without any effective trade associations through which their common manufacturing interests and difficulties can be approached. There are few associations for the various chemical trades which are so well organised and effective as the British Electrical and Allied Manufacturers' Association for the electrical engineering industries, or as the British Engineers' Association for the whole industry. The Bradford Dyers' Association, the Calico Printers' Association and several similar associations are, of course, trading companies.* The Society of Dyers and Colourists, like the Textile Institute, is a professional rather than a trade association, and there appear to be as yet no national trade associations for the organic chemical industries or for the heavy chemicals or for textiles, whether cotton or wool. The Federation of Master Cotton Spinners' Associations is almost exclusively interested in questions affecting the relations of capital and labour. There are local textile associations which are beginning to be interested in questions of research, and reference has already been made to the Silk Association—a national trade association. But, broadly speaking, it may be said that the functions of trade associations in this country are not as wide as those of similar associations in Germany. The movements going on around us make it evident, however, that the difficulties of tradition, trade organisation and national temperament which stand in the way of combination and which extend far beyond the actual sphere of the Council's activities, must be squarely faced if progress is to be made, and must be dealt with as part of a comprehensive plan.

Even those trade associations which exist have hitherto shown but a moderate appreciation of the necessity for research as a means of keeping command of the market. The council have sometimes found that manufacturers were unwilling to try new developments because they appeared to lack any ambition for extension so long as their existing plant was fully occupied. We think a good deal of the inertia which British manufacturers have shown towards research may have been due to a realisation, partly instinctive perhaps, but partly based on experience, that research on the small scale they could afford, was at best a doubtful proposition.

Impediments to Industrial Research.—Our experience up to the present leads us indeed to think that the small scale on which most British industrial firms have been planned is one of the principal impediments in the way of the organisation of research. The Paper Makers' Association of Great Britain and Ireland pointed out last year to the Advisory Committee on Commercial Intelligence under the Board of Trade that "as matters stand at present, the paper maker who desires scientific investigation in new lines of research, suffers from two disadvantages. He must personally bear the whole burden of the high fees of the scientific expert, and he receives the benefit of the skill and knowledge of a single investigator only," and they used this as an argument for the establishment of a great central institute "akin to the Charlottenburg Institute of Berlin."

The Council are not unaware, however, that there are substantial considerations in the minds of many manufacturers, which lead them to hesitate in expending large sums for research of a comprehensive kind. They have complained to us that the recent substitution of the joint stock bank for private banks has hampered enterprise because the modern bank authorities are not acquainted with the personnel and policy of local firms, and are not prepared to finance new undertakings and developments in the same way that the private banks did. We do not presume to offer any opinion upon this important and difficult question of finance, but we are specially glad to note the recent establishment by the Board of Trade of a committee under the chairmanship of Lord Faringdon "to consider the best means of meeting the needs of British firms after the war as regards financial facilities for trade, particularly with reference to the financing of large overseas contracts, and to prepare a detailed scheme for the purpose."

The Council have also repeatedly been told, when they have urged the necessity for expenditure upon research with a view to improvements and developments, that there is no security that new ventures will not be left, when peace comes, to shift for themselves as best they may in face of the highly organised competition of our enemies. We do not need to be convinced of the reality of the danger, but we are inclined to doubt the efficacy of any single device for removing it. Organisation can only be fought by counter organisation.

It appears to be incontrovertible, however, that for those industries at least which are essential to the conduct of other important national activities and which are both scientific in their character and relatively small in bulk, there is very little chance of survival unless special means are taken by the State to safeguard them. We are thinking of those scientific industries—sometimes called key or pivotal or master industries—which can never employ a large proportion of the population because the bulk of their products needed for the world trade is inconsiderable ; and yet without them many other trades would languish or die. Such industries are the magneto industry, the watchmaker's lathe industry, the optical glass industry, the chemical glass and porcelain industries, the fine chemical industry, the dye-stuff, synthetic drug and

* *Cf.* J. H. Clapham, "The Woollen and Worsted Industries," 1907, p. 151 ; and H. W. Macrosty, "The Trust Movement in British Industry," 1907, pp. 145 ff.

high explosive industries. This last group of industries is relatively large. Our annual consumption of dye-stuffs before the war is said to have been about two millions sterling. But if this is compared with the 200- or 300-million pounds' worth of textiles produced annually in the United Kingdom, the dye-stuff industry is seen after all to fall within our definition. We do not necessarily endorse the view sometimes expressed that all key or pivotal industries should be artificially encouraged, by research grants or otherwise, to establish themselves in this country irrespective altogether of the natural disadvantages under which they might be carried on. The question is one of balancing the various considerations that arise. If a particular product is essential to the national safety the case for State action will be stronger than if it is not. If the trade to which the product is a "key" is relatively unimportant the case will be relatively weak. On this principle the case for watchmaker's lathe-making in this country is weaker than that for dye-stuffs. On the other hand, the argument based on natural disadvantages must not be pressed too hard in dealing with scientific industries, for these industries undoubtedly show a tendency to arise and flourish in those places in which the processes used in the industry were developed. Moreover, it is undoubtedly a misfortune for the industrial life of a country as a whole if a fair proportion of the most highly scientific trades is not included among its industries. The general tone and spirit of its manufacture is liable thereby to be lowered, for the best scientific men will not find openings in manufacture, and the status of the industrial man of science will tend to fall. We think, therefore, that it may be desirable for the State to take special pains to encourage those scientific industries which are recognised to be essential to the national well-being, and that accordingly the State may be well-advised to assume a greater responsibility for the cost of the necessary research for these industries than would in ordinary cases be admissable.

Other industries, though not so-called "key" industries, may at the moment need special support or encouragement either because they are languishing or because they are struggling to establish themselves for the first time with a reasonable prospect of success, but the question of assisting these will in normal times undoubtedly raise considerations of some difficulty.

The Council are also persuaded that if a healthy condition of inquiry is to be fostered in the scientific industries, they must for some time to come expend a good deal of attention and money upon convincing the manufacturing world in general that scientific research is a paying proposition. They believe that the shortest means to this end is an attack upon the pressing problems of manufacture which arise in the course of the ordinary routine—problems which the manufacturers ought, no doubt, to solve by means of their own scientific staffs, but which their present staffs are too small to undertake often because the firms are too small to bear the necessary cost. It was in this way that the universities of the middle States of America convinced the farmers that science was useful to agriculture.*

Indeed, we recognise fully that unless the generality of British firms can be induced to alter their present attitude we shall have failed profoundly in one of our appointed tasks. In the United States of America there has in certain industries been an earlier realisation than in this country of the large part which the systematic application of science has played in the rapid progress of German trade. In a Paper on "Science and Industry," which the Council intend to issue, Dr. Mees, of the Eastman Kodak Co., points out that three grades of laboratory are needed by every manufacturer who wishes to get the best results from the application of science to his business. First he needs the ordinary routine or "works" laboratory for controlling the quality of raw materials, finished products and processes. Next he should have what Dr. Mees calls an "industrial" laboratory or, as it might perhaps be described, an "efficiency" laboratory where "improvements in products and in processes tending to lessen cost of production and to introduce new products on the market" are worked out. Valuable as this type of work is, it does not go to the root of things; the results it can give are strictly limited. "Fundamental developments in the whole subject," in which a firm is interested require "something very different from the usual works laboratory . . . In every case where the effect of research work has been very marked, that work has been directed not towards the superficial processes of industry, but towards the fundamental and underlying theory of the subject." The function of the third type of laboratory—the true research laboratory—is to formulate this underlying theory. Without it Abbe's works on lenses, Abbe's and Schott's work on glasses, or the establishment by a firm in this country of the three alkaloids that go to make up ergot and the synthetising of two of them could never have been accomplished. This kind of research work involves, Dr. Mees tells us, "a laboratory very different from the usual works laboratory, and also investigators of a different type from those employed in a purely industrial laboratory. It means a large elaborately equipped and heavily staffed laboratory engaged largely on work which for many years will be unremunerative, and which, for a considerable time after its foundation, will obtain no results at all which can be applied by the manufacturer." The shortest period in which any considerable results can be expected is five years, while results so considerable as to affect the whole industry "cannot be looked for in less than 10 years' consecutive work."

If then, in the early stages of the scheme, we are prepared to recommend assistance to certain industries for the solution of some of the pressing problems with which they are for the moment confronted, we do so under no misapprehensions.

If a manufacturer has the necessary capital and has once realised the value of research, he needs no encouragement to continue. *L'appétit vient en mangeant.* But in other cases we believe the best procedure will be to demonstrate the value of research to industry by carefully selected object-lessons, and by the periodical issue of the pamphlets which will contain accounts of what has actually been accomplished and what needs doing in this field. In course of time we may hope to be able to abandon these missionary efforts and leave more time and money available for the big national problems that lie ahead.

American and German Practice.—It must not be supposed that all American industries or firms are as progressive as the Eastman Kodak Co., the General Electric Co., or the National Electric Lamp Association, which purchased a park of over 70 acres in which to build a series of research institutes for the service of the 20 odd factories included in their combine. America is still in the stage of experiment in this matter, and the experiments are worth watching. One such experiment is described in a pamphlet issued last year by the Director of Special Inquiries under the Board of Education.* It is interesting because it is a frank attempt to establish a connection between individual manufacturers and a university in a manner which will bring the advanced student, the university organisation and the individual firm into co-operation for research without hampering the academic freedom of the university professor or endangering the property in any results of the research which may belong to the manufacturer. A similar experiment has recently been started at Yale University, with the assistance of the brass and bronze manufacturers of the district, under which the trade pays the expenses of one or two years' post-graduate study and research for selected students under an agreement that half their time shall be devoted to the investigation of some problem in which the firms are interested, and which may in part form the basis of a research for the doctor's degree. Both schemes are said to be working well, though it is too soon to draw any certain conclusions. Research undertaken exclusively for the benefit of one among a number of competing firms either by a public institution or at the cost of the State is indeed always likely to give rise to difficulties. Universities and public research institutes are maintained by endowments and public funds for the common good, and any arrangement which gives exclusive rights or benefits to a single firm as against others in the same industry is not easy to reconcile with the public advantage. Even more true is this, as a general principle, of the use of the rates or taxes for such a purpose. It is often said that other countries, and Germany in particular, have made grants to firms for research, but so far as we can ascertain there is only one authenticated instance of a grant from public funds in Germany to an individual manufacturer for research or any allied purpose. The Prussian Government made a grant of, we believe, £10,000 to the firm of Schott in Jena to enable them to work out with Prof. Abbe on a practical scale the researches he had initiated into optical glasses. But Schott was at that time the only firm in Germany which made optical glasses—*i.e.*, it represented the whole industry—and this is a material point. The German Governments no doubt frequently assist a whole industry by suitable tariffs, preferential railway and canal rates and harbour dues; and, most important of all, the German States spend lavishly upon education, and especially upon their universities, their great technical and commercial high schools, and their national research laboratories such as the Physikalisch-technische Reichsanstalt in Charlottenburg and the Chemische Reichsanstalt at Dahlem. They have not, however, save in the single case referred to, used the taxes, either local or Imperial, to pay for research in the interest of a single firm; nor, so far as we are aware, have their universities and technical high schools ever given exclusive privileges to an individua manufacturer.

(*To be concluded.*)

* *Cf.* Reports of the Mosely Educational Commission to the United States of America, 1903, pp. 108 and 293-8.

* Educational Pamphlet No. 30, "An Experiment in Industrial Research." A full description is also given in a publication entitled "The Object and Work of the Mellon Institute," by Dr. R. F. Bacon, reprinted in the "Journal of Industrial and Engineering Chemistry," Vol. VII., No. 4, April, 1915.

THE CONNECTION OF ARMATURE COILS TO COMMUTATOR SEGMENTS.†

BY RUDOLF KNOLL.

If we take a commutator machine, and determine the positions of the poles and brushes, then a given armature coil must have its ends connected to given segments on the commutator. The author has frequently noticed how much time and trouble is in practice devoted to finding the requisite segments. The workman often makes a mistake about this, which is only detected when the finished machine is tested. Sometimes it is asserted that the whole thing is a matter of indifference. Text-books are quoted in which the point is altogether neglected, or in which it is stated that the connections can be made in any fashion. But this latter statement is only true if one is at liberty to place the brushes in any position. But with a given design of machine, the position of the pole and the setting of the brushes are definitely fixed from the first. In this case the connection of the armature coils to the commutator must be made on certain definite principles which have relation to the question of commutation. This

† Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 14, 1916.

is particularly the case with alternate-current machines, which are very sensitive to the correctness of the setting of the brushes.

The following notes are intended to explain the use of a simple formula by which the required segment on the commutator can be found.

$$L_m=\frac{a+b+1}{2}=\frac{y_k+b}{2}+1. \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This formula holds good for wave, lap and spiral windings, on the assumption that with the completed machine, the middle of the brush-position coincides with the middle of the main pole. L_m is that segment which is on the line AB in Fig. 1, on the assumption that AB is equidistant from the two slots; $a=y_k+1$ where y_k is the spacing reckoned in commutator segments; b is the number of conductors required to fill out the slot shown on the right in Fig. 1. (In this case, $b=2$.)

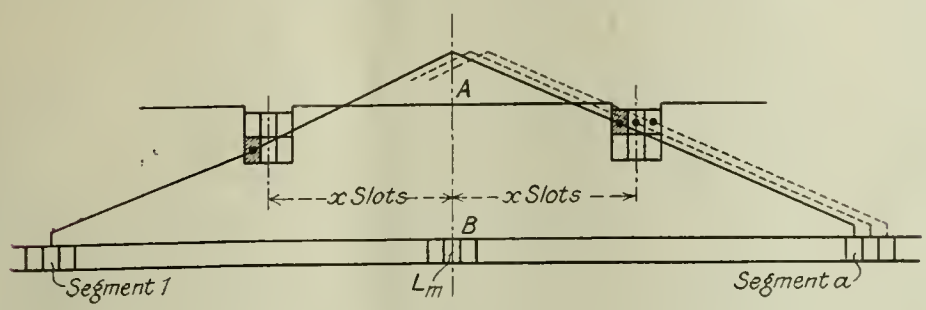


Fig. 1.

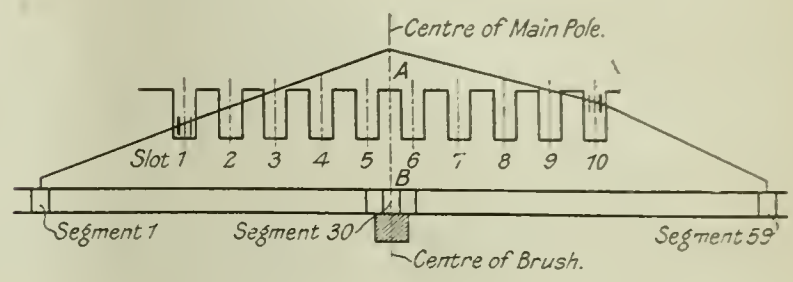


Fig. 2.

Fig. 2 shows diagrammatically a 12-pole motor with series-parallel winding. The number of the slots is 117, the number of the commutator segments is 351, the number of the armature currents is $2a$; *i.e.*, 6. Each slot has six conductors. The thickly-drawn conductors belong to the winding under consideration. Here $a=59$, $b=0$ and $L_m=30$; that is to say, the middle of segment 30 must coincide with the middle of the tooth between the slots 5 and 6, because the line AB is 4·5 slots distant from slots 1 and 10. The drawings for the armature and commutator ought, therefore, to show that in this case the middle of the tooth ought to correspond with the middle of the commutator segment. On the drawing showing the armature winding it should be stated that segment 30 coincides with the middle of the tooth 5-6. If the slots do not run straight across the armature in a direction parallel to the spindle, then the middle of a tooth must have reference to the mean position of the tooth, half way along the length of the armature. It is only if these points are taken into consideration in the design of the machine that it is possible to be certain that the motor will commutate properly in both directions of rotation. In case the machine is so designed as to allow the brushes to be displaced, this may help to adjust matters, but it is not always possible.

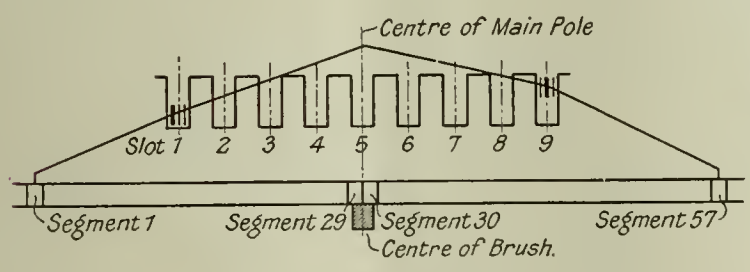


Fig. 3.

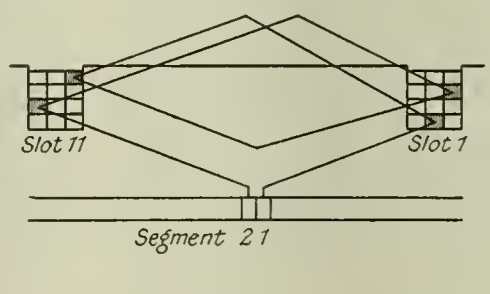


Fig. 4.

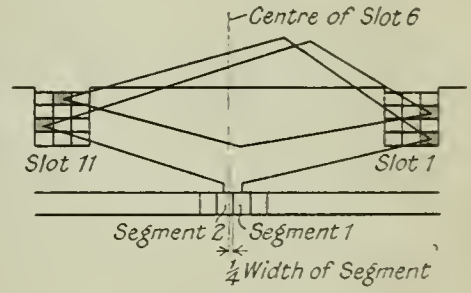


Fig. 5.

For Fig. 3, $a=57$, $b=1$, and $L_m=29·5$; that is to say, the middle of slot 5 coincides with the middle of the insulation separating the segments 29 and 30. A more complicated case is shown in Fig. 4. In each slot there are four rows, each containing three conductors. Let us suppose it is required to know with which segment the middle of slot 6 corresponds, it being supposed, as in the previous cases, that the middle of the brush coincides with the middle of the main pole. It makes no difference to the calculations if we re-arrange the positions of the conductors, so as to get the conditions shown in Fig. 5. The formula shows that, putting $a=2$, $b=0·5$, we get $L_m=1·75$. Therefore, the insulation between the segments 1 and 2 must be one quarter of the width of a commutator segment to the right of the middle of slot 6. For many types of machine, it is advisable on constructive grounds to displace the brushes with regard to the main poles by a definite angle. This is the case with direct-current railway motors, when the main poles are put vertically and horizontally, while the brushes are put 45 deg. to the right and left of the upper main pole. This must be allowed for either by adding or subtracting the proper numbers to the values given by the formula. The formula then becomes

$$L_m=\frac{a+b+1}{2}\pm V=\frac{y_k+b}{2}+1\pm V,$$

where V is the displacement of the brush position with regard to the middle of the main pole, expressed in segments of the commutator.

Fig. 6 is a diagram of a four-pole railway motor. The brushes are displaced with regard to the middle of the main pole by an angle of 45 deg. in the clockwise direction (looked at from the commutator side). The number of the slots is 37, and of the commutator segments 259. Each slot contains 4×7; *i.e.*, 28 conductors. Therefore, V is 32·375 segments, and we have

$$L_m=\frac{130+6+1}{2}-32·375=36·125.$$

Therefore, the middle of segment 36 must be displaced to the left of the tooth 5-6 by one eighth of a commutator segment.

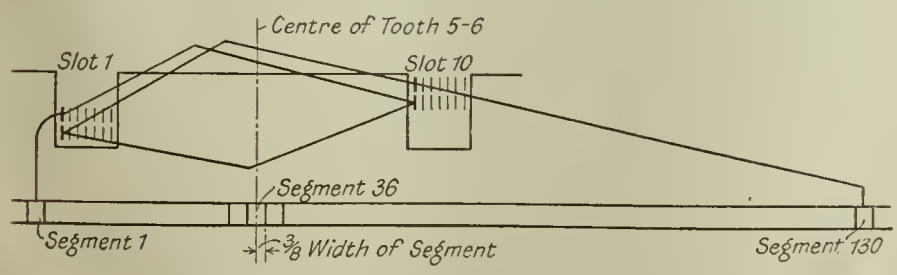


Fig. 6.

Testing Accumulator Electrodes Individually.—According to a writer in the "Electric Journal": "Cadmium readings" are taken on storage batteries by using cadmium as a neutral electrode to enable determination to be made of the relative capacities of the positive and negative plates. Voltage readings are taken between the positive and negative respectively, and the cadmium electrode. In a normal cell the + to cadmium reading is much larger than the − to cadmium reading. For example, if the + reading be 2·12 volts, the cell voltage will be about 2, because the negative reading would be about 0·12. As a cell discharges the + reading decreases, while the − increases. Readings for a cell discharged to 1·7 volts should be about 1·95 for the positive electrode and 0·25 for the negative. On charge the + cadmium reading is at first greater than the cell voltage, but during the charge the latter becomes equal to and subsequently greater than the former until when completely charged the cell is from 0·05 to 0·10 greater. The cadmium test electrode may be a ¼ in. rod of the metal 6 in. long, and protected by some porous sheath to prevent it from causing short circuits. The cadmium should remain in the solution for a short time before tests are taken.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential and a World wide circulation.** *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.*
Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preparation.*

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

"THE ELECTRICIAN" PRIMERS (84 Primers in all, and a GLOSSARY). Single Primers 3d. each post free. *In One Complete Vol.*, 10s. 6d. *nett, or Three Separate Vols. (Vol. I.* 3s. 6d. *nett ; Vol. II.*, 6s. *nett ; Vol. III.*, 4s. 6d. *nett).* Prospectus free. The Primers are revised or re-written as new printings are called for, and new Primers are added from time to time. Five New Primers: Gas Engines (No. 52), Oil Engines (No. 52A), Common Battery Telegraphs (No. 60A), Electric Clocks (No. 79), Electric Impulse Dials (No. 79A), now ready. Revised Primers, 1914 and 1915: No. 29 (Management of Dynamos and Electric Machinery); No. 46 (House Wiring for Electric Light) ; No. 63 (Repairing Submarine Telegraph Cables); No. 42 (Electric Ignition) ; No. 49 (Steam Engines) ; No. 54 (Comparative Advantages of Steam and Producer Gas for Power Production) ; No. 59 (Diplex and Quadruplex Telegraphy) ; No. 61 (Automatic Telegraphic Apparatus).

ELECTRIC TRACTION ON RAILWAYS. By Philip Dawson, M.I.C.E., M.I.E.E., &c. Handsomely bound ; fully illustrated. Price 25s. nett, postage 6d. U.K., abroad, 1s. 6d.

ELECTRICAL LABORATORY NOTES AND FORMS. Arranged by Dr. J. A. Fleming, M.A., F.R.S. Single copies 4d. nett, or in dozens at 3s. 6d. nett. Complete Sets of 50 Notes and Forms, 12s. 6d. nett, or in strong portfolio, 14s. nett ; or bound in strong cloth, 15s. nett. Spare Copies of Tabular Sheets, 1s. per dozen. Portfolios, 1s. 6d. each. Sectional paper, 1s. per dozen sheets. *Complete Prospectus post free on request.* These Notes and Forms are kept revised as new printings are required.

HANDBOOK OF THE ELECTRICAL LABORATORY & TESTING ROOM. Very fully illustrated. By Dr. J. A. Fleming. *Revised Editions.* Vol. I., 12s. 6d. nett. Vol. II., 14s. nett.

SECONDARY BATTERIES : THEIR CONSTRUCTION AND MANUFACTURE. By E. J. Wade. Price 10s. 6d. nett.

THE ELECTRIC ARC. By Mrs. Ayrton, M.I.E.E. Price 12s. 6d. nett.

INTERNATIONAL WIRELESS TELEGRAPH CONFERENCE, BERLIN (1903). Full Report of Proceedings at, 8s. 6d. ; post free, 8s. 9d. ; abroad, 9s.

INTERNATIONAL WIRELESS TELEGRAPH CONVENTION AND SERVICE REGULATIONS (BERLIN, 1906). With complete report of Proceedings. Price 15s. nett.

ELECTRIC SHOCK PRECAUTIONS (IN HANGING CARD, SHEET, AND POCKET BOOK FORM): A complete set of Electric Shock Rules and Precautions. In sheet form, also as a hanging card, also folded in envelope for the pocket. Sheets: 4d each, post free. Hanging Cards : 1/- each post free. Pocket Books, complete in envelope, 2s. 6d., post free.

Now Ready.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E

FIRST EDITION: Price **15s.** nett. post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

THE PRIVY COUNCIL AND RESEARCH.

It was in July, 1915, that the Government took the important step of appointing a Committee of the Privy Council, along with an Advisory Council to the Committee, to direct "the application of any sums of money provided by Parliament for the organisation and development of scientific and industrial research." We now have before us the first annual report of this body, and our readers will find an abstract of it in another column of the present issue. It is only to be expected that work of this kind, which is necessarily novel and rather of a pioneering character, should take time to get into full swing and that not very much information should yet be given as to the final results to be expected. Actually the report of the Committee itself is particularly brief. On the other hand, the report of the Advisory Council is probably much longer than most of us expected to see, but it is very general in its character.

The report starts by dealing with previous Government action on behalf of science in the present century ; but considering the meagre support that has been given in this direction we cannot help thinking that it would have been advisable to omit this introductory section. The statements that are made can only be read as a sort of apology. It is true that the National Physical Laboratory has been founded, but surely the first capital grant of £13,000 and the annual allowance of £4,000 for five years were so modest as to show a lack of appreciation of what was being done, or likely to be done, by other countries ; in fact the report admits that the work of the Laboratory might have been much greater had it been endowed with anything like the annual subvention of nearly £100,000 which the American Bureau of Standards receives for development and maintenance from the Government of the United States. Among the other steps taken by our Government is mentioned the support given to the Engineering Standards Committee. Surely this also has been of a parsimonious character and accounts for the high price at which the publications of this Committee are sold, thus defeating to a considerable extent, the object the Committee has in view. Perhaps, however, it is well that these small efforts, along with the Imperial Institute and grants to the Imperial College of Science, should be mentioned as an inducement to those in authority to spend more in the future.

Undoubtedly the weak point in the constitution of the Advisory Council was the comparatively small number of its members and the largeness of the field over which it was to have control. It is quite impossible for eight men, however eminent, to have a thorough knowledge of all the branches of scientific and industrial effort, and, therefore, fears naturally arose that applications for grants in particular directions would not receive that consideration which was desirable. We are glad to see that this objection is being overcome by the establishment of strong Standing Committees for various subjects. Only by such means can anything like satisfactory results be obtained, for work in these days is necessarily so specialised in many departments that only Committees of specialists can decide in which direction researches will be of the greatest utility.

We note that the Council takes the view that research in pure science should be as much their care as research in applied science. It is well that it should be so. The view may, perhaps, be held that public money should not be spent

to any great extent upon the encouragement of pure science, that this branch of knowledge should be allowed to develop in other countries where such encouragement is given, and that we in this country should take advantage of the results obtained thus cheaply, as and when we like. We do not think, however, that this is the best course to take. Undoubtedly, scientific results are free to the world over, but there is likely to be a very considerable gain to the country that cultivates such work, even at a cost to the taxpayer. The industrial application of scientific ideas, we think, is more likely to be carried out in the land of their birth than elsewhere. We refrain, however, from saying more on this point at the moment, as we hope to publish an article next week dealing with the whole question.

A good deal is said in the report about the difficulties that are encountered in fostering industrial research in this country, but we doubt if the Council have gone to the root of the matter—at least, the point we have in mind is not sufficiently emphasised. On the one hand, many of our firms have not much money to spend in research, and, on the other hand, secrecy is essential to such work. It is the secrecy which is the real difficulty. We imagine that almost any manufacturer would be willing to carry on research at the expense of the State, but he would wish to keep the results so obtained to himself. That is just the condition that the State cannot accept. With few exceptions, such exceptions being broad fundamental problems, the manufacturer wishes to benefit himself without benefiting his competitors. Suppose, for example, that he experiences difficulty with some of his productions. He is certainly not going to tell his competitors about his difficulties, and although it would be exceedingly helpful to have State aid in his troubles, the State obviously cannot fall in with such an idea. We cannot imagine, for instance, that the General Electric Co. of America, when starting their researches upon metal filament lamps, which researches culminated in the production of the extremely efficient gas-filled lamp, would have been willing to allow their competitors to know the results obtained as the work progressed. It was only after the advantages had been fully secured for the company itself that publication of the results took place, which, after all, is the course dictated by commercial common sense. The conclusion is forced upon us that the manufacturer must himself undertake specialised researches, and before he can do so he must be trading on a sufficiently large scale to carry the accompanying burden.

Although the report is only in the nature of a general discourse, we are devoting a good deal of space to its reproduction, for we hope that our manufacturers will give it their careful attention. If any national good is to come of this movement, it is essential that the facts should first of all be well understood.

MR. GERALD STONEY'S ADDRESS TO THE ENGINEERING SECTION OF THE BRITISH ASSOCIATION.

In considering the problems to be considered, both at the present time and after the war, a review of some of the errors committed in the past is most necessary.

As this is an address to the Engineering Section of the British Association for the Advancement of Science, only such problems will be considered as affect engineering and its allied industries.

One thing which has handicapped our industries is the reluctance of firms to utilise highly educated labour or to adopt scientific methods. One is struck by the small number of men who have undergone a thorough scientific training at one of the universities or at one of the leading technical colleges and who occupy a prominent place in the firms in this district.

The general complaint is that university and college men are too theoretical and not practical. It is the usual thing for a bad workman to blame his tools, and is it not because employers do not know how to make use of such labour that they utilise it to such a small and imperfect extent ? In some countries with which we have competed in the past, and with which there may be still fiercer competition in the future, we find the fullest use made of highly educated scientific labour.

How many engineering firms in this district have a skilled chemist on their staff, and what percentage of these pay him a decent salary ? And how many heads of firms have sufficient chemical knowledge to appreciate the work of and utilise the services of such a man, because unless there is appreciation of the work done by such a man his services are useless and he becomes discouraged, generally finding himself up against the blank stone wall of there being no appreciation of his services, and yet chemical problems are continually cropping up in engineering work. Apart from the question of the analysis of raw or partly manufactured materials received, there is the chronic question as to the mixtures of the metals, and large economies can be effected by systematic analyses.

Another direction in which scientific labour is invaluable is in seeing that instruments are in proper order and that tests are accurately carried out. Tests carried out with inaccurate instruments and without proper scientific precautions to see that they are accurate and reliable are most misleading and dangerous, as entirely unreliable inferences may be drawn from them and far-reaching troubles caused in the future. How many firms using steam have any arrangements for testing vacuum and pressure gauges ? and yet there are no instruments more liable to error than these gauges. When one tries to analyse the results of steam tests one is constantly up against the elementary question, " Were the gauges, &c., accurate ? What a misfortune it is that there were no means of testing their accuracy." Under scientific supervision arrangements are made to avoid such troubles and get reliable results which can be depended on for future designs.

What has been said about pressure gauges and the measurement of pressure applies, of course, to all other instruments and measurements. In most works, it may be said with sorrow, that the only moderately accurate measurements that can be made are those of dimensions and weight. It is only by accurate testing of existing plant that reliable deductions can be drawn enabling safe progress to be made in future designs.

One of the great things which helped forward the steam turbine in the early days was accurate and full testing of each plant as soon as it was completed and before it left the works. The late Mr. Willans was probably the first, or one of the first, to recognise the importance of accurate testing of steam plant, and the success his well-known engine had was largely due to this. From the earliest days of the steam turbine Sir Charles Parsons recognised the necessity of such testing, and the test house has always been a prominent feature of Heaton Works. Such methods have enabled the steam turbine to grow from 50-H.P. to some 45,000-H.P. or more in each unit, and the steam consumption to be reduced to less than one-fifth.

And closely allied to such work in engineering works is the general question of scientific research, and here a trained scientific mind is of the utmost importance to see that reliable results are obtained and to make true logical deductions from these results. Without suitable training a man is liable to be unable to grasp all the conditions of an experiment and to make deductions from the data obtained which are totally unjustified and often lead to most disastrous results in the future.

Such research is generally carried out in four places—engineering works, private laboratories, engineering colleges and national laboratories.

The first has already been dealt with, and the second is of comparatively small importance in practice. As regards the third, a great deal of good work has been done in engineering colleges, often under great difficulties for want of plant and money, and it is greatly to the credit of our professors and others that they have succeeded in doing so much with the very inadequate appliances at their disposal and handicapped for want of funds. How inadequate their income is can be understood when it is remembered that Leipzig University alone has an annual income from the German Government of £100,000, as against a total Government grant to *all* the universities here of about £45,000, or less than half.

Of national laboratories we have only one, the National Physical Laboratory at Teddington, and here again the support given to it is totally inadequate. The total income from all sources last year was only £40,000, and of this £23,000 was charges for work done : the Government grant is only £7,000 a year, and besides this £7,500 was received for experiments in connection with war work. Compare this with the Reichsanstalt of Berlin, which has an income of £70,000

a year from the Government, or with the Bureau of Standards, the similar institution in U.S.A., which has a Government grant of £110,000. In the Civil Service estimates of over £20,000,000, less than one-fifth per cent. is allotted to research.

It is difficult to realise what benefits might be gained by investigations which could be carried on by the N.P.L. if only sufficient funds were available. One example may suffice. Some time ago the Reichsanstalt carried out a most complete set of tests on a certain machine at a cost of several thousands of pounds sterling, apart from the time it occupied. The results of this investigation are available to German manufacturers, and before the war preparations were being made to take advantage of this, and from figures stated a large extra economy was expected. The Institution of Mechanical Engineers saw the importance of this problem, and appointed a Research Committee to deal with the question, but the first question met with is that of finance. Should this be the case in a wealthy country such as this, that depends on its manufactures for its very existence?

Investigations in engineering shops do not meet such a case. The question of finance has to be carefully watched, and as soon as results sufficiently good are obtained they are generally accepted, and in any case the problem is rarely thrashed out to the bottom, an almost universal defect in commercial research work. Without the help of the National Physical Laboratory the position of the aeroplane in this country would be very different from what it is, and what has been done for the aeroplane requires to be done in many other directions.

But what firm here would do what has been done in the commercial synthesis of indigo, on which it is said that 17 years' work and over £1,000,000 has been spent by one firm alone abroad? Here in chemical investigations and manufactures the Government refuse *even* to give the help of allowing cheap alcohol to be obtainable. Recently, under pressure, the restrictions have been somewhat relaxed by the Government, but the privileges granted are so tied up in red tape that the concessions are practically useless.

There is also much to be done in the way of putting the management and commercial sides of engineering and other allied works in a position to compete. The growth of engineering works and their being formed into limited liability companies has not been without its drawbacks. In the old days an engineering works was comparatively small, and as a rule one man was at the head. After his death, and often before, the place gradually fell into the hands of a body of men, many of them not technical, who had no further interest in the firm than to draw their salaries as directors and managers, and who had no financial stake in the concern beyond the shares necessary to qualify them as directors. The result is that the place gradually gets to a stage of not paying any dividends, and being kept going for the sake of the directors and other officials.

Such a firm as a rule does not put enough aside for depreciation, and thus its machinery and buildings degenerate and become obsolete, which makes it still less able to compete with more modern firms. At the same time it is not able to afford the money necessary to carry on the experimental and research work which is a necessity for any progressive firm, and thus its manufactures cease to progress with the times. As Sir Charles Parsons truly said, a man or firm in the face of financial difficulties cannot carry on research work, and, further, that the minimum spent on research work should be 1 per cent. of the turnover, and that the amount it is advisable to spend is 3 per cent. Unless a firm makes good profits it cannot keep up to date, and will sooner or later go to the wall.

But the workman says that he should have his share. What is his share under the present state of things? The average capital expended in an engineering works per individual employed is about £200. An investigation the writer made many years ago gave this figure, and it was confirmed by an investigation of shipbuilding yards, which gave £185, and of the cotton, which gives a capital of £1,500,000,000 for 7,000,000 workers, or £214 per head. An investigation of the dividends paid shows them to be about 4 per cent. on the capital employed. Here it must be remembered that firms paying 10 to 15 per cent. on their ordinary capital have often a large preference and debenture capital, on which a much lower rate of interest is paid, and also that often £100 of 5% ordinary capital was issued at a premium. Also account has to be taken of the large number of companies that do not pay any dividend on their ordinary stock, and often none on their preference. Little is as a rule heard of the finances of such companies; it is the ones paying good dividends that public attention is drawn to. It thus means that the shareholders get about £8 per year per individual employed.

On the other hand, the average wages for men and boys, skilled and unskilled, is about £70 per annum in normal times. This means that the worker gets between eight and nine times as much as the capitalist, and shows on what a very small margin the capitalist works. And without the capitalist, under our present system of individualism, there would be no factories erected and run, and therefore no work for the working man, a thing it is well for him to remember, and also that without profits the capitalist will not invest in engineering and other works in this country, but will seek for a more profitable field for his capital elsewhere. Every £200 invested in this country in a factory means work and livelihood for one British working man.

At the same time, I am sorry to say the employer does not look after the welfare of his workmen as he might. In a small factory the head of the firm, as a rule, knows all the leading men among the workmen, many of them having been with him for years. As the place grows he loses touch with his men. The result is that a most deplorable state of things has come to pass. The workman says, "Put not thy trust in employers"; the master says, "Put not thy trust in workmen"; and the official who is between the master and the workman says, "Put not thy trust in either."

It is difficult to say what is to be done to remedy this state of things, but one cannot help feeling much might have been done in the past to have prevented such a regrettable state of affairs as there is at present. Much of this trouble might have been avoided if employers had shown more consideration for the welfare of their workmen. Of course, there are some notable exceptions, but they are few and far between. An example is the necessity of the Factory Acts to ensure proper light and air and other arrangements necessary for the health of the workmen. But much more should be done. Why is it that canteens are being rushed up all over the country, and why were there so few before? In many works to this day the provisions for getting food and drink warmed are most primitive and inefficient, and as to getting anything to eat if one has to work overtime unexpectedly, it is in most works impossible. As a rule the only thing available was a drink at the public house outside the gates, and even this is now closed at five o'clock. Why if a man works overtime should he also starve? And how can efficient work be expected under such conditions? Why, also, should there not be provision for drying clothes after walking to work on a wet morning, and each man be provided with a cupboard where he could keep a change of boots? Why are not sanitary arrangements decently private, and why are they not kept clean and wholesome? They are often in a disgraceful state. These are only a few samples of the directions in which much might be done.

The adjustment of the wages to be paid to the workman is a most difficult one. There are three principal ways of paying workmen: on time, on piece and on bonus.

On time is the only way of paying a man who is on various classes of work. This results often in the highly skilled man making less money than the less skilled man who is working on piece or bonus, and this is obviously unfair. Again, highly skilled erectors who go outside the works to erect machinery, often worth thousands of pounds, and set it to work are only paid on time, and often make less money than their fellows who are on piece inside the works.

The adjusting of piece prices is a most difficult one. They should be adjusted so as to be fair both to master and man, but too often such fixing of prices is left to subordinate officials. The practice of cutting prices by the masters in the past is largely responsible for the present limitation of output by the men about which we hear so much. There is a rule that if a man makes more than time and half or time and third the price of the job is to be cut. If the price has been fairly fixed why should it be reduced because the man makes large wages due to his skill and industry? The larger the output from his vice or lathe the better for the master, as he is getting a larger output from his plant with a certain capital expenditure, and thereby establishment charges are reduced. This is especially the case on machine work, as the hourly value of the machine employed often far exceeds the wages of the workman employed. The result of this "time and half" rule is that a good man by working up to the limit of his capacity "spoils the job" for the next man who comes along, and may not be of the same calibre as the first man. It has, therefore, been found advisable and necessary by the workmen to limit the output of all men to a certain standard, and this results in the end by the pace being set by the slowest man on a particular job.

A fair bonus system is perhaps the ideal way of paying men, but here again in too many cases the times for a job have been altered, and as a result the system is looked on with suspicion by the workmen.

Gradually, bit by bit, the pernicious doctrine that the less work done by a man the more employment there will be has grown up. Be not astray that the cheaper an article can be produced the larger will be the sale for it and the better it will be able to compete with the products, not only of other producers in this country, but of those abroad. And also that very cheapness, combined with good quality, induces the sale for such articles to be large.

Laziness is inherent in man, and *on an average* no man will work unless compelled to do so, and still less will work his best unless there is a great inducement. This is true not only of the working man but of all other classes. The writer has very reluctantly come to the conclusion that the workman of to-day is not doing as much work as was done some 30 years ago, and not only this, but that time-keeping is not as good. In this connection, however, it must be remembered that excessive overtime inevitably leads to bad time-keeping.

With the growth in strength of the trades unions has grown up a system of trades union officials who live by agitation. These men keep the labour world in a constant state of agitation, and make the employers' and officials' existence a burden to them by constant demands of all sorts, many of them utterly impracticable and unfair. When they cannot agitate against the employer they agitate against another trades union. Some of the worst strikes in the past have been due to disputes between two trades unions.

Unless something can be done to bring master and man together and make both work for the common good the supremacy that England has in the engineering of the world will come to an end. Nothing ever was a truer statement than that recently made by Lord Joicey that this country, unless it produces as cheap or cheaper than other countries cannot in the long run keep her trade, and this is true in spite of any tariff walls which may be set up. And if the present state of affairs is maintained of unscientific management and obsolete machinery, combined with limitation of output and high wages, we must sooner or later go to the wall. What is really wanted is common honesty and common sense on both sides, for one side is as bad as the other at present.

And now about the official who comes between the master and the man. Unless he is treated fairly by the master, and unless he treats his men fairly, there is sure to be friction and loss of efficiency. He must also work with his fellow-officials, and to prevent jealousies and to prevent the more unscrupulous taking unfair advantages, demarcation of each official's duties and work is most important. The duties of each man should be clearly defined by the master, and no interference with those of others tolerated. Much more could be said about the relations of the official both with his fellow-official who is on the same level as himself, with his master who is above him, and the workman who is under him, but time forbids. On all three sides much improvement could be effected. The fact remains, however, that for success it is essential that all, from the apprentice to the head of the firm, should work as one homogeneous whole.

Apart from the considerations set out above, combinations among the firms employed in any one trade are most essential for the well-being of that trade. It is by such combination that much of the progress made of late years by our competitors has been effected. Such combinations, to be successful, must be worked fairly to all members, and the larger firms must not override the smaller.

If the Armament Ring in this country had taken such a view when it was found what an enormous supply of munitions was required it is doubtful if there would have been such a shortage as there has been. Under pressure from the Government, the Ring accepted outside help, and in many cases the conditions imposed on the sub-contractors were unfair in the extreme, apparently the whole idea of the Ring being to make all the profit they could out of the troubles of the Empire. It has been just as difficult to persuade the Armament Ring to give up what they thought was their monopoly and to bring in outside works to help in the production of munitions as it has been to persuade the trades unions to forego trade customs and to enable outside sources of labour to be employed. But both have had to do it. In other words, "dilution of works" has been as difficult to effect as "dilution of labour."

Combination among workmen is admittedly a necessity if they are to have fair play, but combination among employers has come later and is equally a necessity.

At present most of the principal federations of employers deal only with wages questions and questions affecting labour, but they require to be extended so as to take in all branches of the business of engineering. Labour has long seen the importance of federation; it is now for capital to do the same. One of the great difficulties has been that certain firms would not join, and a very small proportion acting thus weakens the whole to a much greater extent than the actual ratio of this small proportion of the whole. Such combinations are not only for labour questions, but also for all other subjects affecting the engineering industry at large, and more especially the special industries in which any one firm deals. Thus they resolve themselves into general federations of all engineering industries and minor ones dealing with particular trades. The former deal chiefly with labour questions and questions affecting the industry as a whole, the latter with those affecting any particular trade. Among the questions coming up to be considered by the latter class is the standardisation of specifications and conditions of contracts, as well as in some cases the adjusting of prices to avoid unfair competition, and to put the whole trade on a paying basis. Much has been done in this direction, with most advantageous results in certain cases, but much more remains to be done if this country is going to hold its place in the world.

The necessities of research work have already been dealt with, and by the pooling of such research work enormous advantages in any one trade could be obtained. Such pooling of information has been effected with most beneficial results, especially in the chemical trade abroad. Any workable scheme which would enable this to be done and get over the jealousies between one firm and another would be of enormous benefit to the trade in general.

Another thing that must not be lost sight of is the urgent need of improving our educational system. It is little short of a disgrace that the older universities are closed to those without a knowledge of Latin and Greek. Languages are of the greatest importance to an engineer, but not dead languages, but live ones. And it is only in live languages that a man is trained to speak and understand a language. At the same time, no education is complete unless science is combined with languages and also literature, and here lies one great danger of modern technical education.

After the boy has left school and enters the shops more facilities should be given to enable him to continue his education. In the shops and drawing office, too often the boy is left to pick up a knowledge of his trade as best he can. The apprentice who asks questions is often looked on as a nuisance, and requests for information are generally met by a blank refusal or worse. Often the foreman or chief draughtsman is afraid to answer questions for fear of being charged with giving away so-called "trade secrets," but an immense deal of information can be given to an apprentice without doing so.

Evening classes are all very good in their way, but more facilities should be given for the diligent apprentice to attend day classes, and this can be arranged in various ways if the employer has a will to do it. A thing that at present often prevents boys desirous of educating themselves getting on is the fact that overtime is allowed as soon as a boy is 18, and often he is compelled to work overtime regardless of classes that he ought to be attending.

One complaint is that after a lot of trouble is taken about a boy he leaves after a few years and goes to another employer. The good of the trade in general must be considered, and a man who has had experience of various classes of work is generally a much more valuable man than one whose knowledge is confined to one class only. In any case, the other employer gets the benefit of what has been done by the first, and thus the trade in general benefits.

It is felt that this is a very imperfect review of things as they are at present, but if this Address induces all classes engaged in engineering to consider how things can be bettered the author feels that a part, at all events, of his object has been attained.

THE INFLUENCE OF PRESSURE ON THE ELECTRICAL IGNITION OF METHANE.*

BY W. M. THORNTON, D.SC., D.ENG.
(Professor of Electrical Engineering in Armstrong College, Newcastle-on-Tyne.)

1. The Gas Methane.

Methane, CH_4, is the lightest and simplest of the paraffin series hydrocarbons, having a density 0·55 that of air. At atmospheric pressure it ignites between 650°C. and 750°C.[1] Its limits of inflammability are 5·6 and 13·8 per cent. of the gas in air [2] when ignited at the open end of a horizontal tube. If the temperature is raised before ignition mixtures as weak as 3 per cent. are inflammable.[3] It has at high pressures a remarkable affinity for oxygen, much higher than has hydrogen,[4] and there is some evidence of this at atmospheric pressure.[5] It is nevertheless more difficult to ignite by electric sparks.[6, 7] Pit gas in England derives its inflammability from methane. Ordinary house gas contains from 30 to 40 per cent. of methane, together with hydrogen, carbon monoxide and smaller quantities of unsaturated hydrocarbons. Because of its extreme practical importance and of its relative inertness the present experiments on the influence of pressure on gaseous ignition have been made with methane, in the mixture 9·5 per cent. in air, which just gives perfect combustion.

2. The Electrical Sparks Used.

The limits of inflammability of gases have been measured mostly at atmospheric pressure and by streaming spark discharge. At lower pressures ignition is more difficult, and fails at some definite

* Paper read before Section G of the British Association at Newcastle.

pressure, which depends on the kind of igniting spark. A stream of sparks or one drawn out slowly has all the thermal properties of a steady flame, but in modern practice ignition is usually by single electrical impulses.

There are four kinds of single spark which may be used for experimental ignition, each of which has characteristic features, and all but one of which is in practical use. These are: (1) A transient electromagnetic impulse, (2) the discharge of a condenser placed across the gap, (3) the short arc formed at the point of breaking a continuous current circuit, (4) the same with alternating current. The last two differ so much in some of their effects [6] that they have been examined separately. In each of these groups there are sparks which do not ignite the most inflammable mixtures of highly combustible gases and air.

Although an impulsive or jump spark starts by ionisation, usually across a fixed gap, its igniting power has been shown to follow a different law from that of rupture alone.[5] Condenser discharge passes just before metallic contact of two terminals which are being brought together, and when the charging voltage and the poles are the same throughout occurs at the same spark length. It is, however, an exceedingly rapid effect, and it is probable that the ionisation with which it starts is masked by the intense activity of the discharge, so that the ultimate ignition is proportional to its energy or power.

The two circuit-break sparks are less simple. They are streams of electrons following a path which becomes more difficult as the gap opens. The momentum of the electrons of this stream is comparable with that of the molecules of gas around it. The latter, therefore, penetrate the arc, and are exposed to the dissociating influence of its high temperature. The conditions of ignition arise from the collision of the gas with the ions in the arc. The action is no doubt partly thermal and partly ionic; in some cases ignition is proportional to the current, in others, its change is proportional to the current squared. The extraordinary variety of the reaction between gas and spark, indicated by the limiting electrical conditions of ignition, is not to be accounted for on a simple thermal basis.

3. Ignition by Impulsive Coil-discharge.

Ignition at atmospheric pressure has been shown to have steps [7] which appear, as the percentage of gas is varied, in certain well-defined mixtures. The precise origin of these steps is still obscure, but there can be no doubt that they are examples of selective action which occurs at certain frequencies of collision between the molecules of combustible gas and oxygen. The evidence for this is twofold. In the first place the steps, either up or down, occur in mixtures in which the proportions of the atomic volumes of the two gases can be represented by whole numbers. In methane,[7] hydrogen [7] and cyanogen,[5] for example, there are distinct steps, as in Table I., the limits being regarded as steps.

Table I.

Methane, CH_4.			Hydrogen, H_2.			Cyanogen, C_2N_2.		
$O : CH_4$.	% in air.	Step.	$H_2 : O$.	% in air.	Step.	$O : C_2N_2$.	% in air.	Step.
9	5·55	5·6	½	9·35	9	5	7·6	7·5
4	9·35	9·8	1	29·2	29	4	9·3	9·0
7·2	10·5	11·0	2	45·2	45	3	12·2	12·0
3	12·0	12·0	3	55·2	54	2	17·1	17·5
5/2	15·0	14·8	4	62·2	..	1	29·2	29·0
...	..	...	5	67·4	..	½	35·4	34·5
...	..	...	6	71·2	c. 70	¼	38·0	38·0

These were, however, not all obtained with the same kind of ignition. The occurrence of the steps in some gases with one kind of spark, in others with another, clearly depends on an intimate, but at present unknown relation between the physical or chemical properties of the molecule, possibly on its structure,[8] and the nature or duration of the spark.

Secondly, direct evidence that the steps are due to selective absorption is given by the ignition of hydrogen with alternating current break sparks. In a mixture of 25 per cent. of gas in air and at a pressure approaching 40 lb. to the square inch a step is obtained having the well known form of Fig. 1.

This type of change occurs in nature wherever there is selective absorption. In spectra it is known experimentally as Kundt's Law, and is there represented mathematically by a dispersion formula of the type—

$$\mu^2 = \mu_0^2 + \frac{M_1}{\lambda^2 - \lambda_1^2} + \frac{M_2}{\lambda^2 - \lambda_2^2} + \ldots,$$

each of the variable terms making the refractive index μ pass through an infinite value as the wave-length λ coincides with $\lambda_1, \lambda_2, \ldots$.

In the present experiments with methane, at pressures lower than atmospheric, the least igniting impulsive spark is measured by the primary current of the induction coil, which, when broken, causes a single secondary spark just giving ignition. This varies with the pressure, as in Fig. 2.

The two curves given are with gas prepared by different methods and are seen to agree singularly well when the difficulties of obtaining the same conditions for every spark and precisely the same gas mixture are known. The fact that the steps are so clear is a proof that the selective action is definite and capable of quantitative determination. If it is to be admitted that the primary difficulty in ignition

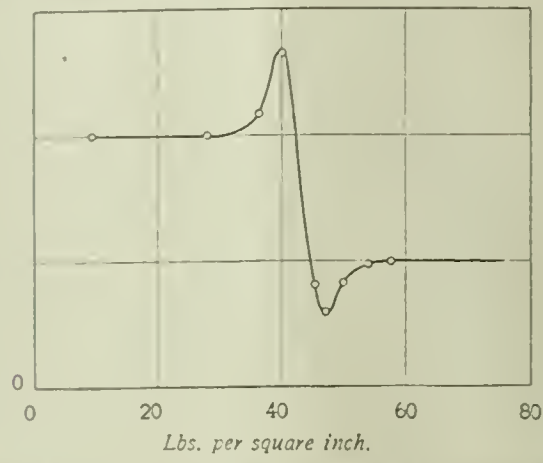


Fig. 1.—Change with Pressure of Least Alternating Current Igniting at Break a 25 per cent. Mixture of Hydrogen in Air.

is the finding by each combustible molecule of oxygen atoms with which to combine, the steps of Fig. 2 may be explained as follows: The collision frequency between combining molecules, or atoms when there is dissociation, can be changed by varying either the total or the partial pressures, that is, either the pressure in the explosion vessel or the percentage of combustible gas in the mixture. The latter has been shown to give rise to steps,[7] and in Fig. 3 of the present Paper they are also found by change of total pressure. The reduction of the total pressure by one-half has the same effect on collision frequency as halving the percentage of gas in a mixture at atmospheric pressure. The mixture used in the present work being $CH_4 + O_2$, or 9·35 per cent., a change to $CH_4 + O_3$, or 12 per cent.,

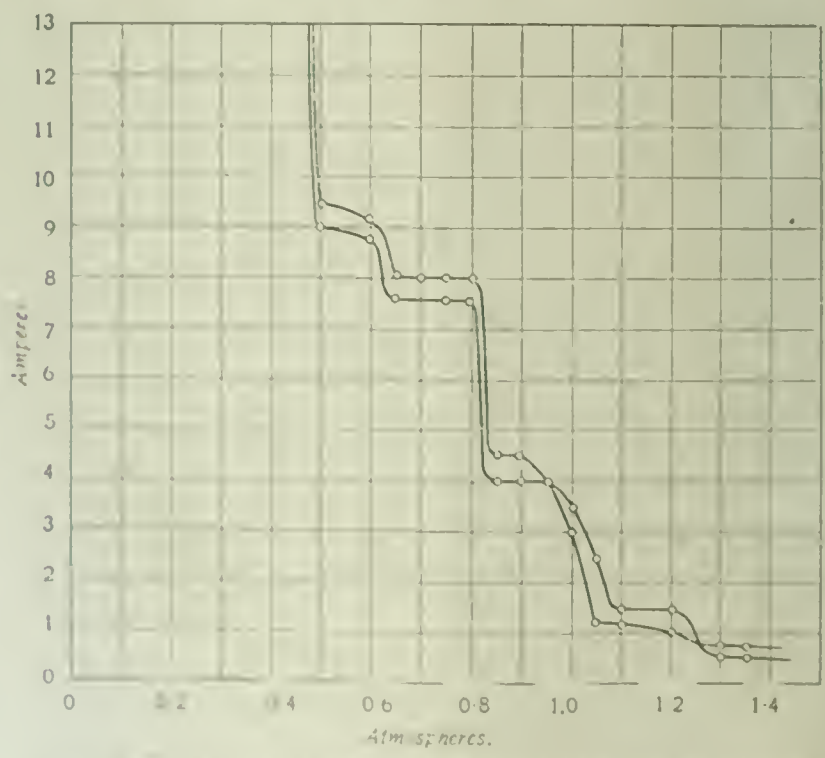


Fig. 2.—Ignition of Methane in Air by Impulsive Sparks. Platinum Points.

has the same effect on the number of collisions as a change of pressure in the ratio 9·35/12, that is, 0·78. The 9·35 mixture being at atmospheric pressure (and the electrical conditions suitable for selective absorption to occur), a step might be expected at 0·78 atmosphere. There is a step at 0·8 atmosphere.

The next step, corresponding to $CH_4 + O_2$, or 17·1 per cent. in air, would be at 9·35/17·1, or 0·54 atmosphere. There is a small step at 0·6 and a large one at 0·5. In Fig. 3 it is shown that steps arise from change of pressure at successive multiples of an atmosphere. In the same way they are to be expected at sub-multiples of an atmo-

sphere, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$..., and there is evidence for each of these, which will be given elsewhere. By a well-known theorem an oscillation of any frequency can be replaced by two, of higher and lower frequency approximately equidistant from it. Thus, if by nearness to the strong effect at half pressure the 0·54 step is suppressed one should appear at about 0·61 atmosphere, and this is found to be the case.

At pressures higher than an atmosphere the collisions with oxygen are increased. Thus, CH_4+O_5, or 7·5 per cent., should on the present view give rise to a step at 9·35/7·5, or 1·24 atmosphere, and, as shown in Fig. 2, such a step is found.

The interpretation of these steps must by the nature of the case be tentative. After consideration of every possible cause this appears to be the only one capable of explaining the facts.

When the mixtures are compressed before ignition there are also steps in the least igniting current curve which are very suggestive. The pressures at which they occur are 1, 2, 3, 4 and 5 atmospheres, absolute, as shown in Fig. 3, the abscissæ of which are, however, pressures above atmospheric.

From this there can be no doubt that the steps are caused by the collision frequency reaching successive multiples of that at atmospheric pressure. It is, therefore, a physical effect, and will be shown to support the conclusion, which has been given elsewhere on other evidence, [9], [10] that in gaseous explosion collision mechanics of the simplest kind are of importance.



Fig. 3.—Impulsive Sparks, Nickel Points.

The pressure most favourable to ignition by impulsive sparks is between two and three atmospheres absolute. There is reason to believe that the steps continue to much higher pressures, and this is now being investigated.

The ignition of methane by impulsive discharge, therefore proceeds *per saltum* as the pressure is changed, this being an example of selective absorption of a kind to be considered later. The step is not to be regarded as discontinuous but to follow the usual laws of dispersion by a resonating system.

4. Ignition by Condenser Discharge.

This differs from the above in two important features. (1) The best igniting spark is *independent of the pressure* from the lower limit at half an atmosphere to just above one atmosphere and so forms one step. (The value of the least igniting capacity was 6 mfd. charged to 150 volts, at every pressure down to 0·5 atmosphere below which ignition by condenser sparks failed completely.) (2) As the pressure is raised ignition becomes *easier* and there are steps, but now down, as 30 lb., 60 lb. and 85 lb. per square inch are approached. In Fig. 4 there are steps at 1, 3, 5 and 7 atmospheres, but not in this case at 2, 4 or 6.

Apart from their physical interest these results are of some practical importance. The curve of Fig. 3 is for ordinary magneto ignition; those of Fig. 4 correspond to the Lodge ignition by condenser discharge, the high effectiveness of which is well known, especially in poor mixtures highly compressed, which cannot be readily ignited by magneto sparks. Electromagnetic jump sparks and condenser discharge, therefore, proceed in opposite directions, one becoming easier as the pressure is raised, the other more difficult. The former are examples of the relatively slow process of ionisation by collision, which is more difficult at high pressure. Condenser

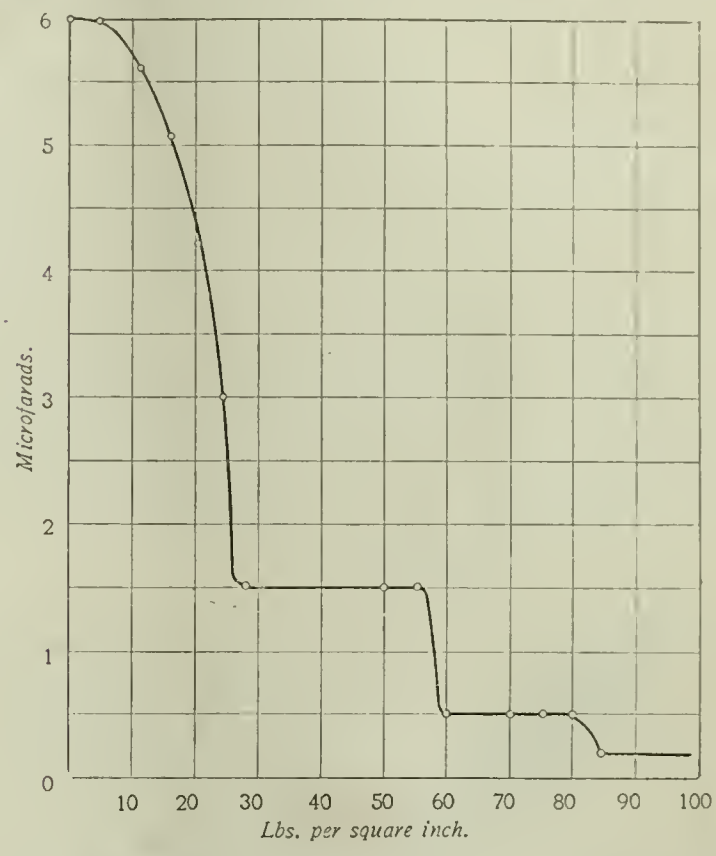


Fig. 4.—Condenser Discharge, 150 volts, Platinum Points.

discharge, on the other hand, is one of the most sudden phenomena in nature, and the spark is, in addition, of high enough temperature to pit platinum freely. Most of the energy of charge is dissipated in the spark. This is equivalent to the combustion of a definite mass of the gas, and the heat of the spark is rapidly communicated to the gas around. If the mass of the latter heated to ignition temperature is equal to or greater than that whose combustion would set free as much heat as there is in the spark, self-ignition can proceed. A short calculation from the observed least igniting capacity will serve to

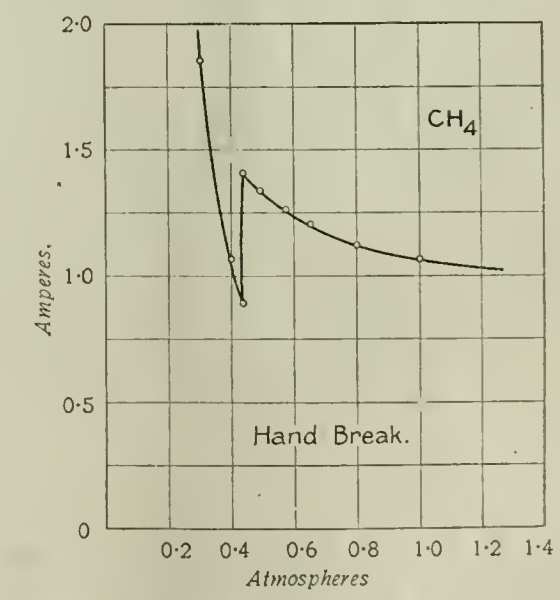


Fig. 5.—Continuous-current, 100 volts, Crossed Platinum Rods.

show that there is more than sufficient energy for the purpose, the remainder being absorbed by the poles or radiated, but the ratio of division cannot at present be measured.

Compression increases the mass of gas in contact with a spark of a given magnitude. It follows that at the higher pressures a smaller spark, provided that its energy is given to the gas as heat, should cause ignition.

On this view the product of least igniting capacity and gas pressure would be constant as a first approximation. The occurrence of steps rising as the pressure is lowered is a modification of this by

selective collision. The next two kinds of ignition illustrate a smoother type of charge.

5. Ignition by Continuous-Current Circuit Break Sparks.

Below atmospheric pressure the least igniting current is found to increase, so that the product of the current and pressure is approximately constant, until at half an atmosphere there is a sudden and most remarkable increase of inflammability. The curve of Fig. 5 dips sharply and rises to the lower limit at a third of an atmosphere. The simplest explanation of this is that it is a continuation of the selective action which gives rise to the steps at higher pressures. Every gas examined, that is, hydrogen, methane, ethane, propane, carbon monoxide and coal gas, exhibits this effect; in hydrogen it is so great that at the dip the igniting current falls almost to zero, the mixture being those for perfect combustion. If, however, the break of circuit is made *slowly* the dip is entirely wiped out and the curve is hyperbolic.

In order to examine the influence of rate of break, which could not be done with certainty with hand, the electromagnetic arrangement of Fig. 6 was used. The current to be broken was led through a brass tube containing an iron plunger carrying at its lower end a platinum head. The explosion tube being set at 45 deg. the rod rested on the lower platinum point, making contact, and was drawn up by a separately excited solenoid, the current of which could be varied to give any desired speed of break. When the break was relatively slow the lowest of the three curves of Fig. 7 was obtained; increasing the speed of break caused the least igniting current to take the form of the upper curves each of these having the same rate of break throughout.

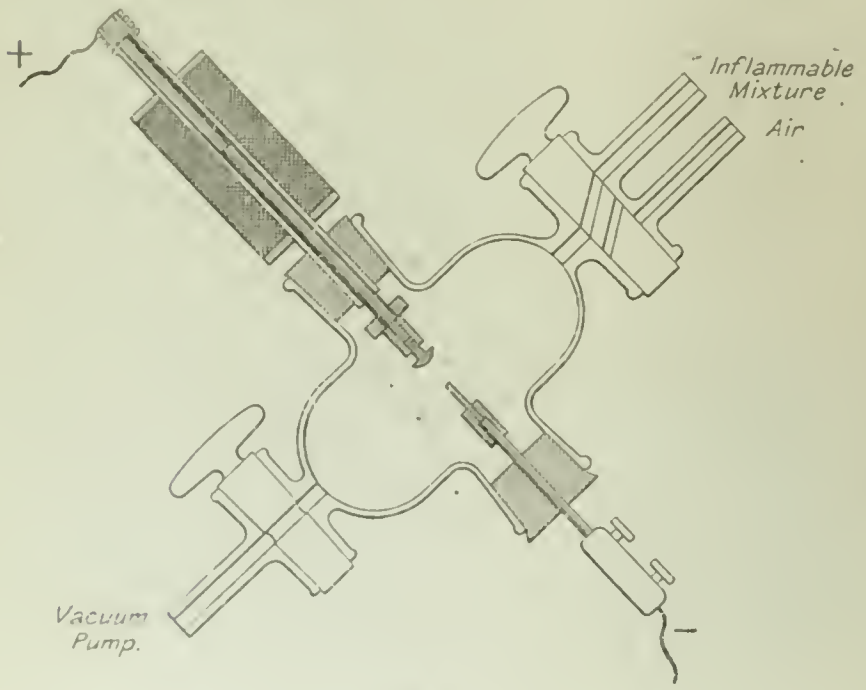


Fig. 6.

There is, therefore, a critical relation between the collision frequency and the spark duration necessary for the observance of this effect. Above atmospheric pressure there is the singular result that the least igniting current is almost independent of pressure, falling slightly at the highest pressures. This is obtained at all voltages from 50 to 180, as shown in Fig. 8.

Continuous-current spark ignition is, therefore, midway between impulsive and condenser ignition; that is, it is not a simple energy effect, for this would cause a falling curve with or without steps, nor does it work by ionisation alone. It would appear to be a very fair mean between ionic and thermal ignition.

6. Ignition by Alternating-current Break Sparks.

Since these have been shown elsewhere to have some of the features of condenser sparks as regards the order of difficulty of ignition by poles of different metals,[11] it might be expected that the current curve would resemble Fig. 5. At the lower pressures (Fig. 9) it follows the type of continuous current slow-speed ignition; that is, the thermal action of the spark predominates, and at the higher pressures it remains nearly constant in value up to pressures approaching 80 lb. per square inch, when it suddenly becomes easier, as shown in Fig. 10.

This kind of spark has not been used in practice, but where break spark ignition by a movable tongue is still in use it might have some advantage. The best voltage (of 150) is readily obtained by transformation. It is, however, better, if possible, to use continuous-current ignition with some inductance added to the circuit. Fig. 10 is of further interest from the fact that there is no step found until the pressure of 80 lb. is reached. At this point the similarity between alternating-current break sparks and condenser ignition, which is also alternating, begins to be evident. Pressure shortens the duration of any break spark, and brings it more into line with, though still longer than, condenser discharge.

7. Stepped Ignition.

To start combustion in a gaseous mixture one or both of the combining molecules must be "activated." Recent work on the formation of oxides of nitrogen by electric arcs[12] has shown that previous ionisation of the oxygen by exposure to streams of sparks greatly increases the yield, while a similar treatment of the nitrogen has less effect. This has not yet been tried with inflammable mixtures; but since almost all the critical ignition data of gases in air, such as the limits of inflammability, points of formation of

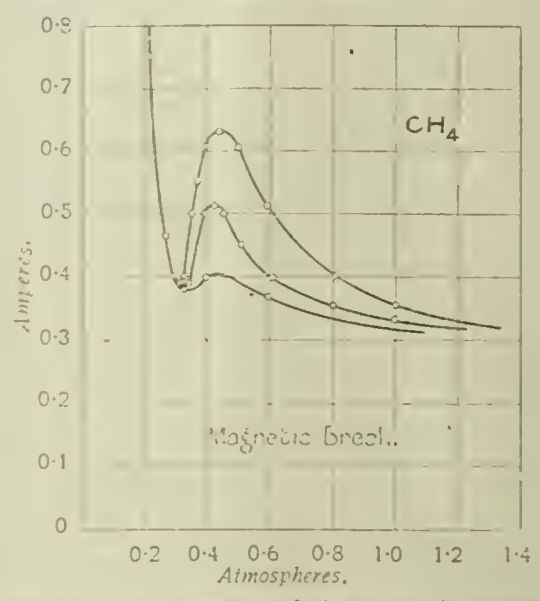


Fig. 7.—Continuous Current, 240 volts, Platinum Points.

steps, most easily ignited mixture, depend directly on the proportions of oxygen present, it is probable that ignition starts by activation of the oxygen molecule.

The resonance that gives rise to the selective absorption of energy which occurs at a step is clearly between the number of collisions in unit time, to which the pressure is proportional, and the number of molecules formed in that time under the influence of the spark, that is to the proportion of oxygen to combustible gas. Varying either of these, keeping the other constant, gives rise to steps when the gas pressure or the proportion of oxygen is a multiple of that in the mixture for perfect combustion at atmospheric pressure.

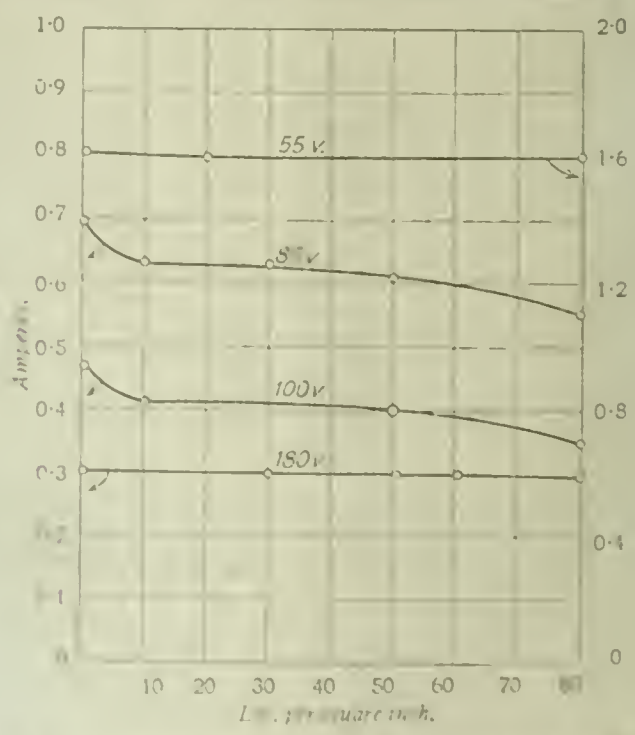


Fig. 8.—Continuous Current, Electromagnetic Break.

In the formation of disruptive sparks there is always a period of retardation during which ionisation by collision is reaching saturation. This period increases with the pressure and delays ignition, which becomes more difficult as the pressure is raised.

If, on the other hand, the spark-gap is so short, as it is with condenser discharge, that the period of retardation is negligibly small and the spark is of so sudden a nature that it acts immediately as a source of heat, there is a series of steps descending as the pressure is raised, for the more molecules there are then formed by contact with the spark the more heat is set free and the less is required in the spark to start ignition.

8. Summary.

The influence of small changes of gas pressure upon electrical ignition is important in coal mining. Apart from the effect of pressure on the presence of gas or the dryness of the mine, a change from a low barometer of 28 in. to a normal 30 in. somewhat increases

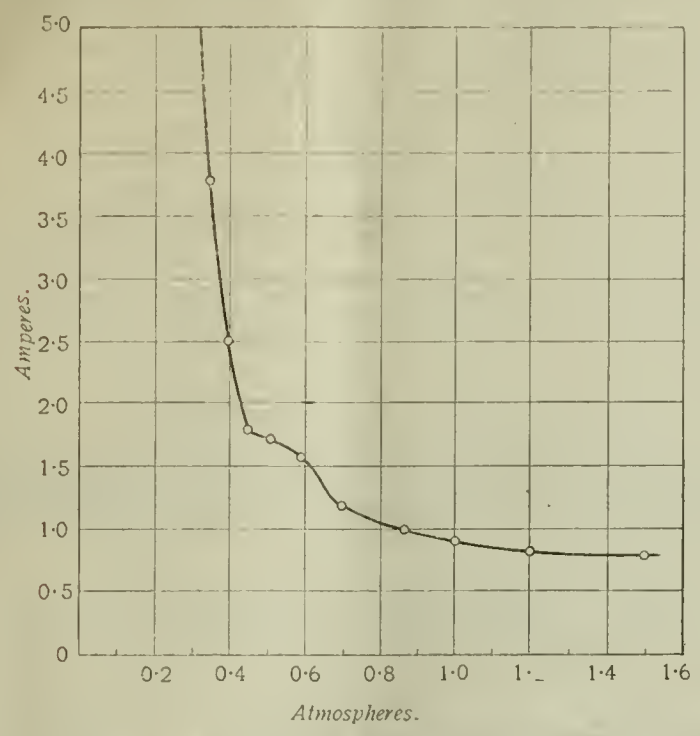


Fig. 9.—Alternating Current, Break Sparks, 200 volts, 36 ∿, Platinum Poles.

inflammability by impulsive sparks, as shown in Fig. 2, but has little effect on that by condenser or circuit break sparks.

The compression of an explosive mixture increases its inflammability by condenser sparks, and lowers it when the sparks are impulsive. Circuit break sparks have the same igniting power over a

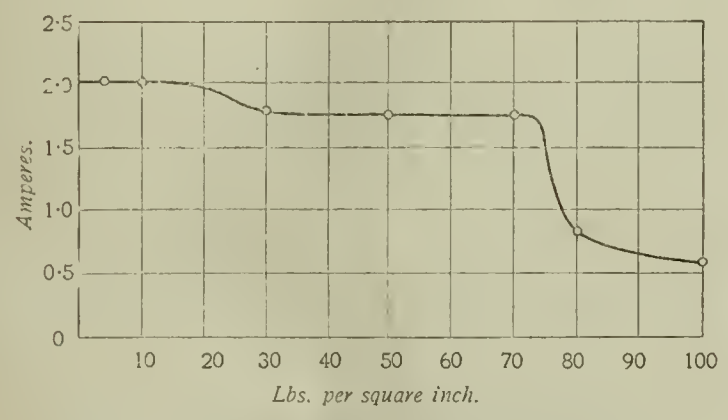


Fig. 10.—Alternating Current, 100 volts, 80 ∿.

long range of pressure. In every case there are mixtures in which ignition is abnormal, giving rise to steps or sudden changes in the form of the curves of observations.

The present work was carried out by the aid of a Government Royal Society grant.

REFERENCES IN THE PAPER.

[1] "The Ignition Temperature of Gases," by H. B. Dixon and H. F. Coward. "Jour." Chem. Soc., Vol. XCV., Pt. 1, p. 514, 1909.

[2] "The Limits of Inflammability of Mixtures of Methane and Air," by M. J. Burgess and R. V. Wheeler, "Jour." Chem. Soc., Vol. CV., p. 2591, 1914.

[3] Taffarel and Le Floch. Comptes Rendus.

[4] "Gaseous Combustion at High Pressures," by W. A. Bone and others. Phil. "Trans." Roy. Soc., A, Vol. CCXV., pp. 275-318, 1915.

[5] "The Ignition of Gases by Impulsive Electrical Discharge," by W. M. Thornton. Roy. Soc. "Proc.," A, Vol. XCII., p. 398, 1916.

[6] "The Electrical Ignition of Gaseous Mixtures," by W. M. Thornton. Roy. Soc. "Proc.," A, Vol. XC., p. 272, 1914.

[7] "The Ignition of Gases by Condenser Discharge Sparks," by W. M. Thornton. Roy. Soc. "Proc.," A, Vol. XCI., p. 17, 1914.

[8] *See* 7, *loc. cit.*, Fig. 1.

[9] "The Lost Pressure in Gaseous Explosions," by W. M. Thornton. "Phil. Mag.," July, 1914, p. 18.

[10] "The Total Radiation from a Gaseous Explosion." "Phil. Mag.," Sept., 1915, p. 383.

[11] "The Reaction between Gas and Pole in the Electrical Ignition of Gaseous Mixtures." Roy. Soc. "Proc.," A, Vol. XCII., 1915.

[12] "The Fixation of Atmospheric Nitrogen," by J. Knox, D.Sc. "Chemical Monographs," pp. 20 to 34.

LEGAL INTELLIGENCE.

Prevention of Corruption Act Prosecution.

At the Atherstone (Warwickshire) Police Court on the 29th ult., W. H. Moore, of the Atherstone Motor Co., appeared in answer to three charges brought by Mr. Arthur Goodwin, president of the Motor Trade Association, under the Prevention of Corruption Act for giving a false invoice on April 6 last to A. A. Goodyear, a chauffeur driving a car for a firm of motor car manufacturers with intent to cheat the employers.

Mr. A. C. Crane (prosecuting) said the attention of the Association had been drawn to a widespread practice over the country whereby owners of motor cars were defrauded by invoices being made out for their chauffeurs for greater quantities of petrol than were actually purchased, and it having come to the knowledge of the Association that the Atherstone Motor Co. was a place at which such invoices were obtainable, the present case was instituted in order that it might be made known that such practices must be stopped.

It appeared from the evidence that on April 6 Goodyear, being in charge of a car for his employer, called and spent 5s. for 2 gallons of petrol, and was asked by Moore whether he should make out the invoice for three, to which Goodyear assented, and the invoice produced in court receipted for 7s. 6d. was then given him although 5s. only was paid.

Defendant admitted the charge, but understood from the chauffeur that nothing would ever be said about it.

In fining defendant £10 the chairman remarked that the Bench dealt leniently because it was the first offence, and possibly its nature not fully realised, but it must be understood that other offenders of this kind would not be so leniently dealt with; indeed, if it had not been for the leniency of the prosecution in giving evidence on one summons only, and withdrawing the others upon his admission, he might in the present instance have been sent to prison without the option of a fine.

EDUCATIONAL.

University of Manchester.—The session will begin on Oct. 5. Complete theoretical and practical training is provided for students preparing for the higher positions in the electrical engineering profession. At the end of a three years' course students may obtain either an ordinary or an honours degree of B.Sc. in electrical engineering. A special course, also extending over three years, prepares for a certificate in electrical engineering. The John Hopkinson Laboratories are fitted with modern electrical machinery and testing appliances, and excellent facilities are offered for educational and research work. Particulars may be obtained from the Registrar.

King's College (University of London).—The new term begins on Wednesday, Oct. 4th. The Faculty of Engineering have arranged courses of study extending over three or four years in civil, mechanical and electrical engineering for the engineering degrees of the University of London and for the diploma and certificate of the College.

The four years' course provides, in addition to the academic training, opportunities for practical training in works. Additions to the engineering department include a large drawing office and lecture rooms for the mechanical and civil engineering departments and a lecture theatre and rooms for research, including wireless telgraphy, for the electrical engineering department. There are well appointed laboratories for teaching and research work. Full information may be obtained from the Dean or the Secretary, King's College, London, W.C.

Aberdeen University.—By the death of Mrs. Wm. Jackson a large sum will become available for the establishment of a Chair of Engineering at this university.

Armstrong College (University of Durham) Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

Royal Technical College, Glasgow.—The session 1916-17 begins on Sept. 26.

The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, &c. There are also full courses of instruction in the schools of navigation and wireless telegraphy, and both day and evening classes are held. The diploma courses extend over three or four sessions, and the average fee is £12. 12s. per session. The college is affiliated to the University of Glasgow, and the degrees of the university in engineering and applied chemistry are open to its students. Prospectuses from the Director.

The calendar for the session 1916-17 has been issued and contains full particulars of the courses of instruction fees, classes (day and evening), examinations, &c. The head of the electrical engineering department is Prof. Magnus Maclean, M.A., D.Sc., and the laboratories are well equipped for practical work. The calendar is published at 1s. (post free 1s. 4d.), and copies may be obtained from the College.

Northampton Polytechnic, London.—In the day engineering college full-day courses in the theory and practice of civil, mechanical and

electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

Manchester School of Technology.—Full courses, leading to the Manchester University degree in the faculty of technology, are provided in mechanical, electrical and sanitary engineering (including municipal engineering), the chemical and textile industries, mining, architecture, &c. During the session 1916-1917, first year courses will be specially adapted to the requirements of students who may wish to take commissions in H.M. Forces.

The prospectus of the University courses in the 1916-17 session has been issued and gives full particulars of the instruction, fees, conditions of admission to classes, &c. The school of technology affords a systematic training in all branches of engineering, the chemical and textile industries, &c. There are part-time day courses for engineers' and other apprentices, and there are also part-time evening courses, the latter course extending over five years. There are well equipped laboratories for practical and research work.

City and Guilds of London Institute.—We have received a copy of the programme for the session 1916-17, containing the regulations for the registration, conduct and inspection of classes and examination of candidates in technological subjects, &c. Among the alterations may be mentioned the revision of the syllabuses in electrical installation work and in heating and ventilating engineering; the examination fees in many subjects have been altered and the lists of works of reference have been revised.

The examinations in wiremen's work will be held in two grades. The examination in Grade I. will be adapted to the requirements of journeymen and the final examination to the requirements of those who may be engaged as foremen. First and second class certificates will be granted on the result of the examinations. Candidates for the final examination must hold a certificate in Grade I., or have passed an examination in Grade I. of electrical engineering. The course of construction with a view to the final examination should cover at least two years.

The works of reference for some of the subjects require revision. In the present edition we notice several books which have been out of print for some time, and in some subjects a number of German technical books and publications, which are at present unavailable, are given. The programme is published by Mr. John Murray, Albemarle-street, London, W., at 9d. net.

Merchant Venturers' Technical College.—The calendar for the 61st (1916-17) session has been issued, and contains full particulars of the courses of instruction, fees, classes, &c.

The head of the electrical engineering department is Prof. David Robertson, and he is assisted by a fully-qualified staff of assistants. The courses lead to the B.Sc. in engineering of the University of Bristol, and the curriculum for the degree extend over at least three years, or, if pursued in evening classes, over five years. Copies of the calendar (6d., post free 7d.) may be obtained from the Registrar.

West Ham Municipal Technical Institute.—The session 1916-17 will commence on the 20th September.

In the electrical engineering department there are full day and evening courses in electrical engineering in preparation for the B.Sc. degree of London University and for the City and Guilds technological examination in electrical engineering, telegraphy, telephony and wireman's work. There are also a shortened two year day course and part-time day classes in electrical engineering arranged with the co-operation of local engineering employers, to enable students to obtain a training in electrical engineering under more favourable conditions than is possible in evening classes. Particulars may be obtained from the Principal.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by Messrs. Mewburn, Ellis & Fryer, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1911 Specifications.

11,168 Baker. Manufacture of electrical condensers [Complete specification 12/4/15.]

11,325 Van Eyck & Crawford. Means for [illegible] on the line. [Complete specification 11/3/15.]

11,335 Tainton. Electrolytic recovery of metals from their solutions and apparatus therefor.

11,336 Tainton. Electrolytic recovery of metals from their solutions and apparatus therefor.

11,510 U.S. Light & Heat Corpn. Dynamo-electric machines. (14/8/14.)
Comprises a dynamo having a ring wound armature, a co-operating field pole provided with a shunt field winding and a pair of field poles on opposite sides thereof, the flux in which poles is consequent upon that due to the shunt-wound pole and to the armature current, whereby armature current will affect the distribution of flux through the consequent poles for regulating purposes at various speeds.

11,512 Kretz. Electric connections for electrically-heated irons and like utensils.

11,544 B.T.-H. Co. (G.E. Co.) Manufacture of incandescent electric lamps.

11,566 Soc. Anon. des Etablissements L. Bleriot. Explosion engines coupled to dynamo-electric machines. (16/9/14.)

11,568 Schaanning & Harlow. Electrical transformers.

11,790 Lancashire Dynamo & Motor Co., Whitmore & Roberts. Short-circuiting and brush-lifting gear for alternating-current motors.

13,901 Burt, & Huntalite Limited. Fittings for electric incandescent candle lamps.

14,214 Foster. Electrical measuring instruments.

14,819 Fergusson. Internal-combustion engines having electrical accessories.

14,995 Coffner. Contact making and breaking devices of magneto-electric machines for ignition in internal-combustion engines.

16,185 Muller. Electric insulators. (Patent of addition, 27,738/12.)

16,540 Marks. (Interstate Electric Novelty Co.) Electric batteries.

17,921 Robert Bosch (Firm of). Rotary interrupter for electric ignition devices. (18/2/15.)

1916 Specifications.

5,398 Sorberg & Andersen. Electric insulating compositions. (12/4/16.) 101,067

5,680 Kennington. Ignition controllers for internal-combustion engines. (18/4/16.) 101,070.

APPLICATIONS FOR PATENTS

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

August 7, 1916.

11,099 McGregor. Sparking plugs for internal-combustion engines.

11,100 Parsons & Waddington. Electrical signalling apparatus for mines, &c.

11,114 Fairweather. (Lake Torpedo Boat Co.) Battery cells or tanks.

11,125 Cole. System of electrical distribution. (12/8/15, U.S.)

11,130 Chertik. Method for producing high-frequency oscillations.

August 8, 1916.

11,169 Huntington. Suspenders for electric cables, &c.

11,175 Miller. Mercury interrupter and induction coil.

11,189 Armstrong, Whitworth & Co. & Cheetham. Means for applying heat produced by passage of electricity.

11,191 Titanic Electric Co. (Cutler-Hammer Mfg. Co.) Motor controllers.

August 9, 1916.

11,212 Beaumont & Hayden. Renewal points sparking plug and high-tension connection.

11,214 Hodgkinson & Kennedy-McGregor. Sparking plugs for internal-combustion engines.

11,229 Hutchison & Hutton. Production of electric incandescent lamps.

11,238 Best. Miner's safety lamps.

11,240 Uren. Means for connecting electrical conduits.

11,242 Indo-European Telegraph Co. & Morse. Controlling electric circuits from a distance.

11,254 Simpson. Generation of electric energy.

11,267 Mayor. Apparatus for medical treatment by electricity. (25/9/15, Switzerland.)

August 10, 1916.

11,286 Crosbee & Sons & Wilks. Sparking plugs for internal-combustion engines.

11,326 Schreiber. Dynamo-electric machines.

11,327 British Westinghouse Electric & Mfg. Co. (Westinghouse Electric & Mfg. Co.) Alternating-current dynamo-electric machines of the compensated commutator type.

August 11, 1916.

11,337 Williams. Ammeter for measurement of alternating currents and electric oscillations.

11,348 Nebe & Switchgear & Cowans. Starters for electric motors.

11,358 Siemens & Halske Akt.-Ges. Automatic selecting devices for telephone systems.

11,360 Allensby & Benham & Sons. Electric heaters for water, &c.

11,361 Allison & Morris & Whitham. Spooling filament for metal-filament lamps.

11,362 Kingsland. Electrical apparatus for obtaining synchronous motions at a distance.

11,363 Greville. Apparatus for passing through the human body currents derived from town main electrical supply.

11,368 Mackie. Alternators for high frequencies.

11,372 Johnson. Spark-testing attachment for internal-combustion engines.

11,381 Lister. Electric knife switches.

11,382 Berry. Electric transformers.

August 12, 1916.

11,397 Warfvinge & Wepner. Means for telephonic communication to and from moving railway trains, &c. (21/8/15, Sweden.)

11,425 Sullivan. Use of relays for telegraphic, &c., purposes.

11,428 B.T.-H. Co. (G.E. Co.) Electro-magnetic switches.

11,429 Hepburn. Bipolar electrode electrolysers.

11,435 Allgemeine Elektricitats Ges. Electrical machines. (6/8/15, Germany.)

August 14, 1916.

11,439 Baillie. Adjustable rest for telephone receiver.

11,454 Towns. Transmission of power.

11,459 Edsall. Incandescent lights.

11,465 Hemitely. Telegraphy.

August 15, 1916.

11,503 Blakey & British Insulated & Helsby Cables (Ltd.) Electric cable connecting [illegible] junction boxes, dividing boxes, &c.

11,520 Scott. Apparatus for locks and locking gates, &c., by electrical means.

11,533 Edgcumbe Cab Limited (Ltd.). Selenium cell.

11,534 Lewis. Selenium cell.

11,537 McLean. Apparatus for signalling or telegraphing.

11,538 Hawkins. [illegible] apparatus.

August 16, 1916.

11,594 Taylor. Electro-magnetic pneumatic furnace.

11,602 Kemp. Current-transforming magnetos, &c.

11,604 [illegible] Aitken & Relay Automatic Telephone Co. Automatic and semi-automatic telephone systems.

11,617 Sykes Instrument Co. & Tarrant. Electrically-operated indicator [illegible].

11,622 Cartwell & [illegible] Electro-Metallurgique Francaise. Electric furnaces.

August 17, 1916.

11,643 Kramer. Sparking plugs for internal-combustion engines.

11,647 Darling. Fixing [illegible] with vessels or cooling tanks of accumulators, &c., [illegible] same.

11,650 Warfvinge & Wepner. Means for telephonic communication to and from [illegible] railway trains, &c. (27/8/15, Sweden.)

11,661 Adam. Electric [illegible] fixtures. (13/9/15, U.S.)

11,663 Chamberlain & Woodhouse. [illegible], &c., electric telegraphic apparatus.

11,668 Siemens Bros. Dynamo-electric [illegible] telegraphy. (16/3/15, Germany.)

11,671 [illegible] Patent Syndicate. Magneto-ignition systems.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	781	Threshing by Central Station Power	166
Imports and Exports of Electrical Manufactures	782	Use of Large Magnetic Clutches	168
Business Notices	782	The Economy of Electric Cooking	170
Liquidations, &c.	782	Half-Watt Lanterns and Fittings	170
Electricity Supply	782	Lamp Filament Breaker	172
Traction Notes	782		
Telegraph and Telephone Notes	783	Tenders Invited	785
Empire Notes	783	Tenders Received & Accepted	786
Foreign Notes	783	Municipal Accounts	786
Miscellaneous Notes	784	Companies' Meetings and Reports	787
		New Companies, &c.	787
The Round Table	165	City Notes	788
Ericsson Apparatus. Illustrated	166	Electrical Companies' Share List	788
Donovan Leaflets	166		

COMMERCIAL TOPICS.

Controlled Establishments. The Minister of Munitions has announced that he had made a further order under the Munitions of War Acts, 1915 and 1916, under which 161 additional establishments have been declared controlled establishments. The total number of controlled establishments is now 4,212.

* * * *

Machine Tools as War Material. In pursuance of the powers conferred upon him by Regulation 30 (A) of the Defence of the Realm (Consolidation) Regulations, 1914, the Minister of Munitions has ordered that the war material to which the regulation applies shall include war material of the following classes and description, namely :—

All machine tools and machinery driven by power and suitable for use in cutting, stamping or working metal, including : Lathes, milling and drilling machines, planers, shapers, screw, chucking, boring, slotting and grinding machines, boring and turning mills, power presses, punching and shearing machines, forging, cutting-off, gear-cutting and centring machines.

The Minister of Munitions also gives notice (1) that he permits all persons, until further notice, to purchase or enter into negotiations for the purchase of the war material referred to in the above Order, provided that such purchase or negotiations are from or with persons holding a special permit from the Minister to sell such war material and not otherwise ; (2) that he permits the insurance of any such war material. Applications for a special permit in connection with the Order should be addressed to the Director of Machine Tools, Armament-buildings, Whitehall-place, London, S.W.

* * * *

Unemployment Insurance. By the National Insurance (Part II.) (Munition Workers) Act, 1916, which comes into force this week, the compulsory scheme of unemployment insurance is extended to certain scheduled trades and to all workpeople engaged in munitions work.

Under power conferred by the Act the Board of Trade have now, by order, excluded various classes of munitions work from insurance, including work on buildings, docks or harbours, the supply of light, heat, water or power, or tramway facilities, when these are certified as necessary in the national interest.

If any class of work is insurable otherwise than as munitions work, the order does not have the effect of excluding it from insurance.

* * * *

Electrical Manufactures in Spain. In a recent report by U.S.A. Consul-General in Spain (Mr. C. B. Hurst) it is stated that domestic electric manufacturing companies increased their output in 1915, and a profitable business was being done by firms at Sabadell and Cornella, near Barcelona, where transformers, generators and motors up to 200 H.P. and electrotechnical apparatus of a superior grade are manufactured. In Barcelona firms employing large numbers of workpeople are in the manufacture of electric cables and electric lamps. Cables are also extensively manufactured there and much electrical material of the smaller kinds. Domestic production is not yet able to dominate the market, however, and Spain is still dependent on foreign supplies.

There are 992 public electric supply plants in the country, 978 private plants and 125 electric power works.

* * * *

British Trade in South America. The Trade and Industry Committee of the Royal Colonial Institute have received a statement as to the possible extension of British trade in Latin America, from which we extract the following :—

British trade has lost ground in Latin American countries. Or to put it in another way, British people have not had as much trade as they ought to have had, for one main reason, viz., there are too few purely British importing houses in Latin American countries. In Central America and in Mexico and South American countries also, business are largely in the hands of Germans. These firms, pursuing the national idea, such an idea being practically unknown to British people, always prefer to import from Germany, and they have a definite policy of promoting German trade. This is a laudable object on their part, and British people should take the lesson to heart, have a definite policy also and try to "go them one better." Most of the German firms are of mushroom growth, young men have come out for a small salary of about Mks.200, or even less per month. They were serious, hard-working young fellows, of great adaptability, got very few pleasures, but by direct close attention to business they were soon able to make themselves valuable to their employers and were admitted as partners. They are a reliable class of people, and all credit is due to them. The head of the firm goes home, often opens a house in Hamburg, makes an occasional trip abroad, and so the process of development goes on. The same thing applies to the agricultural part of Latin America, where large numbers of coffee and sugar estates are owned by the Germans. To increase British trade, initiative of this character is needed. It will do little good to send out travellers, catalogues, samples, appoint agents and spend large sums on propaganda in countries where such a condition of affairs as indicated prevails. It was impossible to make headway before the war, and it will be more difficult after the war.

It would be worth while for some of the Manchester, Birmingham and London exporting firms or associations which might be formed to open up branches in the principal towns of Latin America. It is also suggested that the Board of Trade, Chambers of Commerce and public-spirited men should take the matter up, so that by propaganda the young fellows at home should become interested, and whilst they would do a splendid stroke for themselves like the young Germans do, they would also do something for their country. The opportunity exists, and a sensible fellow always succeeds.

* * * *

Trade After the War. The British Empire Producers' Organisation has issued an "Appeal to British Workers," pointing out the need for a policy to secure and develop the industry and production of the Empire.

After referring to the conditions brought about by the war, the manifesto points out that Germany is making gigantic preparations for a commercial war. To meet this menace the organisation has been formed, "to promote a national policy for a national peril, a defensive policy for the whole of the Empire, which will unite the British Dominions with the United Kingdom for mutual defence and mutual support." The organisation advocates : That the Empire shall produce and manufacture all its own requirements, that British capital shall be attracted to British industries ; that British merchandise shall be carried in British ships ; that British working men shall be employed in preference to foreign working men, and be secured against competition by sweated alien labour. For the success of this policy it is pointed out that it is essential that the two great factors in all industry, labour and capital, shall unite in their common interests for the development of the Empire and for the general good of the State. The association thinks that as a principle of policy labour is entitled to its full share of any benefit which may be obtained through preference being given to any industry, and is prepared to give its support to legislation which has for its object the mutual interests and harmonious working between capital and labour with a view to the development and general good of the State." The Organisation, therefore, appeals to the great labour organisations "to follow the lead of their overseas comrades in the self-governing Dominions, and to unite in demanding a national policy for the security of industry and for the future prosperity of the race."

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From Aug. 26, 1916, *to* Sept. 1, 1916.

IMPORTS.

FOLKESTONE. *France:* Elec. carbons, 15 pkgs.; unenumerated, 13 cases.

LIVERPOOL.—*U.S.A.:* 13 pkgs. unenumerated. *Spain:* Elec. carbons, 156 cases.

LONDON. *U.S.A.:* Carbon candles, £406; glow lamps, £500; telegraph material, £334; unenumerated, £52,600 140 cases. *Holland:* Elec. lamps, 1,129 pkgs.; elec. glow lamps, £11,371; unenumerated, £1,966. *Japan:* Elec. glow lamps, £76; unenumerated, £1,511 218 cases. *France:* Carbon [illegible], £100; unenumerated, £98. *Switzerland:* Unenumerated, £1,200. *Denmark:* Unenumerated, £30. *Sweden:* Unenumerated, £332.

SOUTHAMPTON. *France:* Elec. meters, 20 pkgs.; elec. cable, 15 pkgs.; unenumerated 88 pkgs.

EXPORTS.

TO AUSTRALASIA. *Auckland:* Unenumerated, £263. *Melbourne:* Wire and cable, £1,271; elec. machinery, £352; unenumerated £1,265. *Sydney:* Wire and cable, £355; elec. machinery, £379; unenumerated, £2,651. *Wellington:* Elec. machinery, £523; wire and cable, £41; elec. glow lamps, 16,800 n.o.; unenumerated, £1,077. *Lyttelton:* Unenumerated, £641. *Dunedin:* Elec. machinery, £38; unenumerated, £192. *Adelaide:* Unenumerated, £854. *Christchurch:* Unenumerated, £500. *Perth:* Unenumerated, £139. *Hobart:* Unenumerated, £208. *Fremantle:* Unenumerated, £20. *Brisbane:* Unenumerated, £504. *Napier:* Unenumerated, £90. *New Plymouth:* Elec. machinery, £67.

AFRICA.—*Durban:* Elec. machinery, £370; glow lamps, 12,050 n.o.; unenumerated, £779. *Cape Town:* Wire and cable, £603; unenumerated, £565. *Port Elizabeth:* Wire cable, £2,289; unenumerated £186. *East London:* Unenumerated, £107. *Mauritius:* Unenumerated, £468. *Zanzibar:* Unenumerated, £142. *Zanzibar:* Unenumerated, £84.

EGYPT.—*Port Said:* Elec. machinery, £40; unenumerated, £75. *Port Sudan:* Unenumerated, £580.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS. *Bombay:* Wire and cable, £458; unenumerated, £1,593. *Singapore:* Elec. machinery, £74; unenumerated, £34. *Calcutta:* Wire and cable, £12; elec. machinery, £60; elec. glow lamps, 1,800 n.o.; unenumerated £2,268. *Madras:* Unenumerated, £931. *Colombo:* Unenumerated, £709. *Bankok:* Unenumerated, £91. *Karachi:* Elec. machinery, £27.

CHINA.—*Shanghai:* Elec. machinery, £244.

CANADA. *Montreal.* Telegraph material, £95; unenumerated, £240. *Quebec:* Elec. glow lamps, 16,500 n.o.

U.S.A. *New York:* Elec. machinery, £200; unenumerated, £120.

SOUTH AND CENTRAL AMERICA. *Buenos Ayres:* Telegraph material, £182; wire and cable, £5,041; unenumerated, £4,513 *Monte Video:* Elec. machinery, £126; unenumerated, £27. *Mexico:* Unenumerated, £1,124. *Santos:* Unenumerated, £267. *Pernambuco:* Unenumerated, £51. *Pernambuco:* Unenumerated, £43. *Rio de Janeiro:* Wire and cable, £64; elec. lamps, 1,850 n.o.; unenumerated, £409. *Pelotas:* Unenumerated £286.

JAPAN. *Yokohama:* Unenumerated, £895. *Tokio:* Unenumerated, £1,404.

WEST INDIES. *Demerara.* Unenumerated, £18. *Trinidad:* Unenumerated, £42. *Barbados:* Unenumerated, £28. *St Vincent:* Unenumerated, £40.

HOLLAND.—*Amsterdam.* Wire and cable, £1,610; unenumerated, £176. *Rotterdam:* Wire and cable, £100; unenumerated, £94.

RUSSIA.—*Petrograd:* Unenumerated, £691.

FRANCE. *Dieppe:* Elec. machinery, £737; unenumerated, £652. *Paris:* Unenumerated, £236. *Bordeaux:* Wire and cable, £477. *Calais:* Unenumerated, £105.

DENMARK. *Copenhagen:* Unenumerated, £95.

FOREIGN GOODS (duty paid and free).

Sydney: Unenumerated, £226. *Colombo:* Unenumerated, £19. *Dieppe:* Elec. machinery, £215. *Durban:* Unenumerated, £154. *Cape Town:* Elec. wire, £94; unenumerated £71. *Port Elizabeth:* Unenumerated, £119. *Mauritius:* Unenumerated, £29. *Bombay:* Unenumerated, £32. *Holland:* Unenumerated, £50. *Bordeaux:* Unenumerated, £11. *Copenhagen:* Unenumerated, £4. *Cyprus:* Unenumerated, £30. *Adelaide:* Elec. meters £1,299; unenumerated, £121. *Buenos Ayres:* Unenumerated, £92. *Dunedin:* Unenumerated, £15. *Fremantle:* Unenumerated, £25. *Lyttelton:* Unenumerated, £15. *Fernambuco:* Unenumerated, £20. *Rosario:* Unenumerated, £13. *Valparaiso:* Unenumerated, £253.

IN TRANSIT.

Durban: Elec. cable, £950.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

Messrs. C. A. Vandervell & Co. (Ltd.) have now completed all arrangements at their Manchester depot, 12, Victoria-buildings, St. Mary's Gate, for the carrying out of repairs to accumulators of all descriptions.

The partnership between Charles Dales, Charles Dales the younger and Thos. Hy. Dales (trading as C. Dales & Sons), electricians, &c., 113, Poole-road, Bournemouth, has been dissolved. Debts by Chas. and T. H. Dales, who continue the business under the same style as heretofore.

Robert Walker and Thos. Hy. Large (trading as Caledon Electrical Co. and as Phœnix Electrical Co.) have dissolved partnership. Messrs. Thomson, Jackson, Gourlay & Taylor, 21, George street, Glasgow, will receive or pay debts due to or owing by the firm. Mr. Walker will trade in his own name at 2, Oswald-street, Glasgow, and Mr. Large will trade as the Phœnix Electrical Co., at 10, Broomielaw, Glasgow.

An electrical and general engineering works advertise that they can undertake additional munition and other contract work.

Plant for Sale.—Messrs. Marshalls, Gainsborough, have a 24 h.p. Wilson Hartnell electric motor and an E.C.C. compound-wound dynamo for sale.

LIQUIDATIONS, &c.

The Electrical Oil Refining Co. (Ltd.) is being wound up voluntarily, and Mr. J. E. Frost has been appointed liquidator. A meeting of creditors will take place at 29, Great St. Helens, London, E.C., to-day (Sept. 8).

A meeting to receive an account of the winding up of the Mond Nickel Co. (Ltd.) will be held at 39, Victoria-street, London, S.W., on Oct. 11.

A meeting to receive an account of the winding up of High-Tension Insulators (Ltd.) will be held on Oct. 3 at 32, Sackville-street, Piccadilly, London, W.

ELECTRICITY SUPPLY.

EXTENSIONS.

Leeds.—The L.G. Board have sanctioned the borrowing of £35,000 for electricity supply. £20,000 is for mains and £15,000 for sub-stations.

Salford.—The Council has been recommended to seal agreements for the supply of energy at contract rates to the premises of the Salford Electrical Instruments (Ltd.), Zuma (Ltd.), and Erskine, Heap & Co.

Sheffield.—Extensions of the electric supply mains are to be carried out at an estimated cost of over £1,000.

Walthamstow.—The L.G. Board have sanctioned a loan of £9,610 for the extension of the plant at the electricity works.

GENERAL.

Ballybay (Ireland).—A local electric supply company is being formed in order to take over the electricity works, which are being erected by Mr. Leslie, a resident in the district.

Chiswick.—Hammersmith Borough Council will give a supply of electrical energy to the Chiswick Electricity Supply Corpn. to enable the corporation to give an additional supply to a large factory in their area of supply. The estimated cost of the cables, ducts and transformers is £3,500.

Dublin.—A recommendation of the Electricity Supply Committee to grant an increase of wages to the shift engineers and switchboard attendants at Fleet-street and Pigeon House stations has been postponed till the beginning of the next financial year.

Dundalk.—The Urban Council have asked the surveyor and electrical engineer to report on a proposal to adopt electric heating at the town hall and concert hall.

Lanchester.—The Joint Hospital Board propose to instal electric washers in the laundries at Tanfield Hospital, and at Maiden Law Sanatorium, similar to the one in use at the Langley Park Hospital.

Plymouth.—During the quarter ended June the Electricity and Street Lighting Committee sold 1,369,386 units of current, producing estimated receipts of £11,674, compared with 1,291,320 units and £11,376 received in the corresponding period of last year. The Prince Rock works has 2,091 consumers and Newport-street 1,026, compared with 1,944 and 934 respectively.

Ripon.—The City Council has appointed Mr. Geo. Wilkinson, at a fee of 25 guineas, to prepare plans and particulars for obtaining a provisional electric lighting order.

Worcester.—The Electricity Committee reports that it has been found necessary to accede to requests from the staff for extra pay for overtime and for increases of salaries and wages. The increases will vary from 1s. to 5s. per week, and are exclusive of the war bonus of 2s 6d. The effect will be to add £148 a year to the wages bill.

TRACTION NOTES.

Bristol Tramways.—The Board of Trade have extended for one year from Oct. 31, 1916, the period during which Bristol Corporation are entitled to exercise their option to purchase the Bristol tramway undertaking.

Burnley.—The tramways manager (Mr. Mozley) has submitted a statement showing the capital expended and the sums he considered necessary to set aside annually for depreciation:—

On cars, capital expended is £86,796; annual depreciation, £2,787; paving, £43,770 and £845; overhead equipment, £15,519 and £331; depot buildings, rails, &c., £14,061 and £185; generators, £3,900 and £13; control office, £5,166 and £22; waiting rooms, &c., £407 and £7; machinery, £2,800 and £30; tower wagon, £642 and £32; horses, £ [illegible], £375 and £1. 11s.; rolling stock, £54,047 and £1,399; total amount, £227,213; total annual depreciation, £5,672.

Dublin and Blessington Steam Tramway.—The undertaking of the Dublin & Blessington Steam Tramway Co. is to be taken over by the Dublin and Wicklow County Council. The line will probably be converted to electric traction after the war.

Glasgow.—The Tramways Committee recommend that for the duration of the war the working hours of the following employes, which are at present 51 per week, be as under:—

Drivers and conductors, controllermen and trackmen, sawyers and

wood cutters, 54 hours each ; permanent-way labourers, mains and cables (labourers), and red-leaders, 56 hours ; and car works (labourers) and handymen), 54 hours per week. Time and a half will be paid for the extra hours worked, and male employés effected by the alterations will receive a bonus of 2s. per week and female employés 1s. per week.

A deputation recently waited upon the Tramways Committee to urge the necessity of giving a limited all-night service of tramcars.

Liverpool.—The tramways general manager (Mr. C. W. Mallins) reports that the receipts from July 1 to Aug. 26 were £107,320, an increase of £8,109 compared with the corresponding period of 1915.

The passengers carried numbered 22,697,820, an increase of 1,415,315 ; the car-mileage (1,715,251) decreased by 9,338. Since Jan. 1 the aggregate receipts were £478,451, an increase of £23,913 ; 102,321,389 passengers were carried, an increase of 3,898,851, and car-mileage 8,322,190, a decrease of 58,531.

Salford.—The Tramways Committee propose to grant a further bonus, ranging from 1s. to 4s. a week, to the men in their employment, which will represent £2,774 per annum in wages.

TELEGRAPH AND TELEPHONE NOTES.

New Zealand Telegraphs and Telephones.—The report on the working of the N.Z. Government Post and Telegraph Department for the year ended March 31, 1916, states that the telegraph and telephone revenue was £837,174 (increase 27 per cent.), or with Government telegrams, £846,259, and expenditure on those services was £658,572 (increase 7½ per cent.)

Twenty-seven new offices were opened, making a total of 2,413 (334 Morse telegraph offices and 2,079 telephone offices). The number of ordinary telegrams forwarded by the Pacific Ocean cable route was 114,151 (compared with 106,018 in previous year) or 67 per cent. of the total traffic, against 74 per cent. in previous year, the Eastern Co.'s proportion of the total being 33 per cent., compared with 26 per cent. New Zealand's proportion of the deficit of £7,915 on the 13th year's working of the Pacific Cable was £879.

Telephone subscribers increased by 3,542 and connections by 4,715. The total number of exchanges is 259 and of connections 58,976. There are 3,437 miles of telephone line and 128,525 miles of wire. Toll circuits are available between Wellington and Napier and Napier and Gisborne. The opening of automatic exchanges has been seriously delayed on account of materials not coming to hand owing to the war. The buildings for automatic exchanges have been completed at Blenheim, Hamilton, Ponsonby, Mount Eden and Remuera, and in all these places some of the apparatus is to hand, as well as for the exchange of Oamaru. Plans have been approved for a building in Wellesley-street, Auckland, which will provide accommodation for automatic equipment. At Dunedin, where the switchboard accommodation is practically exhausted, Western Electric automatic equipment is to be installed throughout the area. The Strowger automatic apparatus at Wellington and Auckland works satisfactorily. The whole 1,000 lines at Wellington are in operation, and at Auckland there are 747 in use.

The two high-power radiotelegraph stations at Awanui and Awarua and the low-power stations at Wellington and Chatham Islands have continued to work satisfactorily. The low-power station at Auckland was closed on May 8, 1915, but not dismantled. Ships continue to exercise care not to disclose their whereabouts, and, owing to the restriction placed since the outbreak of war upon business of an unimportant nature, a considerable decline in the volume of wireless traffic has resulted. Twenty-four ship-stations are registered in New Zealand. Observations are being made at Chatham Islands and Awarua of atmospheric electrical disturbances which prevail in greater or less degree at all times. These are despatched to the British Association for the Advancement of Science. Wireless communication on long waves between Awanui and Apia, Samoa, 1,550 knots, established shortly after the seizure of the Samoan group by the New Zealand Expeditionary Force on behalf of the Imperial Government on the outbreak of war, continues to be satisfactorily maintained. Recently the wireless station at Awarua served a useful purpose that is unusual in these waters. The "Aurora" was returning damaged and required correct time to check the chronometers. At 11 a.m., noon and 1 p.m. the observatory clock at Wellington was connected direct to a land-line circuit to the Awarua wireless station. The length of this circuit was approximately 650 miles. The ship was on the lookout for a wireless signal, which was despatched by preconcerted arrangement practically simultaneously with its receipt over the land circuit. The result was found to be highly satisfactory.

During the year the department was asked to supply for the N.Z. Expeditionary Force a wireless telegraphy troop of 62 with officers, and the call was promptly met. The department has also provided a large number of expert telegraphists, mechanicians and linesmen for duty with the Force.

Women Wireless Operators.—At the beginning of the year Marconi's Wireless Telegraph Co. determined to test the suitability or otherwise of women as wireless operators, and established a school at one of their stations, where instruction of a practical and theoretical nature has since been given to women.

The school has (it is reported) been well attended, but applications for admission were latterly refused, as a decision had been arrived at to close the establishment for the present at the end of this month. So far as it has gone the experiment is regarded as encouraging, and some of the pupils have been already drafted to stations, where they are taking night duty in turn with men. Sending by female operators has, however, a tendency to be too light. This defect varies in individual cases, and with some of the women learners it is thought that they will become efficient wireless operators with practice.

EMPIRE NOTES.

Australasia.—The ratepayers of Palmerston North (N.Z.) have agreed to a proposal by the Borough Council to seek authority to borrow £86,000, of which £66,000 is to be devoted to an electric tramway and £20,000 to electricity supply works. The undertakings, however, will not be commenced until after the war.

The "Australian Mining Standard" says the directors of the Melbourne Electric Supply Co., which owns the Geelong electric tramways and the electric supply works of the city, has declined to enter into negotiations for the sale of its business there and in neighbouring municipalities to the local authorities concerned.

The Premier of Tasmania (Mr. W. H. Lee), in outlining the agreement between the Tasmanian Government and the Amalgamated Zinc (De Bavay's), Ltd., with respect to the supply of electric power to the company's proposed new works, says the company is given a lease of 50 acres at Risdon for smelting works, with the right of obtaining a lease of a further 100 acres if required. The rent for the first two years is nominal, and after that 5 per cent. of the unimproved capital value. The Minister agrees to supply the company with 4,000 H.P. from Jan. 1, 1918, the company to pay £14,000 in advance. A further 26,000 H.P. is to be supplied in two years from date of demand. The price for the 30,000 H.P. will be £60,000 a year. A third block of 20,000 H.P. may be demanded at the same rate, but need not be supplied unless available from the Great Lake scheme.

Strathalbyn (S. Australia) Council has decided to adopt electric lighting.

Mittagong (N.S.W.) Council has adopted an electricity supply scheme estimated to cost £3,500.

The Tasmanian Minister of Public Works recently stated that the construction of the Huon Railway could not be proceeded with immediately owing to the shortage of men, but its construction was inevitable, and he presumed that electricity would be the motive power.

The municipal electric lighting plant recently installed for the Dimboola (Victoria) Shire Council, at a cost of £3,750, was officially started on June 21.

A conference between representatives of electric lighting companies and municipalities owning electrical plants in New South Wales and Victoria, and the Engine-drivers and Firemen's Association, with Mr. Justice Higgins, President of the Commonwealth Court of Conciliation, as chairman, was held in Melbourne on June 23, with the object of coming to an agreement as to rates of wages and conditions of labour. No agreement was arrived at, and the points in dispute have been referred to the Court for arbitration.

Canada.—The undertakings of the Montreal Light, Heat & Power Co. and the Cedars Rapids Mfg. & Power Co. were amalgamated on Aug. 1, and are now operated by the Civic Investment & Industrial Co.

Federated Malay States.—It is reported that the Malayan Collieries (Ltd.) raised 11,523 tons of coal in Selanger last year. There is an electric power plant at the colliery, and most of the work is performed electrically.

FOREIGN NOTES.

Chili.—The United States Consul at Antofagasta states that there is little irrigation by pumping in the Antofagasta district. The wells in the pampa contain so much salt and other alkalis that they are not suitable for irrigation purposes.

The market for pumps is almost confined to requirements of nitrate plants, of which there are some 170. A nitrate plant uses from 300 to 900 tons of water per day, obtained usually from wells several miles away. The classes of pumps and pumping machinery used by the nitrate plants are power-driven deep well pumps and surface pumps, and power is usually furnished from a central electric power station some miles distant ; boiler feed pumps usually steam driven, oil pumps, steam or other power-driven pumps for transferring liquors from crystallisation tanks to elevated storage tanks, centrifugal pumps for circulating hot liquors between the boiling tanks, and miscellaneous internal combustion engine cooling water pumps, fuel oil pumps. The general terms of credit given by American manufacturers to importers are cash against shipping documents on arrival of goods in Antofagasta. European manufacturers give extended credit of 60 to 90 days after acceptance of draft against bill of lading on arrival of goods, and in exceptional cases 120 days. Prices should be c.i.f. Antofagasta, and not f.o.b.

Colombia.—Amaga (Department of Antioquia) municipality has been authorised to borrow £1,200 for the installation of electric power plant.

Cuba. The Trade and Industry Committee of the Royal Colonial Institute has supplied the following information as to various articles imported into Cuba:

Electrical supplies come very largely from the States, although Germany sends a large amount of electric lamps and bulbs.

Crockery, Glassware, Enamelled and Iron Ware.—There would appear to be a very good market for the cheap and second grade of crockery, glassware, &c., which at present comes in large quantities from Holland and formerly from Germany also. English cutlery and tools have a good reputation, but have been almost drowned in a flood of cheap German and American goods. Enamelled and iron ware is also in demand.

Both American and British firms still commit the great error of sending their representatives to these countries speaking only the English language, the Germans never. From both Germany and the United States come attractive publications in Spanish, which are given away or sold very cheaply, and serve as very active advertising mediums, carrying well-written articles introducing the different manufacturing houses and describing their products.

The parcel post arrangement proposed between England and Cuba should be pushed quickly through; thousands of pounds go annually to Germany and the United States which could easily be diverted to the United Kingdom. Many American and German houses include in the cost of their goods the probable packing cost, and so appear not to charge anything for packing; the British house generally makes a separate charge for this, and, in the native mind it is not appreciated. In every town of even medium importance some German importing house will be found which serves as an active medium for the introduction of German goods and really is a kind of unofficial commercial consulate.

Russia.—The "Journal of Commerce" states that a committee charged with industrial affairs has recently made an inquiry as to the volume of electric supply which will be available after the war for industrial requirements.

The figures prepared by the Committee show that there is need for a rapid increase in the means of generating electric current in Russia. It appears that in European Russia the total capacity of 93 stations is 79,553 kw. The 12 Siberian stations which have answered the inquiry report a total capacity of 9,500 kw., and five stations in the Caucasus 3,026 kw. It is stated that some 30,000 h.p. is available for new undertakings able to take an uninterrupted supply, and about 60,000 h.p. is available for works requiring only an intermittent supply of current.

Shanghai.—A report on the breakdown of the 5,000 kw. A.E.G. turbo alternator which occurred on June 17 last has been prepared by the electrical engineer, Mr. T. H. U. Aldridge.

In his report Mr. Aldridge states that an examination of the fault suggests that the cause of the trouble was due to the insulation surrounding the high pressure conductors fixed in the slots of the stator core, breaking down and allowing the current to pass to the stator itself. This put the conductors to earth, and caused a serious arc to be set up between them and the iron laminated core of the stator. To such an extent must the arc have developed that both the copper conductors and the iron laminations were fused into one mass, and the end windings of the machine which project beyond the stator frame were so seriously burnt that the insulation was entirely destroyed. It will be a difficult matter to thoroughly repair the generator—in fact, it cannot be restored to its original state because there are no spare iron sheets from which to form the laminations available for replacing those which have been burnt out, nor—if such laminated sheets were obtainable—it would mean a very lengthy process to remove the undamaged sheets and to replace them together with new ones. With the limited appliances for such repair work here the machine would have to be out of commission considerable longer that may be necessary if the repairs are effected without attempting to replace the burnt out sheets. An accident of this nature is a case that makers never supply spare sheets to provide against such contingencies. The method of building up the stator core in the manufacturers' workshops necessitated the employment of a large hydraulic press. Nothing of that kind is obtainable in Shanghai, therefore, any attempt to restore the stator core to its original condition would have to be carried out entirely by improvised means. It is, therefore, considered undesirable to attempt to restore the stator core but instead to trim them up to such an extent that new conductors may be inserted in the slots. The importance of this course cannot be over estimated, inasmuch as the other 5,000 kw. machine is not capable of developing its full output because the blading of one of the velocity wheels of the turbine stripped last year and had to be sent to England for repairs. Consequently, there is a danger that the generating station may not, under certain circumstances, be able to deliver the full output for supplying the requirements of Shanghai. It leaves the station with no reserve plant, and if anything serious were to happen to one of the other generators, it might be impossible to meet the department's full obligations. The alternator is of quite recent design, having been completed in 1914, and the experience gained by large electrical engineering firms who specialise in turbo-alternator work is now such that breakdowns of this nature are extremely rare. It is but necessary to refer to the committee of the various defects which developed in both the 2,000 kw. turbines and also in one of the alternators which were also supplied by the A.E.G., to suggest that the Chinese attention of contractors' alternators was premature, as now proved in the light of actual experience a most unfortunate one. Whilst the alternator under report examination has been taken to examine the steam turbine of the set, and I regret to have to report that here also serious defects are disclosed. The blading of the high pressure wheel, and also that of the intermediate and low pressure stages show signs of extraordinarily rapid deterioration. In the case of the first named the distance pieces between several of the blades have broken off and become detached from the wheel itself and are loosely held between the blades and blade shrouding. The shrouding in some places has become slightly bent owing to the broken distance pieces impinging upon them. With regard to the intermediate and low pressure wheels, the blading of the former is badly eaten away by erosion. The condition of the blades of the low pressure wheel may be both due to erosion, and also to the action of loose metal particles which may become detached from the other wheels. The nature of the defects which are now revealed indicates that the machine may have to be replaced at no distant date, but from the fact that portions of the distance pieces between the blading have already broken out, there is the danger of the turbine blades stripping so seriously as to render the machine useless. Unfortunately, nothing can be done in the meantime and the machine will have to be put back into service as soon as the electrical generator is repaired, but the committee must face the facts as they are and be prepared to have to renew the whole of the blading in this turbine at a comparatively early date. This will be a very expensive process, and will cost the department large sums of money, not only in the provision of replaced blades, but by the additional loss which will be incurred whilst the machine is laid up for repairs, as it represents so much capital lying idle from which no return will be forthcoming. The department has equipped the Riverside Station with 14,000 kw. of A.E.G. turbine machinery, with results which can only be described as unfortunate. The experience gained since the installation of these machines inclines one to the view that further trouble is likely to develop, and the fact has to be faced that the four German machines at Riverside cannot be regarded as reliable units of plants, and the question of setting aside a special fund for replacing these machines should be considered.

Venezuela.—The British Consul at Ciudad Bolivar (Mr. R. Cheney Hart) reports that during 1915 merchants at that port were occupied in adapting themselves to the new conditions which have arisen in consequence of the European war. Importers have found that the generous credits they formerly enjoyed in the United Kingdom, Germany, and to a lesser extent in the United States, have been drastically curtailed.

The trade of the Ciudad Bolivar Consular district is carried on almost exclusively on a credit basis, and any interruption in the continuous circulation of credit between the commission houses and the banks which back them, and the labourers in the forest, produces an immediate financial stringency. Such was the case for a year or more after the outbreak of war. Merchants reduced their advances and used every effort to collect outstanding accounts, and, although they have not met with much success, they have managed to tide over their difficulties by reducing their importations and disposing of old stocks.

Total imports in 1915 were valued at £184,815, a reduction of £57,468 on 1914, and less than half the value of imports in 1913. Exports from Ciudad Bolivar increased from £109,508 in 1914 to £711,901 in 1915. No failures of importance have taken place, and the net result has been a considerable strengthening of the financial position. Merchants must be getting near the end of their tether in disposing of old stocks and restricting imports, and in the current year may be expected to buy more largely. The present would, therefore, be an excellent time for travellers to visit Ciudad Bolivar. Several British travellers have recently paid visits to the district, and they are believed to have taken good orders.

The Minister of Fomento has authorised Señor D. Ramírez, of Maturín, to construct a telephone line about 12½ miles in length in the district of Maturín. Señor L. Merchán, of Clemare del Tuy, has been authorised to construct a telephone line about 31 miles in length connecting an estate in the district of Lander (State of Miranda) with Altagracia de Orituco (State of Guarico). A concession has also been granted to Señor F. R. Naranjo, of Valencia, for the construction of a telephone line about 10½ miles in length between Valencia and estates in the Valle de Chirgua.

MISCELLANEOUS NOTES.

Exports to Liberia.—The "London Gazette" of Sept. 1 contains a list of firms and persons to whom goods may be consigned from the United Kingdom.

Imports into France and Algeria.—It is announced that the French Government has set up an office at King's House, Kingsway, London, W.C., for the issue of licences for the importation into France and Algeria of British goods which are included in the list of articles prohibited to be imported into those countries.

Applications for licences must be sent to the Board of Trade, Gwydyr House, Whitehall, S.W., and must state the place of manufacture and as far as possible the number and description of packages and the marks and numbers thereon, the name of the consignee, the port of discharge and a description of the goods (in French and English).

Inquest.—An inquest was held at Bristol last week into the death of Albert Edward Kemp, electrician.

Ivor A. D. Pearce, pupil engineer, in the employ of the Corporation, said that on the 24th ult. he went with deceased to the Deep Pit, Easton, to change two transformers; they went to a sub-station. Deceased was engaged in removing the current transformer and securing two others in their place. Work came to a standstill for the want of a hack-saw, and a man was despatched for one. Witness spoke to deceased, and was

walking away when he heard a groan. He rushed back, and found deceased in an unconscious condition, leaning against the wall near the switch panel door, which was wide open. Witness had previously closed this door, which could not have swung open by itself. Witness tried artificial respiration, and medical aid and an ambulance were soon on the spot, but the doctor pronounced life extinct. It was impossible to cut off all current while the work was being performed. He considered that adequate precautions were made for carrying out the work which had to be done. Deceased, who was an expert workman, was not wearing rubber gloves, though they were there if required. Witness thought that possibly, in a fit of absent-mindedness, deceased handled a porcelain fuse-holder, when he received the shock, and possibly, in getting away from the first shock, he brushed his hand against the live contact of the fuse, and so received the full voltage—3,500 to earth. Deceased had been employed by the Corporation electricity department for 23 years.

Medical evidence was to the effect that death was due to an electric shock, and the jury returned a verdict of accidental death, by electrocution.

Hard Paste Porcelain.—At the College of Medicine, Newcastle-on Tyne, during the present week, in the laboratory of Physiological Chemistry, an extremely interesting exhibit of British-made white hard paste porcelain was made.

Hitherto this material has been an exclusively Continental product and since the war it has been the desire of British potters to meet the undoubted demand which exists for this article. The specimens shown were indistinguishable from the Continental variety in the matter of colour, quality and vitrosity. The manufacturers responsible for this epoch-making incident are Messrs. Taylor, Tunnicliff & Co. (Ltd.), Eastwood, Hanley, Staffs, who have been generally congratulated upon their achievement of a success, which was at one time considered extremely remote so far as British electrical porcelain making is concerned. The exhibit was arranged by Mr. M. J. Dark, the London director of the company, who will, we understand, be pleased to show specimens of this product to interested manufacturers and engineers.

Trade Union Congress.—The annual Trade Union Congress was opened at Birmingham on Monday, when 668 delegates (representing nearly 3,000,000 workers) attended. This is the third time the Congress has met in Birmingham, and on the last occasion (in 1897) there were only 381 delegates, representing 1,093,191 workers.

The Lord Mayor (Ald. NEVILLE CHAMBERLAIN), who welcomed the delegates, spoke of the changes caused by the war. He said he was not so prejudiced or fanatical as to suppose that tariffs would work miracles. No matter what tariffs we might have, those nations which produced the greatest output at the lowest cost were bound to come to the front. Workers, who now formed the bulk of our army, would want a greater share in the distribution of the wealth they had helped to produce; they would want a wage which would give them a reasonable margin over the cost of living; they would want regularity of employment; and they would want improved external conditions both in factories and the homes. If we were to maintain our position against the competition of powerful neutrals, they must get the last ounce out of our plant and machinery. Therefore, he thought, employers, in return for shorter hours and better wages, would want labour to put forth its utmost effort. Employers would want reasonable notice of any change of wages in order that they might regulate prices and contracts accordingly: they would want some security that labour would not be unreasonably withdrawn. Difficulties of detail must arise, but if an agreement on these lines could be come to between the representatives of capital and labour as the result of the new spirit brought about by the war, then, indeed, he thought they would feel their dead heroes had not shed their blood in vain.

In the course of his presidential address, Mr. H. GOSLING said many institutions imagined to be proof against change had been thrown into the melting-pot of national necessity and emergency. Labour had been the personification of real patriotism; every conceivable sacrifice had been made, and made ungrudgingly. Much of the credit for an adequate supply of munitions of war was due to Mr. A. Henderson, who was now Labour Adviser to the Government, and they would not be content until the Government had admitted the unanswerable logic of their case in demanding the creation of a Ministry of Labour. After-the-war problems would be so tremendous in character that a Labour Ministry was absolutely imperative. They also called for the State to take over the mines, railways, shipping services, and to exercise control over the great cold storage warehouses and granaries, together with their contents. When the Government, on the resumption of peace, suddenly lessened its gigantic pay-roll, and stopped its colossal orders, when millions of soldiers were disbanded at approximately the same time that two or three million munition workers were discharged, there was bound to be a flood of men and women seeking new situations. Then it was that they would see whether the Government had been equal to its task. Unless adequate preparations were made in advance, the trade unions would find their funds rapidly depleted, and their members standing unemployed by hundreds of thousands. It was not to be supposed employers would fail to grasp the opportunity presented by millions of men and women looking for situations to try to reduce the standard rates. Some people were already counting gleefully on large reductions of wages. Trade unionists must let it be known at once that, whilst they did not seek industrial war, they had no intention of submitting quietly amid the rejoicings of peace to any further attack upon the standard of life. There will be many other difficulties to get over, but underlying all those difficulties would be that of the fear of unemployment and the threat of a reduction of the standard rates.

A resolution was passed instructing the Parliamentary Committee to promote legislation to secure that superannuation and other trade union and friendly society benefits should not be taken into account in assessing income for the purposes of old-age pensions. A resolution was also passed asking the Government to introduce a Bill to amend the Old Age Pensions Act by increasing the amount to not less than 7s. 6d. a week and reducing the age limit from 70 to 65 years. A resolution in favour of the nationalisation of railways was also carried with few dissentients.

On Tuesday a resolution was passed in favour of the creation of a Ministry of Labour.

TENDERS INVITED.

Incandescent Electric Lamps.

The COMMISSIONERS OF H.M. WORKS, &c., invite tenders for the supply of Incandescent Electric Lamps. Forms of tender and all further particulars from the Controller of Supplies, King Charles-street, S.W., and tenders must be delivered before 11 a.m. of Friday, Sept. 8, to the Secretary, H.M. Office of Works, &c., Storey's Gate, London, S.W. *See an advertisement.*

Telephone and Telegraph Material, Instruments, &c.

Tenders are invited for the supply to the Postmaster-General's Dept., State of South Australia, of Telephone Material in accordance with schedule No. 428, and tenders are invited (up to Oct. 4) for the supply to the Postmaster-General's Dept., State of Western Australia, of Telephone and Telegraph Instruments in accordance with schedule No. 501. Tenders are also invited (up to Nov. 15) for the supply and erection at the telephone exchanges of Glenelg and Brighton, State of South Australia, of Automatic Switchboards and all associated apparatus (as per schedule No. 426). Tender forms, specifications, &c., may be obtained at the Commonwealth Offices, 72, Victoria-street, London, S.W. *See also an advertisement.*

The Deputy Postmaster-General, Perth, requires tenders by 3 p.m. Oct. 4 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General, Perth, W.A.

The N.Z. PUBLIC SERVICE STORES TENDER BOARD require tenders by 4 p.m. Sept. 13 for supply of 6,000 Four-conductor Telephone Cords. Particulars from Controller of Stores, Post and Telegraph Dept., Christchurch (N.Z.), or the Telegraph Engineers at Auckland and Dunedin (N.Z.).

Tenders are invited by the Deputy Postmaster-General, Adelaide, for the supply and delivery of Telephones, Telephone Material, Instruments and Parts. (Schedule Nos. 429 to 437). Specifications, &c., and sealed patterns may be inspected at the Office of the High Commissioner in London for the Commonwealth, 72, Victoria-street, S.W. Tenders by 2 p.m. Sept. 27.

The "Departamento de Fomento de la Mancomunidad de Cataluna," Barcelona, also require tenders by noon Sept. 25 for the installation of a Telephone System connecting the towns of BALAGUER, ARTESA, PONS and CALAF, at an estimated cost of £2,850.

Electrical Goods, Fittings, &c.

EDMONTON Guardians invite tenders (by Sept. 20) for six months' supply of Electric Lamps. Tenders to the Clerk, Lower Edmonton, London, N.

West Ham Guardians require tenders by 10 a.m. Sept. 14 for three months' supply of Electrical Fittings, Oils, &c. Forms of tender from the Clerk, Union-road, Leytonstone, N.E.

London County Council Asylums Committee want tenders by 11 a.m. Sept. 15 for the supply of Electric Lamps. Forms of tender from the Clerk, 2, Savoy-hill, W.C.

WESTMINSTER Guardians require tenders by noon Sept. 20 for six months' supply of Electric Lamps, Fittings, &c. Forms of tender from the Clerk, Princes-row, Buckingham Palace-road, London, W.

WARRINGTON Guardians require tenders by 10 a.m. Sept. 20 for six months' supply of Electrical Goods. Forms of tender from the Clerk.

Cables.

Tenders are invited for the supply of various sizes of Insulated Copper Cables and bare Hard Drawn Copper Cables to the City of MELBOURNE. Specifications, under forms, &c., from Messrs. Mellwraith, McEacharn & Co. (Pty. Ltd.), Agents for Melbourne City Council, Billiter-square-buildings, London, E.C., to whom tenders by noon Sept. 29. *Further particulars are given in advertisements.*

C.I. Pipes, &c.

SHEFFIELD Electric Supply Committee require tenders by 10 a.m. Sept. 11 for the supply and laying of 48 in. c.i. Water Pipe and Construction of Chambers.

Tramway Track Work, Material, &c.

MANCHESTER Tramways Committee invite tenders for the supply of Permanent Way Special Track Work, Point Tongues and Crossings. Specifications from Mr. J. M. McElroy, general manager, and tenders to the chairman of the Tramways Committee, 55, Piccadilly, Manchester, by 10 a.m. Sept. 12.

The Madrid "Gaceta" of Aug. 4 notifies that tenders will be opened on Oct. 7 for the Construction and Working of an Electric Tramway in Barcelona, an extension to Sans of the lines of the Cia Nacional de Tranvias de Barcelona, which holds an option on the proposed concession. Minimum rolling stock required will be Two Motor Tramcars and Two Trailers.

Tenders will be opened on Oct. 11 for Construction and Working an Electric Tramway in Madrid, from the Calle de Alcala to the Calle de Diego de Leon. Minimum rolling stock Four Cars.

In both cases construction work must be commenced within three months and completed within 10 months and a year respectively from dates of concession. An option on the concession is held by the Sociedad Tranvia del Este, Madrid.

Cooling Tower.

GISBORNE (N.Z.) Council require tenders by noon Oct. 2 for the supply and erection of a Cooling Tower at the municipal electric power station. Specification from the borough offices, or from Mr. E. J. Fenn, consulting engineer, Auckland (N.Z.).

Electric Crane and Compressor.

The NEW SOUTH WALES GOVERNMENT RAILWAYS & TRAMWAYS DEPARTMENT require tenders by noon Sept. 20 for the supply and erection of an Electric Overhead Travelling 50-ton Crane (specification 474); and by noon Oct. 11 for a motor-driven Air Compressor (specification 480) for Zarra-street power house. Specifications, &c., from the Electrical Engineer, 61, Hunter-street, Sydney.

Electric Time-releasing Mechanisms.

The Victorian Railway Commissioners, Spencer-street, MELBOURNE, invite tenders (by 11 a.m. Oct. 18) for the supply and delivery of Electric Time-releasing Mechanisms (100 with two normal and two reverse contacts, and 50 with four normal and four reverse contacts) for automatic signalling. Specifications from the Commissioners, Spencer-street, Melbourne.

Aerial Ropeway, Power Plant, &c.

The N.S.W. DEPARTMENT OF PUBLIC WORKS require tenders by 2 p.m. Sept. 18 for Power Plant, Transmission Line and Aerial Ropeway for Chichester River Storage Reservoir. Specification, &c., from the offices of the Department, Sydney.

TENDERS RECEIVED AND ACCEPTED.

CROOK.—The Co-operative Society have accepted the tender of J. J. Spoor & Son for wiring their Waterhouses branch premises at £169. 15s.

SALFORD.—The tender of Hadfield's (Ltd.) has been accepted for a supply of manganese steel crossings (for £220), that of the Lea Recorder Co. for a steam recorder (at £134), and that tender of Royles (Ltd.) for a feed water-heater (at £115).

BELFAST.—The Corporation has accepted the tender of Messrs. Babcock & Wilcox for four chain-grate stokers at £1,870.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Exeter. The accounts of the electricity department for the year ended March 31 show total capital expenditure £122,085 (increase £265), of which £56,873 has been paid off or provided for redemption of loans.

Revenue was £20,472, working and general expenses were £12,753, leaving gross profit £7,719. Interest and sinking fund required £7,144 and income tax £462, the surplus for the year being £122. The balance-sheet shows a surplus of £30,249 on the year's trade. Units generated for power and lighting were 1,515,088 and sold 1,427,169. The quantity generated and used by tramways was 712,754 units. Total maximum supply demanded was 890 kw. for lighting and power and 300 kw. for tramways.

The capital expenditure on the tramways is £89,117 (increase £299), of which £23,715 is repaid to the Sinking Fund. Revenue was £19,123 (compared with £18,015 in previous year), and working expenses were £11,938 (£11,598), leaving gross profit £7,185 (£6,420). Interest required £2,317, income tax £214, sinking fund £2,189, leaving £2,463 to transfer to reserve and renewals fund. Receipts per car-mile were 10·19d., working expenses 6·362d. Passengers carried were 5,115,382 and car miles run 450,396.

Penang. The annual reports of the electricity supply and tramways departments of the municipality of George Town, Penang, for the year 1915 have been issued.

During the year 351 installations, with an aggregate equivalent of 11,013 30 watt lamps, were connected, and at the end of the year 2,288 installations (= 76,610 30 watt lamps) were being supplied. The total capital expended is $1,407,980·77, including $12,419·24 spent during the year. Units sold were 1,901,980 (against 1,460,115). Total revenue was $304,193·42 (against $281,597·51), and total costs were $124,281·51 (against $126,793·23). The gross profit was $179,811·91 (or 18·22 per cent.), and net profit $76,913·42 (7·78 per cent.). 43 public arc lamps have been replaced by half watt lamps.

The tramways department carried 6,177,871 passengers (against 5,397,991), and the car miles run were 902,731·83 (against 903,923·27). Total revenue was $141,944·27 (against $153,014·50). Traffic revenue was $28·23 (against $30·36) per car mile, and operating costs were $19·05 (against 18·38). After meeting capital charges the deficit was $5,672·52. Better results are anticipated after the war, when extensions can be carried out.

Redditch.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £58,325 (increase £10,029), of which £28,297 is outstanding.

Revenue was £10,587, against £9,588 in previous year, and after meeting working and special expenses, gross profit was £162. Interest, instalment of loans, and other capital charges required £3,525. Working costs per unit sold were 1·68d. (against 1·63d.) in previous year. Units generated were 1,048,773 (against 1,537,683) and sold 1,453,232 (1,283,927). Consumers connected are 1,043 (decrease 6).

The engineer and manager, Mr. R. N. Mayne, states that amongst the causes of the year's unsatisfactory results are the increases of 15 per cent. in the price of fuel, 29 per cent. in price of oil, and 24 per cent. in the rate of wages, a breakdown of the turbine during April, and for 21 weeks in January and February. Also an item of £236 excess expenditure on the old turbine plant was not out of revenue. The small margin between receipts and costs per unit justifies the increased charge which has been decided upon.

Taunton. The accounts of the electricity department for the year ended March 31 show total capital expenditure £81,415 (increase £646); £39,109 of debt has been extinguished, and £13,060 is the amount of loan funds available.

Revenue was £13,034, or £13,002 after providing for allowances and bad debts, and working expenses were £7,046, leaving gross profit £5,955, to which is added £20 for sale of free-wired installations, £25 proportion of pupils' premiums, and £30 from sale of hire motors. Interest required £1,406, loans fund £3,467, depreciation on cooking stoves £51, renewals account £176, and £368 was transferred to capital account, the balance carried forward being £550. Units generated were 1,177,206 (1,085,865), and sold 950,571 (858,704). Total maximum supply demanded was 493 kw. (570 kw.).

Yarmouth.—The accounts of the electricity supply department for the year ended March 31 show total capital expenditure £127,386 (increase £1,467), of which £86,993 is outstanding.

Revenue was £15,926 (compared with £23,401 in previous year), working expenses were £13,572 (£14,282) interest, sinking fund and income tax required £8,980 (£8,085), the net result being a deficit of £6,978 (compared with a profit of £433). Units generated were 1,646,180 and sold 1,287,130. Total maximum supply demanded was 1,036 kw.

COMPANIES' MEETINGS AND REPORTS.

BRAZILIAN TRACTION, LIGHT & POWER CO. (LTD.)—The third annual report for 1915 states that the revenue in Canadian currency was as follows: Revenue from securities owned and under contracts with subsidiary companies $5,339,192.76, and interest on advances to subsidiary companies $273,683.41. Deducting general and legal expenses, administration charges and interest on loans $218,074.43, the surplus available for dividends was $5,394,801.74. Four quarterly dividends at 1¾ per cent. each on preference shares ($600,000) and two quarterly dividends of 1¾ per cent. and two quarterly dividends of ½ per cent. each on the ordinary shares ($4,249,380) absorbed $4,849,380, leaving a surplus of $545,421.74. Although rigid economies have been effected, the cost of operation and maintenance has been adversely influenced by the rise in the price of materials, and by the enormous advance in ocean freights. Conditions generally in Brazil are showing distinct signs of improvement. During the year further shares have been acquired in the capital of the Companhia Telephonica do Estado de Sao Paulo and in that of the Companhia Rede Telephonica Bragantina, and with those subsequently purchased the Brazilian company holds 95 per cent. of the share capital of each company. This company has also made advances for the purpose of carrying out necessary improvements and extensions to the telephone systems. The president (Mr. Alex. Mackenzie) has spent the last 16 months in Brazil in connection with the affairs of the companies.

In the report of the President (Mr. Alex. Mackenzie) it is stated that the gross earnings of the Rio de Janeiro division in Brazilian currency exceeded those of the previous year by 2,923,000 milreis, there being substantial increases in all departments except the tramways, the earnings of which were slightly below those of 1914, the increase in total net earnings was 1,916,000 milreis. Notwithstanding the greatly increased cost of material, freights and other charges, the ratio of operating expenses was reduced to slightly below that of 1914. Eleven new 13-bench electric cars were put into service, and considerable progress was made on the construction of 30 10-bench trailer cars. The car-miles run were 24,409,259, against 24,815,078, and the passengers carried 191,556,302, against 192,103,635. At the end of the year there was connected to the electric supply system 93,892 H.P. in motors, an increase of 19,171 H.P. over that of 1914. There was a large increase in private lighting, 6,203 new customers being added, the number of incandescent lamps (on the basis of 50 watts, or 16 c.p.) being increased from 766,038 in 1914 to 800,802 at the end of 1915. Many applications for light had been received from Maxambomba, Campo Grande, Santa Cruz and other distant suburbs not heretofore served, and as the system has already been extended to those districts, a considerable increase may be looked for during the current year. There was little change in the public lighting—only 23 arc lamps being added, making a total of 8,759 at the end of the year. There are also 2,123 private arc lamps on the circuits. The private lighting consumers number 40,866 (against 34,663) and power consumers 2,208 (against 2,105). The output of the power station at Lages was increased by 6.8 per cent. over 1914, the maximum hourly output being 36,000 kw. Notwithstanding the record drought of 1914 and the increased load, there was at all times sufficient water for operating the hydraulic installations and it was not necessary to make use of the reserve steam plant. An improved cooling system for one of the 12,000 k.v.a. units at Lages power station has given excellent results, and it is proposed to install similar cooling systems for all the generators in the station. There has been little change in the telephone service during the last two years, owing partly to the industrial depression and partly, no doubt, to the increased rates that (in the City of Rio de Janeiro) automatically come into force by reason of lower exchange. During the year the addition to the Sul exchange in the City of Rio de Janeiro was completed, increasing its capacity from 2,000 to 3,500 lines. The station is planned for an ultimate capacity of 8,400 lines. The service of the City of Rio de Janeiro is connected by submarine cable to that of the Inter-urban company in the adjoining City of Nietheroy and is extended to Petropolis and Barra do Pirahy and other towns in the vicinity. In December last legislation was passed authorising the connection of the Inter-urban service with that of the Bragantina company in the State of Sao Paulo.

On Dec. 31, 1915, the Companhia Telephonica do Estado de Sao Paulo had 6,131 subscribers in Sao Paulo, 1,019 in Santos and 753 in Campinas. Arrangements have been made for the use of the poles of the Sao Paulo Tramway, Light & Power Co. and the joint use of the underground duct system of that company, thereby materially reducing the cost of construction and maintenance. The Companhia Rede Telephonica Bragantina owns and operates a telephone service in 99 municipalities in the States of Sao Paulo, Minas Geraes and in Rio de Janeiro. A regular telephone service can now be given between Ribeirao Preto, one of the most important cities in the western part of the State, and Santos, a distance of 310 miles, and between Santos and Guaratingueta, a distance of 177 miles in the opposite direction, the intermediate towns and cities also securing the benefit of this improved and extended service. The circuits of the company will be connected with the new exchange now under construction in Sao Paulo. The Companhia de Telephones Interestadoaes, which was organised in 1913, operates the telephone service in Cataguazes, Sao Paulo de Muriahe and Palma in the State of Minas Geraes; and in the adjoining municipality of Santo Antonio de Padua in the State of Rio de Janeiro. For financial reasons, the construction work has proceeded slowly, but during the year 124 miles of lines were built. Notwithstanding the extensive use of electricity for public lighting, gas is still used, and there were in service at the end of the year 22,080 gas lamps, practically the same as during the previous year. Gas, however, is now little used for private lighting, but there is an immense field for the development of the business by the further extension of its use for domestic purposes, for bakeries and other industries.

The total gross income of the Rio de Janeiro division (not including Companhia Telephonica do Estado and Companhia Bragantina) for the last four years is given in Brazilian currency as follows:—

	1912. Milreis.	1913. Milreis.	1914. Milreis.	1915. Milreis.
Tramway	23,934,427	25,530,923	24,850,432	24,608,003
Light and power	11,262,966	13,842,033	14,752,552	16,684,680
Telephone	1,641,414	2,248,394	2,597,679	2,771,143
Gas	7,735,138	8,296,014	8,423,636	9,484,108
	44,573,945	49,917,364	50,624,299	53,547,934

During the early part of the year the earnings of the Sao Paulo division were maintained at about the level reached during the latter part of 1914, but later there was a marked improvement which continued throughout the year, especially in the light and power departments, which showed an increase in their net earnings of 9·6 per cent. over 1914. There was a slight decrease in tramway earnings. The total increase in gross and net earnings in Brazilian currency was 452,000 milreis and 49,000 milreis respectively. There are indications that there will be a considerable increase in earnings for the current year, especially in the tramways. The car-miles run were 9,425,231, against 9,496,091, and the total passengers carried 51,574,145, against 53,732,292. At the end of the year there was connected to the electric supply system 38,896 H.P. in motors, an increase of 8,656 H.P. over the previous year. There was also a large increase in lighting, 6,028 new customers being added, making 22,414 lighting consumers with 1,439 power consumers. There was little change in the public lighting, but arrangements have recently been concluded with the Government for considerable additions to this service. For public lighting there are 497 arc lamps (against 472). The power plant at Parnahyba was shut down several weeks for installing new headgates in the three feeder pipes at the main dam. During the progress of this work, the plant of the Sao Paulo Electric Co. at Sorocaba supplied Sao Paulo with all the energy required.

The Sao Paulo Electric Co. supplies power to the Sao Paulo Tramway, Light & Power Co. The connections include 7,745 private incandescent and 719 public lamps, with 3,406 H.P. in motors and 1,247 consumers.

KALGOORLIE ELECTRIC TRAMWAYS (LTD.)—Mr. A. H. P. Stoneham, who presided at the annual meeting last week, said that the profits of the undertaking were about the same as last year. The board had found it necessary to allow for depreciation in order to provide for the renewal of machinery, cars, &c., as and when necessary. The outlook was not very bright, and he could see no immediate probability of improvement. The competition of motor cars still continued, but it was probable that the scarcity of petroleum would be felt in Australia as well as in Europe, and so do away with that form of competition. So many low-grade mines had had to close down, so many miners had joined the fighting forces and left Kalgoorlie, and those who remained so strongly objected to work with the alien enemy (Austrians chiefly), formerly employed at the mines, and to supply wood for the mines, that the position in Kalgoorlie had been rendered very difficult for the tramway company. Indeed, about the only thing that could restore prosperity to them was the possibility of immigration on a large scale into Australia after the war. When the company was formed it had been anticipated that Kalgoorlie was going to become a great mining town. That it had not done so was not because the mines had not yielded, but chiefly because the labour problem had proved so difficult. Labour, which some years ago cost 8s. to 10s. per day, was now costing 15s. to 16s. per day, which made all the difference for low-grade mines. Even if a big mine were discovered in Kalgoorlie he was doubtful whether capital would be found in present circumstances to develop it, because directly capital was put into a concern wages began to go up. The question of wages also arose in connection with the possibility of agricultural developments, and he for one did not see how a man was to cultivate large acreages of wheat, employ labour, and hope to sell the crop at a profit alongside Canadian wheat. The condition of Kalgoorlie now was not such as to attract business men from other States, as some years ago they had hoped would have been the case.

ROYCE (LTD.)—The report for the year ended March states that after paying or providing for liberal depreciation, &c., charging repairs and replacements to revenue, and making provision for the estimated amount payable under the Finance and other Acts, the profit was £6,944, to which is added £418, interest on investments, and the balance brought forward (£1,001), making a total of £8,364. It is proposed to pay 5 per cent. on the ordinary shares for the year and carry forward £2,956.

NEW COMPANIES, MORTGAGES & CHARGES.

NEW COMPANIES.

FARADAY & SON (LTD.) (144,736.)—Reg. Aug. 31, capital £5,000 in £1 shares, to adopt an agreement with Rosa B. Faraday, P. Faraday and L. B. Faraday to carry on the business of electrical engineers and manufacturers of electrical fittings as formerly carried on by the said vendors as Faraday & Son. Private company. First directors are P. Faraday and L. B. Faraday (both permanent).

HEMEL HEMPSTEAD ENGINEERING CO. (LTD.) (144,611.)—Reg. Aug. 15, capital £5,000 in £1 shares, to carry on the business of hydraulic

and [illegible] engineers, makers of and dealers in lifts, cranes and hoists, to work by electricity, hydraulic and hand power, makers of and dealers in [illegible] electrical winches, electricians, &c. Private company. First directors: [illegible] J. Christopher, E. R. Elliston, C. M. Evans, E. L. Price, and [illegible] E. Talbot (all permanent). Reg. office, Hemel Hempstead.

MORTGAGES AND CHARGES.

BRILLIANT ARC LAMP & ENGINEERING CO. (LTD.) Particulars of £2,500 debentures created Aug. 9, 1916, have been filed, whole amount being issued. Property charged, company's undertaking and property present and future. No trustees.

FARINGDON ELECTRIC LIGHT & POWER CO. (LTD.) Particulars of £300 debentures created June 30, 1915, have been filed, whole amount being issued. Property charged, company's undertaking and property present and future. No trustees.

CITY NOTES.

MEMORANDA (Sept. 6).—Bank rate 6 per cent. (since July 13, 1916). Consols 57¼. Stocks and Shares Ticket Days, Sept. 13 and 28. Pay Days, Sept. 14 and 29. Price of silver, 32½.

COMPANIES TO BE STRUCK OFF REGISTER. Notice is given that at the expiration of three months from August 15 the names of the undermentioned companies will, unless cause is shown to the contrary, be struck off the register: Acton Lamp Co., Carlsbad Electro-Thermal Bath, Dauphouse Duplicating Recorder Co. and Woodhouse Steel Casting Co., Ltd.

MACKAY COMPANIES. The regular quarterly dividend of 1 per cent. on the preferred shares and the regular quarterly dividend of 1¾ per cent. on the common shares in the Mackay Companies will be paid on Oct. 2. The transfer books will not be closed.

METAL PRICES.

[illegible] & Co., 132, Upper Thames-street, London, E.C., quote under the present business prices:

	per ton.
[illegible]	15¼d.
[illegible] Tubes	18½d.
[illegible]	18½d.
[illegible]	17¼d.
[illegible]	14¼d.
[illegible]	18d.
[illegible]	11¼d.
[illegible]	15d.
Brazed Tubes	£130 0 0
[illegible]	49 0 0

	Per ton.
English Lead	£31 5 0
Antimony	Nominal.
Old Metals.	**Per ton.**
Clean Copper Scrap	£100 0 0
Clean Brass Scrap	63 0 0
Brewery Copper Scrap	89 0 0
Old Lead	26 10 0
Old Zinc	35 0 0
Hollow Pewter	120 0 0
Black Pewter	80 0 0
Cast Metal	80 0 0

[illegible] Lead, Southwark, London, S.E., quotes under date prices of Scrap Metals:

	Per ton.
[illegible]	£110 0 0
[illegible]	64 0 0
[illegible]	78 0 0
[illegible]	83 0 0
[illegible]	58 0 0
Old Lead	£3 15. under English lead price
Old Zinc	35 0 0
Hollow Pewter	125 0 0
Stereotype Plate Pewter	85 0 0

[illegible] at the following prices per ton: Plumber's Solder (finest), £117. Tinman's Solder, £97. Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

We give below the latest prices at which actual transactions took place on the London Stock Exchange on Tuesday, Sept. 5.

Shrs.	Last Dividend	Name	Price, Tues., Sept. 5	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 2,000. [Vol. LXXVII. No. 24.] FRIDAY, SEPTEMBER 15, 1916. PRICE ONE SHILLING. *By Post, 1s. 3d.; Abroad, 1s. 7d.*

CONTENTS.

	PAGE
Our 2000th Issue	789
Arrangements for the Week	792
Milestones on the Path of Progress. By W.R. Cooper, M.A., B.Sc.	793
Some Notes on the Early Developments of Electrical Engineering. By Col. R. E. Crompton, C.B., R.E.	796
The Story of Land Telegraphy. By H. H. Harrison, A.M.I.E.E.	798
The Story of the Submarine Cable. By Charles Bright, F.R.S.E., M.Inst.C.E. Illustrated	801
The Speed of Submarine Telegraphy. A Cursory Historical Sketch. By Edward Raymond-Barker. Illus.	808
The Story of the Telephone. By J. E. Kingsbury	812
Long-Distance Telephony. By B. S. Cohen	814
Dynamo-Electric Machinery, 1878-1916. By Miles Walker. Illustrated	817
The Evolution of the Electric Lamp. By Clifford C. Paterson	822
Electric Traction. By H. F. Parshall, D.Sc.	824
Electric Light and Power Cables. By C. J. Beaver, M.I.E.E.	826
Some Accumulators of the Past. By Frank Crawter	829
Radiotelegraphy: A Retrospect of Twenty Years. By J. A. Fleming, D.Sc., F.R.S. Illustrated	831
Technical Research. By J. Swinburne, F.R.S.	836
Development of Electric Power Stations. By P. V. Hunter. Illustrated	838
Boiler Development, 1882-1916. By D. Wilson. Illustrated	840
Electrically-Driven Coal-Handling Plant. By H. H. Broughton. Illustrated	843
Improvements in the Sensitiveness of Apparatus at the B.O.T. Electrical Standards Laboratory. By A. P. Trotter	851
Measuring Instruments. By C. V. Drysdale, D.Sc. Illustrated	853
Recent Progress in X-Rays and Radiography. By G. W. C. Kaye, M.A., D.Sc., Capt. R.E. (T.) Illustrated	861
Electrochemistry. By F. Mollwo Perkin, Ph.D.	867
Metallurgy in Relation to Electrical Engineering. Illustrated	869
The Nation, the Apprentice and the Polytechnic. By R. Mullineux Walmsley, D.Sc., M.I.E.E.	871
Training of Apprentices. By A. P. M. Fleming	874
THE BRITISH ASSOCIATION AT NEWCASTLE. (From our Special Correspondent)	877
The Calculation of the Capacity of Radiotelegraph Antennæ, including the Effects of Masts and Buildings. By Prof. G. W. O. Howe. D.Sc., M.I.E.E. Illustrated.—*Concluded*	880
Some Characteristic Curves of a Poulsen-Arc Generator. By N. W. McLachlan, B.Sc.Eng., A.M.I.E.E. Illustrated	883
Report of the Committee of the Privy Council for Scientific and Industrial Research. *Concluded*	885
Publicity and Its Relation to Engineering Work. By W. E. Warrilow, A.M.I.E.E.	887
Commercial and Industrial Section	887–896

Our 2000th Issue.

THE present issue of THE ELECTRICIAN bears the number 2000, and we have, therefore, included within its pages a number of specially contributed articles, some dealing historically with the development of various branches of the electrical industry and others with recent advances and some present-day problems.

The first series of THE ELECTRICIAN ("A Weekly Journal of Telegraphy, Electricity and Applied Chemistry") was started on November 9, 1861. At that time the field of view was restricted almost wholly to telegraphic matters, and it must have been difficult to fill even the modest 13 pages of text then presented to the reader, whereas in these days the difficulty is in finding space for all that should be included in five times this number of pages. In the introductory statement to this first issue it is recorded that the journal "is designed to meet the requirements of the student in a field of knowledge which is every day being extended, and which in all probability is destined to solve many of the most important problems connected with the well-being of mankind." This statement speaks well for the prophetic intelligence of those days, when little more than the telegraph had been accomplished in the practical application of electricity. We can gain some insight into the state of knowledge by perusing the pages of this first issue. For example, there is an editorial note on "Artificial Sunlight," which deals with the possibility of using limelight. The Universal Lime Light Co. (Ltd.) had been formed for what we should now consider the hopeless task of pushing this form of light for streets and large buildings. The idea of using electricity had not yet arisen. On the same page is an historic Paper, read before the British Association by LATIMER CLARK and Sir CHARLES BRIGHT on the "Measurement of Electrical Quantities and Resistance." In these days it is quaint to read of the suggestions made by the authors that the unit of tension should be the Ohma, the unit of electrostatic quantity the Farad, the unit of current the Galvat and the unit of resistance the Volt. Ideas have changed since then. Nevertheless, this Paper led to the formation in that year of the British Association Electrical Standards Committee, which carried out such extremely important work up to the year 1912-13, when it was dissolved. In this first issue it is also interesting to notice a description of Casselli's "pantelegraph," which we should now call the Telewriter. The instrument was exhibited at the Italian Exhibition in Florence, and the same arguments were advanced in its favour as are to be heard to-day.

The first series of THE ELECTRICIAN was continued through rather more than five half-yearly volumes, and terminated on May 28, 1864. Presumably the number of those engaged in telegraphy and work of a similar character was not sufficient to support the venture. Or, perhaps, the question, which at one time became acute, whether the technical or the commer-

cial side should predominate the editorial policy, arose once more. As described on another page, the second and present series started on May 25, 1878, a more opportune moment, when the electrical field was beginning to enlarge its bounds very vigorously. How far that field has been enlarged we attempt to show in a small way in our present issue.

The British Association Meeting.

We think it will be admitted that the meeting of the British Association this year was in many respects disappointing, though, of course, it will be equally admitted that the conditions under which the meeting has necessarily been held have rendered it difficult for many of those who habitually take part in such gatherings to be present, or to contribute Papers. In the proceedings of Section A there was very little of general electrical interest, and the programme of Section G was certainly weak in electrical matters. Perhaps this was inevitable, and we might indeed feel that it would be disappointing if it were otherwise, for the present is not a time for ordinary investigations by those who can be engaged on any work of national importance. As will be seen by the account which we publish in another column, by far the most interesting part of the proceedings, from the general engineering point of view, was the joint discussion of the Engineering and Chemical Sections on the important question of fuel economy. To the electrical engineer this question is one of very direct interest, for it must be realised that the most easy means of economising fuel is to generate power electrically, the combustion being carried out in such a way as to enable the most economical results to be obtained from by-products. Therefore such methods can only be followed satisfactorily on a very large scale. It is out of the question to suppose that electrical engineers can carry out the recovery of by-products in addition to generating electrical energy. The recovery of such products can only be handled properly by an expert chemical staff, and any idea that this can be done on a large scale in haphazard fashion must be put on one side, for the supply engineer is far from being a chemical manufacturer. The whole question is one of the very greatest importance to this country, and requires most careful consideration. It is interesting to note that Sir Hugh Bell is putting to a practical test the suggestion made a few years ago by the late Sir William Ramsay that thin seams of coal should be used for power purposes by burning them in situ. The idea does not sound very practicable, but we hope that the results, whatever they may be, will be published in due course. Apart from technical matters, the Association considered the large question of the replacement of male by female labour in consequence of the war. We need scarcely remark upon the importance of this question from more points of view than one, and that it may give rise to serious difficulties when peace comes once again.

Preparedness for Peace.

Little more than a year ago a scribe showed that it was less patriotic to be loyal than to be hostile to the Government. That the truth of this was tardily recognised was not altogether our fault, for our leaders had laboured hard to make us understand that it was our duty to be loyal to them. How near disaster our "loyalty" brought us and our Allies is now a byword, and calls for no comment. The hard lesson we have learned, or which we ought to have learned, as the result of the war applies also to peace, and this is not yet fully realised. We think that Mr. Winston Churchill's advice "to look after the war and after the war will look after itself" is less sound than one would expect to be the advice of a clever and far-seeing statesman. We would go further, and state that we regard such advice as dangerous in the extreme. In our opinion it is on a par with that which, for our sins, we blindly followed in the past, and for which we are now paying at the rate of six millions a day. Unless we see to it now, when peace is proclaimed we shall find ourselves at least as unprepared for peace as we were unprepared for war. It is highly desirable we should be certain that the steps we and our Allies are taking to destroy Prussian militarism does not mean something worse for us and for them. The putting into practice of many of the resolutions made in haste while we have the fever upon us may have an effect opposite to the one intended, and instead of breaking militarism will either break us or enslave us. With what is said to be a half-hearted blockade, with the mishandling of the food question, the fuel question, munitions, recruiting, conscription, pensions and a score of other questions, all under consideration at the present time; with such examples before us as the enormous profits that are being made by everybody having anything to sell, and the absurdly high wages that are being paid to ensure "patriotism," to say nothing of the State's tolerance of our reckless and criminal extravagance—all these lead us to believe that many better understand how to play with words than how to make war. On the ultimate issue of the war there can be no question, nor has there been any question as to the issue since the civilian engineer lent his brains and his business to his country, but it is well that the whole of the Allies should look ahead lest the price of victory be the raising of the cry "Sauve qui peut" afterwards by the victors.

Congratulations from Prof. Elihu Thomson and Prof. A. E. Kennelly.—In connection with our 2000th issue Prof. Elihu Thomson cables as follows: "Congratulations past service, anticipations for future." We have also received the following cablegram from Prof. Kennelly: "Congratulations second kiloissue. Electrician record splendid both quality and quantity. May Salisbury-court long continue illumine electrical world."

Capital and Labour.—A leading article entitled "The Future Relations of Capital and Labour" in the current issue of "Engineering" directs attention to one of the most pressing questions that has ever faced the employer and employé. The recent addresses before the British Association at Newcastle and the Trade Union Congress at Birmingham lead one to believe that the two will come together, and will work together in the future in a spirit of "sweet reasonableness."

British Coal.—In the United Kingdom the amount of coal raised in 1913—the last pre-war year—was 287,000,000 tons, as compared with 230,000,000 in 1903, 188,000,000 in 1894, 160,000,000 in 1884 and 126,000,000 in 1874. Having regard to the character of the new collieries recently established and about to be established in parts of Great Britain, there is every reason to suppose that the next decade will show a great increase in coal production. "It is, therefore, highly probable," says the "Engineer," "that the annual tonnage raised in this country will continue to increase until it has reached the figure of 350,000,000 or even 400,000,000 tons a year."

The Rubber Trade in Germany.—In an article in the "India Rubber World," of New York, the following paragraph appears: "Until a few years ago the Imperial (German) Government recognised what was known as secret patents, claims and specifications of inventions which were filed with the patent department, but not published, yet protected the inventors' rights. The growing of liberal business interests, however, in time disposed of this rather undemocratic institution. But now all are beginning to recognise the advantages of this discarded system which will probably soon be re-established." Evidently we must look after ourselves more carefully in the near future.

American Electrical Machinery.—Statistics gathered by the United States Department of Commerce for 1914 show that the output of electrical machinery in America in 1914 was £72,000,000, or 50 per cent. higher than the output in 1909. The output of dynamos, including parts and supplies, in 1914 was valued at £4,700,000, representing an increase of 34·8 per cent. over the corresponding value for 1909. Under this head are included dynamotors, motor generators, boosters, rotary converters, double-current generators, &c.

Steel Testing.—The "Daily Telegraph" calls attention to the development of electromagnetic methods of testing steel, based on the co-relation of the magnetic and mechanical properties of the metal.

It is stated that recently experimental evidence on this important and fascinating subject has been put forward by Mr. Charles W. Burrows, of the Washington Bureau of Standards. His evidence seems to point to the conclusion that there is one, and only one, set of mechnical characteristics corresponding to a given set of magnetic characteristics, and conversely there is one, and only one, set of magnetic characteristics corresponding to a given set of mechanical characteristics. And it goes on to say that although there is no evidence to refute the preceding rather broad statement, the utility of this generalisation is decidedly limited by the complexity of the relations due to the large number of variables and the lack of sufficient quantitative data, but that such data, however, are gradually being obtained by Mr. Burrows and others, who are working on this problem.

Chicago Generating Stations.—At one time there were 25 separate electric power generating stations in Chicago under many different managements. But the result of centralisation has been a saving in coal, in the cost per kilowatt, in operating costs, and in the charges to the consumer. The characteristics of the peak load have also changed, and the maximum railway load is now about three times that of the lighting output. Larger units are likely in the future; 30,000 kw. units will be installed next year, and larger ones the year after; higher steam pressures are also likely and are being used experimentally at the present moment to some extent.

Aluminium Overhead Conductors.—A Paper was read some time ago before a Swiss technical society on the use of aluminium as an overhead conductor. As regards the relative costs of aluminium and copper, the author, Mr. Wyssling, comes to the conclusion that so long as the price of aluminium is less than 1·89 times that of copper, it is the cheaper of the two as an electrical conductor; a table gives the percentage of saving for variable ratios of the prices. Another table gives the physical constants of aluminium; there are also tables showing the sizes of aluminium conductors corresponding to ordinary sizes of copper conductors, the minimum allowable sections for aluminium overhead wires, and the resistance, mechanical strength, and weight of aluminium cables of different series.

Magneto Testing Apparatus.—A method of testing magneto apparatus was described recently in "La Revue Electrique." The magneto to be tested is caused to produce sparks between Pt-points in an atmosphere of nitrogen enclosed in a glass bulb, across which there also extends a resistance wire in an independent circuit. The expansion of the enclosed gas, due to the heat generated by the sparks, is measured by the movement of a mercury column in a U-tube, one end of which opens into the bulb at the bottom. The apparatus is calibrated by means of the resistance wire. The results of experiments are given, showing the variation in the energy per spark. This rises to a maximum, and then decreases as the speed of rotation is increased.

Utilisation of Engineering Works after the War.—In view of the national prominence of the engineering industry, the Lord Mayor is convening a public meeting at the Mansion House, London, at 3 p.m. on Wednesday, Sept. 20th, to discuss future trade policy with special reference to the economic utilisation of the engineering works of the nation which have been so largely expanded in capacity and equipment during the past two years. The organisation of the meeting is being undertaken by the British Electrical & Allied Manufacturers' Association, with the support of the British Engineers' Association, the British Empire Producers' Organisation and the Engineering and Electrical Sections of the London Chamber of Commerce. Applications for tickets of admission should be sent to Mr. T. C. Elder, Organising Secretary for the meeting, B.E.A.M.A. Offices, 36, Kingsway, London, W.C., or to the Secretaries of any of the above organisations.

Boiler Explosions.—Comparing the boiler explosions in America with those which take place in this country, the American journal "Power" claims that in the United States the number of explosions is no higher than in Great Britain, when the difference in area of the two countries and the number of boilers is taken into consideration. "Power" states that boiler explosions in the United States are largely confined to sawmill and similar plants, in which skilled engineers are not employed. During the past 12 months there were in the United States 265 boiler explosions or failures of all kinds, in which 113 persons lost their lives and 312 others were injured. About one-fifth of these explosions were confined to low-pressure house-heating boilers; 33 were sawmill boilers, and these killed 28 and injured 55 others. Deducting the number of house-heating boilers from the list of explosions, the total of high-pressure explosions is reduced to about 210. This is about 3½ times the number of explosions that occurred in Great Britain during the same period.

Overhead Electric Lines.—The Board of Trade state that a considerable number of applications have been made for the consent of the department to the erection of temporary overhead lines for the transmission of electrical energy, and the Board desire to call attention to their memorandum relating to the particulars required by the department in connection with applications for consent to the erection of overhead lines. The memorandum is as follows:—

Every application for the consent of the Board of Trade to the placing of electric lines above ground should be accompanied by the following particulars:—

1. Where the undertakers are a company, or a local authority supplying outside their own area, evidence of consent of the local authority* for the district.

2. A statement showing commercial or other considerations why underground cables should not be used.

3. A brief description of the proposed system, whether by continuous or by alternating-current, the working voltage; the kind of wire whether copper or aluminium; whether solid or stranded; the total sectional area; tensile strength and elongation; average and maximum length of span; minimum height of wires from the ground; name or description of automatic protective device, if any.

4. A statement whether the supply is to from (1) an extension of an existing system of underground cables, or (2) of an existing traction system, or (3) an independent system.

5. An ordnance map on a scale of 6 in. to the mile, showing the proposed route of the overhead lines and any existing overhead lines. The sheets of these maps must not be fastened together.

6. In the case of high and extra high pressure, plans of construction of poles, &c., on a scale of about 1 in. to the foot, or a reference to previously deposited plans where these are identical with the proposed work.

NOTES.—Codes of regulations have been made (1) for overhead lines for low pressure and medium pressure continuous-current supply, and for low pressure alternating-current supply, and (2) for pressure exceeding low or medium pressure continuous-current and low pressure alternating-current. Regulations will be made for each case separately, following these codes unless special alterations are sanctioned.

Attention is called to the necessity for obtaining the approval by the Postmaster-General of plans and works under sec. 14 of the Schedule to the Electric Lighting (Clauses) Act, 1899.

Radiotelegraphic Investigations by the British Association.—The following report by the British Association Committee for Radiotelegraphic Investigation has been issued:—

The observational work done for the Committee during the past year has been carried out at about 25 stations distributed in Australia, the United States of America, Canada, New Zealand, Ceylon, Trinidad, Dutch East Indies, Fiji, and the Gold Coast.

Of the four kinds of Forms issued by the Committee for the collection of statistics, the first, relating to the number and strength of the strays at 11 a.m. and 11 p.m. Greenwich mean time, has been in most regular use and the stock is almost exhausted. No further edition of this Form will be issued during the war, and thus the collection of statistics will come gradually to an end.

The difficulty of obtaining clerical assistance for the work of reducing the Forms has greatly impeded progress; but a certain amount of work

* The local authorities are: (*a*) In England and Ireland—Borough councils, urban district councils, rural district councils; (*b*) in Scotland—Police commissioners, gas commissioners, town councils, county councils.

has been accomplished and has yielded results of interest. So soon as the several sections of the work are rounded off the results will be published.

The reduction of Form I is proceeding by the collation of records and reports of excessive atmospheric disturbance since August, 1914, in North America and Australia, and by their examination in conjunction with meteorological data from the corresponding daily weather charts.

The reduction of Form II is proceeding by the correlation of instances of exceptionally good or bad transmission with meteorological data, and by analysis of statistics from Cocos, Fiji, Lagos, Malta and Sierra Leone.

Several important exceptional phenomena have been reported which will, after discussion, be published. These include reports of :—

Aurora, strays and signals in Alaska and Hudson Bay.

Severe atmospheric disturbances in Malta.

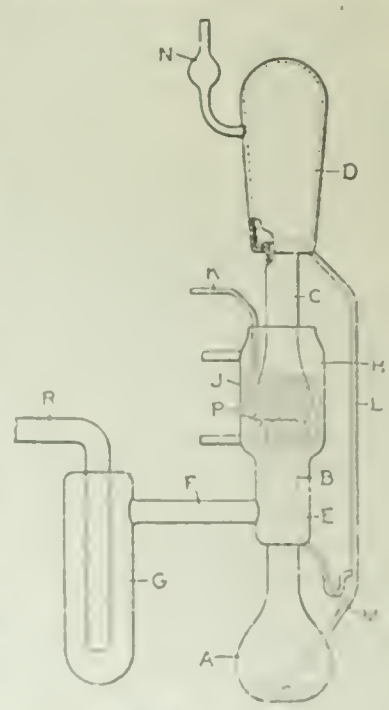
Simultaneous strays on both sides of the Atlantic.

Effect of tropical storm in the Gulf of Mexico, Sept. 30, 1915.

The Committee desire to express their cordial thanks for the favours extended to them by the Colonial Office, the Governments of Australia, Canada and New Zealand, the War Department and the Navy Department of the United States of America, the Telegraphic Department of the Dutch East Indies, the Marconi Companies in the United States of America and Canada, the United Fruit Company of New York, the Eastern, the Eastern Extension and African Direct Telegraphic Companies, Profs. T. Agins, R. S. Hayes and A. Hoyt Taylor. The assistance of those who have taken part in investigations other than those referred to in this report, will be duly acknowledged in a future report.

High-Vacuum Mercury Pump. Dr. Irving Langmuir, in a recent issue of the "Physical Review," gave an illustrated description of a mercury-vapour pump acting on a similar principle as the "Gaeda," but being of simpler construction and more reliable than the latter. It is characterised by its high speed of operation. There is also an absence of lower limits to which the pressure may be reduced.

The construction is shown herewith. A blast of mercury vapour passes upward from the heated flask A through the tubes B and C into the condenser D. Surrounding B is an annular space E connecting through F and the trap G with the vessel to be exhausted. The tube C is enlarged into a bulb H just above the upper end of the tube B. This enlargement is surrounded by a water condenser J from which the water is removed at any desired height by means of tube K, which is connected to a water aspirator. The mercury condensing in D and H returns to the flask A by means of the tubes L and M. The tube N connects to the "rough" or "backing" pump, which should maintain a pressure considerably lower than the vapour pressure of the mercury in A. In this pump the mercury atoms escaping from the upper end of the tube B radiate out in all directions. A part of them pass up into C, but the larger part strike the walls of the enlargement H. If there is no water in the condenser J the mercury which condenses on the walls re-evaporates nearly as fast as it condenses. The molecules passing from the end of the tube B toward the walls H collide with the molecules which re-evaporate, and may then be deflected downward into the annular space E. The blast of mercury vapour down through E prevents the gas from F from passing up into H, so that under these conditions the gas from F may pass through the pump much more slowly than if no mercury vapour were produced in A. On the other hand, when cold water circulates through the condenser J all the mercury atoms striking the walls of H are condensed, so that no mercury passes down through E. The gas from F thus passes freely up through E, and when it meets the mercury vapour blast at D is blown outward and upward along the walls of the condenser H, and finally forced into the main stream of mercury vapour passing up through C into the condenser D.



MERCURY PUMP.

OBITUARY.

SIR JAMES SIVEWRIGHT.—The death of Sir James Sivewright, K.C.M.G., occurred at a nursing home in Shropshire on Sunday.

Sir James was born at Fochabers in 1848, and after passing through Aberdeen University, he spent some time in the Indian telegraph service, and went to South Africa as general manager of the telegraph system in 1877. He retired in 1885, and subsequently entered Cape politics. He held various offices including that of Commissioner of Crown Lands and Public Works. He was joint author of early editions of Preece & Sivewright's "Telegraphy," and he was also chairman of the Bath Electric Tramways (Ltd.)

KILLED IN ACTION.—The following deaths in action or as the result of wounds are reported :—

Lieut. W. C. Carbonell (S. Staffs. Regt.), who died of wounds on Sept. 1 at the age of 24, was at the City and Guilds Engineering College when the war broke out.

Capt. J. Hendry (Royal Scots), who died on Sept. 6 of wounds received on Aug. 2, was an electrical engineer. He received his early training in Glasgow and Pittsburg, and was subsequently a consulting engineer in Rochdale.

Lieut. Victor C. D. Boyd-Carpenter (R.E.), who was killed on Aug. 29, was born in 1887. He studied engineering at Leeds University and at Messrs. Crompton & Co.'s works. Later he was engaged on construction work on the Southern Railway, U.S.A.

PERSONAL.

It is announced that Commendatore Marconi has been transferred from the Engineers' branch of the Italian Army to the Navy, with the rank of temporary Captain.

Mr. R. M. Bishop, formerly associated with the accounts department staff of Messrs. Siemens Bros. Dynamo Works, 38 and 39, Upper Thames-street, E.C., has been promoted while on active service to the rank of sergeant. He was also awarded the military service medal for conspicuous bravery at Pozières.

ROYAL ENGINEERS (T.F.)—The following appointments have been made :—

London Electrical Engineers: Sec. Lts. (temp. Lts.) S. Mathews, R. C. Milliken, J. Gibson, J. R. Birch, J. G. S. Gabriel, H. F. G. Roose, R. Engelbach, H. G. G. Clarke and C. H. S. Evans to be temp. captains. Pte. H. F. Cousins (from Artists Rifles O.T.C.) to be Sec. Lt. (on probation).

APPOINTMENTS VACANT.

Messrs. John C. Fuller & Son (Ltd.), Woodland Works, Chadwell Heath, London, E., advertise for a traveller having connection with mines, municipalities, large electrical contractors, &c.

An assistant master in electrical engineering is required at the Polytechnic (Regent-street, London, W.) for part or whole of next session. Applications to the Director of Education. *See an advertisement.*

A switchboard attendant is wanted at Stoke-on-Trent electricity works for the duration of war. Wages 30s. per week, with 4s. war bonus if married. Applications to Borough Electrical Engineer, St. Peter's chambers, Glebe-street, Stoke-on-Trent. *See advertisement.*

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for the week : —

Officer for the Week.—Platoon Commander N. E. Brown.

Next for Duty.—Platoon Commander C. H. C. Bond.

Resignation.—Major T. F. Hobson resigns his appointment as sub-commandant (dated September 4th).

Appointment.—Sapper T. Baseden to be quarter-master sergeant (dated September 8th).

Monday, September 18th.—Technical for Platoon No. 9 at Regency-street. Squad and Platoon Drill, Platoon No. 10. Signalling Class. Recruits' Drill, 6.25 to 8.25.

Tuesday, September 19th.—Range Practice.

Wednesday, September 20th.—Lecture by W. Eyles, Esq. (late R.E.), 7.15, on "Demolitions." Platoon Drill, Platoon No. 1. Range Practice.

Thursday, September 21st.—Instruction Class, 5.45. Platoon Drill, Platoon No. 5. Range Practice.

Friday, September 22nd.—Technical for Platoon No. 10, Regency-street. Squad and Platoon Drill No. 9. Signalling Class. Recruits' Drill, 6.25 to 8.25.

Saturday, September 23rd.—Instruction Class, 2.30, Coy. Cdr. Fleming.

Sunday, September 24th.—Entrenching at Otford. Parade Victoria (S.E. & C. Rly.) Booking Office 8.45, a.m. Uniform, haversacks, water bottles. Midday ration to be carried. Railway vouchers will be provided.

Musketry.—For all Companies see Notice and Tables A and B at Headquarters.

Corps Meeting.—A General Meeting will be held on Saturday, September 30th, at 5.30.

NOTE.—Unless otherwise indicated, all drills, &c., will take place at Headquarters.

Milestones on the Path of Progress.

By W. R. COOPER, M.A., B.Sc.

It is not an easy task for the present generation to form a true conception of what might be termed the dark ages of the electrical industry some 40 years ago. Many fundamental laws had been discovered, and the electric telegraph was firmly established, but the dynamo was only emerging from the commercially experimental stage ; the value of the electric motor was scarcely realised, and the "sub-division" of the electric light was a problem of the day. Of technical education there was nothing, and laboratories, as we know them now, did not exist.

It was under these conditions that the second and present series of THE ELECTRICIAN ("A Weekly Journal of Theoretical and Applied Electricity and Chemical Physics") came into existence on Saturday, May 25, 1878. The time was opportune. Apart from land telegraphy the Atlantic cable had been in operation for 12 years. The public had become accustomed to the fact that electricity was able to render signal services to mankind, restricted though they were at this period ; and during the previous year, 1877, the telephone had appeared under commercial conditions. And in the year 1878 the scientific world was startled by Hughes' discovery of the microphone.

It is not surprising, therefore, that the want of a weekly journal devoted to electrical subjects was experienced, and that it was decided to supply this want. The first issue of THE ELECTRICIAN contains the following interesting list of those who promised to support the new venture :—

Adams, Prof. W. G., F.R.S.
Anderson, Sir James.
Andrews, W. S., M.S.T.E.
Clark, Latimer, C.E., M.S.T.E.
Cumming, L., M.A.
Dewar, Prof. J., F.R.S.
Edison, Thos. A., M.S.T.E.
Ferguson, Prof. R. M., M.A.
Forde, H. C., M.Inst.C.E.
Foster, A. Le Neve, M.S.T.E.
Garnet, W., M.A.
Guthrie, Prof. F., F.R.S.
Higgins, F., M.S.T.E.
Hocking, C., M.A., C.E.
Hughes, Prof. D. E., M.S.T.E.
Jamieson, A., M.S.T.E.
Jenkin, Prof. Fleeming, F.R.S.
Langdon, W., M.S.T.E.
Lodge, O., D.Sc.
Mills, Prof. E. J., D.Sc., F.R.S.
Moncel, Count Theordore du.
Muirhead, A., D.Sc., F.C.S.
Prescott, G. B., M.S.T.E.
Richards, Admiral Sir Geo., C.B., F.R.S.
Routledge, R., B.Sc.
Sabine, R., C.E.
Schwendler, L., M.S.T.E.
Smith, G., B.Sc.
Smith, Willoughby, M.S.T.E.
Spagnoletti, C., M.S.T.E.
Sprague, T. J., M.S.T.E.
Stewart, Prof. Balfour, F.R.S.
Thompson, Prof. Silvanus P., D.Sc.
Thomson, Prof. Sir William, F.R.S. [later Lord Kelvin].
Thomson, J. M., F.C.S.
Tomlinson, H., B.A.
Tribe, A., F.C.S.
Warren, Thos. T. P. Bruce, M.S.T.E.
Whipple, G. M., D.Sc.
Wormell, R., M.A., D.Sc.
Wilson, W. J., F.C.S.

Of this distinguished list there are, unfortunately, but few who remain among us. The letters M.S.T.E. are now unfamiliar, and stand for Member of the Society of Telegraph Engineers, known later as the Institution of Electrical Engineers.

This first issue consisted of only 12 pages of text, containing articles on the Hughes microphone, on "phonophonic substances," on sources of error in telegraphy, and on the testing of copper. The last page included a "Students' Column," brief abstracts of recent patents, and a share list containing 33 entries, all telegraphic. From the Notes it is interesting to learn that a successful telephone trial was carried out in Bengal between Lucknow and Sitapore with instruments made and lent by Lieut. H. C. Holden, R.A. (now Col. Sir H. C. Holden) ; and that the transmission of a 33-word telegram from New York to Sydney cost nearly $65 (the route being via London, Siberia, Japan, China, Singapore and Java).

When one peruses the writings of years ago one soon comes to the conclusion that the time so spent is by no means unprofitable. Thus, in the second issue of THE ELECTRICIAN is given Clerk Maxwell's Rede Lecture on the Telephone, the opening sentences of which are of somewhat general application :—

> When about two years ago news came from the other side of the Atlantic that a method had been invented of transmitting, by means of electricity, the articulate sounds of the human voice, so as to be heard hundreds of miles away from the speaker, those of us who had reason to believe that the report had some foundation in fact began to exercise our imaginations in picturing some triumph of constructive skill—something as far surpassing Sir William Thomson's siphon recorder in delicacy and intricacy as that is beyond a common bell-pull. When at last this little instrument (the telephone) appeared, consisting, as it does, of parts every one of which is familiar to us, and capable of being put together by an amateur, the disappointment arising from its humble appearance was only partially relieved on finding that it was really able to talk.

Who is there that has not felt similar feelings of disappointment at a new discovery being so simple compared with preconceived ideas ? The fact is that simplicity in such cases is a reflection on one's own intelligence, which would be less aggrieved at the sight of complication.

We must all admit that the telephone is a simple device. Yet how many of us at the present day, if the telephone were not yet in existence, would be prepared to admit the probability of transmission of speech by such a device ? What chance, it would be argued, is there that the receiving diaphragm will be sufficiently disturbed by weak sound waves to cause any variations worth speaking of in the electric current, such that these variations shall again react on a diaphragm at the receiver and reproduce all the intricacies of speech ? It is a mistake to know too much. Perhaps Bell would not have done so much had he known more, and felt it unnecessry to inquire of Prof. Henry what he should do for this lack of knowledge. The historic reply was—*Get it.*

These remarks apply equally to the microphone of Hughes. That a microphonic contact should be capable of transmitting speech seems highly improbable. Indeed, there is a certain mystery about contacts—which is noticeable from time to time—as witness coherers, detectors and Mr. S. G. Brown's telephonic relay—and there seems to be still room for investigation in this direction.

The disadvantage of preconceived ideas and of knowledge which is necessarily often incomplete is that we take too much for granted. There is a great advantage in trying the improbable and in appealing to experiment as the final arbiter. It may yet happen that the investigator of perpetual motion will prove his worth by some valuable discovery, because he will try things that no one outside a scientific lunatic asylum would dream of doing. The only thing against him is that his scientific equipment is probably too poor to allow him to recognise a secret of Nature when he sees it, and if his equipment were better he would not be seeking perpetual motion. The seeker after the philosopher's stone or the elixir of life in days gone by was in less of a predicament.

But to return to history. In the present day it is difficult to realise the limitations of the electric light as they appeared in 1880. The dynamo was in existence, it is true, even though small and inefficient. The Jablochkov candle had been invented (in 1876), and was followed in 1878 by the much more practical Brush arc lamp, and others, with regulating mechanism on modern lines. Thus arc lighting was making some headway. But the "sub-division of the electric light" was the question that was troubling the investigator, for without such sub-division domestic lighting was impossible. Both Swan and Edison were working at this problem, which presented great

difficulties. Incandescence provided a possible solution. Platinum was obviously a suitable material in many respects for the filament, but unfortunately its fusing point was not sufficiently high. The metallurgist was not yet ready to provide the more infusible metals, and the metal filament lamp was destined to wait for yet another 25 years. It speaks volumes for the mental backbone of those investigators that they were not deterred from making filaments from carbon, which, whatever the excellency of its electrical qualities, was a hopelessly poor substance from the mechanical point of view. Nevertheless, patient and persistent work was rewarded, and in 1879 Swan showed his incandescent lamp at a meeting of the Newcastle Chemical Society. Carbonised paper and parchmentised cotton thread served the purpose at first; and these were followed by the cotton and zinc chloride squirting process, which still holds its own, and which gives a filament far stronger than would have been expected by the most sanguine.

Thus the electrical industry arose largely from the pregnant years of the decade of 1870-1880, and more particularly in the last four years of this period. If we except Faure's improvement in the making of accumulator plates (in 1881) the industry now continued for some years without any discoveries or developments of fundamental importance, and settled down to the work of steady development. Various applications of electric power arose, the most important of which was electric traction. Both the Portrush and Brighton electric railways came into existence in 1883, and the Blackpool electric tramways started operations in 1887. It is of interest to note that in Field's electric locomotive in the United States (1887) the motor was coupled to the driving wheels by means of cranks and side rods, a method which has been revived and has found some favour once again after lying dormant for some 20 years.

In electricity supply, perhaps Hopkinson's three-wire patent (1882) was the most important development from the point of view of advance, and the unfortunate Electric Lighting Act of 1882 from the point of view of retardation. Also there was a remarkable Paper in 1886 by John and Edward Hopkinson which laid the foundation of dynamo design.

In 1888 there was published one of those fundamental researches which open up a completely new outlook, for it was in that year that Prof. Ferraris made public his work on rotating magnetic fields.

Although electrical discovery seems to have been somewhat stagnant during the decade 1880-1890, there was a development in mechanical engineering, which, in due time, was destined to have a profound effect upon the generation of electric energy. The invention of the steam turbine by the Hon. C. A. Parsons in 1884 placed a new prime mover in the hands of the electrical engineer. Its advantages, however, were not quickly realised. Except for the desirable feature of the direct production of rotary, as distinct from reciprocating, motion, the small turbines which were at first manufactured showed no saving in steam consumption, the speed of rotation was very high for direct coupling to an electric generator, and the rotor was somewhat delicate. With increase in size the disadvantages have disappeared, and it is now well recognised that although the steam consumption of the turbine is no lower than that obtainable with reciprocating engines the cost per kilowatt of a turbine and generator combined is far less. In fact, this lowering of capital costs must be looked upon as one of the most vital achievements in electric power supply.

Whatever the decade 1880-1890 lacked in brilliancy was amply repaid in the period that followed. The Electric Light Amendment Act of 1888 had paved the way as far as electricity supply was concerned, and among the interesting developments that followed was Mr. Ferranti's ambitious scheme for the supply of a large section of London by means of electric transmission at 10,000 volts from Deptford, the distance being six miles. This scheme was particularly bold for there was no previous experience of such work on which to draw, and the transmission line was underground. It is little wonder, therefore, that many surprises were in store for these pioneers, such, for example, that 8,500 volts at Deptford became 10,000 volts in London. In time, however, all the surprises and difficulties were overcome, and this early work will certainly stand as a monument to the skill and foresight of Mr. Ferranti.

Other countries also began to take an interest in the electric transmission of power. In 1891 the celebrated experiment was made of transmitting 100 H.P. by an overhead line from Lauffen to Frankfort, at the time of the exhibition at that town. The distance was 110 miles, the pressure was 8,000 volts three-phase, and the efficiency was 75 per cent. From that time it may be said that electric transmission made good progress. A notable event in this connection was the "harnessing" of Niagara in 1894, which has resulted in very large industrial developments in Ontario.

In this country at least, the opening of the South London Electric Railway was an event of no small importance, as it demonstrated the commercial possibilities of the tube railway, and was the starting point of the "tubes" which have done so much to facilitate communication between various parts of London. The service rendered by this particular railway is a testimonial to the good judgment of those who acted as pioneering engineers in carrying out the project.

Occasionally it happens that an event of importance stands out in comparative isolation, pregnant with possibilities, yet bearing little or no fruit. Such was the lecture given by Mr. Nikola Tesla before the Institution of Electrical Engineers at the Royal Institution in 1893. This lecture, entitled "Experiments with Alternate Currents of High Potential and High Frequency," made an indelible impression on the minds of those who were fortunate enough to be present. The experiments shown by the lecturer gripped the imagination. At last there were lamps requiring no conductors. The ether, free to all, was used instead of that costly component, copper, which is responsible for so much of the capital expenditure in electricity undertakings. The light was cold, the heat rays which cause all the inefficiency in incandescent lamps being absent. In short, Mr. Tesla's work showed enormous possibilities. And yet, to all intents and purposes the subject still remains where he left it at that date. As to the cause, perhaps, it is due to the introduction of the commercial factor £. s. d., which converts the problem of pure science into one of commerce, and thereby makes it much more difficult. Undoubtedly "cold light" can be produced, but so far it costs far more than light of the usual inefficient character. Perhaps, however, the path opened by Mr. Tesla may yet be explored with success in the near future.

The years 1896 and 1897 were both marked by discoveries of the greatest importance, opening up entirely new fields of industry. In 1896 Prof. C. W. Röntgen made the remarkable discovery of X-rays. This seems to have been due to the following up of chance observations of effects caused by X-rays rather than a search for rays which were supposed to exist.

On the other hand, the commercial advent of wireless telegraphy in 1897 was due to researches having a definite object in view. Here the fundamental step was taken by Hertz in 1888, when he sought to produce electromagnetic waves which had been discussed theoretically by Clerk-Maxwell some 15 years earlier in his "Electricity and Magnetism." The results predicted by theory were found to be true. Later the subject was taken up by Sir Oliver Lodge, Mr. Branly and others with a view to signalling, but the probability of signalling over any considerable distance did not arise until Mr. Marconi earthed one end of his aerial and adopted inductive coupling.

Radiography and radio-telegraphy are unusual as branches of industry, in that they have not merely conferred vast benefits on mankind, but have aroused great interest among purely scientific workers who have found it difficult to account for all the phenomena. The actual character of X-rays, the action of detectors, the bending of electric waves round the earth when apparently the curvature of the earth should intercept them, and other kindred problems have given rise to much speculation.

The last few years of the century saw the advent of the oscillograph, with the development of which Mr. Duddell has been so closely identified. Before this time, wave forms and phase differences were familiar enough on paper, but to see

such curves trace themselves upon the screen and have the effects of capacity and inductance appear as if by magic, must have reassured those who were weak in faith, whether students or an older generation who fought shy of the theory of alternating currents. Apart, however, from the theoretical aspect, the Duddell oscillograph provided a most powerful weapon of investigation, showing the inner working of dynamo electric machinery and the transient phenomena observed on cable networks. The result has been a great improvement in design and a proper appreciation of working conditions.

This work led up to the discovery of the musical arc, which was described by Mr. Duddell in 1900. The importance of this investigation was that it gave us a generator of undamped oscillations, and although the frequency as obtained by Mr. Duddell, was low, a comparatively small modification by Messrs. Poulsen and Pedersen resulted in the undamped system of radio-telegraphy in 1906. This branch has experienced a somewhat chequered career except during the last few years, but is now fully proving its value.

In 1900 there also appeared a Paper which was destined to have a marked effect on telephonic transmission, and which was the outcome of earlier work by Mr. Oliver Heaviside. We refer to the Paper by Prof. M. I. Pupin before the American Institute of Electrical Engineers. At that time electricians were accustomed to the transmission of electrical energy over lines of some length, but telephonic transmission presented special problems. Although the transmission might still be considered to be one of alternating currents, the frequency was considerably higher, say, 800 on the average instead of 50 or 100 per second. Moreover, there was a large number of frequencies instead of a single predominating frequency, and since the effect of a line upon the transmitted wave depends on the frequency, the wave as a whole becomes distorted; yet, if the inductance of the line can be sufficiently increased the attenuation becomes independent of the frequency. In his Paper Prof. Pupin showed that if such inductance is lumped at intervals along the line it becomes, within limits, practically equal to distributed inductance, and, therefore, a great improvement may result in the speaking qualities of the line. Such a method was particularly desirable on submarine telephone cables, for there the difficulties of transmission are emphasised, but submarine cables are very costly and those responsible for them require to be very well satisfied that any modifications have a good probability of being successful. It is not surprising, therefore, that nothing very much was heard of Pupin's method until it was tried on a cable laid in Lake Constance in 1906. Since then it has come very materially to the fore, both in long land lines and in submarine cables. As an example of the latter, mention may be made of the cable laid in 1910 between Dover and Cape Grisnez for the London–Paris telephone service.

Returning to the more ordinary applications of electricity, it may be said that the introduction of the multiple unit system by Mr. F. J. Sprague (described in a Paper before the American Institute of Electrical Engineers in 1899) showed an unusual appreciation of the conditions of suburban traffic. Although it has not been worth while to carry this system to its logical conclusion it is in general use for the handling of suburban traffic, so that the power is applied to a large proportion of the train-axles, and control can be effected from any of the motor coaches. Another important event in electric traction was the advent of the single-phase commutator motor.

In the utilisation of electric power the flywheel load equaliser has played a most important part in enabling the electrical engineer to draw for short intervals upon accumulation of mechanical energy, and thus to apply the electric drive to rolling mills and winding for mines, which would otherwise have been difficult owing to the great fluctuations in the power demanded.

After the carbon glow lamp had been accepted for some 25 years as the only practicable device of this kind the metallurgist began to provide alternatives in the shape of high melting-point metals. The tantalum lamp appeared in 1905 and the tungsten lamp soon followed. But the next change was to be physical rather than metallurgical. The desirability of the vacuum, which had served us so long, was questioned by Messrs. Langmuir and Orange. The idea that gas at ordinary pressures in the bulb must lead to serious thermal inefficiency was shown in 1913 to be wrong under certain conditions, and so the gas-filled, or "half-watt," lamp arrived on the scene during the last few years. Thus the consumption per candle fell from 4 watts with carbon to half a watt in this latest type—certainly a remarkable advance.

In the field of radio-telegraphy Prof. Fleming's valve receiver introduced an important principle. An extension of work in this direction by Dr. de Forest led to the audion receiver, and thence to the audion amplifier. The latter bids fair to play an important part in telephony, and has already rendered it possible to transmit speech across the Atlantic by radio-telephony.

Not the least of modern achievements have been due to the work of the metallurgist and the electrochemist. It is now many years since commercial aluminium was rendered possible by the work, independently, of Héroult in Europe and Hall in America. Considerably later Héroult devised his electric arc furnace, and since that time the electric furnace has made rapid progress. Even electric iron smelting is making marked headway in certain countries, and the latest furnace under construction in Sweden for this purpose is said to be of 25,000 H.P.

Less sensational, but none the less important, has been the production of certain alloys. Among these is Stalloy, made of iron, manganese and silicon, due to Sir Robert Hadfield, which is remarkable for its low hysteresis and eddy current loss as compared with soft iron, and which has thus been the means of saving an enormous amount of energy in the magnetisation of transformers. As another example we have "nichrome," the alloy of nickel and chromium, which may be said to have rendered electric heating and cooking commercially possible.

Lastly, we have the fixation of atmospheric nitrogen, an industry which has arisen with extraordinary rapidity. It was only in 1898 that Sir William Crookes, in his presidential address to the British Association, called attention to the enormous importance of obtaining nitrates from the atmosphere in view of the exhaustion of the Chile deposits of nitrate in the near future. Yet only eight years later, in 1906, Prof. Birkeland was able to read a Paper before the Faraday Society describing the successful commercial operation of the Birkeland-Eyde arc process in Norway. Since that date this and other processes have been worked on an enormous scale, more particularly during the present war The rise of this industry shows the importance of emphasising the needs of mankind, in which case they will probably be supplied, assuming that the reward appears sufficiently substantial.

In the above remarks we have rambled past many of the more important milestones on the path of progress. It is easier to judge of their value when placed some 20, 30 or 40 years ago, when they have weathered the criticism of time. In recent years the process becomes more difficult. What seems to be merely a molehill may eventually become a landmark when time brings a proper sense of perspective; and conversely, an apparent milestone may eventually mark merely a blind alley from our main path.

A glance at the past is sufficient to show that there are two chief classes of investigator—the qualitative and the quantitative. It is usually the qualitative investigator who opens out new fields, for he observes new phenomena; and so from time to time we are startled with such new ideas as the telephone, the microphone, X-rays and radio-telegraphy. The quantitative investigator, on the other hand, seeks for improvement on known results, and so we have the metal filament lamp, the gas-filled lamp and the fixation of nitrogen. Of course, no hard and fast line can be drawn; but the two types of investigator are certainly distinct and both should be encouraged.

If any lessons are to be drawn from the history of electrical progress, they are in the main two. The first is the importance of avoiding set ideas—that because a certain course has been followed for years it is necessarily the best. There is nothing

more fatal to progress than this state of mind. The second is the importance of breadth of view. In this connection the following words of Clerk-Maxwell may well be quoted :—

. . . Whatever may be said about the importance of aiming at depth rather than width in our studies, and however strong the demand of the present age may be for specialities, there will always be work, not only for those who build up particular sciences and write monographs on them, but for those who open up such communications between the different groups of builders as will facilitate a healthy interaction between them. . . . I suppose that when the bees crowd round the flowers it is for the sake of the honey that they do so, never thinking that it is the dust which they are carrying from flower to flower which is to render possible a more splendid array of flowers and a busier crowd of bees in the years to come.

In these days of ever extending knowledge it is increasingly difficult to keep in touch with branches other than one's own, but it is all the more important to carry on the "cross-fertilisation" if the milestones are to mark the greatest progress on the path to the unknown.

Some Notes on the Early Developments of Electrical Engineering.

By Col. R. E. CROMPTON, C.B., R.E.

Although electrical engineering as a commercial proposition might be said to commence with the development of telegraphy by Cook, Wheatstone, Varley and others, my own recollections only date back to the time when—shortly after I left the Regular Army—Wilde, Varley, Siemens, and others began the manufacture of machines to generate electricity by mechanical power.

About 40 years ago, some time in the year 1876 or early in 1877, I had just completed the design and installation of a large pipe foundry for the Stanton Ironworks Company, in which I had introduced hydraulic machinery for working pipe pits, and I found it necessary, for night working, to use the electric arc as a means of lighting the foundry, and had ordered for this purpose a Gramme machine and a Serrin lamp from the well-known firm of lighthouse engineers, Messrs. Sautter Lemonnier, of Paris. I had been working this apparatus for some time previous to a meeting of our Institution of Mechanical Engineers held in Paris during the summer of 1878, and was, therefore, able to take a practical part in the discussion which followed a Paper on electric lighting, and particularly on Gramme's inventions, read by Mr. Hippolyte Fontaine. I then found myself almost the only English engineer at the meeting who had any practical experience in electric lighting. This constituted me an authority on the subject, and during the years following I was frequently consulted, and I imported and installed quite a number of Gramme dynamos and Serrin lamps, not only for engineers' use on out-of-door contracts, but for the lighting of large shops such as Whiteley's.

At that time practical knowledge of electrical engineering was confined to very few. Messrs. Wilde, Siemens, Varley and others had already made dynamo machines for electro-plating work, but all these gave rather too low an E.M.F. at the terminals to enable a good arc to be maintained through any length of cable. I, therefore, chose the "A" Gramme for my purpose because of its higher E.M.F., and shortly after commenced manufacturing dynamos under the Bürgin patents. I had already manufactured a little electrical apparatus in the form of arc lamps, switches, and the like in my extensive (?) establishment, consisting of three—myself, Mr. A. P. Lundberg (still alive) and Mr. Sidney Baynes (still the Chief Engineer at St. Pancras). My lamps were at first based on the Serrin principle, but I altered the arrangements so that the arc should be below the mechanism.

At that time I attended several meetings of the Institution of Telegraph Engineers, of which I became a member, being proposed by the late Sir William Preece. In those days our knowledge of electrical phenomena and laws was comically small. We measured current in webers, E.M.F. in terms of Daniell cells, resistance in miles of telegraph wire, or, if we were very advanced, in B.A. units. We also had some idea of Ohm's law. But somehow or other we blundered on to successive improvements in the manufacture of electrical apparatus. At first most of these improvements were mechanical ones.

During one of my tours on the Continent with the Institution of Mechanical Engineers I had made the acquaintance of the elder Brown, then superintendent of the Winterthur locomotive works in Switzerland, who was the father of the afterwards well-known Charles Brown, head of Brown, Boveri, of Baden. Brown, senior, then asked me why I did not manufacture dynamo machines myself instead of importing them from France—I had been complaining of the shoddiness of the Gramme machines made in France—so he introduced me to a Swiss inventor, a friend of his, Emil Bürgin, of Basle, who had designed a dynamo electric-generator superior from a mechanical point of view to the Gramme. I arranged with Bürgin to manufacture his machines in England, and for this purpose I enlarged my small lamp workshops by taking over a part of the works of Messrs. T. H. P. Dennis & Co., of Chelmsford, and this was the foundation of the firm of Crompton & Co.

We commenced by manufacturing small Bürgin machines to supply one arc lamp. They were wound for an output of about 20 amperes at 70 volts, but as I knew that various American inventors were attempting to run more than one arc lamp in series, I thought I would also have a try in this direction, and modified my own lamp by actuating the feed mechanism by an electro-magnet, the circuit of which shunted the arc. I soon found that by running my Bürgin machines faster and putting on more turns on the armatures I could greatly increase the output at small cost, and within a year was producing machines which would run four or five lamps in series, the output being about 20 amperes at 250 volts.

My first exhibit was at the first International Electrical Exhibition held in Paris in 1880. It was followed by one held at the Crystal Palace, in England, the same or following year. In both cases my main exhibits consisted of these Bürgin generators and the new form of arc lamp.

At an early date, from recollection I think about 1880, I remember receiving an order for an arc lamp from Messrs. Mawson & Swan, photographic chemical manufacturers, of Newcastle-on-Tyne. Shortly after I had delivered this lamp a gentleman called upon me at our office at Mansion House Buildings, in London, telling me that he was instructed by Mr. Swan, of Newcastle, to bring me along with him that very evening and without fail, as the matter was very urgent, and my visit could not be delayed. Up to the very last moment I had no idea that I was to be honoured by being the first man to see Mr. Joseph Swan's invention of incandescent electric lamps on a considerable scale. I remember my introduction to Mr. Swan—already then an old gentleman with a white beard—who asked me to follow him, and without a word suddenly opened a door into a back laboratory, and switched

on 20 or 30 incandescent lamps, all burning evenly and brightly. Mr. Swan then told me that he considered that this was the first time that the division of electric light, which had been so much hoped for and talked about, had been practically accomplished. Up to that time Mr. Preece and others had lectured on the great loss which *must* (?) theoretically take place if we attempted to supply more than one light from one generator; even then, what we had done in producing several arc lamps to burn in series was considered very wasteful and uncommercial. The idea of burning arc lamps in parallel circuit had not then occurred to us, but Mr. Swan's experiment showed that there was no difficulty in dividing a current of 30 amperes or so between 30 of his lamps arranged in parallel circuit, although he showed me that the circuit was only partially self-regulating. Mr. Swan discussed this difficulty with me, and then and there set me to solve the problem of making a generator which when feeding incandescent lamps arranged in parallel circuit would keep its E.M.F. constant, no matter how many lamps were switched on or off. After some months of experimenting, assisted by Gisbert Kapp, who was then my manager, we succeeded in winding the field magnet of our Bürgin machines with two sets of windings, thus getting sufficient regulation for our purpose, and we used these machines in 1881 or 1882 for country house lighting at Berechurch Hall, and for a large installation of electric lighting at the Law Courts. There is no doubt that at the opening of the Law Courts we had solved the problem of banking a number of compound wound Crompton-Bürgin machines, so that the lamps supplied by them throughout the Law Courts, of which there were several thousands, could all be switched off and on independently and with very little change in E.M.F.

Just about the time that we completed the work on the Law Courts the London Swan Company was formed, and shortly afterwards amalgamated with the Edison Company, the owners of the Edison rival patent for incandescent lamps. I became the engineer to the new combination, but carried on our works at Chelmsford as before, my first partners being Harold Lyon Thomson, who two years ago became Mayor of Westminster, and W. A. Kyle, of Belfast, whose place was afterwards taken by the late J. F. Albright. It was not until some years later, in order to increase our capital, that we turned that partnership into a limited company.

At an early exhibition of electrical apparatus in Glasgow, held, I think, in 1880, I had been introduced to the late Lord Kelvin—then Sir William Thomson—and from the very first he gave me the most valuable advice and assistance. I took all my difficult problems to him, and he ungrudgingly gave me of his best, and undoubtedly led me up to many of the early developments of electrical engineering.

I, of course, was greatly helped by my partners and staff.

Referring to the ordinary familiar forms of electrical apparatus—*i.e.*, switchboards, fuse boards, ceiling roses, pendants, portable fittings, with which we are all now so familiar—you can hardly believe how many of these were thought out and developed by Harold Thomson and Lundberg, and how much of the theory of the magnetic field and of the armature and magnetic winding of modern dynamos was developed by the Crompton staff of the early days.

We were a happy mixture of practical mechanical engineers and bold theorists with sufficient mathematical knowledge, so that it was small wonder with such men as Kapp, Swinburne and the late P. W. Willans—all working together—that by 1885 we had gone a long way towards developing the modern electric generating station.

Our next large job after the Law Courts was to deal with the lighting of the whole of the Viennese theatres, and we designed and manufactured the whole of the machinery for quite a large central station. There, for the first time, we put in accumulators as a reserve, always to work in parallel circuit with our generators, and we had the boldness to generate at 500 volts and distribute in the theatre at 100 volts by a five-wire system. The late P. W. Willans assisted me to work out the electrical governing for the whole station, and the staff, who were trained in Vienna, afterwards became the staff which carried out so much of the work of the lighting of the West End of London.

My friendship with Willans was even then of old standing, and I think all we who were engaged on electrical problems at that time will acknowledge how much the electrical world owed to his advice and assistance and to the fact that as his were almost the only high speed engines which could be coupled direct to our dynamos, we—the dynamo makers—were really able to compare our progress in efficiency by observing the comparative net output we were able to obtain from our dynamos when coupled to Willans engines. I think it was Willans himself who suggested that his engine losses could be accurately determined by running the generator as a motor, coupling on to it, first, the Willans crankshaft only, and then adding the connecting rods, pistons and the other parts one by one; conversely, in a similar manner, we were able to arrive at the dynamo losses in the armature cores, armature winding, and so on. Willans' sudden accidental death was undoubtedly a great loss to the electrical world.

The success of the large generating station at Vienna led us to start the Kensington Court Company in London on similar lines—*i.e.*, direct currents generated in parallel with accumulators as a reserve, the current being generated by dynamos coupled to Willans engines. About the same time Ferranti started the Grosvenor Gallery Station to distribute electrical energy for lighting by high-pressure alternating currents transmitted through overhead wires and transformed on the consumer's premises to a pressure usable on the Swan lamps by Goulard and Gibbs' development of induction coils which began to be called transformers. The electrical world began to divide into two camps—those who like myself believed in direct currents and accumulators, and those with Ferranti who believed in transformed high-pressure alternating currents. The older engineers will remember what interest this controversy gave to the Papers and discussions at the Institution of Electrical Engineers. The discussion on one of my own Papers lasted, I think, through 8 or 10 evenings, and the net result was that at that time, I formed the impression that we—the direct-current people—had got the best of it, as the majority of the lighting companies formed to carry out electric lighting of the West End of London followed our lead, and the same was largely the case in the provinces. It was not until John Hopkinson showed that there ought to be no trouble in producing alternating motors that I began to change my mind, and, of course, the discovery of three-phase generation and transmission materially altered the whole question.

Although these recollections are necessarily very personal, giving the views of myself and my personal circle of friends and co-workers, I think I can state with considerable impartiality the relative importance which the English electrical industry had attained during the first 10 years of its life as compared with developments in other countries. I believe that in all branches we were then ahead; we had developed direct-coupled high-speed generating sets (usually Willans engines) driving English dynamos by three or four makers up to a pitch of efficiency—measured by low cost first, low cost of maintenance and high efficiency of conversion of 85 per cent. from indicated horse-power to the kw. delivered on the switchboard—at the time when our American and Continental friends were still using slow running steam engines of the mill engine type, driving by belt and giving only 60 per cent. conversion efficiency.

I well recollect the first attempts at direct driving made by the German engineers in their first large generating station in the Mauerstrasse, Berlin. For this station Rathenau had purchased splendid and exceedingly perfect steam engines made by Van der Kirchove, of Ghent, driving direct the most ineffective type of generator it is possible to conceive. These generators were huge Gramme rings made by Siemens, revolving outside star-shaped magnets; I do not think the efficiency of electric output on the terminals to the indicated horse-power of the engines was greater than 50 per cent., even at three-quarter

load. Of course, the coal bill per unit delivered was excessive. Again, in cables, switchboards, the use of accumulators and the study of high-pressure plant and transformers, we were distinctly ahead, but whereas owing to the conservative nature of the English investor we were only gradually beginning to obtain financial assistance to carry out the supply of electrical energy on a large scale, having to show dividends fairly earned before the English investor would come forward, during this period Rathenau had initiated the German Group Bank system of financing electrical undertakings, and developed the German manufacturing businesses largely from his watching the results of our English work, so that, shortly after the end of the first decade, just at the time when in England the development of electric supply by the municipal authorities called for the manufacture of plant on a large scale, we—the English manufacturers—who had been compelled to develop so slowly, were unable to supply our home demand, and the already well-equipped German manufacturers were able not only to fill all the Continental orders, but in many cases competed for and obtained our English municipal orders.

It is not fair to blame the English investor alone for this delayed development of the English electrical industry, but to his discouragement caused by Chamberlain's Act restricting the concession for public supply companies to 21 years, which had much to answer for. Again, on the other hand, the rapid extension of electric lighting in our war and mercantile marine occupied the attention and filled the order sheets of our small English firms and kept them going on a limited scale.

The Story of Land Telegraphy.

By H. H. HARRISON, A.M.I.E.E.

Hark! the warning needles click,
Hither—thither—clear and quick
Swinging lightly to and fro,
Tidings from afar they show.
While the patient watcher reads
As the rapid movement leads,
He who guides their speaking play
Stands a thousand miles away.
Sing who will of Orphean lyre,
Ours the wonder-working wire!

Neglecting the elementary methods of signalling employed by the ancients, land telegraphy may be said to have dated from the invention of the telescope. Visual signalling at that time was carried out by means of shutters or semaphore blades capable of taking up several positions, the permutations thus formed being assigned to different letters and figures. The range of transmission depended upon the distance at which the setting of the transmitter could be observed and long distances could, of course, only be bridged by employing a chain of stations and frequent retransmission. The telescope greatly increased the range between a pair of stations, and from 1791 to 1795 the adoption of aerial telegraphs, as they were called, spread all over Europe. Among the several workers in this field, Claude Chappé, a French engineer, stands out most prominently, and he subsequently became telegraph engineer to the French Government, probably the first appointment of its kind.

This class of telegraph survived the introduction of the electromagnetic telegraph, the last, that maintaining communication between Liverpool and Holyhead, disappearing in 1852-3. The cost of maintenance and working was given as about £1,500 per annum, while a similar telegraph system between London and Portsmouth cost rather more than double this sum.

In all European countries, the aerial telegraph was a Government monopoly and appeared to be used entirely for official, and not for commercial, traffic. There was thus no revenue derived, and also, as no traffic data are available, it is not possible to compare the figures given above with the costs for a modern plant. The result would have been interesting. One or two facts stand out. The aerial or optical telegraph was invariably a State monopoly; it was a wireless system and utilised the ether as the transmitting medium; it had its telegraph engineers just as any Administrations of to-day, and it employed a wave length far smaller than any adopted in modern wireless telegraphy. Optical telegraphy survives to-day in the semaphore signalling of semaphores or flags by the Army and Navy.

The era of practicable electric telegraphy commenced in 1836 with the work of Wm. Fothergill Cooke, but innumerable suggestions and experiments were made from 1774 up to that date. One of the most interesting is that of Francis Ronalds of Hammersmith, who employed two synchronously moving dials at each end of the line. The letters of the alphabet were engraved on the dials, which were mounted behind a shutter having a window which revealed one letter at a time. High-tension electricity applied to the line wire at any moment caused the divergence of a pith ball which, taken with the appearance of a certain letter at the window, formed the indication to the receiver. The attention of the distant operator was gained by exploding a quantity of gas by a spark from a Leyden jar. On receipt of a preconcerted signal both operators started their clocks simultaneously and provided the going rates of the clocks were sufficiently near to one another, identical letters would appear at both ends of the wire simultaneously. Thus as early as 1816, the principle of division of the line time was put into effect.

Numerous suggestions were also made for the employment of space signals, using as many wires as the desired number of signals, but economy in line material was secured by adopting the principle of permutation, and Cooke and Davy in 1837 and 1838 adopted three line wires which just suffice for the formation of 26 signals by assigning three possible conditions to three things taken singly or in combination. Cooke's receiver was three single needles; Davy recorded his signals by chemical action on a tape. This telegraph was greatly improved by Highton who, in 1848, invented an ingenious type bar translator, but in spite of this, the cost of the line wires killed the class of telegraph employing space signals, and electric telegraphy settled down to the form employing time signals only: the step-by-step indicator telegraphs of Cooke, Wheatstone and others and single and double needle telegraphs.

Whitehouse invented in 1853 a five-wire recording space-signal telegraph, but converted it to a time signal apparatus, using a rotary distributor in the following year.

In 1838 the telegraph in this country was almost entirely of the galvanometer or needle type or else the step-by-step indicator while in America the electromagnet method introduced by Samuel F. B. Morse was exclusively used.

A great impetus was given to telegraphy at this time by the discovery of Steinheil that the earth could be used in place of the second or return wire. Steinheil did a good deal of experimental work at Munich, and his remarks on the relative advantages of iron and copper wires are interesting reading.

considering the date. He found that the cost of the two metals worked out to about the same figure, as the iron required to be six times the gauge of copper wire for equal conductivity. He preferred copper to iron owing to its freedom from oxidisation by exposure to the atmosphere. He pointed out, however, that galvanising the iron wire would be a remedy for this trouble.

Subterranean wires were largely used in the early days of electric telegraphy. The Prussian Administration employed insulated wires covered with gutta-percha and enveloped by a lead tube, the whole being buried in the earth 20 in. deep. Owing to frequent interruptions and high cost of maintenance they finally resorted to pole lines.

The Magnetic Company also used gutta-percha covered wires laid in troughs of creosoted wood covered with a galvanised iron lid. Usually six wires were drawn into these troughs, but the London to Manchester route consisted of 10 such wires.

The cost of laying varied for six wires from £180 to £200 per mile. For 10 wires the figure given was £230 per mile.

The Electric Telegraph Company used glazed earthen pipes of best quality stoneware for their ducts, the cost of these being given at £60 per mile.

Although Morse claimed 1832 as the "date of conception" for his apparatus, it does not appear to have been put into practice until May 27, 1844, between Washington and Baltimore. By this time he had invented one-way repeaters for extending the distance of transmission, but the first two-way repeater was one due to Ezra Cornell. It was not automatic in its action, and the direction of transmission could only be reversed when the repeater attendant turned a switch. Morse supposed that the wires of the electromagnets should be the same size as the line wires, and his first electromagnets, as a result, weighed 185 lb !

Most of the railway telegraphs by 1842 were using pole lines with porcelain insulators. Cooke's insulators were porcelain tubes fastened to the poles by iron clips. The wires were threaded through these and at every tenth pole a straining ratchet was introduced. In 1854 poles were generally pine saplings, sometimes poplar or fir. The size used ranged from 40 ft. to 20 ft. in length and the prices from 14s. to 2s. each. The butt of the pole was charred, and in 1859 impregnation in a solution of sulphate of copper had become general.

By 1850 the use of the electromagnet or Morse telegraph had spread to Europe, while the double neeedle or galvanometer telegraph with its two-line wires was beginning to feel the rivalry of its simpler and cheaper brother, the single needle, requiring only one line wire. By this time also the electric telegraph had become a public utility, the first company being formed in England in 1846.

In 1851, 1,752 miles of railway were covered by telegraphs, the wire mileage being 7,303, 198 stations in existence and the annual traffic 48,490. In 1870 the whole of the company-owned telegraphs were transferred to the State. Some idea of the immediate expansion following this step may be gathered by the following figures :—

Year.	Line mileage.	Stations.	Messages per annum.
1851	1,752	198	48,490
1862	12,711	1,616	2,676,350
1872	25,000	5,179	15,500,000

The inland rate was 1s. for 20 words, the address being sent free. How far this tariff affected the expansion may be left to conjecture, but the following rates in existence before the acquisition of the telegraph companies by the State are interesting :—

London to Birmirgham	6s. 6d.
„ „ Cheltenham	7s. 6d.
„ „ Glasgow	10s. 0d.
„ „ Hull	9s. 6d.
„ „ Liverpool	8s. 6d.
„ „ Newcastle	10s. 6d.
„ „ Southampton	5s. 6d.
„ „ York	9s. 6d.

The foregoing figures were for messages of 20 words.

I have said that by 1850 the Morse system extended to Europe. It received a further impetus by the invention of duplex telegraphy, permitting the simultaneous transmission of a message in each direction over a single-line wire and also, later, by the introduction of the Wheatstone automatic system.

Duplex working by division of the line time, rotary switches being employed, was first suggested and put into practice by Moses Farmer in 1853, but the differential duplex system was devised by Frischen, a telegraph inspector at Hanover in 1854. The bridge duplex system was invented by Maron in 1863. Stearns had added the compensating condenser to the differential and bridge duplex by 1868. A central battery duplex was evolved by T. A. Edison in 1873, and is substantially the same as that so widely used in European and Colonial Administrations at the present day.

The Wheatstone automatic, largely developed by the late Augustus Stroh and officers of the British Post Office Administration, among whom may be mentioned the late J. B. Chapman, has remained almost entirely a British system. Some early speeds taken from a Paper by Culley are given below :—

London—Manchester	120	words per minute
„ Liverpool	120	„ „ „
„ Cardiff	120	„ „ „
„ Aberdeen	60	„ „ „
„ Cork	38	„ „ „
Dublin	40	„ „ „
Dublin—London	80	„ „ „

The apparatus is capable of working at 300 to 400 words per minute as a result of improvements in design and construction effected from time to time, and these speeds have been frequently attained on actual circuits.

Repeaters were described in the very early days of telegraphy. Davy in 1838 illustrated a "renewer" and Morse, as before mentioned, used a one-way repeater. These were necessitated largely by the poor character of the line insulation. Usually the insertion of a repeater of the type prevailing about 1871 resulted in a reduction in speed of the whole circuit. Sir John Gavey greatly improved such repeaters by the introduction of direct repeating from the relays. Previously the relays had actuated electromagnetic keys and the inertia of these slowed down the rate of working so that a repeater was only introduced when bad weather conditions prevailed. As a result of Gavey's improvement, the introduction of a repeater actually increased the speed of a circuit, by reducing the effective KR to that of the longest section.

Probably the longest Wheatstone circuit was that of the Indo-European Telegraph Company which worked directly between London and Teheran with 10 automatic repeaters inserted. The direct working was carried into effect on Jan. 1, 1903. Formerly there were two retransmissions between London and Teheran, viz., at Emden and Odessa. The total length of line is 3,800 miles, of which 200 miles consists of submarine cable. The circuit is at present interrupted.

The leak method of control on automatic repeaters was also introduced by Gavey.

T. A. Edison was the first to produce a practical quadruplex, which he did in 1874. This system permits of two messages being transmitted simultaneously in either direction or four in all, and is accomplished by adopting two strengths of current. The quadruplex has, thus, a fundamental defect which renders its utility variable.

Multiple Morse working by the division of line time was carried out first by the French Administration, the system employed being due to Bernard Meyer, a Controller of telegraphs in the French Service. This was a letter-by-letter system, and worked with fair success from 1871 to 1874. Synchronising trouble and poor performance partly accounted for its disappearance, and the invention of the multiple type-printing telegraph of Baudot about 1874-75 finished it off.

P. B. Delany introduced in 1884 a multiple morse system on the same general principle as Meyer's, and this was actually adopted by the British Post Office and used by them for some years. At the hands of the Post Office engineers it underwent numerous improvements, but it had a fundamental defect and the inexorable law stepped in. It has since gone out of use.

Type-printing systems have always been in use from the earliest days of commercial telegraphy. The system of David Hughes, invented in 1855 was widely employed in America and to some extent in this country in the old company days. Its adoption spread later to the Continent, and it is to this day largely in use all over Europe. One reason for the remarkable success of this apparatus was the principle introduced by Hughes of the free-running isochronous type wheel. Up to the time of its appearance all printing systems were of the step-by step type of rather delicate construction and generally made by clockmakers. The Hughes printer as originally made was robust, and improvements in detail were made by the eminent firms of telegraph engineers who, from time to time, took up its construction. The early work on the Baudot apparatus was very largely influenced by the construction of the Hughes.

In 1874-5 the first multiple printing telegraph system appeared. It was the work of Jean M. E. Baudot, a telegraphist employee of the French Administration. Baudot realised that printing systems, such as the Hughes, only utilised a fraction of the transmitting capacity of inland telegraph lines. He therefore employed synchronously rotating distributors to divide up the line time between two, three or four printing instruments. The time at which any of the operators may signal is indicated by a "cadence tapper," a device used by Meyer but first suggested in 1860 by W. H. Burnett, an Englishman. Due to the alphabet employed, the five-unit code of Gauss and Weber, and to the excellent construction which has always been a characteristic of Baudot apparatus, the system met with extraordinary success in France and of late years it has spread to Germany, Belgium, Holland, Spain, Italy, Denmark, Norway, Russia, Switzerland, the United Kingdom, Argentine Republic, India and Ceylon.

International communication is now almost entirely carried on by Baudot circuits, though the Hughes is still very largely employed.

From 1899 to 1902 a number of new high capacity systems sprang into more or less precarious existence. The Rowland invented by Prof. Henry Rowland, was an octoplex system, *i.e.*, four channels each way, by the combined use of rotary distributors and the duplex balance. It employed an 11-unit alphabet and sine-wave impulses. This system, as arranged by Rowland, is no longer in existence. The length of the alphabet seriously reduced the transmission possibilities of the system, but it had other fundamental defects.

The Buckingham system, a single channel or automatic high-speed system, had a short life. Slightly modified by Barclay it has had some vogue in the United States, but it is rapidly being displaced by multiplex systems using the five-unit equal letter code.

Siemens and Halske introduced a photographic printer using the 11-unit alphabet of Rowland. It had two fundamental defects, its alphabet and the damp photographic tape, and it has played no serious part in carrying the telegraphic traffic of the world. Numerous other systems have been proposed and have languished for a while, but two systems are emerging which seem like avoiding the printing telegraph scrap heap: the modern multiplex of which the system due to Murray is the best example, and the high-speed Morse code system, the sole representative being that due to F. G. Creed.

The Creed Morse code system uses keyboard perforators and a standard Wheatstone transmitter at the sending end. At the receiving end the line signals pass through a reperforator which furnishes an exact copy of the transmitting tape. The received tape is them made to set permutation slide valves which open an admission port to a cylinder controlling a small piston actuating a typebar which imprints the letter corresponding to that punched on the tape. This system is extensively employed by telegraph administrations, as the translation of the Morse signals is accomplished at high speed without skilled intervention.

The Murray multiplex is generally on the same lines as Baudot, except for some differences of fundamental importance. It employs synchronously run distributors and the five-unit code, but there its resemblance ends. The Baudot is a tape printer and the tape has to be gummed to a message form. The Murray is a page printer. The Baudot is a cadence controlled system. There is no storage of signals between the transmitting operator and the transmitting distributor and any pauses on the part of the operator lead to loss of line time. This has been shown to amount to about 30 per cent. Murray employs keyboard perforators and a transmitter controlled by the cadence current. Due to the fact that with a typewriter keyboard the instantaneous rate of an operator may, with favourable letter sequences, be double the actual working speed for which the distributors are set, the loss of time due to intermittent stoppages is largely obviated, signals being stored on the loop of tape between the transmitter and the keyboard. In the event of the operator stopping for such length of time that the perforated tape is reduced to a certain minimum length an automatic device acts to stop the transmitter which is automatically started again as soon as the operator commences reperforating.

By the removal of the nervous strain imposed by the necessity for observing the cadence and also the storage of signals above described, speeds of 40-45 words per minute per channel can be attained on the Murray as compared with a theoretical 30 and actual 20 words per minute on the Baudot.

The internal arrangements of large telegraph offices have, in recent years, undergone much alteration due to the adoption of "telephone" type test and switch frames. A number of circuits have been concentrated on telephone switchboards controlled by a telegraphist who distributes incoming calls to a few operators located at instrument tables close by. Thus the equipment of a comparatively large number of circuits with telegraph apparatus is saved and economy in table space effected. The traffic can also be more efficiently distributed and with less delay.

The idea has been extended to intercommunication between suburban offices through a central switch, thus saving retransmission at the central office.

At all large offices secondary cells are used, and the transit of messages from floor to floor, at one time exclusively effected by pneumatic tubes, is largely done by band and cord carriers. The power department of a large telegraph office is now an important branch.

A feature of the British service has always been the efficient distribution of news. The old companies maintained a news distributing agency. At the transfer this work was done by private agencies, the Post Office merely undertaking the telegraphic work. The distribution telegraphically is done by the Wheatstone automatic system, several towns being strung on one wire, and a number of such wires radiating from the central office. Many of the important provincial newspapers rent a private wire from the Postmaster-General and man it with their own staff, providing their own apparatus as well. These wires were formerly worked manually at about 30 words per minute, but now, invariably, Wheatstone is used with a Creed printer at the receiving end. Such installations have been extraordinarily successful.

A few years ago it might have been thought that land telegraphy had reached finality. To-day it is very different. The era of machine telegraphy is only just commencing. In a few years' time we shall see a revolution in methods carrying far-reaching results. It may be possible (who knows?) for a Postmaster-General in his annual report to announce, at least, no loss on telegraphs. So may it be!

The Story of the Submarine Cable.*

By CHARLES BRIGHT, F.R.S.E., M.Inst.C.E.

When asked to write on this subject certain difficulties presented themselves owing to the prevailing war, the most immediately interesting part of my story up to date being vetoed for strategic reasons.

It happens, however, that the Atlantic cable holds a jubilee this year—indeed, this month. That fact has been probably entirely lost sight of, by the general public at any rate, due to the lack of any festivities which under ordinary conditions go to mark such an event. Even though conditions do not lend themselves to any function by way of celebration, it occurs to me that the 2000th number of a journal so closely associated with the pioneering of cable telegraphy may suitably be made a vehicle for briefly summarising the events in cable history up to that of which we should, as I say, by right, be celebrating the jubilee. To do more than this—*i.e.*, to enter into any technical description or particulars—would be impossible within the prescribed limits. My theme is, therefore, largely composed of realistic history, which has the advantage of being a practical and at the same time interesting weapon of instruction, besides helping us to follow in the steps of those that make history. With this preamble, I will now proceed.

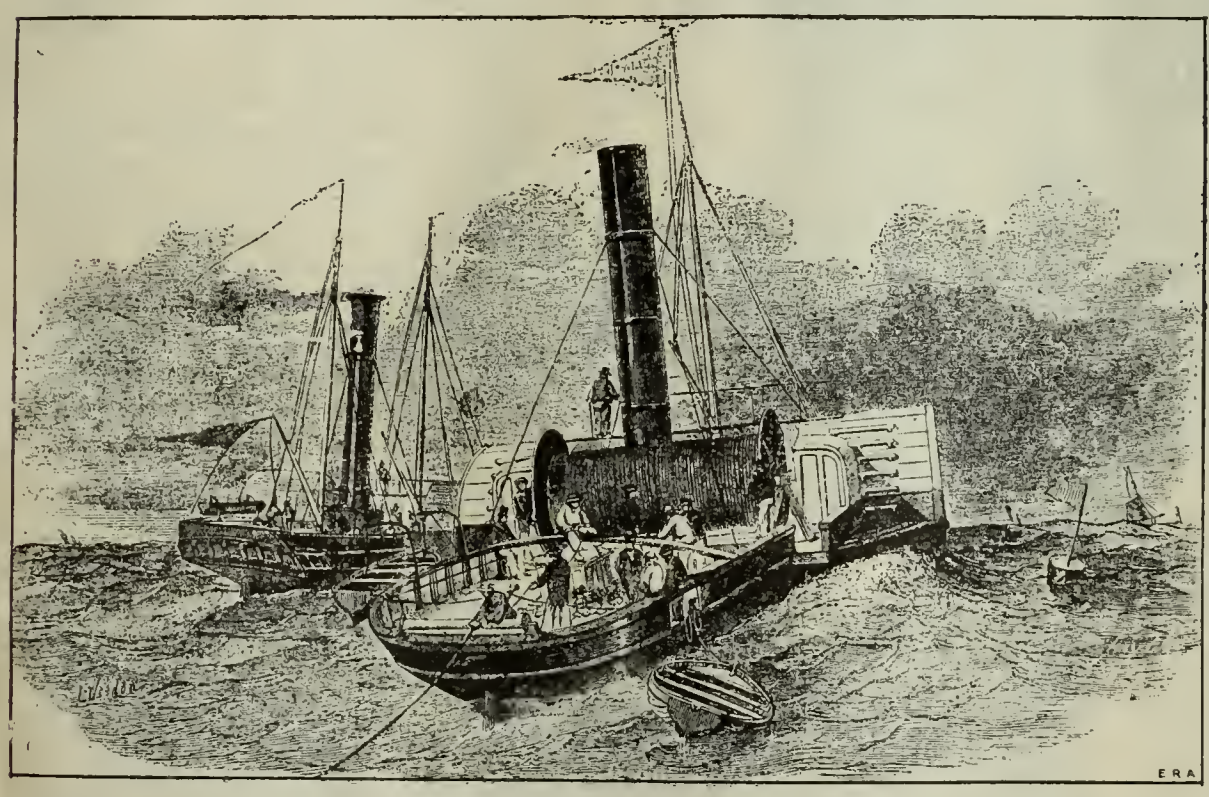


Fig. 1.—Laying the First Channel Line.

Unquestionably, the *bric-à-brac* shopkeepers, Jacob and John Watkins Brett, were the first to deal with submarine telegraphy from a public and commercial standpoint. On June 16, 1845, they registered a company for the purpose of telegraphic communication between this country and France, and a little later they addressed themselves to the Prime Minister, Sir Robert Peel, who did not, unfortunately, share their confidence. This move, indeed, only involved the Bretts in a departmental correspondence—more academic than useful—in which they were diplomatically passed backwards and forwards from one Government office to another.

By 1849, however, the Bretts had obtained consent from the authorities of both countries to lay a cable across the Straits of Dover.

Fig. 1 illustrates the laying of this line from the "Goliath," a small Thames tug with a very big name! The line only consisted of a gutta-percha covered copper wire. This was unwound across the Channel from a huge reel on the deck of the vessel, and the further end connected to a Cooke and Wheatstone needle telegraph instrument set up in a bathing machine. The carrying out of this enterprise excited little or no attention at the time. It was, indeed, looked upon as a mad freak—and even as a gigantic swindle—indulged in only by wild minds. When accomplished, "The Times" remarked, in the words of Shakespeare, "The jest of yesterday has become the fact of to-day." But a few hours afterwards it might with equal truth have been said: "The fact of yesterday has become the jest of to-day!" Messages were, however, certainly sent through this insulated wire.

Brett had a document, signed by 20 Frenchmen, dated September 6, 1850, who declared that they had seen the electric telegraph working between France and England. The signals, it must be confessed, were somewhat incoherent; the operators at each end blamed those at the other, and tauntingly suggested that the excitement, or something else, must have gone to their heads. In any case, the glory of this telegraph was, unfortunately, short-lived; for after the first evening it maintained an obstinate reserve, and never spoke again. An attempt was then made to raise the wire; but as a leaden weight had been attached at every 100 yds. in order that it might be successfully sunk all efforts were in vain. A considerable length was, however, brought up by a fisherman in his trawl, who carried it off to Boulogne in triumph as a "piece of rare seaweed with a pith of gold."

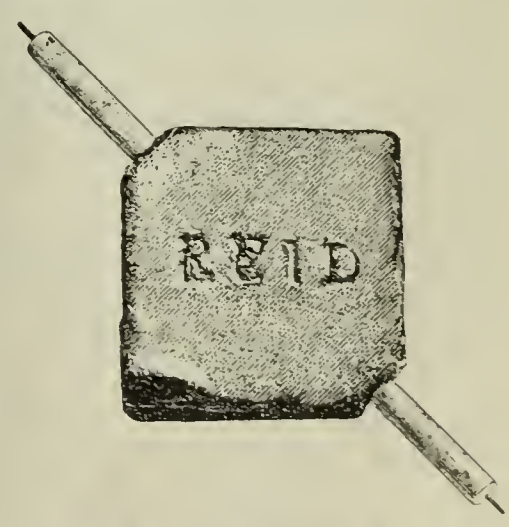


Fig. 2.—1850 Line and Weight.

Fig. 2 shows the line which did such short duty, with the leaden weights attached. It will be observed that Mr. Reid (the contractor) was determined that, at any rate, the fishes at the bottom should know of him, and that he made leaden weights.

Then, again, on December 19, 1850, a concession was granted to Jacob Brett by the French Government, and on the strength of this the Submarine Telegraph Co. was formed. But £300 was all that the public would subscribe, because it had been *proved* that submarine telegraphy was an impossibility! Yet these early pioneers, with that peculiar obstinancy that characterises inventors, actually went on believing in their own ideas.

* Copyright reserved by the Author.

Crampton, the well-known railway engineer, came to the rescue with £7,500 of his own and a similar amount from his friends. Then Küper, a colliery engineer, came along and said: "Why not protect your gutta-percha covering by an iron sheathing?" The cable with its sheathing was duly made, and on September 25, 1851, a procession, with a man-of-war to lead the way, started from the South Foreland to the shores of France. All went well until they were in sight of the opposite coast, when the cable gave out. Another mile was ordered, manufactured, and laid; and on November 13, 1851, the public sent a message through a submarine cable, the cable shown in Fig. 3, for the first time in the history of the world. As may be observed, there were four insulated conductors covered with hemp and iron wires; but in those days the main reason for conductors in multiple was that if one failed there were others to do the work.

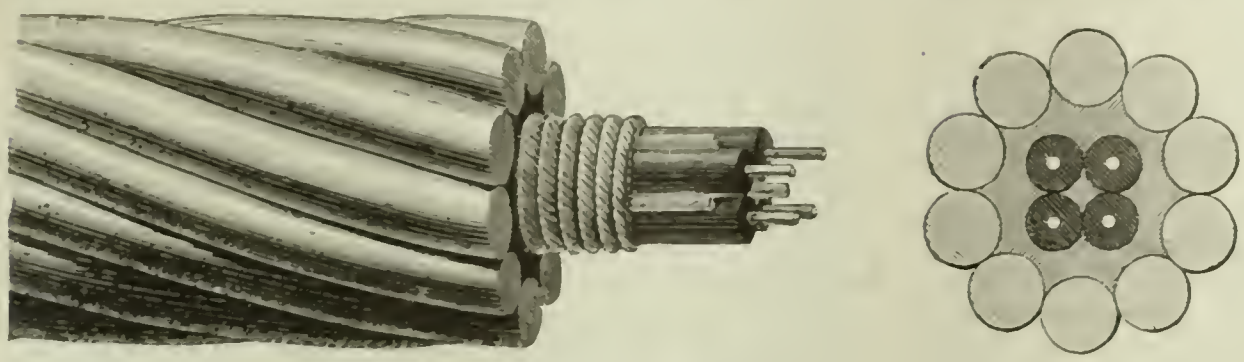


Fig. 3.—The First Channel Cable, 1851.

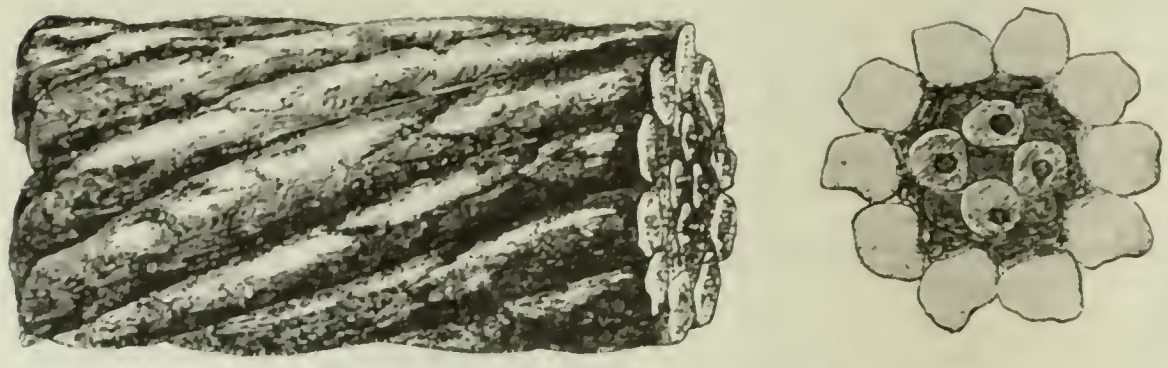


Fig. 4.—Piece of 1851 Channel Cable Picked up Later.

The cable had a very good life, and this class of armour has been adhered to ever since. Fig. 4 illustrates how little this cable was affected by time when picked up a good many years later.

The Bretts then applied to the Government for a monopoly to electrically connect England and Ireland. This time they were not so fortunate, for on September 10th the Admiralty wrote that "they had watched with interest the progress of the experiments, but had no power to grant a right." On the 18th, the "Foreign Office is directed by Viscount Palmerston to congratulate you upon the success of your experiment, and to state that the matter does not relate to the business of his lordship's department." On the same day the Admiralty again wrote "that whatever privileges can be granted can proceed only from the Treasury." The next day the Treasury "acquaint you that it is not in the power of the Lords Commissioners of Her Majesty's Treasury." They got the same answer on September 28th. On October 18, 1850, they received the following letter from the Treasury: "Although sensible of your perseverance in bringing the submarine telegraph about, and in view of the great public benefit likely to arise in connection . . . but it is not in their Lordships' power, &c."

Cables were eventually laid between England and Ireland; and although the first two were failures, in 1853 my father, at the age of 21, successfully connected the two islands. It was similar to the Dover-Calais cable here referred to, but contained six insulated conductors round a heart of hemp.

Then followed a number of lines laid across the English Channel, in the Mediterranean and elsewhere. Many of these early attempts either resulted in breaking the cable, or in paying it out with so much slack that it reposed in festoons at the bottom of the sea, as there were no means then of indicating what force was being exerted by the brake used to restrain the running out of the line.

We now come to the period when a much more difficult problem was dealt with—I mean spanning the Atlantic Ocean by laying and speaking through a cable 2,000 miles in length, the depth being upwards of 3 miles. Many eminent scientists had said it would be impossible to deposit the lines at all at so great a depth; and that, even if laid, it would be a mathematical impossibility to transmit electrical signals through such a length. The Atlantic cable was, indeed, considered at this time (1857) a wild freak of people that were to be pitied.

On the opposite page you have the portraits (from photographs taken at that period) of some of those who were the subject of "pity." Brett had, as I have shown, already been associated with other pioneer cables. Cyrus Field was a wealthy American business man of far-seeing and enormously active character,* and my father had already attracted attention as an engineer.

There were evidently some spirits who believed in the enterprise, or in those at the back of it, for the Atlantic Telegraph Co. was formed within a few days, the entire capital being raised—almost entirely in England—by the public issue of 350 shares of £1,000 each.

The proposed route was surveyed in what we should now consider a somewhat "sketchy" fashion: for whereas in the present day we sound at intervals of about 10 miles, at that time soundings every 100 miles were considered abundant. The general character of the bottom was, however, correctly



Fig. 5.—U.S.N.S. "Niagara."

* Field had achieved a commanding position in respect to any such scheme by acquiring a concession from the late F. N. Gisborne (a well-known Canadian engineer) for communication between Newfoundland and Canada.



JOHN WATKINS BRETT.



CHARLES TILSTON BRIGHT.



WILLIAM THOMSON.



CYRUS WEST FIELD.



JOHN PENDER.

FIG. 5.—SOME OF THE PIONEERS IN SUBMARINE TELEGRAPHY.



Fig. 7.—H.M.S. "Agamemnon" Completing the First Atlantic Cable.

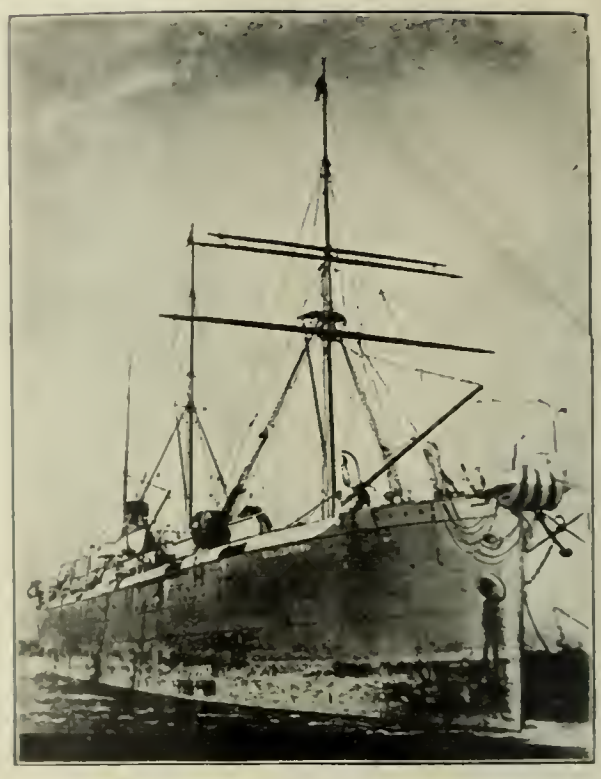


Fig. 14.—T.S. "Silvertown."



Fig. 10.—S.S. "Great Eastern" Picking up the Second Atlantic Cable at 0.50 A.M. on September 2nd, 1866. (Depth 2 Miles.)



Fig. 13.—T.S. "Colonia."



Fig. 15.—T.S. "Faraday."

arrived at from the specimens brought up, being, in fact, the usual oceanic ooze of extremely minute shells—a perfect bed for cables.

The manufacture of the cable was duly proceeded with, partly at Greenwich and partly at Birkenhead, near Liverpool. The iron sheathing was composed of several strands of fine wire. Thus the entire length of wire employed was as much as 340,500 miles—enough to engirdle the earth 13 times and considerably more than enough to extend from the earth to the moon. This stranded sheathing had clearly certain mechanical advantages at the outset, but has since been found by experience not to be a durable type of armour.

The Governments of the countries concerned encouraged the scheme to the extent of lending certain vessels for laying the cable, as they had done previously for the survey.

The main contribution from the United States was the "Niagara" (Fig. 6), a splendid example of the frigates at that time. H.M.S. "Agamemnon" was loaned for the purpose by the Admiralty. A smaller vessel was also provided by each Government to land the ends, pilot the way, and to act as consort generally.

Mishaps soon occurred; for it was only four miles that had been paid out when the cable broke. Another start was made; but after 226 miles had been laid, it again broke, this time, however, at a depth of two miles. So ended the first attempt to electrically connect America with Europe. Morse, who was on board in an honorary capacity, recorded the circumstances as follows: "The cable parted just before daybreak. The machinery having stopped, all hands rushed on deck and gathered in mournful groups; their tones were sad, their voices low, as if a death had occurred on board."

The next year (1858) more cable was made, and a second expedition started with 3,000 miles. The two vessels were this time to meet in mid-ocean and make a joint, and then sail in opposite directions, laying the cable towards their respective shores. This they did, but the joint broke. They made a second, and again it broke. They made a third, and then one ship sailed towards Ireland and the other towards America. On her way the "Agamemnon" encountered a whale, and though the ponderous monster made commendable attempts to carry off the cable, these attempts were attended with no evil result. The "Niagara," however, had not gone far before another break occurred which ended in the loss of 500 miles of cable. Sufficient yet remained on board for a third trial.

Meanwhile, however, both ships had run out of stores, and it was therefore necessary to put into Queenstown. On the way a terrific storm was encountered, and the "Agamemnon" nearly "turned turtle." The boots, food and crockery—not to mention the coals—got terribly mixed up; but so did the cable in the tanks, and that was a much more serious affair.

Matters were, however, righted; and after stores had been procured the telegraph fleet again met in mid-ocean to make the splice, and again set forth on their respective work. The first expedition created considerable excitement, but when it came to the second and third, everyone, except the shareholders, merely pitied those that were continuing such a futile errand. The pity was, however, now beginning to be misplaced; for this time the entire line was laid successfully.

Though having little to do with the actual work, our American cousins were, as might be expected, more demonstrative on the subject, and wild excitement prevailed on the landing of the end at the Newfoundland station. But even "The Times" remarked: "Since the discovery of Columbus nothing has been done in any degree comparable to the vast enlargement which has thus been given to the sphere of human activity."

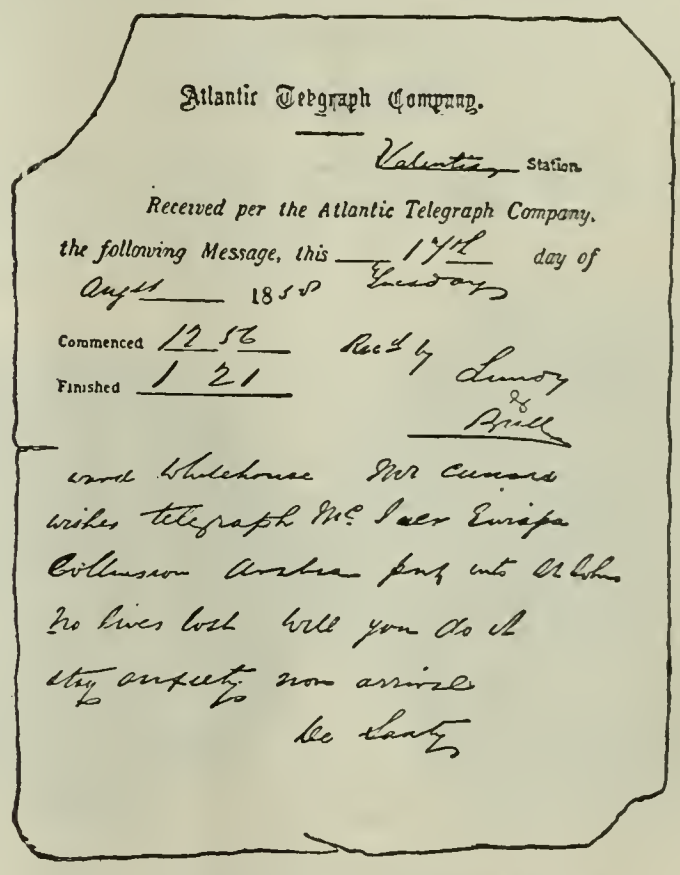
It was on August 5, 1858, that England spoke for the first time electrically with America. Formal and reverential were the first words of greeting between Her Majesty Queen Victoria and the President of the United States.

The cable never worked very satisfactorily from the outset: for the message from the United States President to our Queen occupied over 30 hours in transmission, though only containing 150 words! Moreover, the utmost speed achieved was some six words a minute.

Fig. 8 shows the first public news message that was sent through the cable; and in allaying the anxiety of passengers after collision between two ships it served a most useful purpose. The line also further illustrated the great utility of a cable service, by conveying two messages from the War Office to Canada, the effect of which was to countermand the return of two regiments—thereby saving the expenditure of £50,000!

But though doing useful work for some two months, the line was gasping under its efforts throughout, and gradually reached the sinking stage. It was suffering—and ultimately succumbed—from the effects of the electrician's mistaken electrical views, in which even the great Faraday shared. The line was, indeed, an electrical failure, though a complete engineering success. It had been proved that such a length of cable could be laid in really deep water; and, though various mishaps had occurred before final engineering success was achieved, these were only due to unavoidable accident on the one hand, and lack of perfection in manufacture on the other, such as could be improved on by the experience gained.

From the next cable, however, that laid by the Government in the Red Sea in 1859, nothing useful was learned. The sections failed one after the other, and it is doubtful whether


Atlantic Telegraph Company.

Valentia Station.

Received per the Atlantic Telegraph Company, the following Message, this 17th day of August 1858 Tuesday

Commenced 12.56 Rec'd by Lundy & Bell

Finished 1.21

and Whitehouse Mr Cunard wishes telegraph Mrs Saer Europa Collision Arabia put into Queenstown has lives lost will you do it stop anxiety now arrive be Lundy

Fig. 8.—The First Public News Message.

a message was ever sent through the whole of the cable: but it is certain that the British public continued to pay for 50 years £36,000 per annum for the privilege of having put some copper wire, gutta-percha and iron sheathing at the bottom of the Red Sea.

There were several other cables laid soon after—from Malta to Alexandria, to India and elsewhere, and these proved a complete success. Indeed, the line to India, viâ the Persian Gulf, may be said to have been the pioneer in regard to full and satisfactory arrangements for testing previous to, and during, laying. A little later a project was mooted for an extreme North Atlantic cable, with stepping-stones at Iceland and Greenland; but possibly the temperature there was not thought to be sufficiently inviting, for certainly the scheme came to nothing.

It was not until 1865 that the question of re-spanning the Atlantic took active shape. My father and the late Latimer Clark had, in the interval, persuaded the financiers that a larger and more costly insulated conductor was essential. Moreover, the electricians were also better advised in regard to the generating power and apparatus for signalling purposes; indeed, Prof. William Thomson (afterwards Lord Kelvin) had not only introduced his mirror speaking instrument, but was

taking a more active part in the electrical arrangements generally. There is something peculiarly life-like in the working of the mirror apparatus; and it certainly proved the turning point in ocean telegraphy, both as regards signalling and testing, though now superseded by the "Recorder" for the former purpose.*

Then, again, at this stage in the history of submarine telegraphy, the improvements in manufacture, due to experience, were altogether encouraging, and the late, highly esteemed, Willoughby Smith, as well as C. F. Varley, and the brothers Werner and William Siemens, had done much towards developing the electrical and manufacturing sides of submarine telegraphy.

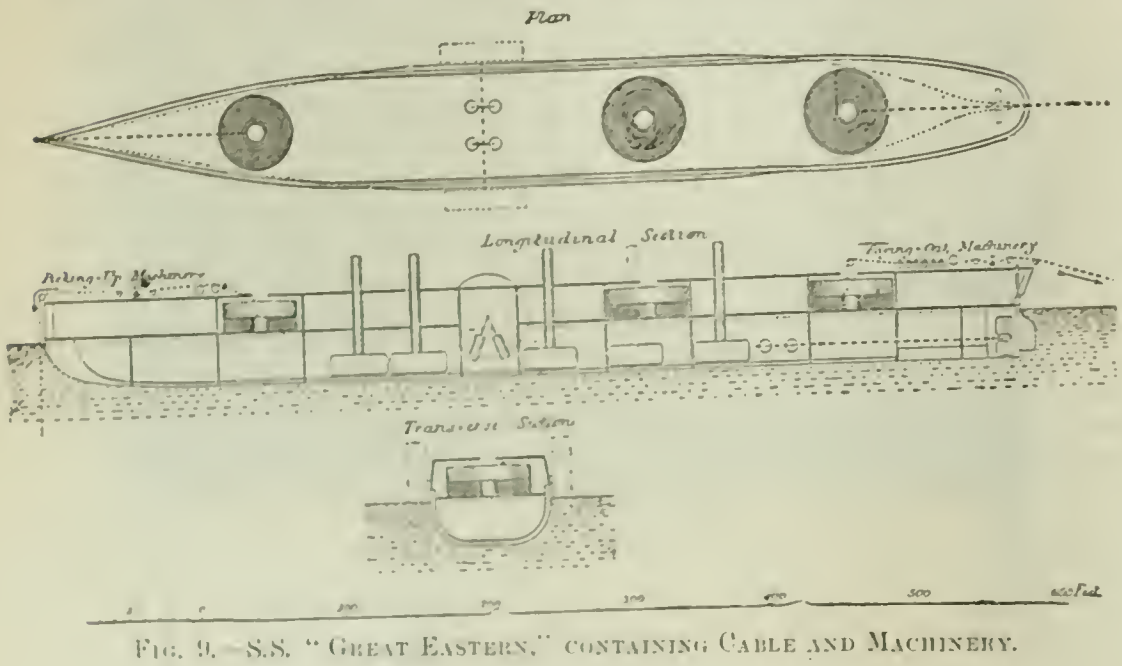


Fig. 9.—S.S. "Great Eastern," containing Cable and Machinery.

The larger sized core meant a larger sized cable,† and this could not have got into any other vessel than the "Great Eastern" (Capt., afterwards Sir James, Anderson), which, as it chanced, happened to be available.

Fig. 9 serves to illustrate the "Great Eastern," with a length of 600 ft., loaded up with the 1865 Atlantic cable. Here also is presented a general idea of the arrangements for paying out the cable from the stern, or picking up from the bows, of a telegraph ship.

In the 1865 cable several faults occurred; and it was feared they were produced intentionally by people on board sticking pins or iron wire through the gutta-percha. They watched the tanks, but still the faults occurred: and while attempting to haul the cable back to repair a fault, the cable snapped, after 1,186 miles had been laid. For nine days they made strenuous efforts to pick up the cable; but though they grappled it many times, the rope broke, and thus the 1865 cable had to be abandoned. A new cable like that of 1865 was then made by the Telegraph Construction & Maintenance Co. This company contributed £100,000, and undertook to make and lay the cable for half a million of money, whether it was successful or not, this sum to be increased to £600,000 if it were successful, and to £737,000 if they could also pick up and complete the 1865 cable. So three-quarters of a million of money was the prize; and it was won. Nowadays the prize would be only about half a million for a cable giving, of course, far better results.

The new cable, after a few further misfortunes, was eventually laid. From an engineering standpoint, however, this was really work that had already been effected eight years previously, with about the same number of misfortunes, though with no applicable experience to go upon. The work to come—that of recovering the 1865 cable—was, indeed, the matter of the moment.

For 13 days they alternately hooked and lost the cable. Once they brought it to the surface; but it slipped away from them like a great eel. On lowering the grapnel, however, for the thirtieth time (Fig. 10) they succeeded, thanks mainly to Mr. (afterwards Sir Samuel) Canning, the engineer to the contractors: and thus two good cables were laid between England and America.

On this expedition a remarkable incident occurred—that of the "Great Eastern," whilst in the act of picking up the cable, bumping against the very mark buoy put down to indicate the supposed line of the cable. This was, indeed, a striking suggestion of accurate navigation! For it we were indebted to the late Captain Henry Moriarty, R.N., who was lent by the Admiralty as navigator.

Fig. 11 shows the machine which ultimately succeeded in picking up a cable from a greater depth than had ever been achieved hitherto.* This was the great achievement in regard to the second and third Atlantic cables; and with reference to this machine, "The Times" representative on board (the late Sir William Howard Russell) said: "So delicately did she coil in the film of thread-like cable that she put one in mind of an elephant taking up a straw in its proboscis."

Other cables to the East and Far East followed in more or less rapid succession; and these, thanks to the commercial foresight and enterprise of men like the late Sir John Pender, have all proved a lasting success.

Though not by any means all in operation at the moment, there are now as many as 18 cables across the North Atlantic and several different routes to various Eastern points. Fig. 12 shows the different types of a modern Atlantic cable, and also the various coverings of the deep sea type. There is, further, the much-discussed All-British Pacific Cable to Australasia, and also the more recent American Pacific Cable to Japan. Both these run into depths of 4 miles; and just as the first Atlantic cable was considered at the time a wild freak of people that were to be pitied, so also the first Pacific cable was similarly spoken of by some, mainly on account of the great length—3,458 nautical miles—of one of the sections. It was, however, laid almost without a hitch, and will no doubt serve an increasingly useful purpose.

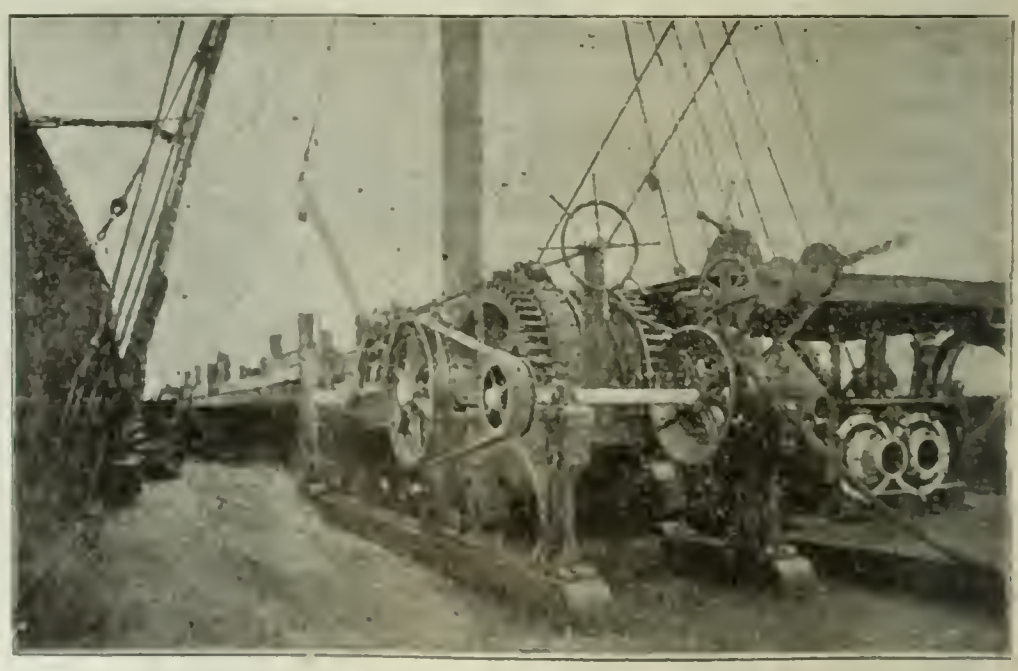


Fig. 11.—"Great Eastern" Picking-up Machine.

In the present day, cables have no history. Happy is the cable without a history! It must not, however, be supposed

* One of the most remarkable features of Lord Kelvin's great career—that of pursuing an invention, entirely himself, up to the point of practical application—was strikingly brought out in connection with his cable signalling apparatus.

† For statistics of working speeds from different sized cable cores, the reader is referred to "Tables to Find the Working Speed of Cables," by Arthur Deasleve, M.Inst.C.E.

* There is sufficient similarity between a paying out and picking up machine for either to be used, under certain conditions, for each other's work.

from this that we do not have occasional minor mishaps nowadays. Even though our materials are so vastly superior to what the pioneers had at hand, there are still the usual eventualities, many of which—as we have seen—are scarcely under control ; and there comes a time for all cables, when the iron wires are too decayed to permit of profitable repairs, bearing in mind the fact that a repairing expedition often costs as much as £200 a day.

As with other branches of the subject, it would be easy to fill an article by discussing the social, political, diplomatic and strategic value of cables ; and it is in the latter respect—added to that of Imperial unity—that the All-British Pacific Cable may some day prove of inestimable value to the nation. It has indeed, to a considerable extent already.

Personally, I am not one of those who believe in the early consignment of cables to the region of antiquarian museums, though having great faith in the utility of wireless telegraphy for all maritime purposes, and as a helpmate to our cable systems. Certainly, so far, there are no signs of cables being replaced by wireless telegraphy when further means of communication are required.

In the year 1867 the then Sir William Thomson introduced what is known as the Siphon Recorder for receiving signals through more or less long lengths of cable, and this is now in general use, one of its main advantages over previous apparatus being that it supplies a record of the signals as received.

With this system, the Morse alphabet is turned to account, by those serpentine caligraphics that so many are now familiar with.* It might naturally be supposed that great difficulty would be experienced in deciphering such a language. Skilled clerks, however, can make out almost anything in these snake-like movements.

Increased accuracy and speed are further secured nowadays by automatic machine transmission apparatus on the same principle as is in vogue for the despatch of Press news on land telegraphy—the tape at the receiving end of the line being distributed amongst various clerks.

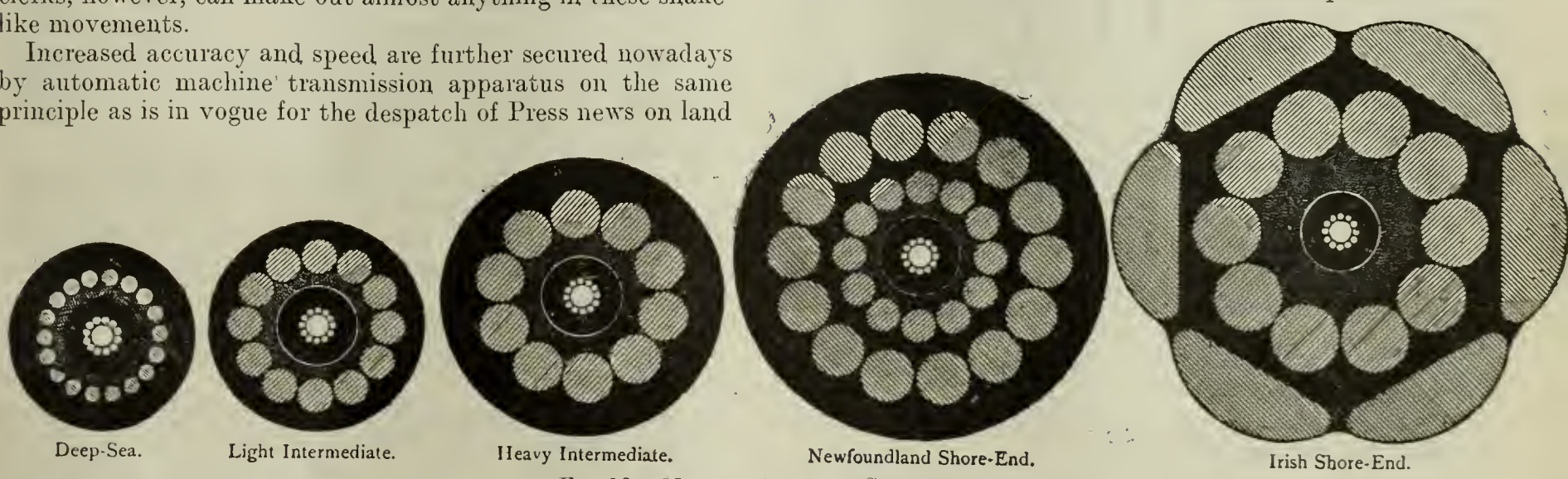


Fig. 12.—Modern Atlantic Cable.

Duplex telegraphy was first applied to cables by Dr. Alexander Muirhead and the late Mr. Herbert Taylor in 1870. It is—as is, I suppose, now fairly generally known—a system in which the output is nearly doubled, by sending and receiving messages from both ends at one and the same time. This system is adopted on all lines with a sufficiently large traffic to warrant application, thereby tending to save the cost of an additional cable. This, again, is a little too complicated for dealing with in detail here. The general principle is, however, that—by means of resistance and capacities corresponding to that of the cable itself—artificial establishment of an exact electrical balance at each end of the line is secured under normal conditions. This balance is, then, only upset in accordance with the transmission of signals, thus permitting these to be despatched and received from either end at the same moment. The application of condensers at each end of the line, as well as other methods for curbing the current, also tend towards increased speed and greater clearness of signals. Thus, an Atlantic cable of to-day designed to give with auto-transmission and ordinary reception methods a speed of 50 words per minute can, with modern amplifying receivers, be worked up to well over 100 words a minute simplex working. There is also every likelihood that by means of recently invented selective damping devices the said improvements will—without sacrifice to sensitiveness—be wholly applicable to duplex working, thus securing a consequent total output in the above case of some 200 words per minute.

With a view to effecting automatic, instead of manual, translation between lengths of submarine line, the cable relay may be said to have been the dream of the cable manager for years, and one that has seriously occupied the minds of many an electrician. Only comparatively recently, however, has complete success in this direction been achieved by Mr. S. G. Brown, Dr. Muirhead and others ; but, though a subject of the day in cable circles, anything more than this passing allusion would be impossible here. The same applies to the apparatus for increasing the size and clearness of signals due to Mr. E. S. Heurtley and others, which is found in some cases to render possible an increase of speed of as much as 60 per cent. Then again, the Orling Jet Relay has been found to increase the speed for "ordinary" working during an actual trans-Atlantic trial by even over 100 per cent. Of still more recent date, too, is the plan of the late Mr. John Gott for applying to cable work the ordinary Morse system—with its attendant automatic translating facilities. By this plan, inverse currents are employed for every signal sent into the cable, the said signals being rectified at the receiving end by Mr. Raymond-Barker's method.

The practical effect of submarine telegraphy is further achieved by the code and cipher system, whereby a number of words are represented, in secrecy, by a single word or a combination of figures. To take an example, the word "Elgin" in a certain mercantile code stands for as much as "Every article is of good quality that we have shipped to you."

Though not at the present time a suitable subject for material ventilation, in closing this article light reference may, at any rate, be made to the highly important and successful war work accomplished by the various modern telegraph ships* (in charge of highly skilled engineers and electricians) some of which are illustrated in Figs. 13, 14 and 15 respectively.

The second largest—T.S. "Silvertown"—has, however, recently been converted into an oil tank ship.

All those engaged in the art of cable telegraphy may be said to have done their best for the country during this epoch-making war under the assiduous administration of Sir John Denison-Pender and others.

Approximate Statistics.

Total length of cable laid, 300,000 miles.
Total cost of cable laid, £60,000,000.
Cost per mile, construction and laying, £200.
Useful life of a cable, 30 to 40 years.
Messages conveyed by cable per day, 20,000.
Percentage of code and cypher messages, 90 per cent.
Maximum cable tariff, to Dutch Guiana, 6s. 9d. per word.
Minimum cable tariff outside the Inland Post Office telegraph system, by Government cables, to the Continent, 2d. a word ; by companies' cables, to United States or Canada, 1s. per word (originally £1).

* The late Dr. S. P. Thompson's "Life of Lord Kelvin" gives full particulars of the evolution of the Siphon Recorder, and the same is also to be found in the present writer's "Submarine Telegraphs : Their History, Construction and Working."

* Belonging respectively to the Telegraph Construction Company, the Silvertown Company and Messrs. Siemens Brothers & Co.

The Speed of Submarine Telegraphy.

A CURSORY HISTORICAL SKETCH.

By EDWARD RAYMOND-BARKER.

Deference to the Editors of THE ELECTRICIAN, and goodwill to this journal and all concerned with it, on this occasion of the publication of its 2000th issue, compels the writer to accept the Editors' invitation to write on "The Speed of Submarine Telegraphy."

The writer accepts this honour the more gladly remembering that, nearly 39 years ago, the arrival of the first issue of the 2,000 at St. Vincent, C. de V., where he then was, caused him, on that now far-distant "cinder-heap," not a little gratification.

The writer is invited to deal briefly in historical fashion with submarine cable speed as it used to be 40 years ago; as it is at the present day; and with what, perhaps, it is likely to be. This, to a man possessed of a normal modicum of diffidence, seems a rather tall order, especially when—as is the case at present—he finds himself away from private notes, data, records, correspondence, signal records and all the many items so convenient for reference on an occasion like the present.

Despite all this, the writer will do his best to submit to our Editors, and to the readers of THE ELECTRICIAN whom it is the writer's honour to address, one or two points worthy of consideration.

It is impossible to deal historically with submarine cable speeds, their early circumstances in the past, their gradual development to present-day standards and (the writer is convinced) their wonderful future, without some statement to non-telegraph readers, as to what exactly is meant by the term *cable speed*.

The writer, who lays no claim to be anybody but a mere student in matters relating to current-propagation through cables as considered in the light of present-day advanced mathematical treatment, salutes with respect the names of Drysdale, Fleming, Kennelly, Malcolm and Squier for their several developments of the work so brilliantly conceived and instituted by Kelvin.

Cable speeds, then may be stated in terms of any convenient unit, such, for instance, as:—

(*a*) *n-letter words* per minute. (*n* has, generally, been taken as = 5, but, really, *n* varies with class of traffic.)

(*b*) *Letters* per minute.

(*c*) *Signal-contacts* per minute. (Tantamount to automatic-transmitter slip centre-holes per minute.)

(*d*) *Elements* (viz., contacts *plus* spaces), per minute.

The following note is here pertinent: On the basis of independent data respectively from the Eastern Telegraph Company, and from the writer:—

"Cable"-code: $\frac{\text{Centre holes}}{3{\cdot}7}$ = letters.

Morse-code: $\frac{\text{Centre holes}}{4{\cdot}7}$ = letters.*

Also, it is impossible to consider the matter of cable speeds—historically or otherwise—without careful definition of terms in regard to modes of telegraphic working, and methods of current-transmission.

Firstly, there is *Morse* with its rectilinear record of short *dots* and long *dashes*, ratio one to three, or one to two.

Secondly, there is the equal-time-value *dot-dash* code commonly called the "cable" code, a term—in view of *Morse* sometimes being worked over long cables—quite inappropriate.

Then, also, as regards current transmission. Will it be believed that the following terms supposedly indicative of absolutely different methods, are, in reality, interchangeable:

(*a*) Double-current,
(*b*) Inverse-current,
(*c*) Current reversals,
(*d*) Alternating current?

All the greater reason is there, therefore, carefully to define terms before any attempt to review speed products of various systems during the past 40 or 50 years.

Double-current is the customary term to describe (in Morse work) a *marking* current of one polarity, and a *spacing* current of opposite polarity.

Inverse-current means that all transmitted currents rigidly alternate in polarity.

Two-power inverse-current means that *dot* and *dash* signals are produced and differentiated respectively by lower and higher power equal-time-value currents rigidly alternating in polarity, whatever may be their power.

The term *current reversals* indicates the transmission with two keys (or the mecano-electrical equivalent) of the equal-time-value *dots* and *dashes* used for the Kelvin mirror or siphon-recorder code—generally termed the cable code—one polarity producing *dot* signals, the opposite polarity *dash* signals.

Alternating current is an expression as a rule confined to the Squier method of transmission with an unbroken current in which equal-time-value sine-wave pendular alternations of three different amplitudes severally determine (*a*) *spaces*, (*b*) *dots*, and (*c*) *dashes*.

Figs. 1 and 2 show graphs illustrative of the various modes and methods already mentioned, and of other matter to be referred to later.

Rightly, the graphs *A*, *B*, *H* and *I* (in Figs. 1 and 2) of current impulses as transmitted at the sending-end of a cable, ought to be supplemented by sets of graphs showing, at a given transmitting speed, the same signals, as these arrive at the receiving end of a cable of given KR, where K = total inductive capacity, and R = total conductor resistance. Unfortunately, in the time available this is impossible. Were the production of this second set of graphs feasible, the current impulses in their received form would be found to be distorted: so much so that beyond a certain given speed of transmission the degree of distortion would be such as to render signals wholly illegible.

Kelvin found that current propagation along a cable core followed a rate of progress in a curve similar to that of the passage of heat along an iron bar (as enunciated by Fourier), and he established by calculation that figure so well known as Kelvin's *curve of arrival*. Another product of Kelvin's genius, the siphon-recorder, if joined up direct to a cable at the far end of which a prolonged current is applied, will itself trace in ink on a paper band a perfect curve of arrival equivalent to that calculated.

This curve is brought about by the opposition the conductor resistance R offers to any abrupt taking-up of electrical charge by the cable-core considered as an electrical condenser of capacity K, and by the consequent *gradual* rise of potential at the receiving end of the cable.

Between the moment of voltage-application at the sending end of the line and the initial rise of potential at the receiving end, a certain time elapses. This time—interval α (alpha)—Kelvin showed to be = KR 0·0000000295 *second*. For example,

* Full treatment of these matters is to be found in "Measurement of Telegraphic Speeds," by John Rymer-Jones. Published by Alabaster, Gatehouse & Co.

α in the case of the Brest–St. Pierre cable would be about 0·21 *second*.

The writer refers at length to this *curve of arrival* for the reason that the question of working speed may be said to be governed mainly by the degree of nearness to the curve base (nearness to *alpha*) at which the received potential is utilised by the receiver apparatus ; a matter bearing directly upon cable speeds.

Brief mention must here be made of, at least, a few main factors involved in Kelvin's so-called *KR* law, by means of which—as long as only telegraphic speeds are concerned, and telephonic-speech frequencies are not involved—the signalling speed S over a given length of some newly-projected cable may easily be calculated on the basis of the known speed s obtained over some other cable already laid.

The comparative signalling speeds over any two cables irrespectively of core dimensions, type, or length, will be inversely proportional to their respective *KR*'s.

If s=maximum safe speed already obtained over the laid cable taken as standard ;

If S=speed which will be obtained over some new cable projected ;

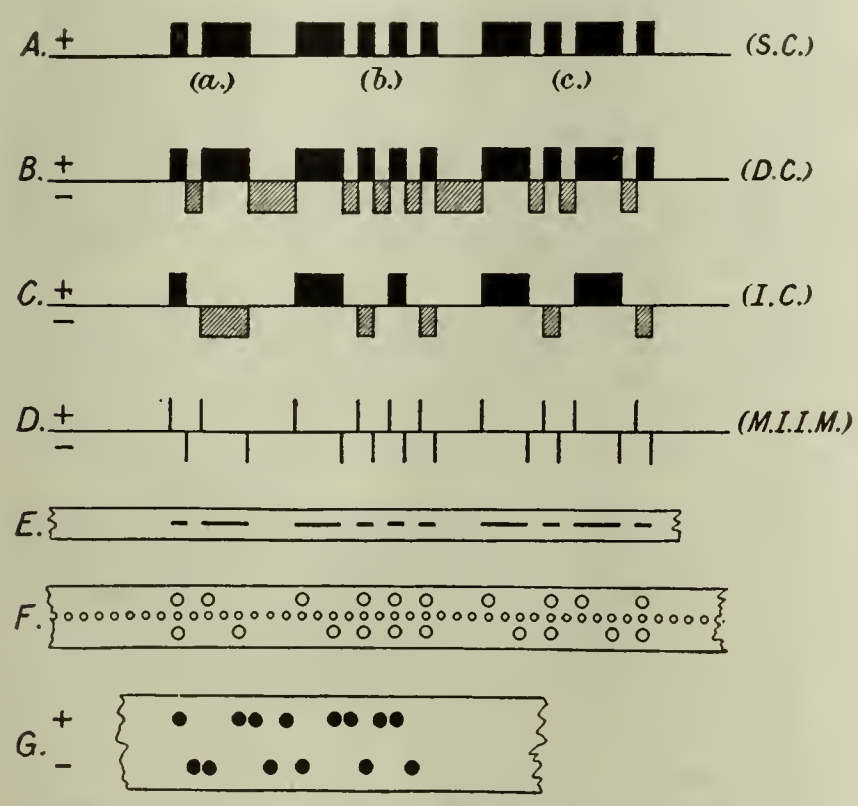


Fig. 1. (Morse.)

A = Single current transmission (S.C.).
B = Double current transmission (D.C.).
C = Inverse current transmission (I.C.).
D = Inverse momentary impulse transmission for Morse (I.M.I.M.).
E = Morse record.
F = Slip perforated to transmit Wheatstone Morse.
G = Slip perforated for auto-transmission of inverse current Morse. (Dating from 1879).

If kr=product of inductive capacity (microfarads) and conductor resistance (ohms) of the standard cable ;

If KR=product of inductive capacity and conductor resistance of the new cable ;

the aforementioned law gives the inverse proportion $S : s :: kr : KR$, or $S = skr/KR$.

Or, again, the KR of a new cable designed to carry traffic at a speed of S will be $KR = skr/S$.

Naturally it is here taken for granted that, in the working of both these cables, similar conditions obtain relative to (*a*) system worked (simplex or duplex) ; (*b*) use of " sending " and " receiving " condensers ; (*c*) use of S. G. Brown's magnetic shunt ; (*d*) whether with received-current amplifiers with recorder worked on local circuit, or with direct recorder or other reception ; (*e*) mode of transmission—nature of transmitted impulses, that is to say, whether square-topped, or sinusoidal as in Squier sine-wave unbroken alternating current ; (*f*) sending voltage, &c.

Another point of view from which *speed* must be considered is that of the users of the cables—the telegraphing public. After all it is the effective speed of the message between expéditeur and destinataire that really matters.

To take two extreme cases : Let two different and separate chains of cables be supposed to exist, covering approximately equal distances. On one of these chains, the cables are individually and separately worked through the medium of slip-perforating machines, and auto-transmitters at maximum speed, with here and there at certain stations a cable relay. At terminal or other stations messages are handed to the public in pencil hand writing, or, perhaps, are manually typewritten. The individual speeds of the several cables may here be very high, but strain and friction probably are great, and service efficiency suffers.

The second of the two cable chains is worked on other principles. Transmitted impulses genuinely scientific in their formation, coupled with the use of receivers of high periodicity characteristics, capable of reliable working almost on the base line of the cable potential curve, enable some few of the cables to be " joined through " direct. Improved auto-relays at other stations, and the use of auto-perforators and electro-

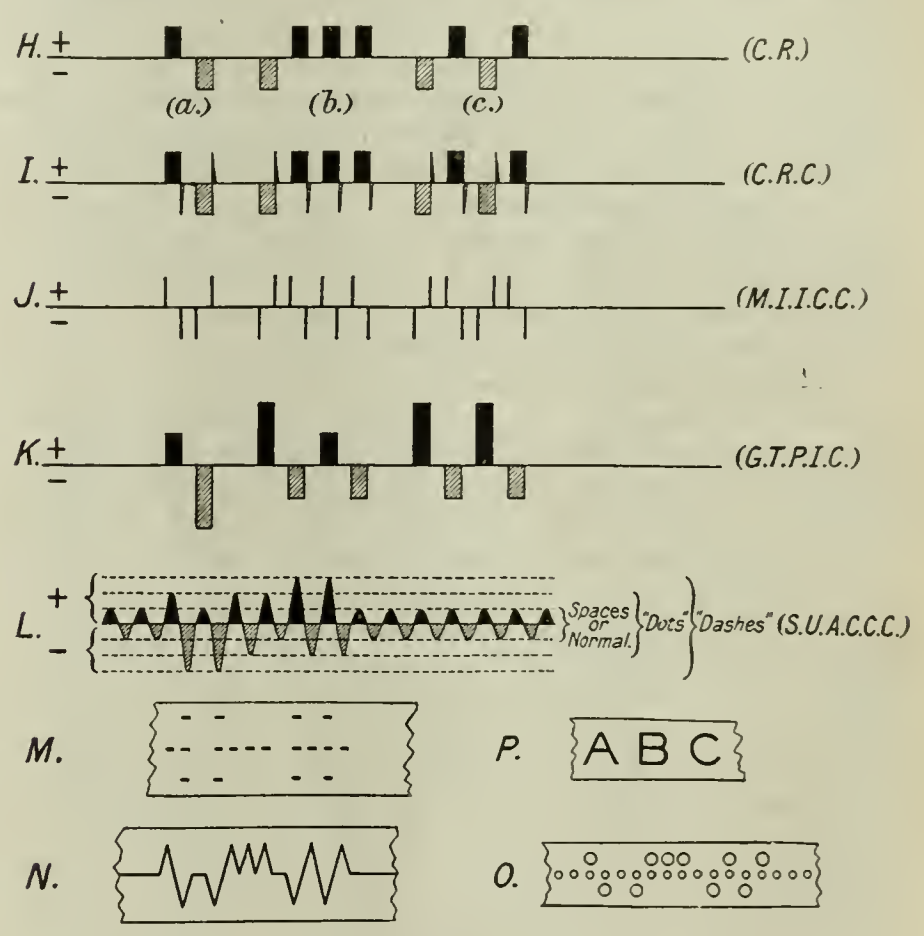


Fig. 2.

(Equal-time-dot-dash or so-called siphon-recorder or " cable " code.)
H = Transmission by current reversals (C.R.)
I = Transmission by current reversals—curbed (C.R.C.).
J = Transmission by inverse momentary impulse for cable code (I.M.I.C.C.).
K = Transmission by Gott's two-power inverse-current method—cable code (G.T.P.I.C.).
L = Transmission by Squier's unbroken alternating-current in three amplitudes, severally for *spaces*, *dots* and *dashes*—cable code (S.U.A.C.).
M = Squier's reception record.
N = Approximate appearance of letters " A, B, C," registered on a local-circuit siphon-recorder from Gott or Squier's received currents, by the writer's proposed system of rectification.*
O = Corresponding letters perforated on a paper slip from Gott or Squier received currents (rendered possible by the writer's system of rectification).†
P = Corresponding letters as printed ready for delivery to the public ; a quite feasible method, by means of the *rectifier*, for effecting final records from Gott two-power inverse current or from Squier unbroken current alternations.†

magnetic type-printing machines at terminal or other stations serving the public, render possible " *through working* " between terminal stations at both of which messages reach the public straight from the instruments and in clear Roman type.

In this second instance, the actual speed of transmission, on each separate cable, may not be much higher—if at all—than in the first-mentioned case, but *effective* speed certainly will be higher, both cost and friction will be less, and the telegraphing public will be better satisfied.

H. H. Harrison, in his recent very informative I.E.E. Paper on modern type-printing telegraphy, mentioned (the writer quotes from memory) how, in multiplex type-printing telegraphy, several comparatively low-speed " circuits "—

* *See* former issue of The Electrician.

† Creed's electromagnetic perforator and type printer would here be controlled and utilised through the medium of the writer's *rectifier*.

each with individual touch between operators at terminal stations—conduce to better working than is the case where all traffic is confined to one very high-speed system involving, perhaps, photographic reception and record.

These few instances, out of a possible infinite variety, are here quoted merely to show how many points of view are involved in any considered treatment—historical or otherwise—of cable speeds.

The suggestion has been made that this article should refer back to cable speed matters as they were "10 years ago." That, of course, goes back only to 1876, whereas a great step was made regarding cable speeds in 1858—just 18 years earlier. That is to say 58 years ago.

Perhaps the suggested limit of "10 years ago" was in order to avoid all harrowing recollections of the 1858 Atlantic-cable electrical tragedy. That famous first ocean cable—the laying of which from H.M.S. "Agamemnon" and U.S. frigate "Niagara," under the direction in chief of Charles Bright, will, as a masterpiece in pioneering, be held in undying remembrance—met its fate, after much suffering, some 11 days after its happy completion; pierced to its very soul by high voltages used in ill-considered electrical methods. Incidentally, the expression *soul* as applied to the *core* of the mistakenly-treated cable, is all the more apt, as French and Spanish renderings of the English term cable-*core* are "l'âme du câble" and "el alma del cable," literally the *soul* of the cable. The whole sad story is given in Chap. II. of "Submarine Telegraphs," a book the work of Charles Bright, a well-known son of the famous Atlantic cable pioneer and engineer.

The foregoing remarkable episode has been mentioned, as it immediately preceded the triumphant vindication of other electrical methods which, as far back as 1856, had, by Thomson, the future Kelvin, been proclaimed as the only sane ones for submarine cable purposes. Too late for the saving of the 1858 cable was Thomson's advice followed, but his electrical methods have been adopted in all cable work since then carried out.

It may be said that the adoption of Thomson's mirror and siphon-recorder which readily responded to all *variations* of quite low potentials, raised trans-Atlantic cable speed—even in those early days—from something between three letters and seven letters per minute to quite 85 letters per minute. This last figure represents a signalling *constant* (*KR* × *letters per minute*) of about 340×10^6. The method of transmission and nature of current impulses here involved would be as shown in *H*, Fig. 2.

To revert, for a moment, to the 1858 cable. Apart from the ruin due to high voltages, the failure to produce any signalling speed higher than from three to seven letters per minute, was because, with Morse transmission as shown in *A*, Fig. 1, not only had the sending key to be kept down long enough for potential at the distant end of the cable to rise sufficiently to work a Morse relay, but, after the completion of each contact element, the cable has to be fully discharged before the following current-impulse could be usefully applied. On the other hand, if the transmission used were as shown in *B*, Fig. 1, the changes in received polarities necessary to control a relay would be equally slow and laborious and still more injurious to the cable core.

During ensuing years throughout the sixties, seventies, eighties and nineties, cable signalling *constants* which Thomson methods brought—as we have seen—from close on nothing at all up to 340×10^6, rose to 500 and onwards up to 600 and 700. (Millions understood.)

This reference to the *rise* of cable speed *constants* requires explanation, for, considered under similar conditions as to operating methods, nicety of electrical and mechanical adjustments and operating skill, the expression *KR* = *letters per minute* is—within certain limitations—the same for all cables.

Example: A certain North Atlantic cable (K = 886 mfds., R = 6908 ω) was worked up to 113 letters per minute, while a South Atlantic cable (K = 557, R = 8202) gave a safe maximum of 155 letters per minute. The respective *constants* are 701 and 708: that is, practically the same.

The afore-mentioned gradual improvement was due, then, to a multiplicity of causes. To give a few examples. (*a*) The better understanding of curbing methods—electrical and mechanical—causing, at the sending-end of a cable, every transmitted contact signal from a point low down on the *curve of arrival* to be followed—before the discharge to earth period—by a short sharp reversal, as shown in *I*, Fig. 2. (*b*) The proper adjustment of electrical condensers, either at the receiving end or at both ends of a cable, together with suitable shunting of the same for the squaring-up of the recorder signals.

Also, any required transmitting speed was made reliable and constant by the use of automatic transmitters controlled by perforated slip. Many inventors, makers and cable superintendents have contributed in this matter, but this beautiful class of apparatus is very closely associated with the name of Alexander Muirhead in whose apparatus varyingly relative voltage-contact periods, curbing and earthing periods, were made adjustable, and so easily adaptable to any given conditions. Much excellent work of cognate nature—yet by different devices and methods—was effected on Atlantic cables by Patrick B. Delany.

Then, again, an important factor in the rise of speed *constants* was the ever-increasing experience of an intelligent staff. Indeed, normal working was dealt with at speeds so high that all definition disappeared from siphon-recorder signals, which, however, were accurately read from their general conformation in groups, just as one reads Roman print in words and groups of words without (excepting complicated codes) paying attention to each separate letter.

The nineties saw still further rise in speed *constants*, this being due to S. G. Brown's invention of the "magnetic shunt," or inductance shunt, which, placed across the terminals of the siphon-recorder receiving-coil, still further squared up recorded signals, thus rendering them "safe" at speeds higher than ever before.

Actual speeds, also, rose with the adoption of heavier cable cores: in one case giving about 250 letters *simplex*, and nearly double that figure under *duplex* conditions, while increase in traffic output and general efficiency came with the almost universal application of duplex working, and the appearance of S. G. Brown's drum relay for auto-retransmission between cable and cable.

With the 20th century the coming of received-current *magnifiers* or *amplifiers* brought about a further considerable rise in cable signalling *constants*. Much splendid work on many cables has been done in this direction by E. S. Heurtley, whose amplifier has raised speeds some 50 or 60 per cent. on previous safe maxima, and, as far as the writer is aware, has raised *constants* to 850, or thereabouts.

In the Heurtley "hot-wire" amplifier, signal-movements of a freely-suspended receiving coil cause a current-traversed fine platinum wire to pass in or out of a cold blast. Consequent variations of temperature correspondingly affect the balance of a Wheatstone bridge across which is connected the local circuit siphon-recorder by which minute and consequently rapid signals received on the amplifier, are reproduced and magnified or amplified.

Various other amplifiers are in the field, including one, invented by Axel Orling, which, tried as a simplex instrument on Atlantic cable *duplex* connections, has raised previous safe signalling maxima over 100 per cent., with cable constants of from 1,200 up to over 1,500 (the latter on simplex connections). Over one Atlantic cable ($KR = 4 \times 10^6$) an actual speed of 300 letters per minute was obtained, with perfectly defined separate contact-elements apparent on the record. These results were obtained with an old form of Orling amplifier, and with an auto-transmitter not made to go faster than 300: otherwise the effective signalling speed would have been much greater.*

Far higher figures than those here quoted are confidently

* We have seen the original service-messages which passed on this occasion.—Eds. *E.*

expected in the future from the present improved and greatly simplified Orling amplifier, a brief description of which may here be of interest.

A fine jet of current-traversed acidulated water issuing from a glass nozzle, impinges at a distance of about 1 cm. on to a glass knife-edge, the two wet sides of which form two of the four arms of a Wheatstone bridge. A light arm projecting at right angles from the receiving coil tends to intersect the water-jet. Coil movements, of high periodicity, absolutely invisible even under a strong lens, cause corresponding defined movements of the jet which, at each succeeding contact signal, deflects to a minute degree without, however, leaving the glass knife-edge. Yet these minute variations in the position of the jet-diameter astride the knife-edge—variations capable of being produced at very high speed—suffice to produce, at similar speed, perfect signals on the local-circuit recorder connected across the Wheatstone bridge. The only difficulty is in adjusting cable duplex-balances with sufficient exactness for the avoidance of amplifier disturbance during simultaneous signalling in both directions. The writer has good reason to think that this difficulty has been overcome. With transmission by Squier's unbroken alternating current this difficulty would disappear.

As far as one line of practice is concerned, we have here, in the matter of cable speeds, brought this subject up to date. We cannot, however, omit mention of schemes for Morse working over ocean cables.

The double-current principle (*B*, Fig. 1) was due, the writer believes, to that prolific inventor, Cromwell Varley. As applied to long overhead lines subject to vicissitudes of our dear country's uncertain climate, it was beneficial, but it was obviously unsuitable, for long cables.

An attempt to make cable Morse practicable emanated from Foote and Randall in America, about 1880. Graph *C*, Fig. 1, shows their mode of transmission termed *inverse current*. As a matter of fact, the current duration of *dashes* and *dots* was as 2:1 instead of the customary 3:1. *G*, Fig. 1, shows how the Foote and Randall slip was perforated for the transmission of *I.C.* Morse, alternate polarities being used for successive contact signals. The present illustrations show "International Code" Morse instead of the American code used by Foote.

In the eighties P. B. Delany worked at cable Morse, first using a mode of transmission as shown in *D*, Fig. 1. He originated an extraordinary number of neat schemes for producing intervening "earth" periods, as well as correction devices working synchronously at both ends of the cable. At Atlantic cable stations, Delany had excellent opportunities for his Morse experiments during which he reverted, also, to *I.C.* transmission as in *C*, Fig. 1, using alternately the tappers of a "mirror" key to send Morse.

But Delany, in his strivings after cable Morse, with very promising results over the cables due to ingenious Morse reception connections, got no encouragement from London headquarters. One eminent authority told him he would not for a moment consider cable *Morse* even at 40 words a minute (200 letters).

Not so many years later, on other cables, John Gott revived inverse current Morse (*C*, Fig. 1) in conjunction with his highly ingenious utilisation of cable discharge to reverse, after each contact signal, the battery polarity ready for the next inverse signal. What really facilitated this revival of *I.C.* Morse over Atlantic cables was the use of such receivers as Heurtley's amplifier, or others of the same order of merit. In any case, Gott's organisation here described, resulted in the highly-impressive feat of "through" working, when required, between Vancouver or San Francisco and London, not, perhaps, at any very high speed, but with all advantages accruing to individual touch between operators at the two ends of a practically continuous circuit.

Judging from the interesting statements made by Walter Judd, the Eastern Telegraph Co.'s electrician-in-chief, during a recent discussion at the I.E.E., cable Morse is used on his company's cables just as effectively as is cable-code working, to control through the medium of special cable relays, *direct* working between London and Alexandria. In a short time similar working will be effected from London to Bombay, a truly magnificent performance even under present conditions, especially in view of the fact that all records at terminal stations, or wherever required by the public, are recorded in type-written or Roman characters. The advantages attending this class of working are obvious, even without any exceedingly high speed of transmission. What this *is* in practice the writer regrets he is unable to state.

About 1900 a great increase in efficiency and speed was brought about on the French Government Mediterranean cables. Old methods gave place under Pierre Picard's direction, to fast Baudot between Paris and Algiers with auto-relays at Marseilles. All messages reached the public straight from the instruments, printed. For this Picard devised special relays, also a mode of transmission as shown in *D*, Fig. 1, due to a highly ingenious condenser-charge device. This caused the "free-ing" or insulating of the sending end of the cable during all periods between the momentary inverse-current impulses or "*flicks*" transmitted. Under these conditions the *whole* energy of each impulse, at the beginning of a contact signal and during the *cable-free* period, is free to go forward and do good work with minimum distortion, until its limit is decided by the opposite-polarity "*flick*" which ends each contact signal. A French engineer expressed these conditions very tersely: "*On parle, pour ainsi dire, avec des silences.*"

Picard always maintained that his methods for producing absolute electrical equilibrium in the cable, and for *cancelling out* the two inverse polarities contact by contact, were applicable to Atlantic cable conditions. The writer shares this opinion in view of the advent of the Orling jet amplifier or relay already mentioned.

Lastly we are faced by the endless possibilities following on the cable-signalling system invented by George Owen Squier. This is based on unbroken alternating-current sine-wave transmission, as illustrated in approximate fashion by graph *L*, Fig. 2, and the corresponding received record, *M*, Fig. 2.*

Squier's novel departure, which is adaptable to Morse as well as to cable code, demands a treatise to itself. It here suffices to give one or two aspects directly connected with cable speeds. Squier's unbroken alternating-current signals, free, in their transmission, from charge and discharge jarring shocks at the cable sending-end, depend merely on voltage increase, to rise to any legible speed required. Also, owing to the unbroken nature, or continuity, of the current, and the curvilinear (as opposed to square top) characterics of the sine-wave alternations, transmission powers of hundreds of volts may safely be employed with corresponding as-yet-unheard-of cable speeds; and this without risk of repeating the electrical tragedy of 1858, as long as special core is used over a certain moderate distance at the two cable ends.

On a former occasion in THE ELECTRICIAN, the writer has described his system—which has received the appreciative endorsement of Squier himself—for local-circuit rectification of Squier received impulses (*L*, Fig. 2) so as to produce ordinary curvilinear siphon-recorder signals (*N*, Fig. 2). Not only would this rectification facilitate auto-retransmission of Squier sine waves, but auto-perforation and *auto-type-printing* with Creed apparatus, would become a simple matter (series *N*, *O*, *P*, Fig. 2).

Pierre Picard, to the great benefit of the cabling public, led the way by harnessing the Baudot type-printing telegraph system to fairly high *KR* cables. The Eastern Telegraph Co., with their own methods, have done the same on a bigger scale and on higher *KR* cables. Across from Britain to America type-printing on a cable has already been tried.

With adoption and extension of methods here summarised, the writer does not consider presumptious the foretelling of trans-Atlantic and trans-Pacific telegrams at signalling speeds of *hundreds* of *words* per minute.

---

* Vide Colonel Squier's recent Physical Society of London Paper, also Colonel Squier's contribution to the discussion following the reading of Mr. H. H. Harrison's Paper at the I.E.E. (1916).

The Story of the Telephone.

By J. E. KINGSBURY.

I gladly comply with the request which the Editors have conveyed to me to contribute an article on the telephone to their birthday number. The electrical field is so wide that the separate departments can evidently receive only limited space. I anticipate, then, that the story which is expected from me is not the full story which the title would suggest, but the local story, with more particular reference to the period covered between the first and the two thousandth issues of THE ELECTRICIAN. May I add that I appreciate the editorial hint that a strictly impersonal narrative is not looked for ?

When the No. 1 of the new series of THE ELECTRICIAN was published on May 25, 1878, Alexander Graham Bell was in England. Just two months before—on March 25, 1878—he had addressed from Kensington a letter to a group of financiers outlining the exchange system, admitting that it might then be regarded as Utopian, but recommending, nevertheless, that the private lines immediately in contemplation should be run through a central office, so that ultimately intercommunication would be possible. Specimens of the Edison carbon transmitter were in London some time during the summer of 1878. They were connected up on a demonstration line which was short, but more ambitious essays were contemplated. During August arrangements were in progress for an international trial, which was finally fixed for September 8th, as I find from the following memorandum to Edison's London agent :—

COL. GOURAUD, September 7, 1878.

I have been over to the Submarine Company, but find Mr. Despointes has left for the day. The gentleman who came over here this morning states that the trial between here and Dover *may* be made after ten o'clock. Between London and Calais (should the connection be made) they cannot say anything as to time. Mr. Adams, who is now here, states they will probably experiment between Dover and Calais about nine o'clock. I find that neither Mr. Despointes nor the other gentleman will be on duty to-morrow, so that there will be no one there who understands anything about the instrument. I have accordingly arranged to delay my departure for Paris until Monday evening (which will be equally convenient to me), and will be at the Submarine office to-morrow morning between eight and nine o'clock, to connect telephone and do whatever may be necessary. I will then wire you in any case, whether the connection be made with London or not, and what is the result of the trial between Dover and Calais. Should London be connected, I shall wait at the Submarine office until you arrive. Should it not be so, I shall not wait, as I do not suppose in that case you would come in. Mr. Adams has taken the Exchange instrument with him to Dover, and I take down the one which is here to-morrow morning, which I think you will consider more satisfactory than to leave it at the Submarine unattended during the night.

I trust these arrangements will meet with your approval.

J. E. KINGSBURY.

The " Exchange " instrument meant the instrument which had been connected up at the Cornhill offices of the Exchange Telegraph Co., who had, I think, also laid the line across from Cornhill to Lombard-street, which was then the demonstration line. Presumably these were the only two instruments in London, which accounts for the solicitude indicated in the memorandum. Mr. Adams was the expert sent over by Mr. Edison, and the only technical man in the establishment. Mr. A. T. Turney came in later, but long before the starting of exchanges. I recall that I had planned to start on my holidays to visit the Exhibition in Paris, but on discovering that no arrangements had been completed, determined to stay over and see the trial through myself. To take advantage of the arrangements made for the use of the long lines seemed important, and I could not remove from my mind that an instrument which would talk as I had heard this talk had a future which justified any personal inconvenience at the moment. But we had disappointments. This was one. I do not recall all the circumstances, but I remember a long wait, some almost inarticulate words, and I certainly sent no very satisfactory telegram. The same instruments, I think, were used in the London–Norwich experiments on November 11th. On this occasion Mr. Adams was at Norwich and Prof. (Sir William) Barrett at London. The line was very noisy, but the talk quite intelligible. The instruments were the Edison carbon button transmitter and a magneto receiver, which was, without doubt, an infringement of the Bell patent. It was this fact which delayed commercial work and limited operations to demonstration and experiment. Early in 1879 the loud-speaking receiver was brought out, and was not only an extremely interesting scientific production, but also a very valuable advertising medium.

I can only speak from personal experience on the Edison side, but I think that the Telephone Co., as the Bell interest was called here, was, during this time, also adopting a waiting attitude in starting exchanges, because the magneto telephone did not transmit with sufficient power. Precise information as to the starting of the Bell Exchange has hitherto been lacking, and I was glad to find in the July issue of the " Telegraph and Telephone Journal " a report from the then Engineer-in-Chief of the Post Office which supplies a missing link in telephone history. From this report it appears that on November 7, 1879, when the official inspection was made, there were some 50 subscribers connected to the " switch frame." In a supplementary report Mr. Preece stated that the Edison Telephone Co. had only 10 wires connected with their central station, " and we cannot find out that they have any bona fide subscribers." The 10 lines connected to the switchboard at No. 6, Lombard-street were, in fact, demonstration lines, and there was no capacity for increase. It was not until the establishment of the exchange at 31, Queen Victoria-street that real business commenced. From this official report it is also clear that Blake transmitters were used at this time by the Bell Co. " The instrument was introduced from America some months ago by (probably) Mr. Hubbard, who is a director of the Telephone Company of New York, and who appeared to have the sale of Blake's instruments in his charge."

The two companies set out to give the public telephonic intercommunication, and the prior delay was made up for by energy and expressions of unlimited confidence of the great superiority of each system. The two systems were happily combined in the following year. By the time the exchanges started technical assistance was of course available. Mr. Fletcher was engineer to the Bell Company, and Mr. Phillips soon joined him. Mr. E. H. Johnson, with a corps of American assistants, was engineer to the Edison Company. But before the actual starting of the exchanges technical assistance was scarce. Mr. Adams was the one expert, and he had all Europe for his province. He seemed, moreover, desirous of maintaining the exclusiveness of his information. The instruments had an inconvenient habit of suspending work at critical periods. The more important the people who called to have the privilege of talking over the telephone the more prone the telephone was to sullen silence. I formed the impression that there must be something democratic in its constitution to account for the especial dislike evinced to dukes. Apologies were often necessary, and my first technical experience was undertaken with a view to avoid repeated contretemps. By dint of inquiry and research I had discovered the necessity of continuity in conductors, and it will readily be believed that the receiver cords were the most frequent source of trouble. If our expert happened to be in Paris and our instruments main-

tained a tactless silence I was generally appealed to for assistance, and earned something of a reputation as a magician. I remember remarking to the agent that if our expectations of wide and general use were to be realised it was necessary that there should be nothing mysterious about the instruments, and that anything in the nature of exclusive information should be discouraged.

The expectations which were formed as to the extent of use of this new public service are not to be very readily expressed. The promoters had every confidence that they were inaugurating a service which must be beneficial and remunerative. The public had every reason to be satisfied with the efficiency of speech transmission. The scientific interest was continued from 1876 when the marvellous results obtained by Bell were related by Kelvin, through 1877, when Bell instruments were perfected, and 1878, when Edison produced his carbon transmitter, and Hughes explained the microphonic principle. These were all helpful in enlisting public interest, and there was no want of recognition that an era of practical utility was before the telephone. The optimist and the pessimist are not confined to wartime. There were optimists and pessimists then. But none was optimistic enough to foresee what has resulted. And very reasonably, too. Speech could be transmitted—that was clear. Lines could be interchanged. That was clear also. But it was not reasonable to expect the very rapid developments which followed. The multiple switchboard work of Scribner, Wilson, and Kellogg; the cable developments of David Brooks and Patterson had yet to be made. The endless improvements could not be foreseen because the growth which prompted those improvements had not yet developed. And so it may be said that whilst much was expected; whilst it was believed that a beneficial and profitable field lay before the telephone, the expectations fell far short of the reality. I think it may be taken that the expectations were that the principal business firms would become exchange subscribers. It was not contemplated that the service would become general. Looking forward one sees how much was done that was not expected, and looking backward it is inevitable that one should see how much greater still might have been the progress. The service grew as its utility was demonstrated, and grew not merely without external assistance, but in spite of every possible difficulty put in its way.

Governments, both local and national, interposed restrictions; private property owners desired its use for their own purposes, but refused any assistance for their neighbours. Having no legal powers or public way facilities, the companies were dependent upon way-leaves over private property, which were difficult to obtain and very expensive to hold. Criticisms of the backwardness of English telephones were not unknown. THE ELECTRICIAN in 1885 quoted a story to the effect that a merchant had asked "How is it that telephony makes so little progress in London?" and was surprised at being informed that he himself had given a practical reply by his refusal to allow an attachment to be made to his residence. There was, perhaps, some lack of tact on the part of the management in London, if not in other places in the country, which partly accounted for the want of ready assistance. But in spite of all drawbacks, whether from without or within, the telephone had to progress. In 1888 "The Rise and Progress of Telephony in the United Kingdom" formed the subject of a series of articles in THE ELECTRICIAN. On April 27, 1888, a plan of the London system was given, showing the number of wires connecting the exchanges in London with each other and with the central exchange, which was at Oxford-court, Cannon-street, in the building now occupied by the London Chamber of Commerce. Some of these exchanges have ceased to exist, and many others have, of course, been added; but it may be of interest to note the number of junction lines from East India-avenue. There were 11 to Mincing-lane, three to the "Hop," six to Queen Victoria-street, 18 to the "Central," two to Chancery-lane, six to Coleman-street, eight to Cornhill, two to Smithfield and seven to Leadenhall-street. Of these exchanges, Mincing-lane, "Central," Coleman-street, Cornhill, Smithfield and Leadenhall-street have been amalgamated with neighbouring exchanges, Queen Victoria-street has changed its name to "Bank," and Chancery-lane has become Holborn. From the Avenue there were in all 63 junction lines. In the new switchboard installed in 1912 provision was made for 1,728. Further comparisons may be made by the number of instruments in use in the London area in June, 1887 (13,477) and those in June, 1916, which were about 268,000 In the whole of the United Kingdom there were at the first mentioned date 52,031, and now about 750,000.

These figures are indicative of growth, but any satisfaction which might be felt from them is dissipated when we reflect upon what they might have been.

According to the latest compiled statistics (1914), there were in Great Britain 1·7 telephones per 100 of the population, against 9·7 in the United States, 6·5 in Canada, 2·8 in Australia, 3·5 in Hawaii and 4·6 in New Zealand.

In European comparisons Great Britain occupies a fairly average position, which on the surface would suggest the explanation that densely populated countries cannot expect so high a ratio of stations; but density of population implies commercial activity, and such activities should justify the expectation that any facilities should be utilised. The fact is patent that the facilities offered by the telephone have been but poorly utilised in the United Kingdom.

There is a story current which may be true, though a general scepticism as to the reliability of the teacher and pupil variety of story is permissible. This one might be more readily believed if the poet whose name is attached to it had a reputation for greater industry than had Thomas Campbell; but the story is:—

Teacher: "Now, children, listen to this: Thomas Campbell, the famous poet, once walked six miles to a printing office to have a comma in one of his poems changed to a semi-colon. Why did he take all that trouble?"

Bright Boy: "Because he didn't have no telephone."

Not being punctilious about punctuation, I have certainly not had occasion to take a long walk to make an alteration, but I have had to expend much energy and suffer much inconvenience from the absence of a telephone. And the absence was not due to any neglect of mine or any want of business enterprise on the part of the Telephone Company. It happened that my house was on an estate which had been left by a pious founder who was a friend of Shakespeare, in order that the income might be applied to educational purposes, for the pious founder believed in progress and advancement in the arts. One of the conditions which his successors enjoin from anyone building upon this land is that no telephone pole should be allowed and no wire be attached to a house without their permission. Consequently no telephone was obtainable on the estate. After a few years the Telephone Company found it possible to bring a line to my house from a distant exchange, and I gladly paid the extra mileage rate in order that I might not suffer the ills which are inevitable where telephones are not.

We are now all taking stock of our national situation under circumstances which behove us to deal faithfully with the facts. We have much to guide us in a review of the telephone situation over the period covered by THE ELECTRICIAN articles. Why, from start to finish, has the telephone had almost every man's hand against it? Why has it occurred only to a few to realise that its use should have been encouraged and not thwarted? Why have the many thought only of some petty detail and never realised the national economy which its development implies?

The Government's restrictions are well known, and I do not need and have no desire to dwell upon them. Ownership has changed the circumstances, and the old-time restrictive influences no longer operate. Whatever individual views may be as to the most suitable authority for conducting telephone business Government management here is an accomplished fact, and it behoves everybody to render the department such support as may serve to promote development, and especially to take care that it is not baulked by ill-advised efforts at unremunerative rates or public misconceptions as to rights of way.

In early days the private owner was frequently either a

Shylock or a dog in the manger. The public landowner was governed by what was assumed to be the amenities of the neighbourhood. But the educational authority which I have cited was as a land-owning body by no means alone in its attitude. The telephone was never thought of as an advantage to its tenants.

How comes it that the mind which is so far cultivated as to be able to attach importance to the æsthetic effect of an insulator on a chimney stack should lack imagination enough to realise the increase of efficiency which telephonic communication produces? But let us not deceive ourselves on this point. Such a lack, not merely of imagination but of the appreciation of realised facts, has characterised the attitude of any men or body of men who had any influence to exercise.

With what satisfaction we can turn to technical achievements. From day to day new problems have been presented, growth to provide for, distance to be increased. Interchange of tens has become interchange of tens of thousands. A talk over 20 miles of line has developed into a talk from NewYork to San Francisco. Progress in Great Britain was never retarded by lack of the necessary means. By the time Liverpool had outgrown standard boards the multiple was ready, though the cautious directors stipulated that it should be taken out again at the supplier's expense at the end of three months if not satisfactory. When the turn of one of the next important towns came to adopt the multiple the purchasers insisted, against the contractors' advice, that the ultimate capacity should not exceed 2,000. These were, of course, single-circuit boards successively superseded by branching and common battery.

The success which attended long-distance transmission over a conductor has been equalled or excelled by wireless. It is inevitable that some visionary ideas should find expression of a possible future in which one carries a telephone in one's pocket and makes a wireless call. Such ideas omit from consideration governing conditions which make their realisation impossible. A wireless telephone talk is a talk upon the house tops with the whole world for an audience. The communication sent from Washington to Paris was overheard at Honolulu. The single tone used in telegraphic signals permits of tuning and selection, whereas vocal articulation may require so wide a range of tones that none can be shut out.

Another idea that needs to be combatted is that, since the telegraph has been superseded by the telephone, so the telephone may itself be superseded by some other agency. It only needs to remark that when Bell succeeded in transmitting speech he achieved the highest possible. Speech is nature's own best method of transferring thought, and no medium of transmission superior to the telephone can be possible until Nature has evolved a new method. Until telepathy is achieved telephony is finality.

There is a practical bearing even in such apparently immaterial points as these. They serve to give greater stability to the telephone as an investment than almost any other enterprise. And as the world has invested over 400 millions of pounds in telephone plant practically since the period which THE ELECTRICIAN is reviewing, and as, moreover, there are some parts of the world with considerable leeway to make up, the British investor might be well advised to take a little more interest in telephones than he has done yet. Financiers are perhaps amongst the most pessimistic of the pessimists of the present day. But in the great reconstruction and reorganisation of the immediate future means will certainly be found for works of true economy. Electrical applications as a whole must be so classed and of them there is none which is so clearly demonstrated as a labour and time saving appliance as the telephone. Its progress must rapidly increase, for in the future we cannot afford to ignore its beneficent effects.

Dealing faithfully in the spirit of the times with the circumstances and the period reviewed, one must, whilst recording a certain degree of progress, note many lost opportunities, a lack of the imaginative faculty, and a singular tendency to ignore logical results. The specialised engineering nature of the industry was long in attaining recognition, and is by no means generally recognised even now. Of similar importance is the specialised nature of telephone finance. The prudence of other standards may become imprudence, and lack of enterprise a snare. There is no secret about successful telephone enterprise. Examples are before the world. Success requires that its conductors should recognise that it is a public service, that the public has a right to good service, and that development must be provided for. There is no credit in earning dividends from an unsatisfactory and undeveloping service, and though the circumstances may render it possible for a time, Nemesis will certainly overtake those having control who fail to recognise and give full effect to the public service character of telephone enterprises. It is true that the telephone public is a difficult public to serve. It is equally true that no public has ever refused to pay cheerfully a remunerative rate for a good and growing service. It is the business of the suppliers to study the difficulties and with their knowledge meet the general ignorance.

We have still some lessons to learn in the development of such industrial enterprises. Amongst them is to apply logical reasoning to practical facts, to give encouragement to growth at home where we are masters, and to promote development in the spheres of our influence abroad, where, if we don't, somebody else will.

Long-Distance Telephony.

By B. S. COHEN.

Early History.—The history of long-distance telephony has been a record of comparatively gradual and uniform progress unmarked by any revolutionary strides until within the last few years.

Improvements in the propagation of telephone speech broadly resolve themselves into two main groups: Firstly, the development of the sending and receiving apparatus; and, secondly, the development of the propagating medium, *i.e.*, the line plant.

Notably progressive steps in the early days in the first group were the introduction of the induction coil, enabling the telephonic voltages to be stepped up and the percentage resistance variation of the transmitter circuit to be greatly increased. The introduction of the granular transmitter and the use of double-pole permanent magnet receivers can also be included as notable steps.

As regards early progress in the line plant, prominent land marks were: the introduction of copper and bronze wires in place of iron, the replacement of the single wire or earth circuit by the metallic circuit and the inductive balancing of lines by means of rotation and transposition, thus minimising the effects of electrostatic, electromagnetic and leakage disturbance.

For many years after the introduction of these fundamental improvements the development in long-distance telephony was

extremely gradual. Telephone development generally was chiefly concentrated on the pressing problems of providing local telephonic communication to the increasing number of subscribers; and the large towns and their suburbs were gradually provided with telephonic communication and formed more or less isolated nuclei only interconnected by long-distance lines to a limited extent, and the maximum commercial limit was reached at a comparatively short distance.

The increase in the use of the local telephone, so far from assisting in the progress of long-distance telephony, at first actually tended to retard it technically, although providing sound financial reasons for the construction of intercommunicating lines between the large cities. The replacement of open wires on the introduction of telephone cables overhead and underground firstly for junction lines, and then also for subscribers' lines, although greatly improving the reliability of the local service, resulted in increased difficulty in long-distance transmission owing to the lower speaking efficiency. Traffic improvement also, designed to increase the speed and reliability of connection was too often obtained by the use of more complex signalling circuits introducing unconsidered transmission losses. Finally, the development in electric tramways, railways and power schemes, introduced further problems with regard to the more efficient protection from inductive and leakage disturbance.

During this transition period the inventor in the domain of long-distance telephony appears to a very great extent to have concentrated on improvements in the transmitting and receiving apparatus. A notable exception was the introduction of dry core paper cable which at once reduced the capacity to about half and thus increased the talking efficiency about four times. Even so, the cable line still gave a much lower transmission efficiency than the open wire.

Early Limits of Long-distance Telephony.—It will be of interest to consider the limits of long-distance telephony before the developments of the last few years.

The high-water mark in long-distance line construction was reached on the introduction of 800 lb. copper aerial lines carefully insulated, rotated and regulated, to reduce leakage and inductive losses and disturbances to a minimum. A length of 45 miles of 800 lb. line is approximately equal in transmission efficiency to 1 mile of standard cable, and working on the assumption that the efficiency of a long-distance line cannot safely be reduced beyond that given by 20 miles of standard cable, having regard to other losses in the apparatus, and subscribers' and junction lines, &c., this gives a maximum radius of 700 miles. The cost of such construction is extremely high, amounting to about £88 per circuit-mile with copper at £100 the ton, or a total for the limiting value of £79,200.

It must also be noted that the assumption is made that there are no intermediate or terminal lengths of cable which, however, become necessary when leading the line into its terminating cities.

Modern Progress.—The era of scientific long-distance telephony may be said to date from 1887, when Oliver Heaviside published his classical Paper on "Electromagnetic Induction and its Propagation." This Paper was the first that clearly indicated the possibility of annulling the effects of distributed capacity. The late Prof. S. P. Thompson appears to have been the first to suggest a practical application for annulling capacity effects, and in a British patent dated 1891 he described methods involving the use of distributed leakance or, alternatively, bridged self or mutual inductance. Prof. Thompson's methods have never been practically worked out and applied, and in the light of present-day knowledge it can be demonstrated that the leakage method would only diminish the distortion of the telephonic waves at the expense of considerable reduction in the amplitude.

Telephone Line Loading.—In 1899 the theory and practice of inserting inductance coils in series in telephone lines to annul the capacity effects and thus reduce the attenuation was described by Prof. M. I. Pupin, and in the next few years this fundamental departure was rendered commercially applicable by Prof. Pupin himself and the engineering staffs of the American Telephone & Telegraph Co. and the Allied Western Electric Co. In this connection it may be of interest to mention that the question of inserting series and bridged inductances in telephone lines was considered, and inductance coils constructed and experimented with at an early date by the British Post Office.

The telephone line inductance coil, technically known as the loading coil, became, however, a practical proposition on the introduction of the modern form with an iron core. The modern loading coil of the highest quality with a very finely divided iron core has a ratio of R/L, or effective resistance to inductance at telephonic frequencies, of 25. It will be of interest to compare this figure with the ratio of about 4,000 for an ordinary solid core electromagnet coil as used for telephonic relays, &c. The introduction of the loading coil had an immediate effect on long-distance telephony not only enabling open wire lines to be considerably extended, but permitting of the use of long-distance cable lines of not excessive conductor gauge.

The following table gives limiting lengths of 300 lb. open wire conductors, loaded and unloaded, on the assumption that the equated length should not exceed 20 miles of standard cable :—

Table I.—*Limiting Length of 300 lb. Open Wire Line Loaded and Unloaded.*

Inductance added henries per mile.	Effective leakance per mile in micromhos.	Limiting length in miles.
Unloaded	2·5	340
Unloaded	1·0	372
Unloaded	0·0	392
0·037	2·5	492
0·037	1·0	734
0·037	0·0	1,060
0·017	2·5	492
0·017	1·0	642
0·017	0·0	784

The detrimental effect of leakance on loaded lines will be noted from these figures.

The 300 lb. open wire line, loaded to give an improvement factor of 2·7 with infinite insulation has the factor reduced to 0 when the effective insulation falls to 187,000 ohms per mile. It will also be noted that with a leakance of 2·5 micromhos there is no advantage in heavy loading. The problem of leakance with open wire lines is probably more acute in the United Kingdom than in any other country which has progressed to the point of having extensive long-distance telephone lines, but even here the experimental loading of a 300 lb. open wire conductor may be considered a commercial success. Particulars of this case have recently been given in a Paper on long-distance and cable telephony, published in these columns, and need not be referred to here. It is sufficient to mention that a maximum leakance value of 2 micromhos per mile can be assumed for very wet wintry weather.

The following table of notable foreign loaded open wire lines is not as complete as it might be owing to the unfortunate difficulty in obtaining definite figures for the leakance, which can only be inferred by calculation back from the given attenuation constants.

Table II.—*Foreign Loaded Open Wire Lines.*

Line	Length in miles.	Electrical constants per mile.				Eq'ated length in miles of standard cable.
		Resist. ohms.	Induct henries	Capacity mfds.	Attenuation.	
New York to San Francisco 435 lb. copper	3,400	4·95	0·0365	0·0091	0·0013	41
Berlin to Rome 500 lb. bronze	1,300	4·6	0·0354	0·009	0·00177	21

The attenuation constant of 0·0013 for the trans-continental American lines indicates a very high insulation resistance and illustrates the great climatic difference between the United States and Europe. The inferred insulation for the Berlin-

Rome line as deduced from the attenuation constant is considerably lower. It should be noted that in both cases the lines are duplexed and the phantom, as will be mentioned further on, loaded. The loaded phantom would be higher in efficiency than the loaded side circuit. In addition the New York-San Francisco line has telephonic speech relays inserted, which will considerably reduce the equated length. The rate for a 3-minute conversation is $20.70, but it must be remembered that plant valuing $2,000,000 is involved.

Loaded Cable Lines.—The advantage of long-distance underground cable lines from the point of view of freedom from disturbance, both electrical and storm produced, are obvious, and have been well exemplified recently in this country by the havoc wrought during the great storm in the early part of this year when the underground main lines between London, Birmingham, Liverpool, &c., may be said to have prevented the almost entire temporary dislocation of long-distance telephonic communication in this country.

It is not loading alone that has rendered the long-distance underground telephone lines a paying proposition, but the additional possibilities of duplexing.

The superimposing of a third circuit on two existing circuits and the loading of both the existing and the superimposed circuits, or, as they are technically termed, the physical or side circuits and the phantom circuit, is a development of the utmost importance.

This application has been rendered practicable by the use of multiple twin cable in which the twisted pairs of conductors are themselves rotated with respect to each other. This in itself is insufficient to prevent overhearing, and requires to be supplemented by the accurate inductive balancing of cable pairs. This balancing has been highly developed in this country. The method adopted is to measure accurately the wire to wire and wire to earth capacities of all the conductors in each short section of cable as laid and to so join up the sections as to give a capacity balance accurate within a few micromicrofarads.

The following table gives particulars of some important long-distance loaded cable lines :—

Table III.—*Particulars of Long-distance Loaded Cable Lines.*

Line.	Length in miles.	Conductor weight, lb. per mile.	Electrical constants. Resistance, ohms.	Inductance henries.	Capacity mfds.	Attenuation.	Approx. Equated length in miles of standard cable.
Boston to Washington	475·0	175	17·0	0·15	0·07	...	32
Do. phantom circuit	475·0	350	10·5	0·1	0·1	...	26
London Liverpool	200·5	100	18·38	0·053	0·0568	0·0107	22
Do.....	200·5	150	13·13	0·054	0·0697	0·0088	16·5
Do	200·5	200	9·62	0·054	0·0655	0·0066	12·9
Do	200·5	300	6·55	0·055	0·0568	0·0041	9·1
Do phantom on 150 lb.	200·5	300	6·56	0·035	0·1057	0·0075	14·2

Terminal Reflection and Transition Losses. The high characteristic impedance of loaded lines has brought into prominence the reflection losses caused by the jump from the propagating medium to the terminal instrument, or *vice versa*, and by the transition from a line of one characteristic impedance to a type with a much higher or lower value.

These effects are readily calculable, and tapering methods which minimise the abruptness of the change can be utilised to minimise or even totally annul these losses. These methods have been described in a Paper on long-distance telephony recently appearing in these columns and need not be entered into here.

Telephonic Speech Relays.—A further development of considerable importance is the production of a practicable telephonic speech relay. From the earliest days of telephony inventors have been attempting to produce apparatus capable of efficiently relaying telephonic speech waves, and until quite recently the great majority of these attempts have been mechanical contrivances coupling some form of receiver and transmitter. The electro-mechanical type of speech relay has, however, now found a serious rival in the gas discharge relay, of which a number of designs are available and which is capable of giving considerable improvements when used on long lines.

Submarine Cable Telephony.—Submarine cable introduces a difficult problem in long-distance telephony. The objection to using dry core paper dielectric appears almost insuperable, and the addition of loading coils becomes a more difficult problem than in the case of underground cables. Coil-loaded cables have, however, been successfully laid by the British, French and Belgian Administrations, and are now in satisfactory operation.

An important step in advance is the use of a special G. P. dielectric which gives a ratio of leakance/capacity or G/C of the order of 12. The ratio G/C is an important factor in transmission efficiency, and the value of this ratio for the old form of G. P. dielectric is of the order of 120. This value applies to the first Anglo-French loaded cable laid in 1910.

Loading coils inserted under the cable sheathing have been adopted, and full particulars of such cables as the Anglo-French, Anglo-Belgian, &c., have been published.

Continuous Loading.—The advantages of continuous loading, which has been advocated in some quarters as a general substitute for coil loading, appear more marked when applied to submarine cables, and a number of continuously loaded submarine cables are in operation, notably a Franco-British. By continuous loading is understood the application of inductance continuously to the conductors by means of a wrapping of iron wire or tape.

The main disadvantages not common to the coil loading system are the comparatively low inductance which has been attained, the additional capacity caused by the iron wrapping and the increase in bulk and cost. The main advantages are the absence of loading coils at intervals and the slight reflection caused by these coils. The loading coil has also to be carefully guarded against excess currents which might introduce a reduction in efficiency by magnetisation.

In connection with this table it may be explained that the Anglo-French 1910 cable is not phantomed but, that in the case of the Anglo-Belgian and Anglo-Irish cable, the conductors are phantomed and the phantom circuit loaded. This results in the increase in effective resistance per naut due to the introduction of the phantom loading coil despite the fact that owing to progressive improvements in R/L loading coil ratios the effective resistances of the Anglo-Belgian and the Anglo-Irish show a progressive decrease over the unloaded conductor value. The greater efficiency of the Anglo-Irish cable over the Anglo-Belgian will be observed to be entirely due to lower effective resistance per naut.

Table IV.—*Giving Some Data of Loaded Submarine Cable.*

Cable.	Length nauts.	Conductor weight in lbs. per naut.	Electrical constants per naut at 800 ∞. Resistance in ohms.	Inductance in henries.	Capacity mfds.	Ratio G/C	Attenuation.	Equated. Length in M.S.C.
Anglo French (1910) .	21	160	20·9	0·102	0·138	120	0·017	4·16
Anglo-Belgian (1911) .	48	160	25·7	0·1	0·162	12	0·018	8·5
Do phantom	48	320	11·7	0·05	0·314	12	0·0173	8·5
Franco-British (1912) continuously loaded	21	300	8·54	0·0135	0·176	109	0·0185	3·75*
Anglo Irish (1913)	64	160	21·0	0·1	0·166	13	0·015	9

* The constants of the Franco-British continuously loaded cable have been measured at 1,000 ∞.

Wireless Telephony.—Wireless telephony seems destined to play an important rôle in what may be called ultra long-distance telephony, and the fine inter-continental achievements in this direction by the American Telephone and Telegraph Co. are still quite recent.

No technical details of the system adopted in the recent transatlantic telephone experiments are yet available for publication. Prior to this achievement successful experiments had been carried out by Italian, French, American and English investigators, and results up to 600 miles distance had been successfully obtained. In this connection the results obtained by Prof. Vanni between Rome and Tripoli (1,000 km.) may be mentioned.

The principle generally adopted is to superimpose telephonic waves produced by telephone transmitters on continuous oscillations produced by a high-frequency alternator or other source. These oscillations pass from the receiving antenna through a detector which may also be a magnifier connected to a telephone receiver. The high-frequency oscillations themselves have no audible effect on the receiver, which, however, responds to the fluctuations superimposed by the transmitter. An important feature is the transmitter. Various forms of transmitter have been used with more or less success, *i.e.*, a jet of liquid, water-cooled forms of carbon transmitter, gas discharge relays, &c., capable of transforming high power current into speech waves.

Conclusion.—The problems involved in long-distance telephony are many and complex, and the theoretical principles first enunciated by Maxwell, Kelvin and Heaviside and since developed by Pupin, G. A. Campbell, Kennelly, Fleming and others, supplemented by the research work carried out by most of the big telegraph and telephone administrations, has resulted in the present advanced position of long-distance telephony, which is favourable to considerable extension of the existing working limits, not only for inter-city but also for international communication when political considerations permit.

Dynamo-Electric Machinery, 1878–1916.

By MILES WALKER.

A review of any branch of science is of use in so far as it indicates the lines along which development may be expected in the future, and brings the experience of the past to enable the present-day worker to avoid the mistakes made by those who went before him.

Anyone who has followed the progress of the dynamo from its early beginnings to the present time will have observed that at each stage of development the designers of the time were fairly well satisfied with the design as they had it, and believed that the art of dynamo building in their day was a well-established and standardised art. Small improvements would, of course, be made and the demand for machinery would increase, but any revolutionary changes were not expected. We all know the picture of the future central station which Edison in his foresight knew would come some day. It shows rows of small belted two-pole dynamos of the Edison type.

During the decade 1885-1895 the introduction of direct driving from the engine at lower speeds led to multipolar designs with an increase in the diameter of the armature, and then the output of single units increased by leaps and bounds. In a few years the sizes of dynamos had so increased that a single machine would give as much output as a whole acre of the belted bi-polars. Having arrived at the stage of a slow-speed generator of enormous diameter, manufacturers were quite prepared to regard this as the last word, and to lay down enormous boring mills to cope with the supposed future demand. That demand never came. The steam turbine ousted the slow-speed engine, and the turbo-generator had to be built to run at turbine speeds. So the shape went back to roller-like dimensions. Then came the march in output of high-speed generators. At first it was thought that to help the electrical designer it was necessary to employ low turbine speeds for large outputs. Speeds of 1,000 to 1,500 revs. per min. were thought to be the maximum for generators of 5,000 kw. As 50 cycles became a standard in this country, a two-pole generator running at 3,000 revs. per min. was the desideratum from the turbine builders' point of view, but as late as the year 1900 it was thought quite a good performance to build a generator running at 3,000 revs. per min. as large as 500 kw. Some bold spirits suggested the possibility of 1,000 kw. at that speed, but there was much shaking of heads. About the year 1905, 1,000 kw. at 3,000 revs. per min. became quite usual, and then the outputs still went on rising. After that 5,000 kw. was regarded as a goal which might possibly be reached by some very special type of construction. When 5,000 kw. at 3,000 revs. per min. became usual, it was only a step to make it 7,500 kw. and another to make it 10,000 kw.

At this point the electrical designer had not caught up the steam turbine designer, for the difficulty of dealing with the exhaust steam seemed for the moment to preclude the steam turbine greater than 10,000 kw. running at 3,000 revs. per min. But that difficulty has now been overcome, and units much above 10,000 kw. at a high speed will probably be the order of the day. Things have changed, for when the turbine designer looks back doubtingly at the electrical man, the latter says assuringly, "Go on, I'll follow you."

It is interesting to plot curves showing the sizes of single units built on various dates. In Fig. 1 are plotted five such curves.

A relates to continuous-current engine-driven generators.

B relates to alternating-current engine-driven generators.

C relates to water turbine-driven alternating-current generators.

D relates to steam turbo-generators (any speed).

E relates to steam turbo-generators 3,000 revs. per min.

One would have expected from theory that the mechanical limitations would have made some of these curves (notably curve E) asymptotic to a horizontal line, and no doubt if extended far enough the curves will have that feature, but curve E at present has a very decided upward slope.

As might be expected, the individual output of dynamos used as motors has not increased to quite such a great extent as shown by these curves. The most powerful continuous-current motors at the present time are those used for driving rolling mills, some of which are designed to yield 20,000 H.P. for short intervals of time. No output as large as this has been required of the induction motor. Very powerful induction motors are used for colliery winding, and as the speed of this work is low, the motor sometimes has a very imposing size.

This matter of the output of the individual unit is closely associated with the cheap supply of electric energy. Not only is the capital cost of the generator, prime mover and housing accommodation per kilowatt greatly reduced, but much higher efficiency is possible in the large units. Some eight years ago

the cost of a large central station at Manchester, including the cost of boilers, prime movers, generators, switchgear, land and buildings might be taken at about £12. The present time is not a good one to make a comparison of cost, because prices

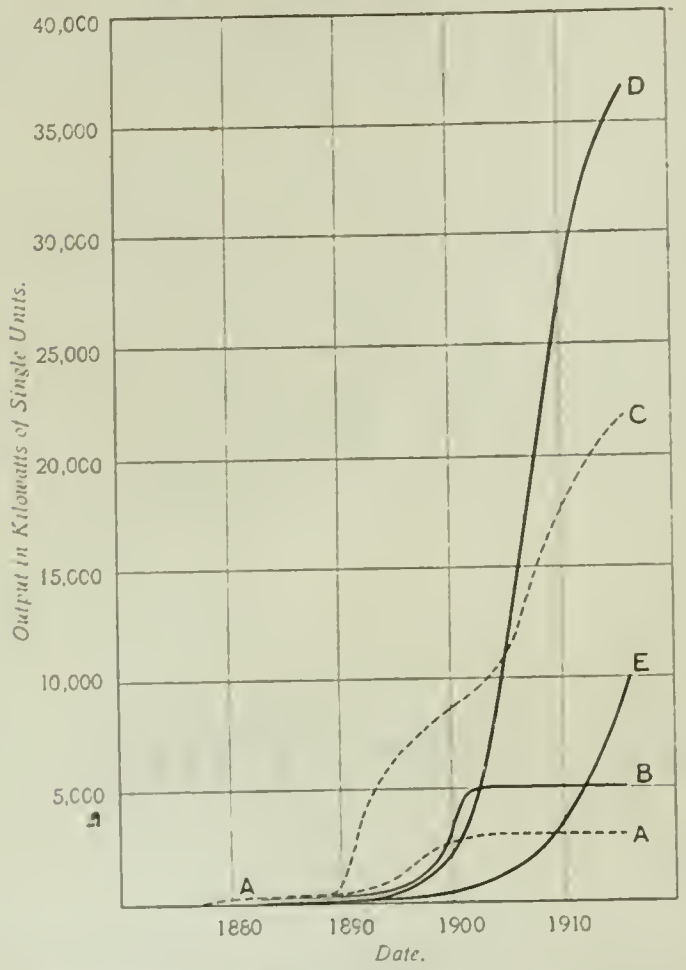


Fig. 1.—Curves showing Sizes of Single Turbine Units at Various Dates.

A relates to continuous-current engine-driven generators.
B relates to alternating-current engine-driven generators.
C relates to water turbine-driven alternating-current generators.
D relates to steam turbo-generators (any speed).
E relates to steam turbo-generators, 3,000 revs. per min.

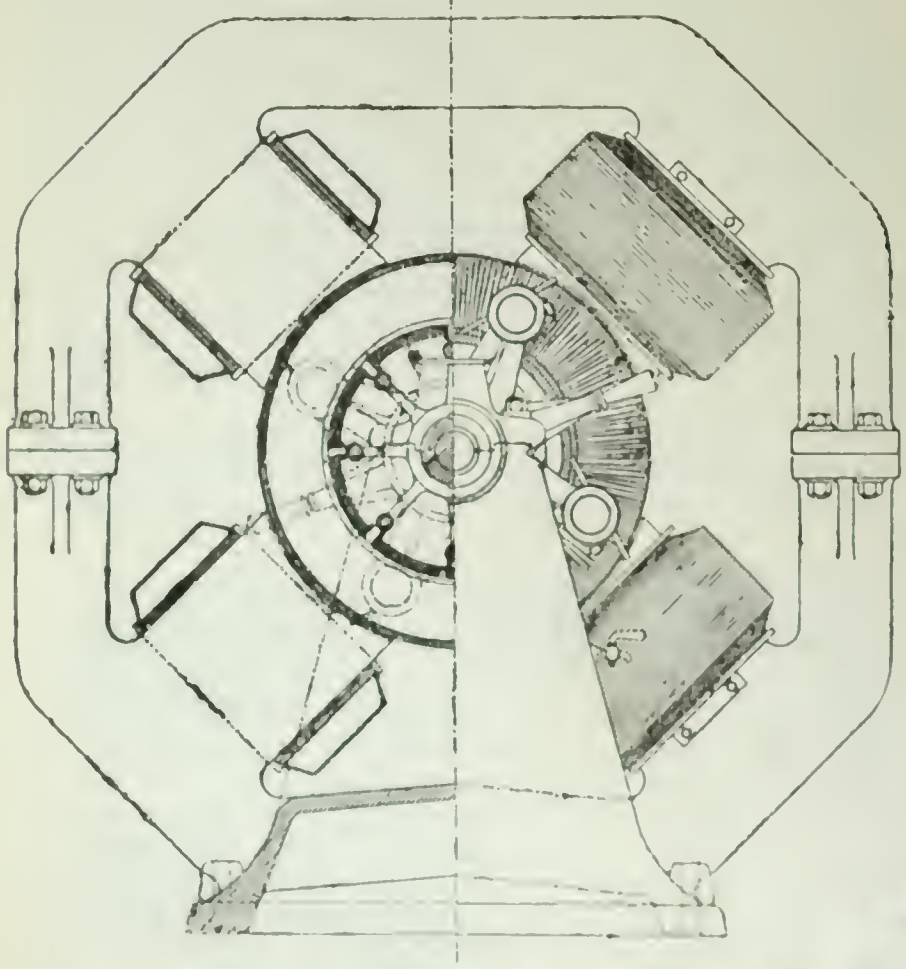


Fig. 2.—C. E. L. Brown's 170 kw. Dynamo (1889). Scale 1/24.

are increased by the war, but if the cost of material and labour after the war falls to normal the cost of a central station per kilowatt ought not to be much more than two-thirds of what it was in 1908. This will have quite an appreciable effect upon the cost of electric power, because as steam economy increases the capital cost of the plant becomes more and more important. Then again, the number of men required to operate the plant is reduced.

The capital cost per kilowatt of a generator has been affected by so many matters in the past that it would take too long to trace its history in detail. While from the first it has always been evident that the velocity of the conductors was the most important factor controlling the weight of active copper, a number of practical considerations in the early days induced the designer to keep peripheral speeds down to what he regarded as safe limits. The surface wound armatures of 30 years ago could not be run at our present turbine speeds. But there was another consideration which made the weight of copper and iron per kilowatt very great. After the good performance of Hopkinson's dynamo, with its powerful two-pole field, designers laid great stress on the importance of having large field magnets. As a consequence, we find that the machines built after 1886 and up to about 1890, and even later, had field magnets which we should now regard as being out of all proportion to the output.

The weight of field copper in Hopkinson's 33·5 kw. generator running at 750 revs. per min. was 410 lb., or about 12 lb. per kilowatt, and later designers increased this figure until 17 lb. was not uncommon. Moreover, the limbs of bipolar machines designed about this time were very long, and the whole magnetic circuit very heavy, so that the output per pound of material was low even when the speed was high. It was not uncommon for a designer to use 150 lb. to 200 lb. of material per kilowatt in standard central-station dynamos. Between one-eighth and one-tenth of this was copper.

The introduction of the multi-polar continuous-current dynamo was the first step towards the reduction of weight, but the early multi-polars were still very heavy for their output. In order to get good commutation, designers still employed very heavy field magnets, as seen from Figs. 2 and 3, which illustrate C. E. Brown's 170 kw. dynamo* running at 500 revs. per min., exhibited at the Paris Exhibition of 1889. This machine had 17·7 lb. of copper per kilowatt on the field magnet and a total weight of 201 lb. per kilowatt. Brown, however, was one of the first designers to show how to reduce weight, and was not long in getting his weight down to 50 lb. per kilowatt on a moderate speed dynamo.

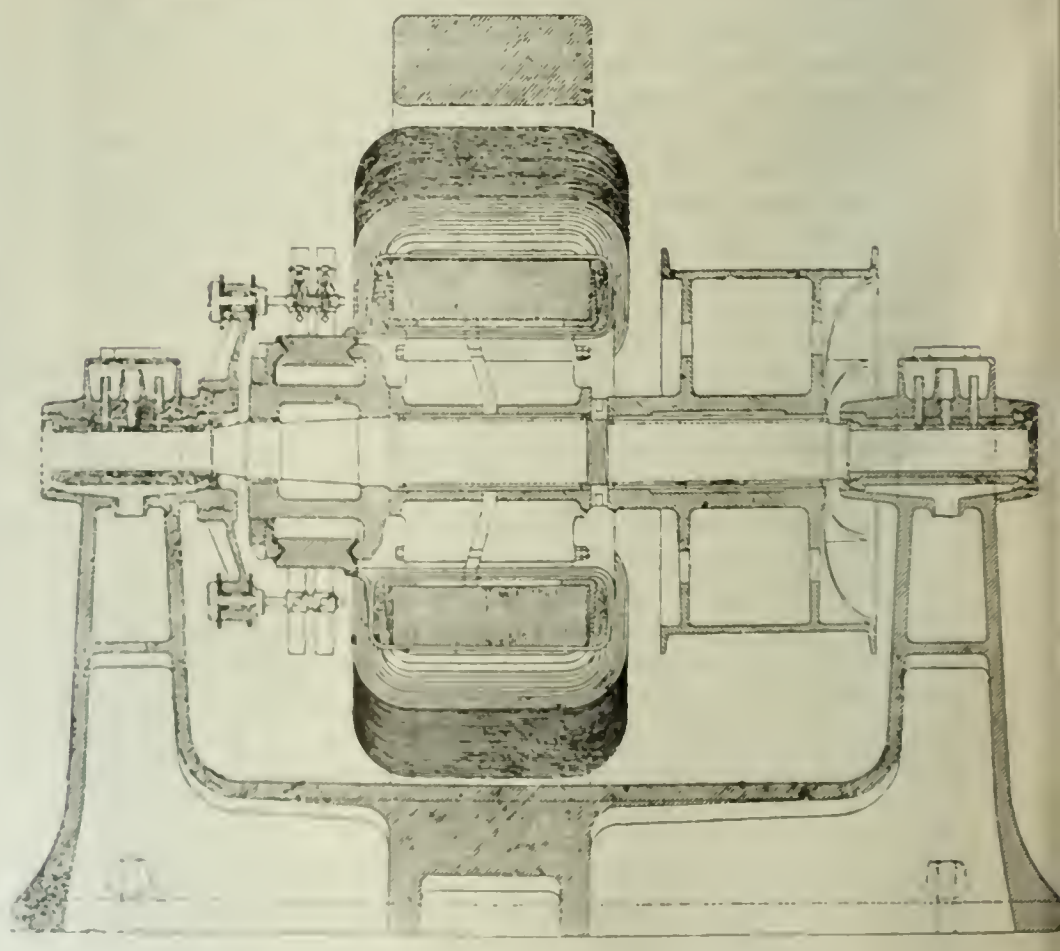


Fig. 3.—C. E. L. Brown's 170 kw. Dynamo (1889).

* Particulars of this machine are given in the Historical Notes in Dr. S. P. Thompson's "Dynamo Electric Machinery," from which these figures are taken by the courtesy of the publishers, Messrs. E. & F. N. Spon.

The decrease in the weight per kilowatt in modern continuous-current machines has been greatly aided by improved systems of ventilation and by the introduction of commutating poles. The latter have not only enabled the total field copper to be reduced, but have increased the permissible ampere-wires per centimetre of periphery while maintaining good commutation. It is interesting to see the change in the value of the output coefficient of dynamos during the last 30

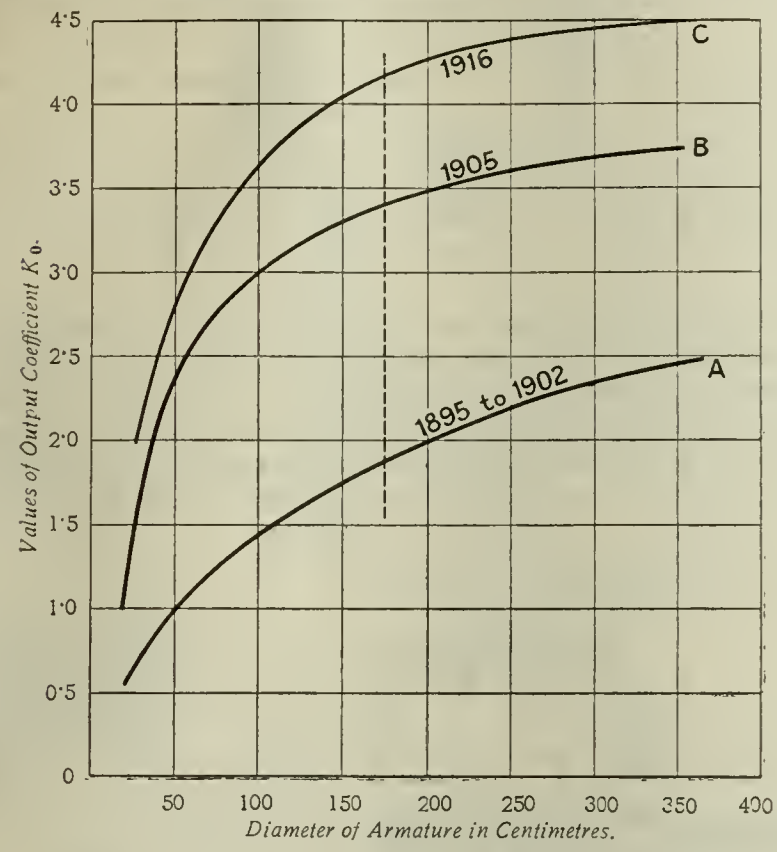


Fig. 4.—Curves of Output Coefficient.

years. Let us for this purpose define output coefficient K_0 as the output in kilovolt-amperes divided by the product $D_m^2 L_m R_{pm}$, where D_m is the diameter of the armature in metres, L_m the gross axial length of iron in metres, and R_{pm} the revolutions per minute, so that

$$K_0 = KVA / D_m^2 L_m R_{pm}.$$

We may observe that this output coefficient is not a complete index of economical design, because, in the first place, it only relates to the armature, taking no account of the metal of the field system ; and, in the second place, even when given the dimensions of the armature, we cannot determine the cost, unless we know the ratio between the copper and iron weight.

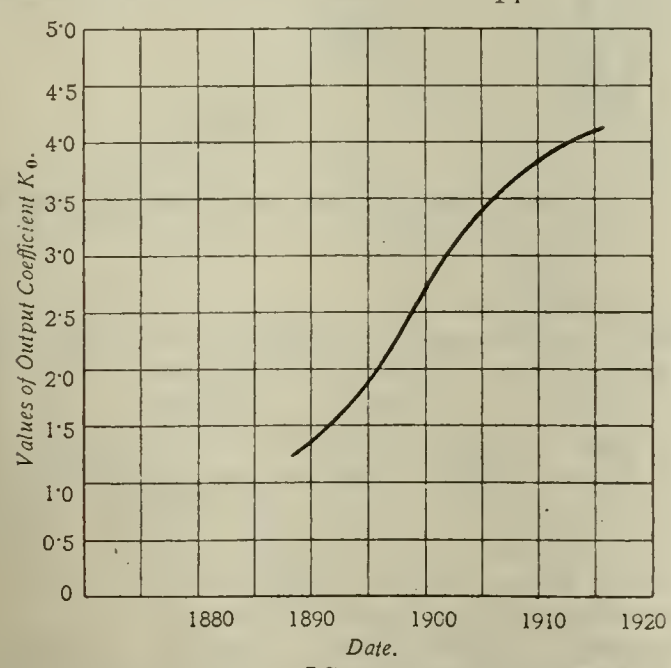


Fig. 5.—Curve of Output Coefficient of Continuous-current Generator (175 cm. Armature Diameter), showing how the Values have Increased.

For it is well known that we can increase the output of a given frame by increasing copper and reducing the iron ; but the resulting machine costs more then an iron machine built upon a larger frame. Nevertheless, with machines of the same type, employing the best ratio of iron to copper, the output coefficient does give us a fair guide to the progress that is being made in the use of material. One must remember, however, that K_0 is strictly not a constant for a given mac ine, but varies with the speed, being greater at higher speed. We shall assume where it is used here that the peripheral speeds are sufficient to give the right ventilation. The early Gramme armatures had very low output coefficients, so that writers on the dynamo before 1900 gave values as low as 1 for the output coefficient of machines less than 50 cm. in diameter ; but this value was too low for bi-polar drum armatures. As the size of machine was increased up to 2 metres in diameter, the value of output K_0 improved up to 2·5. Hobart, in his "Continuous-current Dynamo Design" (1906), gives curves showing values of output coefficients at various dates. Two of these curves are reproduced in Fig. 4. The lowest of these, A, is after Fischer-Hinnen and relates to machines dating between 1895 and 1902, and curve B gives good values of output coefficients in 1905. Curve C, which is here added, shows somewhat how the matter stands to-day, when commutating poles and a good system of ventilation are employed.

If we take any diameter, say 175 cm., and plot the output coefficient for various dates, we get a curve like that shown in Fig. 5. The shape seems to indicate that we are by no means at the end of our improvements.

With smaller machines, in order to get high outputs, it is necessary to provide a fan on the armature, such as that shown in Fig. 6, which shows a modern continuous-current armature having an output coefficient as high as 2·4 at 750 revs. per min., and 2·8 at 1,000 revs. per min. This rotating part is housed in a frame so arranged that it draws a blast of air through the arma-

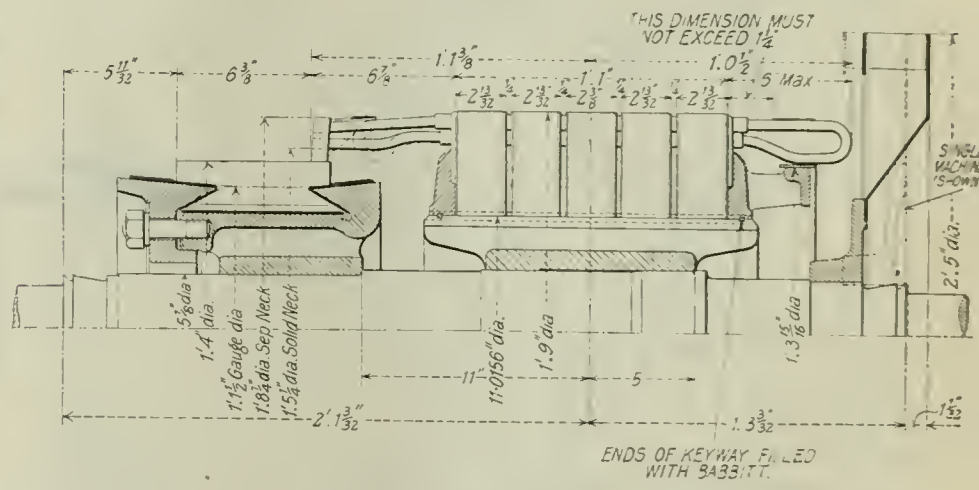


Fig. 6.—Small Continuous-current Generator Cooled by Means of a Fan. K_0=2·8 at 1,000 revs. per min.

ture and field magnet, and throws it well away from the intake. Someone has said that in order to become a good dynamo designer one should first learn how to build a good fan, and then see how it can be converted into a dynamo without affecting its efficiency. The statement is not far from the truth. Fans are sometimes added to large continuous-current generators, but the big diameter gives so much more access to air that it is usually found sufficient to open out the armature coils on the ends so that air can pass easily between them. These then form their own fan. Fig. 7 shows a continuous-current machine of modern standard pattern of about the same $D_m^2 L_m$ as the machine in Figs. 2 and 3. Its output is 600 kw. at 500 revs. per min. The output coefficient on the basis of the I.E.E. standard rules as to temperature rise is 3·7, as against K_0=0·74 of the 1889 machine based on its rated output. It will also be seen that the weight of the yoke is very much lighter on the new machine.

The main changes which have increased the output coefficient five times can be seen from inspection of the figures. In the first place we have a drum-wound armature instead of a ring-wound armature. This permits perfect ventilation of the core by means of radial air-ducts, and also good ventilation at the end windings when they are arranged as an open lattice-work instead of being packed closely together in a ring-winding. Then the armature coils are placed in slots presenting a large cooling surface to the iron. The ratio of the diameter to length is increased so as to give a higher peripheral speed.

The number of poles is increased from four to eight, and we have thus a reduction in the weight of the yoke. In order to give good commutation on the increased load, inter-poles are provided. These take copper for their windings, but they release a great deal of the shunt copper which was invariably heavy upon the old machines. The total field copper does not amount to more than 3 lb. per kilowatt, as against 17·7 lb. per kilowatt on the old machine. The commutator on the new machine is, of course, very much bigger in order to take the increased load.

Great though these changes are, there are other factors which contribute quite as much to the lowering of the cost per kilowatt. In the old days insulation was even more treacherous than it is to-day. Cotton braiding saturated with shellac and baked in an oven until it was vitrified, though it seemed pretty good at the time, was not anything like good enough. The present methods of insulating with mica in the slot and sealing of the ready-formed armature coils with Sterling varnish is very much more satisfactory, so that the manufacturer has not now to put on to his price quite such a large sum for insurance against breakdown. Then the methods of manufacturing have very much improved during the past 20 years. The standardisation of sizes has enabled the various parts to be manufactured in quantities by means of tools and jigs requiring less skilled labour than was employed on the early dynamos. The improvement in the iron has led to reduced iron losses, and this, combined with the increased output, has enabled the efficiency to be very much improved.

But when we speak of the improvements in continuous-current generators and their effect upon the cost of electric supply, we must remember that even a greater change has taken place than any of those mentioned above. The continuous-current generator now supplies only a very small fraction of all the continuous current required in the world. The bulk of the current for traction work and electrolytic work is supplied from rotary converters. This has come about because the three-phase generator is a very much more convenient machine for coupling to a large steam turbine than a continuous-current generator, and the power has often to be transmitted at high pressure. The development of both 25-cycle and 50-cycle rotary converters within the last 15 years has been remarkable. Rotaries are now built up to sizes of 3,000 kw., and are capable of taking enormous overloads. Some machines will take 10 times full-load current, while the circuit-breaker is coming out, and go on running as though nothing had happened. Rotaries are built to supply 1,500 volts direct to traction bus bars, and are thoroughly satisfactory on traction work. The main changes that have been made in rotary design cannot be entered upon in a review of this kind. They have been mainly directed to the increasing of the output per pole, so as to increase the speed and get a higher efficiency at a lower price. This increase of the output per pole could only be done safely by eliminating one by one the defects in commutation, which were particularly numerous in this class of machine. There is a great saving in cost, convenience and efficiency in the use of rotary converters for traction work instead of the huge continuous-current generators of 15 years ago. Fig. 8 shows a 2,000 kw. 6,000-volt rotary converter running at 333 revs. per min. The value of K_0 in this case is 4·9.

The great advances that have been made since the early days in the methods of insulation has given much more certainty to the dynamo builder's art. Though there is still much to be desired in the behaviour of insulation we can build machines to run at 15,000 volts or more with a reasonable prospect of their doing good service for many years. At one time the great mechanical forces which came upon windings when short-circuited caused so many breakdowns that users became afraid of high voltage windings, and specified in some cases bar-wound machines and step-up transformers. This is a mistake for large turbo-generators unless the voltage of transmission is to be over 13,000. There are just as many difficulties with large currents per bar as with high voltages in the slot. The reliability of high voltage windings is of special importance in the case of large induction motors, as it enables these to be connected direct to high-voltage mains.

It is impossible to give values for output coefficients of induction motors in a simple manner because the values are affected by such a large number of circumstances. They depend upon such considerations as the following: The rated output, the number of poles and incidentally the frequency, the voltage, the temperature rise allowable, the facilities for ventilation, the ratio of copper weight to iron weight, the efficiency and the power-factor desired at full-load. Many motors intended for ordinary commercial service can yield a maximum output from 2 to 2·5 times the rated output, the

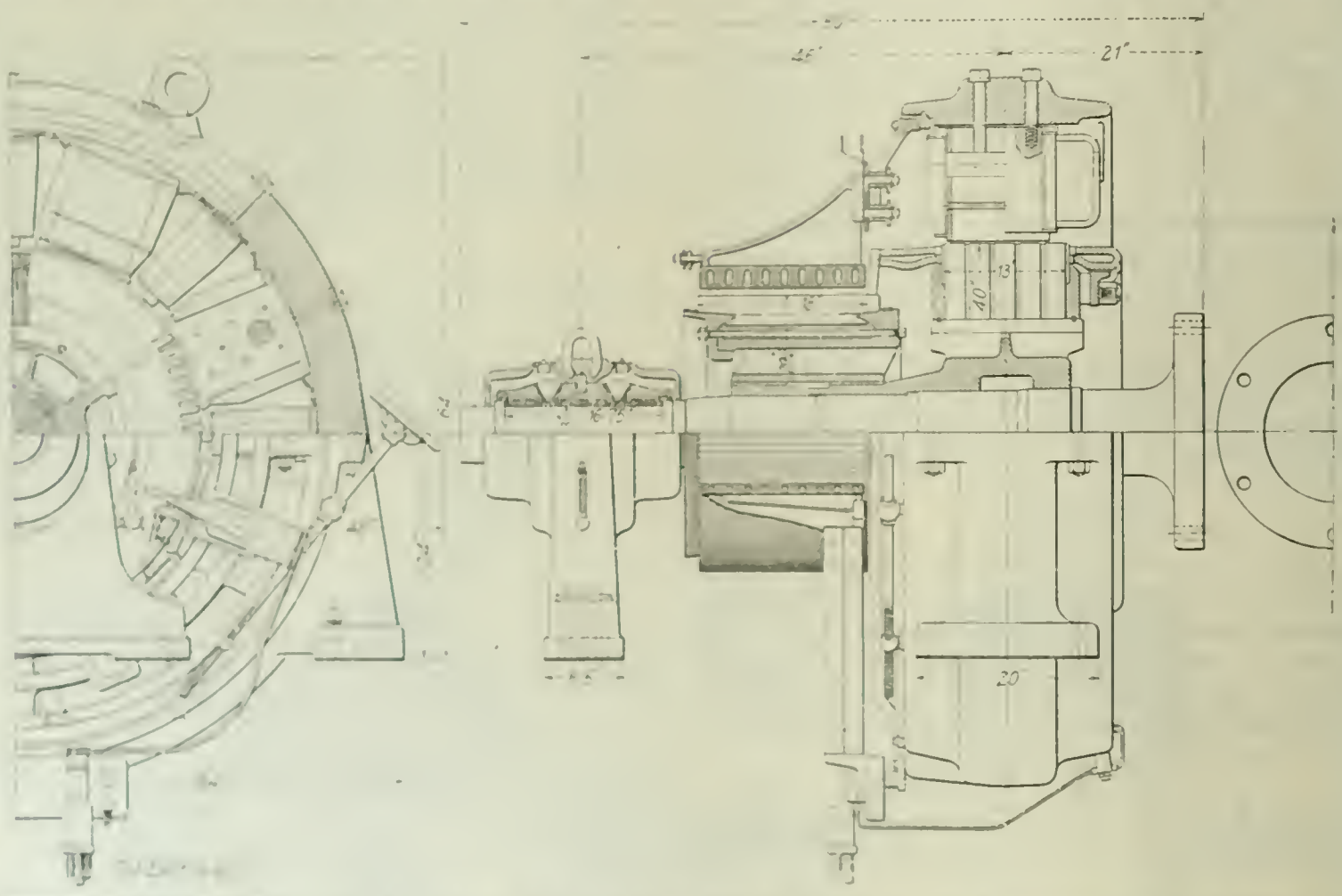


Fig. 7.—Continuous-current Generator by British Westinghouse Co., having an Output Coefficient of 3·7 at 500 revs. per min. (Scale 1:24.)

larger figure referring to larger motors. Taking this as the basis of design and allowing temperature rises in accordance with I.E.E. rules and taking a frequency of 50 and voltages not above 500 for 50 k.v.a. motors, or 2,200 for 100 H.P. motors, or 6,000 for the larger sizes, we may with ordinary facilities for ventilation obtain output coefficients at the present time somewhat in accordance with the values given in the accompanying table.

Table *of Output Coefficients of 50-cycle Induction Motors of the Voltages Specified and Overload Limited to 2 to 2·5 times Normal Load.*

K.V.A.	4 poles	6 poles	8 poles	K.V.A.	12 poles	K.V.A.	16 poles	24 poles
	K_0	K_0	K_0		K_0		K_0	K_0
1	0·4	0·4	0·4	50	1·6	100	1·8	1·85
2	0·55	0·57	0·6	100	1·7	200	1·95	2·0
5	0·75	0·85	0·9	200	1·8	500	2·05	2·1
10	1·0	1·1	1·15	500	1·9	1,000	2·15	2·2
20	1·15	1·25	1·35	1,000	1·95	1,500	2·15	2·2
50	1·3	1·45	1·55	1,500	2·0	2,000	2·15	2·2

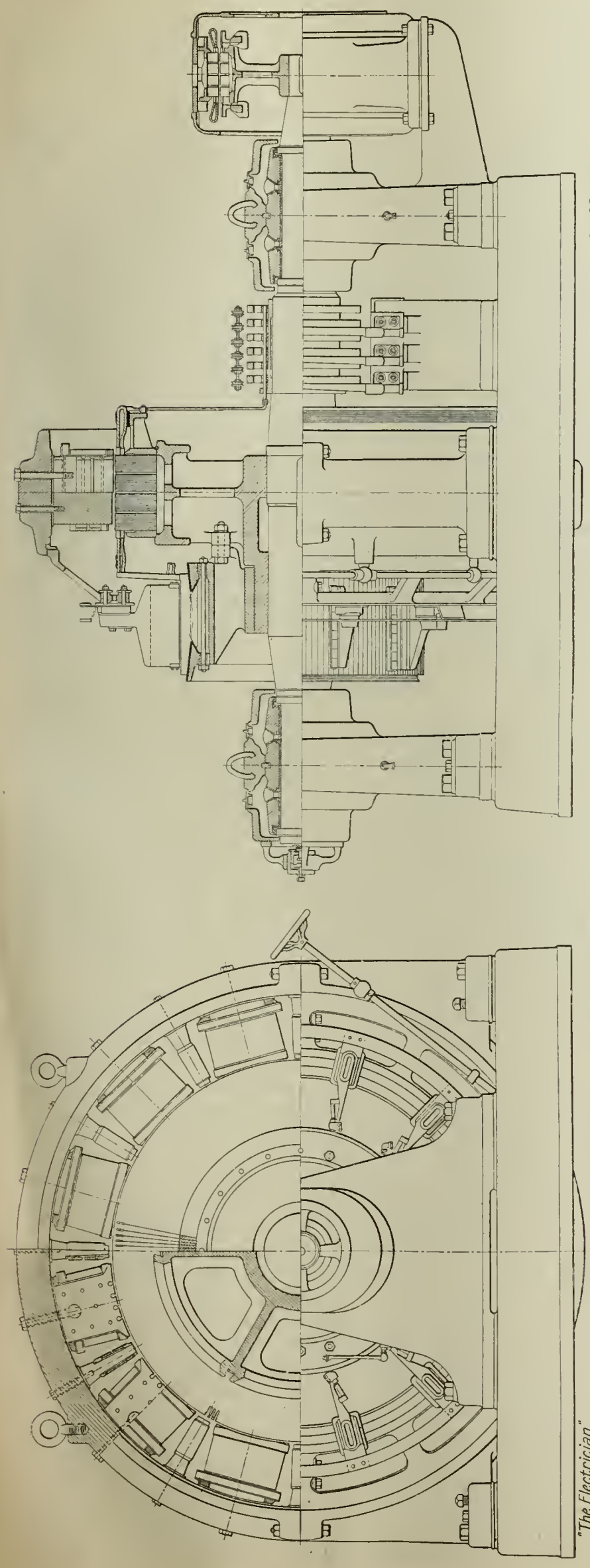


FIG. 8.—ROTARY CONVERTER BY BRITISH WESTINGHOUSE CO., HAVING AN OUTPUT COEFFICIENT OF 4·9 AT 333 REVS. PER MIN. (SCALE 1 : 32).

"The Electrician"

These values are very much higher than they were 10 years ago, and there is still a prospect of increasing them by still better ventilation and by using a better quality of iron.

The cheap manufacture of silicon iron having a low hysteresis and eddy-current loss is of great importance to the electrical industry of this country. Researches should be carried out on an extensive scale to see if the price cannot ultimately be brought down nearer to the price of ordinary iron. Silicon is cheap enough. It is mainly a matter of cheapening the manufacturing processes. In the case of heavy electrical machinery a very large fraction of the works-cost is the cost of the iron punchings, so the country that can produce the cheapest low-loss iron is going to make a very big bid for the world's trade in electrical machinery. One objection to silicon iron, as we have it at present, is that the permeability at high flux densities is lower than the permeability of ordinary iron. Is this defect really inherent, or is it possible to produce low-loss iron with a higher permeability at high flux densities? That is another important subject for investigation. Perhaps if we alloyed the iron with boron, or some other fairly cheap element, or combination of elements, we might get a better result. Here is much scope for industrial research.

Nothing is said above about the values of the output coefficients of alternating-current generators. These are affected by the same considerations as those affecting the output coefficient of induction motors. The regulating quality of the generator corresponds with the ratio of maximum to normal output of the induction motor, and no statement of output coefficient can be made until the regulation is fixed. Twenty years ago it was the custom to give alternating-current generators very good inherent regulating qualities. This and other matters in the design lead to very low values of K_0.

It was quite common to find K_0 below unity, for big machines. On small machines, particularly if single-phasers, it had very low values indeed. The keen competition between manufacturers at the beginning of the century led to generators of poorer regulation taking the market as standard machines, and K_0 for 500-kw. engine-type generators rose gradually above 2 as the methods of keeping down the losses and improving the ventilation advanced. To-day it may be taken at about 2·5 for an ordinary engine-type generator regulating within 10 per cent. on unity power-factor.

In the case of turbo-generators it is impossible to give any figures which have any meaning without very exact statements as to what we mean by temperature rise, what means of ventilation are available, and what other conditions have to be met. Needless to say the methods of forced ventilation at present in vogue have enormously increased the output coefficient. The value of K_0 approaches 3 for two-pole machines and 4 for four-pole machines. If we plot the values of K_0 for a large number of turbo-generators we do not get a curve but a whole constellation of points. Nevertheless the stars of this constellation are rising, and they foretell the dawn—the coming of the cheap and efficient central station. Then will come a flood of light over our dirty, smoky cities. Coal will be banished, the housewife will be emancipated, and the happy inhabitants of the City Beautiful may, in their leisure, turn over the pages of these 2000 numbers, and see how wonderfully it has all come about.

The Evolution of the Electric Lamp.

By CLIFFORD C. PATERSON.

The two principal forms of electric lamp which exist at the present time have undergone development side by side since the earliest days of applied electricity. The electric arc, it is true, was discovered some 30 years before the first incandescent lamps, but it had to wait for the development which comes from the possibility of practical application, until sufficiently large sources of power appeared. It was not until the invention of the Grove battery in 1836, followed shortly afterwards by the Bunsen battery in 1842 that a sufficiently large current was obtainable to maintain an arc light for an appreciable time. Even then, little real development took place until about 1860. It was about this time that the possibilities of electric generators had been demonstrated and began to be recognised, and with the development of the generator, progress in both arc and incandescent lamps was stimulated. The very earliest incandescent lamps appeared between 1840 and 1850. Although certain experimental types were produced during this period, it would appear from the records that the electric arc lamp received the greater attention. It was not until about 1879 that the incandescent lamp received the attention it deserved, when the results became known of the independent investigations of Swan and Edison. It is from this period that the birth of the incandescent lamp, as we know it to-day, may be said to date; and interesting as are the earlier records, they have little importance compared with the very thorough work of these investigators. In contradistinction to this, the development of the arc lamp was continuous. The patent records show a multitude of different types produced by many inventors throughout the whole period from 1845 to 1880. After this time the arc lamp began to assume the form in which we know it to-day. Till quite recently it had been recognised that the sphere of usefulness of the arc lamp was an entirely different one from that of electric lamps of the incandescent type, and little rivalry existed between the two until the appearance of high power tungsten lamps and especially those of the gas-filled variety. The gas filled lamp is now entering into serious competition with even the most modern forms of flame arc lighting.

The history of the development of the incandescent lamp from 1879 to the present date is one of absorbing interest. It forms one of the most striking examples of the application of physical science to industry. There is scarcely a process in the manufacture of incandescent lamps which has not associated with it obscure physical problems, the solution of which has been the subject of continual investigation and experiment. Some problems are still unsolved after nearly 40 years; on others, recent continuous discoveries begin to throw much light, while many of the problems which have been successfully solved yield evidence of experimental ability second to none in the history of applied science. The advances in electric lamps have been continually towards operation at greater efficiency—the obtaining of more light for a given expenditure of energy—the pushing up of the temperature so that the wave-length in which the maximum amount of energy is expended, moves from the invisible part of the spectrum towards the visible. These successive increases of temperature have brought with them their own difficulties; or, more often, perhaps the old difficulties and defects which it had been thought were surmounted, have re-appeared under the more exacting temperature conditions.

The earliest incandescent lamps were tried with platinum or platinum-iridium filaments, but it was soon found that the volatility and relatively low melting points rendered these metals unsuitable materials for incandescent lamps. Experiments on metallic filaments soon gave place to filaments consisting of, or coated with, carbon, and it is instructive to note how, when the attention of inventors had once been directed towards carbon filaments, there was little real effort, for a period of over 20 years, to return to metals for filament materials.

Mr. Edison describes in 1880, the kind of substances from which suitable carbon filaments can be produced. The material most in favour was a fibrous grass from South America, called "monkey hast" fibre, which was made uniform by passing through a dye and afterwards carbonised. Then followed experiments with bamboo fibre, which eventually proved to be the most suitable natural material for filament making. The fibres had first to be shaved down to the uniform diameter desired and then carbonised in special moulds. These were some of the first practical filaments made, and produced a great sensation when exhibited in public buildings. Swan's invention of the squirting process by which a solution of nitro-cellulose is squirted through jets into a coagulating liquid, soon enabled filaments to be prepared which were both better and cheaper than those from natural fibres on which Edison had first worked. This process also enabled smaller diameter filaments to be produced, more suitable for lamps designed for the commercial supply circuits at that time being installed throughout the country. Although improvements took place by the discovery of flashing methods, for producing greater uniformity, in essence the form of incandescent lamp invented by Swan and Edison held the field for some 25 years. It was only about 1906 that any serious improvement took place in the carbon filament lamp as the outcome of experiments in America. These resulted in the appearance of the "metallised" or "graphitised" carbon filament, produced by carrying the filament, during manufacture, to a higher temperature. If this improvement had arrived earlier the inventors would have reaped a much greater reward. However, the first experimental metal filament lamps were already appearing, and it was clear that the carbon lamp would soon have to yield up the premier place.

The first successful metal filament lamp to appear was of tantalum, but experiments with osmium had apparently preceded those with tantalum. Whereas tantalum forms readily a pure metal which could be rolled and drawn into a form suitable for filaments, osmium could not be treated in this way and a process of filament forming was eventually developed, in which the finely divided osmium was mixed with an organic binder and squirted through very fine diamond dies. The carbon present had then to be driven off by heating the filaments in a suitable atmosphere and submitting them subsequently to a sintering process at very high temperature. By this process the filaments never partake of the real characteristics of metals. They are still without fibrous texture, but the particles of metal adhere together sufficiently to enable the filaments to keep intact between their supports. Although osmium lamps were actually made commercially and sold they did not prove satisfactory. Breakages occurred in transit, and there was a tendency for the filaments to sag if burnt in other than the vertical position. These causes operated against its reputation and its slightly higher efficiency of 1·7 watts per candle did not give it such an advantage over the tantalum lamp as to constitute it a serious rival. The lamp, however, is of great interest since it was the first to meet with any measure of success in which the metal filaments were formed by the squirting process, and the experience gained was in-

valuable in assisting with the production of some of the first tungsten lamps.

The tantalum lamp was only put on the market after its characteristics had been thoroughly investigated and after the lamps had been well proved by every possible test. It immediately achieved a great success in spite of the fact that only lamps of the low voltage type were available. It had an efficiency twice that of the carbon lamp, *i.e.*, about half a candle per watt expended. The makers were wisely conservative as regards the temperature at which they ran the filaments, and the general robustness and reliability of the lamp constituted it a rival of the tungsten lamp for several years after the latter appeared.

An unexpected feature developed soon after the lamp came into general use. The life on alternating-current was found to be much shorter than with continuous-current, due to the curious phenomenon of filament "off setting," for which no satisfactory explanation has yet been found, although it is a trouble which also affects present-day metal filament lamps.

The tungsten lamp appeared very soon after the osmium lamp. The first experimental work on the metal was carried out about 1904 and the early lamps appeared on the market in 1906. The filaments were made in the main by three rival processes, and the unfortunate result of the competition was that there was a tendency in the early days to make claims for the lamps which they were incapable of fulfilling. Efficiencies were pushed up beyond the point which was safe at the time, and a short life and a merry one was the rule of the day. The initial claim was that the lamps would yield 1 candle per watt and ever since the claim was made they have been trying without success to live up to their reputation. It has never been found possible to put tungsten filament vacuum lamps in general on the market at a higher efficiency than about 0·8 candle per watt. Reliability in lamps is found to be a more important factor, both commercially and practically, than efficiency, and on this account the tantalum lamp was able, for a considerable time, to meet the competition of the many rival lamps of the tungsten variety which sought to oust it.

The three processes used for making the earlier tungsten filaments are not without interest, and their development has exhibited great experimental ability. By the first a deposit of tungsten was "flashed" on to a fine carbon filament, the carbon being subsequently extracted by glowing in an atmosphere of hydrogen and water vapour. By the second, colloidal tungsten was made by burning an arc between tungsten electrodes under water. The resulting finely divided particles suspended in water were partially dried and then squeezed through fine dies to form filaments. These had subsequently to be sintered. The third process was similar to that used in the making of the osmium filaments. Powdered tungsten was mixed with an organic binder to facilitate squirting, after which the carbon had to be driven off and the filament sintered.

For a long time the filaments made by these processes suffered from fragility. Tungsten is not like tantalum in its metallic properties, and the filaments thus made had no fibrous texture. Improvements, however, were already being made in producing stronger squirted filaments when a process was developed in the United States for giving tungsten filaments all the characteristic fibrous qualities of metallic wire. By this process a well sintered ingot of tungsten powder is subjected to a continuous and vigorous hammering or "swaging." The treatment is carried out in such a way that the hammering first elongates the ingot into a cylindrical rod and then gradually transforms it into fairly coarse wire. When it has been reduced down to a small diameter in this way it is found to have lost all its "shortness" and to be capable of being rolled or drawn into wire like an ordinary ductile metal. The wire so made, and before it has been subjected to prolonged burning, is exceedingly strong. Owing to this, and its greater ease in handling during manufacture, the drawn wire is now almost universally employed.

When the tungsten filament lamp first appeared greater things were expected of it than were found by experience to be possible for several years. The ordinary burning temperature for 0·8 candle per watt was about 2,050°C., whereas the melting point of the metal was over 3,000°C. Filaments could be run up to an efficiency of 2 candles per watt without being destroyed; surely, then, it was reasonable to expect in the near future a considerable improvement in the existing efficiency of 0·8 candle per watt. Unfortunately the trouble of blackening and flashing showed themselves at every attempt to push up the temperature, and it was not until the gas-filled lamp appeared that a way was indicated of taking fuller advantage of the very high melting point of the tungsten metal.

The gas-filled lamp was the outcome of investigatory work carried out in the experimental laboratories of the General Electric Co. of America. The blackening of the bulbs of ordinary tungsten lamps at extra high temperature was the direct result of the sputtering which takes place in a vacuum at high temperatures, and the flashing was caused by ionisation under the same conditions. Both effects were intensified as the temperature of the filament was raised above that which corresponded with an efficiency of about 0·8 candle per watt. Up till then all efforts had been directed towards improving the vacuum and maintaining its good condition during the life of the lamp. The desired result might, however, be attained by running the filament in an inert gas at atmospheric pressure. This remedy was found to be successful as far as the immediate troubles were concerned, but other difficulties arose. In the ordinary electric lamp nearly all the energy put in is dissipated in radiation. The losses by conduction are exceedingly small, and those by convection, owing to the high vacuum, are quite negligible. The introduction of gas, however, caused a large quantity of energy to be carried away through the gas by convection, and consequently considerable extra power had to be supplied to the lamp in order to make up for that which leaked away in this manner.

It is true that if sufficient power was supplied the filament would stand running at a much higher temperature than in a vacuum, but the increased brilliancy which resulted did not compensate for the additional energy losses. An ordinary lamp, for instance, when filled with gas showed an efficiency of little more than one-tenth of a candle per watt in spite of the fact that the filament was many times more brilliant than the normal. It was found, however, that much better results were obtained if the filament was coiled up into a close spiral instead of being straight. Each coil tended to heat up those in its neighbourhood and itself received heat from the others. There was less opportunity for the free circulation of convection currents, and although there was still considerable waste of energy a point was reached at which, on a balance, the new lamp was superior in overall efficiency to the old one.

The lamp, however, still had its limitations. The smaller the diameter of wire in the coil the less efficient it became, and only large units were therefore available. All effort in the manufacture of gas-filled lamps is now being directed to the production of smaller units, and there is little doubt that considerable advances will take place in the near future. It is, however, most unfortunate that the very high temperature to which tungsten is capable of being carried cannot be obtained without the wastage of so large an amount of energy through the gas in the bulb. But for this, efficiencies of several candles per watt would be possible.

Even, however, with gas present in the bulb an efficiency approaching 2 candles per watt is obtained in the large sizes, a result which has brought the gas-filled lamp into competition with arc lamps for outdoor lighting. Their freedom from the necessity of attendance and their adaptability to artistic street fittings are qualities which will operate greatly in their favour when the time comes to revert again in this country to normal street lighting.

The following table traces the progress which has been made in the development of the incandescent filament lamp.

It is early days yet to say what field of usefulness is in store for the tungsten arc. The lamp was put on the market early this year by the Ediswan Company It is

Table I.—*Showing the Progress in Incandescent Lamps.*

Date (approx.)	Type of filament.	Candles per watt.	Approx. filament temp.
1880.....	Carbon	0·25	1,800°C.
1906.....	Graphitised carbon	0·35	1,880°C.
1905.....	Tantalum	0·5	1,950°C.
1905.....	Osmium	0·6	1,980°C.
1906.....	Tungsten (vacuum).....	0·8	2,050°C.
1914.....	Tungsten (gas filled)	1·5	2,400°C.

eminently suited for certain types of projector work. An efficiency of 2 candles per watt is claimed, and it is probably very similar, from the point of view of efficiency, to the gas-filled lamp. Although these lamps will burn in series, individual lamps will only operate on low voltages, and an additional contact and external lead is required for actuating a cut-out for the mechanism by which the arc is struck. In this respect the lamp resembles the Nernst burner, which required a special cut-out for the heater circuit.

The Nernst lamp, the mercury vapour lamp and the Moore Light have been omitted from the above brief survey of the development of the electric lamp. Each caused a sensation on its appearance and gave rise to great hopes. The ideal of lighting may be said to be the discovery of a selective radiator which would concentrate the energy received by it, into radiation in those wave-lengths which lie within the visible spectrum. The filament materials used in incandescent lamps are far too much in the nature of perfect radiators. Over 90 per cent. of their energy is radiated in those longer wave-lengths, which it is true are wanted in heating apparatus but are out of place in lamps. At the other end of the scale we have the glow worm and firefly in which light seems to be produced with an exceedingly small total expenditure of energy. Tungsten is to a very slight extent selective. The Nernst glower was still more so. It is well known that the incandescent gas mantle owes its high efficiency to the selective action of the small amount of cerea present, and it was hoped that, by the use of similar rare oxides in such a lamp as the Nernst, a similar increase of light efficiencies might be anticipated. The degree of selectivity of solid glowers, however, from a lighting point of view has not been very considerable.

The mercury vapour lamp and the Moore light are gaseous radiators which differ greatly in spectral distribution from ordinary solid radiators, and their departure from the normal is all in favour of the visible spectrum. They run at relatively low temperatures and yet they rank as regards efficiency with solid radiators operating at temperatures above 2,000°C. With the mercury vapour lamp the limiting factor is the temperature which the containing vessel will stand. When quartz is used an efficiency greater than 2 candles per watt can be obtained. If the containing vessel would admit of the temperature being further increased, phenomenal efficiencies would be realised. The mercury vapour lamp has not come into general favour for various reasons, the chief being the absence of red in the light emitted. This lamp, however, together with the Moore light, and certain flame arc lamps, serve to show that at least there has been some progress towards the practical realisation of the ideal lamp in which all the energy supplied will be radiated in correct proportions throughout those wave-lengths only which give rise to the sensation of light. Meanwhile considerations of theoretical light efficiency do not, of themselves, appeal to the ordinary user of lamps. Reliability and general convenience are also important factors, and for the immediate future it looks as if the type of lamp to gain in favour would not be one having a high radiant selectivity but would continue to be the lamp of the incandescent filament type operated at extra high temperature.

Electric Traction.

By H. F. PARSHALL, D.Sc.

The present article on "Electric Traction," being written with a view to emphasising the 2000th issue of THE ELECTRICIAN as an event worthy of recognition, must be very naturally to a considerable extent reminiscent and historical in character.

My acquaintance with THE ELECTRICIAN began when I was a student of electrical engineering in Lehigh University, U.S.A., and it was then regarded by the faculty and the advanced students as the one authoritative journal on electrical engineering from a technical point of view. It is of interest to note that practically all of the electrical literature considered standard in those days was English in origin. The books to which the writer and those educated with him would acknowledge their indebtedness in gaining a correct elementary insight to electrical engineering are:

Thompson's "Dynamo-Electric Machinery."
Thompson's "Elementary Lessons in Electricity and Magnetism."
Maxwell's "Treatise on Electricity and Magnetism."
Faraday's "Experimental Researches."
Hopkinson's Classical Papers on "Dynamo Electrical Machinery" and "The Magnetisation of Iron."

Having regard to the general fact that the physical knowledge on which electrical engineering is founded is so largely English in origin, it is remarkable that so much of the actual development and application have been on American soil. Without venturing into the field of politics, the writer ventures the general opinion that the technical application of knowledge is most likely to attain rapid development in those countries where industries find the greatest protection and there is the greatest security afforded for capital invested in such industries. It is unreasonable to expect parents to educate their children on a speculative basis, and only reasonable to expect them to educate their children on the basis of certainty and regularity of employment. For this reason the number of students preparing for electrical engineering in England on the broad educational basis obtaining in Germany and America has been disproportionately less.

Referring next to the state of electric traction in America in the late eighties, there were only a few examples of electric tramways, and these were principally by Daft and Vanderpoel. The class of apparatus was so crude that operation was not particularly reliable and was excessively expensive. In 1887 Sprague began the first serious scientific exploitation of electric traction apparatus, the result being the equipment of the now historical line of Richmond-Virginia. The writer was associated with Sprague during this period and has been associated with the development of electric traction ever since. The motors designed by Sprague proved defective from practically all points of view, principally because it was thought that two 7½ H.P. motors should be capable of doing the work

commonly done by two horses. There were numerous mechanical defects in the motors, the kind of defect that could only be eliminated by protracted experience. There was also difficulty with the controllers because the magnetic blow-out principle had not been developed ; also great difficulty from sparking, since the advantages of the carbon brush at that time had not been recognised. Great difficulty was experienced with the trolleys, resulting more from lack of experience of the operating staff than from the design, which did not differ very particularly from the trolleys as designed to-day.

This first motor was superseded by a double reduction 15 H.P. motor, for which the writer was responsible. Several hundreds of these were built, but the experience gained during the first year was generally to the effect that something better had to be discovered, otherwise the future of electric traction would be limited. As a result of studies, the modern four-pole single-reduction motor with projection armature was evolved and a machine that was fairly commercial produced.

After the consolidation of the Edison and Thomson-Houston Companies, the designs of the two companies were merged into the motor very widely known as the G.E. Co. 800, which motor is still in operation in some places and which has, in many respects, a strong similarity to the most advanced designs of to-day. The improvements that have been made since the time of the G.E. 800 are increased ventilation, interpoles, greatly increased range of commutation, so that 2,000 to 3,000 volt direct-current motors give commercially good operating results, larger bearings and improved mechanical construction generally, so that the operating cost has been diminished many fold. Further, the output per unit of weight has been largely increased. The method of driving remains the same, since with the vastly greater number of applications of electric motors to electric traction the single reduction form of drive is the most effective.

Before passing from the tramway motor to other elements that have been developed to meet the growing requirements of electric traction work, brief notice should be taken of the progress that has been made in the design of electric locomotives. The first really important step in this direction was the Baltimore and Ohio tunnel. These motors were of the gearless type, the armature being carried on a hollow shaft so that practically the whole of the motor system was spring borne. These locomotives were successful from the beginning from all points of view, but the weight efficiency from the electrical standpoint was somewhat low. Subsequent designs were of the geared type with attendant higher weight efficiency and lower first cost.

The development of electric locomotives may be fairly said to have proceeded along three lines, viz : gearless of the above type, or the type in which the armature is carried solidly on the axle, such locomotives being more suitable for passenger and high-speed work ; the geared type which is to-day being built of capacities as great as the largest steam locomotives, and the connecting rod type, which is still in a state of development. The particular advantage of the connecting rod type is that there is greater flexibility in the general arrangement, so that the centre of gravity of the moving system may be located with due regard to strains that may be brought on the track through centrifugal force, the disadvantage of the connecting rod type being its lack of flexibility for different speeds. Speaking broadly, there appears to be a particular field in which each class of drive has certain advantages. In the larger class of locomotive it would appear that, neglecting considerations of first cost, the type originally selected for the Baltimore and Ohio locomotive, that is, the gearless type, all weight spring borne, possesses greater advantages.

Passing next to the different systems of motor control. In the beginning there were practically two systems, the Thomson-Houston, which was broadly rheostatic, but with a field loop ensuring a certain amount of field control, and the Sprague, which was known as the commutating field method, in which a number of field coils were turned from series to parallel in starting, and which in practice resolved itself into a combination of field and resistance control. Both of these systems met with some degree of success in the light class of tramway work, but soon it became apparent that the conditions could only be met by lessening the energy losses during starting by a series parallel method of control. Sprague evolved the cylindrical type of controller now in general use. The Thomson-Houston Company had evolved what may be termed the plunger type of controller, but with magnetic blow-out. Neither of these was completely successful, but the combination of the different elements, made possible by the consolidation of the interests, lead to the modern magnetic blow-out cylindrical type of control now in general use.

The work done during this transition period was largely under the direction of Mr. W. B. Potter, who still retains the position of chief engineer of the traction department of the General Electric Company, and it should also be mentioned that the work done in connection with the combination of the different elements to produce the modern motor was largely done under the direction of Mr. E. D. Priest, who is still devoting his energies to greater refinements in traction motor design.

The motor controller design with separate control units in different parts of the train was first proposed by myself in connection with Baltimore and Ohio locomotives, but such a system did not find favour at that time. Later on it was exploited and successfully developed by Sprague, first by a master controller operating a system of motor driven cylindrical controllers distributed throughout the train.

By the consolidation of the General Electric and Sprague interests, the now practically universal type of master controller and individual solenoid units was developed, largely under the direction of Mr. W. B. Potter and his assistants.

It may be fairly said that the magnetic arc extinguisher device of Elihu Thomson has been the fundamental element in determining the success of the series parallel control to as great an extent as the carbon brush has been the element determining the success of the projection armature motor.

Passing now from the motor element to the system as a whole, it became apparent from the amount of trouble caused from electrolysis by stray currents from the rail return as the size of electric traction installations became larger and larger, that the direct-current central station method of generation with feeders could not be indefinitely extended. Before going abroad the writer had designed the first large rotary converters constructed in the United States. The theory of the action of these machines was collaborated jointly with Elihu Thomson and E. W. Rice. The reasoning was somewhat as follows :—

Continuous-current machines may be likewise used as alternating generators, and the performance of a machine acting both as a continuous-current and alternating generator improves as the number of phases is increased, so as to exert constant armature reaction, as opposed to intermittent armature reaction ; consequently, the best result would be obtained in machines having double generating functions by generating as multiphase current on the alternating-current side. Further, a machine so designed could be used as an efficient synchronous motor, and, in the event of direct-current output, the generator reaction being to a considerable extent opposite in magnetic phase to the motor armature reaction, and the disposition of the currents in the armature being such that in general the algebraic sum of the current of the different conductors is less in a machine acting both as a motor and a generator, the rotary converter should have greater output when used as such than it would when used exclusively as a direct-current or multiphase machine. To justify this line of reasoning, a direct-current generator was suitably connected up with three slip-rings, and was found to operate satisfactorily as a rotary converter, and the correctness of the above reasoning was proved. The first designs, however, were very conservative both as regards commutation and as regards strong synchronising effort. The result was entirely satisfactory from an operating point of view, although the weight efficiency was somewhat lower than that in machines as designed in present-day practice. After serving abroad the writer was asked to study the conditions imposed on electric traction

installations by the Board of Trade, and it became apparent that the economical way of distributing power for electric traction would be through the means of multiphase transmission and rotary converter sub-stations. The Central London Railway was the first instance of this class of installation. This installation proved a success from the beginning, and has been the forerunner of the class of installation that has become practically universal.

Notice should be taken of the progress made in steam generation. The first generators used in connection with modern traction installations were belt-driven by Corliss engines and of limited output. Owing to the insight of the late Dr. F. S. Pearson, the writer was permitted to design direct-connected generators of 1,500 kw. output, and this has become the accepted practice since the success of these first machines. This class of machinery has now become practically obsolete through the perfection of the electric turbine. Units of 20,000 kw. or 30,000 kw. do not now attract more attention than units of 1,500 kw. 20 years ago; the net result of central station improvements being that the cost of generation to-day under the same conditions of load factor and output is not much more than half what it was in the early days of electric traction.

This sketch would not be complete without some allusion to the progress that has been made in alternating-current systems. At the beginning of the general period referred to, alternating-current motors were very little heard of, and until the inventions of Tesla it was not apparent that the application of alternating-current motors for traction purposes would be immediate or would open up a large field. The general progress made proves that, while alternating-current motors are not as generally applicable to meet the problems arising in connection with electric traction as direct-current motors, there is the fact that motors have been produced with certain limitations as to weight and energy factor that give fairly satisfactory results, both from an electrical and mechanical point of view.

Another matter that should be touched upon is in respect to transmission systems and contact conductors. In the matter of underground cables it can be safely said that the improvements made in cable manufacture are such that the safe working pressure for underground cables has increased tenfold during the last 20 years.

As regards overhead systems in tramway working, the improvements have not been very marked, since the original methods of construction were well thought out, and with little modification meet the requirements of to-day.

In connection with heavy high-speed traction installations, the catenary method of suspension has been developed, and, speaking generally, has proved entirely satisfactory, both as regards insulation and as regards the life and reliability of the contact conductor.

In the matter of third-rail construction, the principal development has been for working in the open, and this by means of what is technically known as the protected third-rail conductor. Such conductors are now found satisfactory in practice up to 1,200 volts, the limiting pressure being determined by operating conditions and safety to human life under the conditions obtaining in ordinary working practice.

What may be termed the "slot conduit" has been developed to a high degree of efficiency. In the first conduits the working conductors were defectively insulated, and a vast amount of trouble was experienced. Eventually this trouble was overcome, likewise the many difficulties encountered with the collecting plough have been largely overcome. There is, of course, the very broad question whether under most exceptional conditions there is any justification for the very great expense incident to conduit construction. Amongst engineers there exists the strong conviction that public interests are best served by the use of overhead conductors, and that these overhead conductors are not objectionable from an æsthetic point of view, and that the great capital burden put on a tramway undertaking by the use of the conduit is economically unjustifiable. Many substitutes for the conduit have been proposed in the way of surface-contact systems, but none have proved satisfactory and none appear likely to.

As the matter stands to-day, for tramway work the ordinary trolley system is the only economically justifiable one. In the case of heavy traction work within the limits of safe working pressure, it may be that the third rail is the most economical both as regards first cost and maintenance; but the utility of the high-tension overhead system comes in force for extra-high-tension systems when the economic conditions are such as to justify very high working pressures. There is also the case of weather and other conditions where a third rail might be unsatisfactory.

Broadly, the present-day situation may be summed up in the statement that when THE ELECTRICIAN was founded commercial electric traction was of the future, and every class of apparatus necessary for car propulsion had to be developed, whereas to-day apparatus exists in a perfected form commercially applicable and mechanically suited to practically every class of demand—*i.e.*, from the simple tramway motor operating a car of 10 to 15 tons to locomotives hauling trains of 3,000 tons or more over trans-continental systems extending into hundreds of miles.

Electric Light and Power Cables.

By C. J. BEAVER, M.I.E.E.

Few branches of the electrical industry have been started on such rule-of-thumb foundations as cable making, or have been in their early days so completely enveloped in the darkness of trade secrets. Truly it was a darkness "which might be felt."

The reasons were not far to seek. Conductors had to be "insulated," and the electricians—there were no electrical engineers in those days—who required them had only the vaguest ideas as to the methods and materials which should be employed. The plant required for the manufacture of insulated wires and cables was entirely foreign to makers of other electrical equipment, and so it came about that the earliest cable works were evolved from concerns which were already dealing with products which were related to or were components of the desired article.

Some, for instance, were evolved from wire rope factories, some from rubber works, one at least from the bitumen industry and some from mills engaged on textile materials. One notable instance of the latter was a factory which was on the point of being adversely affected by the abatement of the feminine fancy for crinolines, which are understood to have been covered with cotton lappings and braidings and treated with a "preservative compound" to prevent rusting of the steel hoops.

Later one or two works were equipped *de novo* as cable factories, but the earlier ones struggled on until a sufficiently

strong combination of capital and courage made their reconstruction and re-organisation possible.

Re-organisation naturally entailed more rigid and regular methods of manufacture, but the trade secret era was not sharply curtailed ; it trailed on from sheer conservatism and the innate preference of the man with the money at stake for the devil, he knew rather than the devil he was unacquainted with.

Not more so, perhaps, than circumstances justified, because the scientifically trained man—electrician, physicist or chemist—had not really justified his existence in industrial life to an extent which would entitle him to consideration as a serious substitute for the undoubtedly mechanically clever rule of thumb and trade secret man.

Manufacturing re-organisation was naturally inseparable from the technical systematising of testing methods and procedure, and some incredible happenings of the old days (such as the short-circuiting of all three conductors of a triple concentric cable by a mass of lead escaping the vigilance of the testing staff as well as the lead press operatives) could no longer occur.

In retrospectively surveying the field of progress it should not escape notice that from all aspects of efficiency, the submarine telegraph cable was far in advance of electric light and power cables. It had firstly, the advantage of an earlier start ; secondly, the conditions under which it was used compelled a very high standard of electrical efficiency and allowed only a comparatively small margin between this and absolute failure ; and thirdly, it had the incalculable advantage of being nursed by some of the most brilliant electricians the world has yet seen.

It was, therefore, unfortunate, to say the least of it, that the dielectric material (gutta-percha) on which all the pioneer manufacturing work and a great deal of investigation of cable phenomena had been carried out, and which was so pre-eminently suited to submarine work, was not, by reason of its physical and chemical properties, suitable for electric light and power cables.

Parenthetically, one cannot help wondering whether it would not have been better for the cable-making industry if the exigencies of early electric lighting practice had imposed similar stern and definite requirements on the materials which were used and the methods of manufacture adopted for lighting and power cables.

If we contrast the standard of electrical efficiency demanded of lighting cables in the early days with that called for by submarine telegraph conditions, we at once get the fundamental reason of the slow and troublesome progress of cable practice, not only from the manufacturing aspect, but also—and to a much greater extent—from the user's point of view.

Cotton-covered wires stapled to boards and afterwards varnished often did duty at 50 volts in lighting installations, although better insulated wire installed under other conditions nowadays occasionally gets into trouble on 4-volt bell circuits.

In the same way, cheap—and consequently inferior—foreign vulcanised rubber wire sometimes stands up for a long time at 220 volts under dry and otherwise favourable conditions, but fails when exposed to condensation or other moisture conditions. Indeed, the chief fundamental difference between good and bad stuff in this connection is that the former is made to withstand the worst conditions of wiring installation practice, and the latter to scrape through under the best conditions.

In mains and feeders laid in the ground, similar comparisons hold good ; and there are many reasons connected with practice why cable troubles—due in some cases to manufacture, and in some to conditions of installation—come in battalions instead of as single spies.

In short, the great drawback to the rapid attainment of maximum efficiency has been that moderately good or even bad cables have not been readily distinguishable from superlatively excellent ones at the time of purchase, nor in many cases for a long time afterwards. Even the ultimate judgment of them has often been clouded by issues connected, not with their original quality, but with deteriorating actions consequent on faulty installation.

In spite of these discouraging conditions the British manufacture has in most cases done his part to raise the standard of efficiency, and it may be said without fear of contradiction that during the past 15 to 20 years, the cable-making branch of the electrical industry has been fully as progressive as any other branch, especially if the disadvantages just referred to as regards tardy and difficult demonstration of the excellence of his products as compared with the inferiority of those of his foreign competitor are taken into account. He has toiled patiently for many years to combat the various weaknesses which he has diagnosed from failures in practice, and his labours have also included prognosis of the behaviour of his raw and manufactured materials. He has gradually hedged in by control tests—physical, electrical and chemical—all the enemies which are likely to militate against the efficiency and durability of his products. As a result of this principle of *respice prospice* he is now in the position of not only being up to date but to a reasonable extent prepared for the future.

It is a curious fact that although the cable-maker's products form a most important part of the equipment of any installation or supply system and represent a large proportion of the capital cost thereof, they have not captivated the imagination of the electrical engineer to the extent which less passive portions of his equipment have done. There is, perhaps, a combination of reasons for this. In the first place there is the fact that the composition and properties of cables are not so familiar to him as the various mechanical and electrical components of his station equipment, and secondly, any failure in them is, as a rule, simply more or less inconvenient but not disastrous, and does not seriously affect the performance of the whole system of supply. He is perhaps inclined to regard cable failures as generally due to act of God or interference of the devil. Thirdly, there are practically no fields for him to conquer in the way of obtaining increased efficiency of performance, as in boilers, prime movers and generators. Ohms (or their reciprocal) and megohms are often regarded as the end of everything from the user's standpoint.

One outstanding feature which experience has taught, although the lesson seems to have taken an unconscionable time in the process of absorption, is that the maintenance of a cable system is a matter of the utmost importance. It is a matter which is full of difficulties and traps ; and it is illuminating to compare the histories of cable systems which have been laid out with this object in view with others in which it has been ignored. In the former the troubles are usually local and sudden ; in the latter they may be infrequent, but widespread when they ultimately occur. The type of cable and method of laying has considerable influence on this matter. Lead-covered or otherwise metal-sheathed cables having their sheaths continually bonded are much easier to maintain than non-metallic sheathed cables laid solid, because test values obtained on the former more nearly represent the true condition of the cable dielectric than on the latter. Even in the former case it pays on large networks to embody test sheaths in the cables.

To revert to the manufacturing side of the matter, it is interesting to note that the rise in working voltages adopted for extensions or new schemes during the past 15 to 20 years or so has not necessitated any general alteration in the methods of manufacture of high-voltage transmission mains, nor has it led to the production of new insulating materials. The same paper insulation is used to-day for working pressures of 20,000 or 30,000 volts as was then employed for one-tenth of these pressures. The materials have, of course, been perfected in the meantime, but the necessity for revolutionary methods which was encountered, for instance, in high-voltage generator design has not arisen in connection with cables. The susceptibility of rubber to the influence of ozone has to some extent limited its use for very high-pressure work, but as—for reasons of cost—its sphere of usefulness was already limited to tail-end connections this is not a serious matter. It is within the bounds of possibility that a more inert material having otherwise similar properties may be evolved in the future.

The general trend of advance in working voltages, together with the fact that the present E.S.C. standards of dielectric thicknesses (which only cover pressures up to 11,000 volts), not being scientifically based on electrical stress requirements, would appear to provide a very ample margin of safety, has led to a desire in some quarters to increase working pressures on existing systems, utilising existing cables. This is a step which should be taken with the utmost caution, not solely from the cable point of view, but because joints, trims and clearances also enter into the question. The majority of engineers will admit that faults (apart from mechanical damage) usually occur on their cable systems at or about joints, and the results of research on the subject show that the requirements of jointing practice appear to be on a new plane when working pressures of 20,000 or 30,000 volts (with the necessary margin of safety) are involved.

As regards the cables themselves, the pressure limitations (in perfectly sound cables) merely amount to a matter of maximum stress in the dielectric. This should not be such as to cause appreciable heating through dielectric losses, and this is one of the chief factors which determine where the commercial necessity for some form of grading enters into design.

In a high-class paper cable designed for 20,000 volts, three-phase, no dielectric heating whatever will occur at the working pressure, and its proportions are such that relatively heavy current densities are also permissible, say, 1,500 amperes per square inch on a 0·1 sq. in., or 1,000 amperes per square inch on a 0·25 sq. in. cable.

It will therefore be seen that a modern extra-high-tension cable is quite in line with the rest of the electrical equipment of an extra-high-tension supply system as regards commercial feasibility.

The Board of Trade limitations with regard to the maximum amount of power to be transmitted by extra-high-tension cables (1,000 kw.) appear not to be insisted upon in modern schemes, and in view of the extended use of protective gear in connection with extra-high-tension cables this relaxation appears to be quite sound. The various schemes of protection have affected the design and construction of cables considerably during the past few years, a notable instance being the splitting of conductors and balancing of the halves according to the Merz-Hunter scheme, eliminating the necessity for pilot wires outside and separate from the main cables. Other systems have entailed auxiliary conductors laid up in the cable encircling each core (or having conductors arranged between cores) and around the overall insulation concentric with the sheath.

There appears to be a tendency to carry these special constructions rather too far, and in view of the fact that modern multicore cables seldom, if ever, break down between cores, and that practically all failures arise from extraneous causes, it appears doubtful whether the interposition of auxiliary conductors elsewhere than near and concentric with the sheath is desirable or necessary.

Methods of laying and installing cables have not undergone much change with the passing years except in regard to details and general efficiency. So far as underground work is concerned the three systems, solid, draw in and direct laying have not been supplanted. The first named has from time to time tempted various people to evolve systems of laying uninsulated cables in compound filled troughs, always with the same disappointing results. The old Crompton culverts containing bare copper strip stretched on earthenware bridges are, however, still in existence and use in one or two places after nearly 30 years, but the lesson which he who runs may read is that conductors which require to be insulated should be entirely made in the cable factory.

Many practical brains have been busy on jointing and bonding problems, with the result that during the past 10 to 15 years the efficiency of underground cable installation practice has improved enormously and electrolytic troubles have consequently been almost fought to a standstill, for it has never been sufficiently appreciated that these factors were supplementary to that other great preventive, the Board of Trade 7-volt drop Rule for tramway earth returns.

The introduction of electric power into all kinds of places has demanded many varieties of protective coverings to resist actions of various influences, some much exaggerated, some insufficiently appreciated.

A notable instance of the former occurs frequently in connection with coal pit waters. It is seldom that a water is encountered in or about the coal measures which, on analysis, is found to be as bad as it was pictured. There are, of course, exceptional cases, but usually at the worst it is only slightly alkaline. In many cases, not only in pits but elsewhere, leakage current is responsible for the effects which give rise to fears as to the character of waters, fumes and other influences.

Mining work during the past decade has offered great scope for electric power, and considering its special character, a review of cable practice would be incomplete without some reference thereto. The Home Office Mining Regulations, issued in 1912 and revised in 1914, devised entirely from the safety point of view, have already had a marked influence on the standard of maintenance of cables in mines, and in principle are, therefore, worthy of imitation elsewhere.

They have had some influence on cable design and manufacture, both in bitumen and rubber cables. The former type of cable has been eminently successful in mining work, especially in the case of three-phase double-wire armoured cables of the solid bitumen type in which the laid-up conductors are (in effect) embedded in a cylindrical mass of vulcanised bitumen without the inclusion of hygroscopic materials of any kind. This form, which was in use prior to the advent of the Regulations, coincided with their requirements as to the inclusion of all conductors of a medium or high-pressure circuit in one metallic covering: but the case of a direct-current circuit demanded a twin cable, and at the same time, the success of the three-core cable as well as non-hygroscopic requirements made it desirable that it should be of the same type.

The mechanical pressure between the two insulated cores when laid up, being concentrated along the line of contact, prohibited similar construction: but the difficulty was overcome by interposing between them a shaped web or cradle of vulcanised bitumen so that the pressure was distributed over a large area. This cradled core construction is, of course, also applicable to multicore cables where circumstances require it. The ribbed overall bitumen sheath completes the cylindrical mass enclosing the insulated conductors, as in the three-phase type.

The chief modification as regards rubber cables in mining work has reference to the well-known "cab tyre" sheathing of trailing cables for coal cutters, &c. The Mining Regulations do not favour metallic coverings for these cables, and this type of multicore cable has many qualifications which eminently fit it for "portable" cable work.

Rubber-insulated wires and cables still hold the field for electric lighting and interior cabling for power work, and where flexibility, small bulk and non-hygroscopic qualities are a desideratum.

Although much progress has been made as regards the efficiency of manufacture since Hooper invented the vulcanised rubber cable in 1860, it is a curious fact that the general form of the various component parts remains practically the same as in the earliest days of rubber cable manufacture.

Unfortunately, most of the efforts made to modify the rubber dielectric either in composition or form have had cheapening for their main object, and this has led to many complications, the effect of which has not been fully appreciated. For instance, the degrading of the material rendered it unsuitable for the usual methods of application to the conductor. As an illustration of this, it will be found that a piece of dielectric stripped from a cheap foreign wire is capable of being easily torn along a longitudinal seam, this constituting a weakness which can easily develop into electrical faults under any but perfectly dry conditions. Now that there is a prospect of cutting out foreign competition the cable maker may perhaps live down the reproach of the stereotyped newspaper fire report—"due to the fusion of electric wires."

With reference to methods of installing rubber-insulated wires, perhaps the most popular method of latter years is that of running in steel conduit, and while in the past this has led to a lot of trouble it must be admitted that many improvements have been made as regards accessory fittings, bonding, draining and ventilating which tend to obviate the drawbacks, chief of which, so far as the cable dielectric was concerned, was condensation of moisture. There has been of late a tendency to revert to metal-sheathed rubber wires and cables in connection with certain wiring systems, and now that the importance of efficient continuous bonding is understood, lead or harder metal or alloy covered wire should come into its proper sphere of usefulness.

Lead-covered wire was severely discredited about 15 to 20 years ago, chiefly through lack of appreciation of these requirements, resulting in electrolytic corrosion by the passage of leakage currents over badly trimmed end connections; and various things, from CO_2 in the air to old battery plates in the lead pot, were suggested as the cause by bewildered wiring contractors. In conjunction with suitable fittings, lead or other metal-covered rubber-insulated wire has a great field before it, especially where full advantage can be taken of the chemical and waterproof protection afforded by such coverings.

With regard to the vulcanised rubber dielectric, there is great scope for research in the direction of determining the relationships between chemical, physical and electrical properties.

The same remark applies to many other parts of the whole field of cable manufacture. The cable maker has only touched the fringe of many of his more obscure problems, but the Augean stable has been cleansed, and scientific evolution may now proceed as freely as industrial circumstances will permit.

Some Accumulators of the Past.

By FRANK CRAWTER.

While these notes indicate a few of the milestones along the road of progress, they are necessarily incomplete and do not deal chronologically with the events referred to.

Although Gaston Planté investigated the utilisation of polarisation phenomena as far back as 1859, the commercial history of accumulators may be said to have been inaugurated in the year 1881 when Camille Faure took out his first patent for preparing the active material of lead storage cells from oxides or other salts mechanically applied to the surfaces of the electrodes and thus avoid the long and tedious formation process evolved by Planté.

In view of present-day knowledge of the uses to which accumulators have been put, it is interesting to note the applications for which Faure claimed that his patent could be utilised. In the original patent (No. 129, Jan. 11, 1881), he says: "The invention also relates to various applications of the piles and batteries constructed according to the said invention, such as their employment as powerful regulators and magazines of electricity or electrical energy." Bearing in mind the embryonic state of the electrical industry generally in those far-off days the claim for the utilisation of buffer batteries and stand-by batteries must be admitted as far seeing, but he proceeds: "The invention further relates more especially to the novel application of the system to vehicles of all descriptions propelled by electricity, as carriages on wheels, or boats and barges, by the combination on such vehicle, or on another vehicle drawing it or pushing it, of an electrodynamic machine with a polaristaion battery constructed according to the said invention, and capable of being charged at convenient intervals by any suitable means." Even after allowance is made for an inventor's claims, which, like the articles of association of a limited liability company, are usually all-embracing, one cannot help admiring the perception which 35 years ago could include practically all the leading applications of accumulators at the present time.

In the same year (1881) other patents were taken out by Sellon, Volckmar, and Swan, but all of them were acquired by one firm, who were the first to manufacture accumulators on a commercial scale in this country.

During the next few years applications for patents in connection with accumulators were filed by the hundreds, both for the Planté type and the Faure type, and there were innumerable attemps to improve both the shapes of the grids and the character of active material to be applied to them. In this connection Mr. Wade has pointed out: "Every kind of substance likely or unlikely appears to have been tried: acids, alkalies and salts, both organic and inorganic, and a whole host of other organic compounds including such familiar names as glycerine, sugar, amber, milk, and gutta-percha. If not fluids themselves, they have been dissolved in some suitable solvent, but solid bodies such as charcoal or pumice stone have also been frequently mixed with the paste to impart increased porosity to the active materials." Every conceivable form of grid was designed and patented, all of them with the object of retaining the active material in place and prevent it from becoming detached from the grid. It is of interest to note in passing that so far no departure in principle has been made in accumulator practice since those early days and that most modern types have ancestors so to speak, prototypes, who lived and died in what would be considered electrically, prehistoric times. Improvements have, however, been effected in details both in design and manufacture which while comparatively small in themselves have produced far-reaching results.

Meanwhile, the manufacturers of pasted plates were acquiring experience, and many of the applications in Faure's original patent were tried experimentally. It was about the year 1883 that Profs. Ayrton and Perry completed their electric tricycle, which the writer believes was the first electric vehicle that ever ran in this country. On an ordinary tricycle of that period they managed to place an electric motor and half a ton of accumulators, on top of which Prof. Ayrton sat to control the speed trials up and down the measured mile in Queen Victoria-street, London, under cover of darkness, when a speed of 8 miles an hour was obtained. It was closely followed in point of time by Mr. Radcliffe Ward's electric omnibus, which for a short period was housed in a building in what is now Horse Guards Avenue, on the site on which the War Office is built. In 1888 the first private electric pleasure vehicle ran in the London streets. It was a four-wheeled dog cart equipped with a battery in lead-lined wood boxes placed under the seats and provided with a 1 H.P. series motor, driving by chain on to the near side rear wheel. The effect of this design was that, when turning sharp corners to the left, the near side wheel was practically stationary and the fuses were always going. At that period, in order to avoid having a man in front with a

red flag and keeping to the regulation speed of a road locomotive, it was necessary to obtain a police permit to run the vehicle in the streets, where the noise it made with its iron tyres and its chain attracted everyone's attention, and anything in the nature of a breakdown necessitating a stop (which was not infrequent) resulted in the immediate gathering of an open-mouthed crowd. What life was obtained from the accumulators the writer does not know, as this vehicle and three others completed soon after were shipped abroad, one of them being sent to America about the year 1890, so that it was one of the first, if not actually the first, electrical vehicle in America.

The first electric launch was equipped in 1885 by Reckenzaun, and the daily papers of that period were much impressed by the fact that on a trip across the Channel the occupants of the launch were able to catch a seagull asleep on the water, so noiseless was their approach.

At that time there was very little data available regarding high-speed propellers, and on several occasions the design of propellers was altered on a novel "hit and miss" plan of taking a set of readings with the propeller as made and then, if not satisfactory, altering its design with a hammer!

The first accumulator tramcar was completed by Reckenzaun in 1884, and its public trial after experiments at the works took place early in April, 1885, when a demonstration was given on the lines in the Battersea Park-road to afford the members of the Battersea Vestry an opportunity of judging of its practicability. On the journey home the car left the track, and got back to the depot "with the hind wheels bumping over the paving stones." This car was subsequently sent to Berlin, and used by the Grosse Berliner Pferdebahn Gesellschaft.

Another early application of accumulators to tramway work was the appearance about 1886 on the South London tramways at Stratford of Elieson's electric tractor. This was to all intents and purposes an electric accumulator locomotive, which could be coupled up to the ordinary horse cars. The whole motor of the loco was arranged to revolve somewhat after the style of a modern Gnome petrol engine.

A short length of tramway from Canning Town to Barking was operated with accumulators in 1890, but the service was not long continued. The Bristol road section of the Birmingham tramways was equipped with accumulator cars in 1889, and the service was continued by various makers until 1901.

In the year 1888 Nordenfelt's submarine boat fitted with accumulators was exhibited in one of the London docks.

About 1885 the Crompton Howell cell appeared, in which both positive and negative plates were Planté type, the method of manufacture resulting in a highly porous mass of crystalline lead. The Dujardin Planté cell was put on the market soon after, and it also had Planté type positives and negatives. A number of grooved strips of lead were grouped together, with a small space between them, and connected together by casting bars of lead on to their ends.

There were also many attempts to develop the idea of the large surface offered by lead strips. In one of them alternate layers of plain and corrugated lead strips were employed, in another lead ribbon was wound into a spool on a core, which was afterwards withdrawn and a number of these spools were then mounted on a frame. At a later date the Blot plate appeared, in which two lengths of pure lead tape, one embossed and corrugated, the other embossed only, were wound on a shuttle of antimonial lead. The layers of tape were barred together and to the shuttle at one end but were cut through at the other end and left hanging free. The shuttles were then mounted in a suitable hard lead frame. With the same object of obtaining a large surface, the "Lamina" plate was made of sheets of perforated and corrugated lead, the sheets being arranged so that the corrugations ran alternately vertically and horizontally. An interesting effort to accomplish the same result, viz., an increase in surface area, was the Majert plate, which was produced from a sheet of rolled lead, which was fixed in a kind of shaping machine, and a series of parallel ribs of any desired depth, thickness or spacing were cut on its surface. The first plate on the English market having cast grooved electrodes with a central web of metal was the Epstein, which was the forerunner of the Planté type positive which is standard practice to-day.

Another line of research which was actively followed as a means of obviating the difficulty of retaining the active material in position in pasted plates was the preparation of the active material in the form of lozenges or pellets, round which the supporting grid was then cast. Among many designs of this character may be mentioned Reckenzaun's plate, in which the active material was arranged in cylindrical rods about $\frac{1}{4}$ in. diameter and 1 in. long. As the plate itself was only $\frac{1}{8}$ in. thick, these rods projected about $\frac{1}{16}$ in. each side.

In Frankland's plate the active material was in the form of convex edged tablets of the same thickness as the frame which was cast round them. The original chloride plate was constructed on this principle, the positive active material being lozenge shaped, and the negative active material hexagonal pastilles about $\frac{3}{4}$ in. across, each provided with two small holes produced by pins in the mould in which they were cast. When being made up into a plate the negative pastilles were placed on similar pins in another mould, which kept them in position, and the supporting grid was cast round them under an air pressure of 150 lb. per square inch. The unformed negatives were then reduced by various processes which left the active material in a very high state of porosity.

In 1895 the chloride "built up" positive was introduced, in which the active material consists of pure lead tape coiled up into rosettes which are expanded during the process of formation into holes in the lead-antimony grid, these being cast countersunk on both sides for the purpose. This special design with modifications in detail has been made ever since that date.

Many of the makers in the early days used to couple individual plates to the cross-bars by means of bolts and nuts, instead of casting them on or burning to a channel bar, and this together with a long plate lug of comparatively small area increased the resistance of the cells very materially.

The process of evolution, perhaps accelerated by the increased demand for higher working rates, tended towards the elimination of the pasted positive plate, except for small cells, and gradually it became standard practice to have Planté positives and pasted negatives, and subsequently box negatives, in which the plate is made in two halves rivetted together after the insertion of the active material.

A great variety of materials have been used as separators between plates of opposite polarity. Planté in his original battery employed a long piece of coarse cloth or felt, which was rolled up with the two long strips of sheet lead which formed his cell. Attempts were made by other inventors to do without any separators at all, while such substances as thin porous sheets of silica, grooved wooden combs, notched vulcanite frames at the base of the plates, and grooved cross-bars of the same material tightly wedged in at the top were also used. In one design the plates were fitted into a stout wooden frame and held in position by bars on the plate, in another the positive plates were contained in an asbestos envelope, while another employed a grooved celluloid rest for the plates to stand on and fixed a celluloid comb on the top of the plates to ensure correct spacing. For many years ebonite fork separators were largely used, then glass tubes or rods became popular, and these, in turn, since the year 1904, when wood diaphragm separators were introduced, have gradually yielded to the merits of this latest improvement in separator material.

Practically every available substance has in turn been used for the containing vessels. Circular and rectangular earthenware jars, wood lined with rubber, sheet-iron similarly protected, and lead boxes inside an antimonial crate have all been tried. In modern practice glass boxes are universally adopted with lead-lined wood boxes for the larger sizes for stationary service, with ebonite boxes for special purposes and celluloid for ignition and portable work. It is interesting to note, in passing, an opinion expressed by a well-known battery expert

about 20 years ago regarding the use of celluloid for battery work, which was to this effect : " The compounds known to the public as ' celluloid ' are far too dangerous for use outside of the laboratory, except when immersed in a non-inflammable liquid. Except on the smallest scale the most ordinary prudence must forbid the use of this substance for boxes to contain accumulators." What would be his feelings if he could see its extended use at the present time ?

One of the earliest applications of accumulators to public electricity supply was that inaugurated by the Cadogan Electric Supply Co., at Chelsea, in the year 1888. This was prior to the issue of provisional orders by the Board of Trade, and overhead mains were used throughout. The idea of the system was that all the current required should be supplied from accumulators, and on the premises of each consumer three small 100-volt batteries were installed connected in parallel, each set of cells in turn being taken off discharge and put on charge, so that two sets in parallel were always ready to take the load on each consumer's premises. At the generating station four machines were connected in series so that sufficient voltage should be available to charge the cells in each consumer's premises at once. This would represent about 1,800-1,900 volts, and one cannot withhold admiration at the courage which planned and operated such a system. It entailed in one instance seven sets of 52 cells on one consumer's premises, which were charged in series and discharged in parallel. Meantime, in 1889, the Chelsea Electricity Co. commenced supply in adjacent territory on what was considered an improved system in that the batteries were no longer on the consumer's premises but in substations, a " storage station," as they were termed, being installed for every so many consumers, the total supply being from accumulators. In each substation were installed 432 cells in glass boxes with a capacity of 660 ampere-hours at the 11-hour rate, arranged in four parallels of 54 cells each. The generating plant running at one time consisted of three machines giving 75 amperes at a maximum of 500 volts each, and were coupled in series to charge half the total number of batteries in the substation, while the other half were on the load. A considerable amount of somewhat complicated apparatus was used to obviate attendance.

Radiotelegraphy: A Retrospect of Twenty Years.

By J. A. FLEMING, D.Sc., F.R.S.

Amongst the astonishing scientific achievements of the past 20 years, covered, say, by the issue of the last 1,000 numbers of THE ELECTRICIAN, the inception and growth of radiotelegraphy takes a foremost place. Casting our glances still farther backward, we find that half a century has elapsed since Clerk Maxwell gave to the Royal Society in 1865 his great Paper on " A Dynamical Theory of the Electromagnetic Field." In this epoch-making work he proved that an electromagnetic impulse or disturbance must be propagated as a wave through any insulating medium with a velocity determined by its dielectric constant and magnetic permeability, and he based on this his novel electromagnetic theory of light. None but a few advanced physicists at that date appreciated the full meaning of it. Twenty years later G. F. Fitzgerald showed that a high-frequency alternating current in a closed circuit must create Maxwell's electromagnetic radiation, and suggested that the oscillatory discharge of a Leyden jar might be able practically to produce it. Nevertheless, although Sir Oliver Lodge was closely engaged about that time in studying the oscillatory discharge of a condenser, and had succeeded in producing stationary electric waves on a pair of parallel wires, the creation of free or space electromagnetic waves was not achieved until Heinrich Rudolf Hertz described in 1888 his remarkable experiments with an open radiating oscillator and nearly closed circuit spark receiver or resonator. Hertz constructed a condenser with the two metal plates connected by a straight thick wire, in the centre of which was a spark gap. He thus made a form of Leyden jar which had vastly greater power of creating Maxwellian radiation than Fitzgerald's closed circuit when high-frequency electric oscillations were set up in it. Combining this with a nearly closed circular wire resonator, used as a receiver, he furnished both himself and the world by this stroke of inventive genius with simple appliances for creating and detecting Maxwell's electromagnetic waves in free space. His great experiments proving that this electric radiation was susceptible of reflection, refraction and interference like rays of light and heat originated at once a new department of electro-optics, and established Maxwell's electromagnetic theory of light on an experimental basis. Hertz's ring-shaped resonator, with its minute spark gap, was, however, too insensitive for anything but laboratory experiments, and it is, indeed, remarkable that he and others should have been able to do with it as much as was accomplished.

Prof. E. Branly, of Paris, had, however, discovered in or before 1890 facts concerning the power of an electric spark to increase the conductivity of metallic powders which had previously been imperfectly noticed by the brothers Varley and by D. E. Hughes. These observations, extended by Croft, Minchin, Lodge and others gave us the appliance called by Lodge a coherer. Hence when, six months after the early and lamented death of Hertz, Lodge gave in June, 1894, a well-remembered lecture at the Royal Institution on " The Work of Hertz," he was able to demonstrate to his audience the principal facts concerning electromagnetic radiation by the

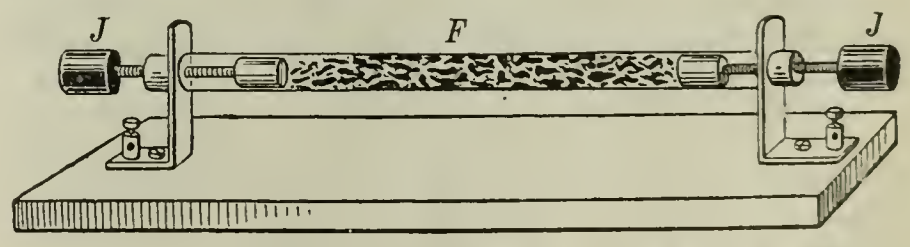


FIG. 1.—LODGE'S IRON FILINGS COHERER OR ELECTRIC WAVE DETECTOR, AS USED IN 1894.

aid of his metal-point coherer wave detector, and also one consisting of iron filings or borings in a glass tube (*see* Fig. 1).

There was no direct reference in this lecture to the application of Hertzian waves in telegraphy, though it may have been present in the mind of the lecturer. Nevertheless, it seems clear that either the lecture itself or the accumulated knowledge which preceded it imparted to several minds a stimulus which caused them to realise the possibility of electric wave telegraphy.

Two years previously Sir William Crookes had even written an article in the " Fortnightly Review " for February, 1892, entitled " On Some Possibilities of Electricity," in which he made a remarkable forecast of the coming of this new telegraphy. His ideas had probably been initiated by witnessing

some little-noticed experiments of D. E. Hughes, the ingenious inventor of the carbon microphone, made between 1879 and 1886. Hughes appears to have constructed a metallic microphone consisting of zinc and silver filings, contained between two terminal electrodes in a glass tube. This he placed in series with a single voltaic cell, and also a Bell telephone receiver, and found that the action of an electric spark at a distance was to impart sudden conductivity to the filings, and hence to create a current, and therefore sound, in the telephone receiver. He did not publish any account of these experiments at the time, having been too easily discouraged from continuing them; but many years later he put the results on record (*see* THE ELECTRICIAN, May 5, 1899).

The early forms of coherer, whether in the form of metallic filings in a tube, as made by Hughes or Branly, or the imperfect or light contact of a metallic point and plate or balls as devised by Lodge, or other numerous derivatives, were undoubtedly very capricious wave-detecting devices, requiring great patience even in laboratory experiments, and not, therefore, appearing very promising as telegraphic appliances. In spite of this, however, the telegraphic possibilities had become evident to Mr. Marconi, then a young student in Italy, and in England to Admiral Sir Henry Jackson, to Mr Campbell Swinton, Dr Muirhead, and, perhaps, several others, and more or less experimenting was undertaken in consequence. The automatic tapping back of the coherer to sensibility had already begun to engage Lodge's attention All this brought us to the year 1896, when some important advances were made. In January of that year Prof A S Popoff, of Cronstadt, sent a Paper to the "Journal" of the Russian Physical and Chemical Society, in which he described experiments made with a metallic filings coherer wave-detector, combined with an ingenious electromagnetic tapper for continually restoring the coherer to sensitivity (*see* Fig 2). Popoff employed this device not for telegraphy, but for studying the production of atmospheric stray electric waves due to distant lightning discharges His apparatus was accordingly connected to a lightning conductor He made the production of conductivity in the metallic filings by the action of the oscillations set up in the lightning rod, acting as a collector, operate a relay and set in operation a Morse printing telegraphic recorder Furthermore, by that date both E Rutherford at Cambridge, using a form of magnetic detector, and Lodge, using a coherer, had been able to detect electric waves produced by a Hertz radiating oscillator at a distance of perhaps half a mile Here then we had not only the clear conception of the possibility of a form of Hertzian wave telegraphy present in the minds of inventors, but the appliances for it in a certain rudimentary form Something, however, was necessary before these materials and ideas could be transformed into practical telegraphy. That missing element was unquestionably supplied by the work of Guglielmo Marconi, who had been attracted to the study of the subject in or before the year 1895. He directed his attention, in the first place, to the improvement of the metallic filings coherer, and, after a careful study of the structure and dimensions of previous models, he finally adopted as the best a mixture of nickel and silver filings very carefully sifted and mixed, the silver being about 5 per cent. of the total mass. A very small quantity of this powder was included between two bevelled silver plugs sealed into a glass tube, which was subsequently exhausted. Associated with this coherer was an improved form of electromagnetic tapper capable of exact adjustment, so as to administer to the tube a series of taps just sufficient to restore it to non-conductivity. He placed this tube in series with a single voltaic cell and with the primary circuit of a sensitive telegraphic relay and used it to actuate a Morse printing instrument, and so record in dots and dashes on the paper tape. The whole receiving apparatus was enclosed in a metal box. But the improvement in the coherer, though making it more certain in its action, would not by itself have been sufficient to create a new telegraphy. His great contribution to the subject was the invention of a type of radiator far more effective in making long-wave electric radiation than anything previously devised. Hertz had used short metal rods in line with each other, their adjacent ends separated by a small spark gap, and such an oscillator created waves a yard or so in length. But Marconi attached respectively to the two spark balls of an induction coil a metal plate sunk in the earth and a long aerial wire insulated at its upper end. In the primary circuit of the coil he placed a key which when pressed for a longer or shorter time caused a torrent of oscillatory sparks to bridge the spark gap, and, therefore, trains of highly-damped but very long electric waves to be radiated from the aerial wire.

Corresponding to this improved radiator, he constructed an appropriate receiver by connecting one terminal of his coherer to a similar elevated aerial wire, and the other end to the earth. Early experiments with such apparatus at Bologna showed him that he had then the means of conducting a practical method of telegraphy by electric waves capable of transmitting intelligible signals in the usual Morse code.

Coming to England in 1896, he then obtained patent protection for his inventions, and brought his apparatus to the notice of Sir William Preece. Space will not permit a detailed history

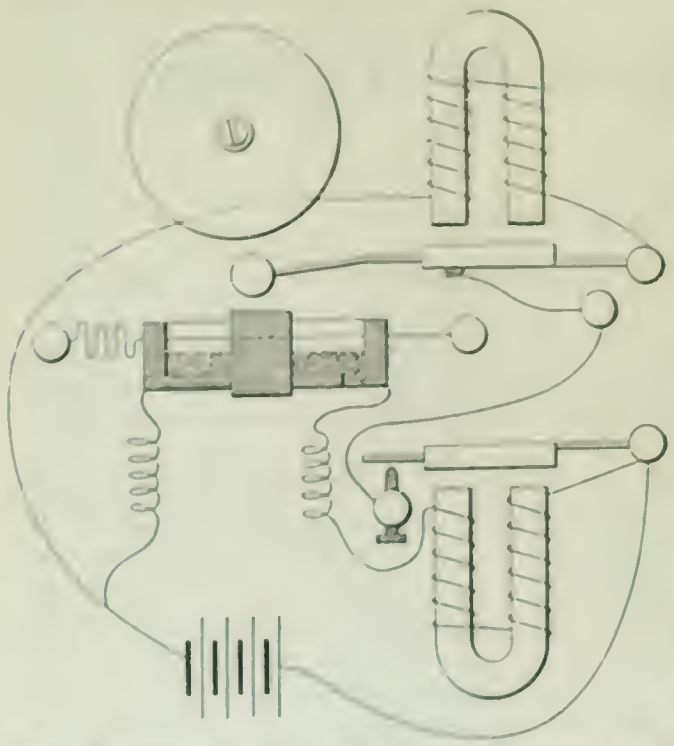


FIG. 2.—POPOFF'S COHERER AND AUTOMATIC TAPPER FOR REACTIVATING THE COHERER TO SENSITIVITY, AS USED IN 1896.

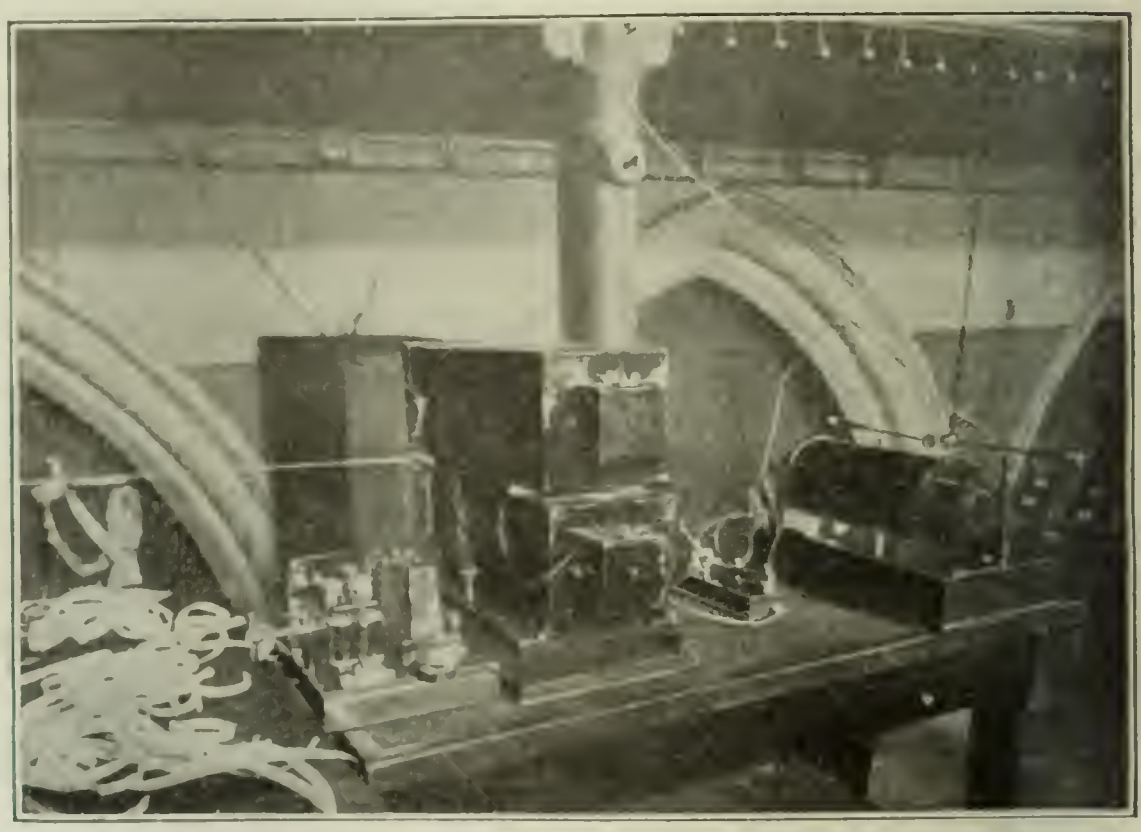


FIG. 3.—EARLY TYPE OF MARCONI RADIOTELEGRAPHIC APPARATUS AS USED AND EXHIBITED AT THE BRITISH ASSOCIATION MEETING AT DOVER IN SEPTEMBER, 1899.

of subsequent early demonstrations and improvements. Suffice it to say that the invention and use of the aerial wire combined with the earth connection changed the outlook entirely, and transformed appliances for experiments on electric waves into apparatus suitable for telegraphy in the proper sense of the word. Marconi's rapid progress was also undoubtedly due to the singleness of his purpose. He did not allow himself to be drawn away into purely physical investigations or measurements. His one aim was to transmit by electric waves intelligence to a distance appropriately reckoned in miles, and as soon as he had covered one distance he set to work to increase it. The clue to success once given, inventors began in 1897 to contribute to the subject. Sir Oliver Lodge stated clearly, in a fundamental patent applied for in 1897, the right conditions for conducting syntonic radiotelegraphy and for isolating stations, and the necessity for the employment of trains of feebly damped waves. Others endeavoured to make self-restoring coherers to obviate the necessity for the complications of the tapper. Messrs. A. C. Brown and G. R. Neilson

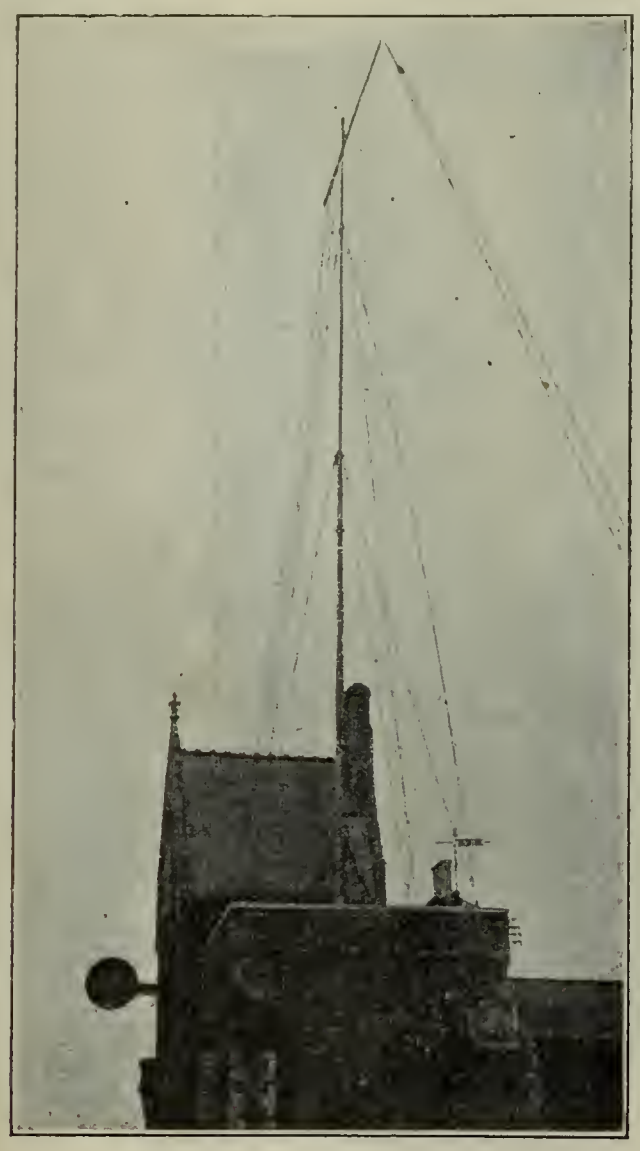


Fig. 4.—Mast Erected on the Tower of the Town Hall, Dover, in September, 1899, for Conducting Cross-Channel Marconi Radiotelegraphy on the Occasion of a Lecture by Dr. J. A. Fleming on "The Centenary of the Electric Current."

even patented at the end of 1896 the use of a telephone in series with a voltaic cell and carbon coherer as a means of detecting electric waves, thus originating the telephonic method of reception. Mr. Marconi, however, greatly improved his receiver and maintained his lead in practical achievement. When the writer first saw his apparatus at work in April, 1898, he had established it at Bournemouth in a house near the pier, and was daily intercommunicating with a station in the Isle of Wight, 12 miles away. Lord Kelvin, who there inspected it, sent several messages to his friends, and with characteristic enthusiasm insisted on paying for them at postal rates, as a proof that he thought it had reached a commercial stage.

At Easter, 1899, Mr. Marconi bridged the English Channel with electric waves, and public attention was strongly drawn to this feat of cross-Channel radiotelegraphy. Its immense practical utility was apparent to some observers, and also that it formed an ideal method for intercommunication with ships.

In September, 1899, the British Association met at Dover, and the writer had been invited to give one of the evening lectures "On the Centenary of the Electric Current." At his suggestion, Mr. Marconi's apparatus was used for public demonstrations, and messages exchanged across the Channel during the lecture (*see* Figs. 3 and 4). For the naval manœuvres of that year this radiotelegraphy was employed with striking proofs of its utility, and all naval powers set to work to use and experiment with it. The cross-Channel experiments proved that the signals could be detected as far as Chelmsford, where the "Wireless Telegraph & Signal Company," formed to operate Mr. Marconi's inventions, had their works. Hence, when Mr. Marconi returned from the United States in that year he had firmly formed the intention of attempting trans-Atlantic wireless telegraphy. As a preliminary, it was necessary to devise a transmitter radiating more power than the plain aerial already used Accordingly he began the investigations



Fig. 5.—View of the First Buildings Erected at Poldhu, Cornwall, for Trans-atlantic Radiotelegraphy by Marconi Methods.

which led him to the type of transmitter and receiver described in his British specification No. 7777 of 1900, which proved to be a master patent. Up to this stage the apparatus employed for radiotelegraphy had been of a physical laboratory type—ordinary induction coils, Leyden jars and current from a few storage cells being used; but the accomplishment of trans-Atlantic radiotelegraphy demanded the translation of this apparatus into engineering plant. The writer was entrusted with some of the duty of this work in its early stages. In the spring of 1900 Mr. Marconi selected a site for the first long-distance radiotelegraphic station on the coast of Cornwall at Poldhu. The plans for the first buildings of this station were drawn by the writer at University College, London, and the specifications for the first plant, comprising oil engine, alternator, transformers, switchboard, condenser and storage cells settled by him in the summer of that year (*see* Fig. 5). In the first weeks of 1901 the erection of the station and plant enabled preliminary experiments to be begun. At that time no data existed for determining whether the electric waves so far used, about 1,000 ft. or so in length, could be propagated 45 deg. round the earth, or whether they would glide off at a tangent. These and other problems formed the constant subject of discussion between Mr. Marconi and the writer in 1901 during the work of constructing and altering the plant and erecting the circle of masts to support the aerial wires at the site on the Cornish cliffs. Mr. Marconi preserved, however,

an unfailing confidence in the possibility of trans-Atlantic radiotelegraphy, and the result proved he was right. To record the details of all the rearrangements of plant, experiments and accidents of those 12 months would need a long chapter. Suffice it to say that, after innumerable tests and trials between Poldhu and receiving stations at Poole and at the south of Ireland, Mr. Marconi was satisfied that the time had come to see if the waves sent out from Poldhu could be detected at St. John's in Newfoundland. He set out on this quest on November 27, 1901, in the s.s. "Sardinian," taking with him some kites and balloons to elevate a temporary aerial wire. He previously arranged a programme of operations with assistants left at Poldhu. On December 11, 1901, he was able to cable to his directors that signals denoting the letter S had been unquestionably received at St. John's, coming from the station at Poldhu. This achievement was the more remarkable because the true physical explanation of it was not at all obvious, and even now mathematicians and physicists have not yet settled how far the effect is due to true diffraction of a space aetherial wave, to ionic refraction by the atmosphere, or to a surface electric wave travelling over the ocean surface. Nevertheless, it was sufficient to encourage those supplying the capital for these large scale experiments to authorise the construction of larger permanent stations.

Passing over the details of the earlier equipments of stations at Poldhu, Cape Cod, Mass., U.S.A., Clifden, Ireland; and at Glace Bay, Nova Scotia, with the accompanying unremitting labour, constant invention and countless voyages across the Atlantic by Mr. Marconi, we pause to note the unexpected effect of daylight and darkness on the long distance signalling discovered by him on a voyage in the s.s. "Philadelphia" in February, 1902. Up to that time short-distance radiotelegraphy seemed to be conducted without disturbance by the atmosphere, save that the great bugbear of all radiotelegraphists was the intrusion of false signals due to natural atmospheric electric discharges. Long-distance working revealed at this stage that waves of certain wave-lengths travelled far better by night than by day, and that the sunlit half of the earth's atmosphere seemed more opaque to this radiation than the portion in darkness. But there were curious phenomena in connection with variation of signal strength at sunrise and sunset, extraordinary differences at irregular intervals and with variation in direction whether east-west or north-south, and intrusions of natural vagrant waves, all of which required immense research to explore, unravel and overcome.

Apart from all this, evidence accumulated showing the advantages of greatly lengthening the wave-length. This implied a larger aerial and more condenser capacity, and this, again, better means of controlling the heavy discharges, and if possible directing the waves in one direction. Mr. Marconi, however, was never at a loss for expedients, and his indefatigable labours were directed to improving each element in the plant. By the invention of the bent antenna, partly vertical and partly horizontal, he gave a certain directivity to the radiation. One very important invention concerned the form of the spark discharger. In the earliest work at Poldhu fixed iron balls were used. A powerful discharge between such balls not only irregularly erodes them, but the discharge is partly an electric arc superimposed on the condenser oscil-

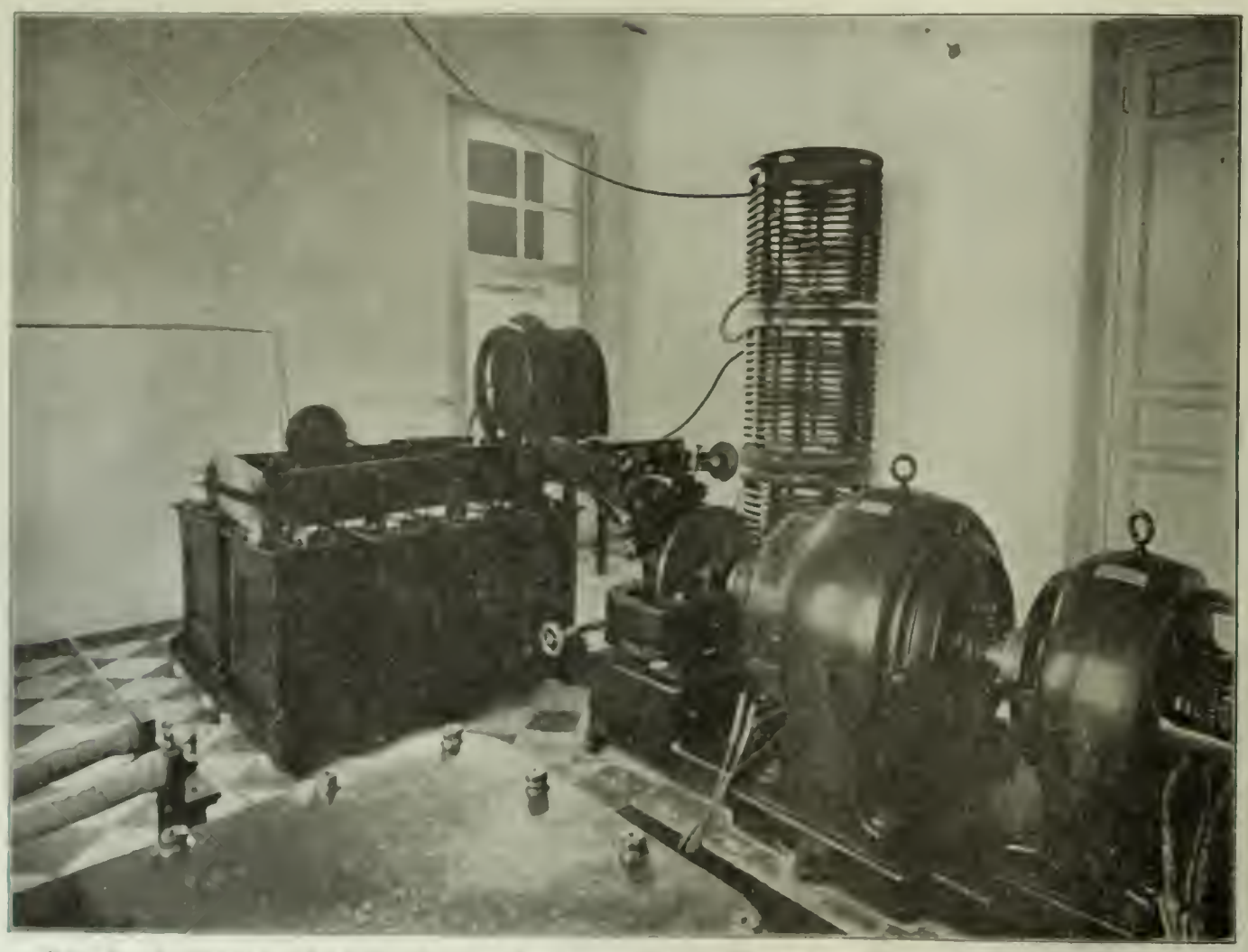


Fig. 6.—A Modern Marconi Radiotelegraphic Spark Transmitter, showing the High Speed Quenched Spark Rotating Discharger on the Shaft of the Motor driven Alternator.

latory discharge. For some years a discharger devised by the writer, consisting of two massive iron disks slowly rotated by motors, was used at Poldhu: but this did not completely prevent arcing. By his invention of the high-speed rotating studded disc discharger Mr. Marconi accomplished two things—viz., obtained absolute uniformity in the interval of time between the condenser discharges, thus making a musical discharger producing 300-500 discharges per second, and creating in the telephonic receivers a high shrill note easy to hear above the atmospheric sounds, but also he completely quenched the primary spark, and therefore eliminated all reaction between the condenser and aerial circuits. This had a most remarkable effect on the speed of signalling. In all modern Marconi transmitters the studded disc discharger is fixed on the shaft of the alternator, and rotates with it, thus providing a perfectly uniform quenched musical spark of the best kind. (See Fig. 6.)

Turning then to wave detectors, almost the only forms now used in spark telegraphy are the Marconi magnetic detector

the Fleming oscillation valve or glow lamp detector or some kind of rectifying crystal or contact and to some extent the electrolytic detector. The coherer in its various forms has been nearly discarded. The Marconi magnetic detector is a most useful and simple one for ship and military work. The Fleming oscillation valve in certain forms is more sensitive. Much work has been done in the United States in devising forms of thermionic detectors, all of which are lineal descendants of the Fleming valve. The rectifying crystals and contacts, such as Dunwoody's carborundum crystal or the zincite-chalcopyrite or " Perikon " detector of G. W. Pickard, are also widely used and a large proportion of all wireless reception is conducted by these crystal and contact rectifiers. Much work has been done in devising forms of receiving circuit which shall immune from disturbance by atmospherics. One of the problems inventors have had before them from early days is that of duplex working, so as to send and receive simultaneously.

Mr. Marconi's solution of the problem, like all his inventions, is singularly simple, and yet effective. He places the receiving apparatus at some little distance from the transmitter, and provides the receiving system with two antennæ, one large and one small placed in certain relative positions to the transmitting antenna. These are so arranged that the powerful waves from the near-by transmitter affect both these receiving antennæ, and the currents neutralise each other on the detector. But the waves from the distant transmitter chiefly affect the larger of the two receiving antennæ, and so the detector responds. This system is in operation at the Carnarvon Transatlantic Marconi station, the transmitter being at the main power station, and the receiving station 60 miles away on the Welsh coast. These two correspond with a pair of similar stations in the United States.

So far we have referred only to the progress of the spark system of radiotelegraphy, conducted with trains of damped waves. A few words must, however, be said on continuous-wave systems.

In 1900 Mr. Duddell had shown that a direct-current electric arc shunted by a condenser and inductance could produce persistent oscillations in the condenser circuit. But with the ordinary carbon arc in air the volt-ampere characteristic curve is too flat to enable high-frequency oscillations of great power to be obtained. In 1903 V. Poulsen discovered that if the arc is established in hydrogen or hydrocarbon vapour and a transverse magnetic field superimposed very high frequency oscillations of great energy can be obtained in a suitable shunt condenser circuit. This provided the means for constructing a radiotelegraphic transmitter emitting undamped waves. This had long been seen to be necessary for the accomplishment of wireless telephony, and enthusiasts hailed it as a great improvement also for wireless telegraphy. But the arc generator even in its latest form is certainly less easy to manage than modern spark system generators, and it has not made the headway expected. Modifications of it have been employed by Vanni, Fessenden, Colin and Jeance and others for wireless telephony as an experimental matter.

A certain number of arc generator stations have been established, but the musical quenched spark system maintains its position and superiority for systematic commercial working.

A more promising line of advance has been opened by improvements in high-frequency alternators. Starting from early work by Tesla and Elihu Thomson, R. A. Fessenden constructed high-frequency alternators of the Mordey type driven by De Leval steam turbines about the year 1907. In the same year R. Goldschmidt described a type of alternator in which by reactions between the fields of a stator and rotor each shunted by condensers and inductances frequency was multiplied up. Machines of this type have now been made up to 100 kw. in size, which can augment frequency from, say, 10,000 to 50,000.

E. F. W. Alexanderson has, however, by careful attention to mechanical details, built improved inductor alternators, giving frequencies up to 100,000 and output up to 50 kw., the necessary high speeds being obtained by step-up helical gearing running in oil. High-power stations for transatlantic working have been constructed at Tuckerton, U.S.A., and Hanover, in Germany, in which Goldschmidt alternators are employed. These continuous wave generators necessitate special receivers. With the Poulsen arc a form of rotating chattering contact called a tikker is used. Goldschmidt has invented a tone-wheel receiver which reduces the radio-frequency of received waves to an audio frequency suitable for affecting a telephone. R. A. Fessenden devised a very ingenious method of beat reception called a heterodyne receiver. The principle involved is that the high-frequency oscillations in the receiving antenna are made to create *beats* of frequency 300-500 by interference with a local service of high-frequency oscillations, and these beats can affect a telephone. The methods of undamped wave generation have rendered wireless telephony possible, and much interesting pioneer work has been done in this by Fessenden, Poulsen, Colin and Jeance, Vanni, Marconi and Round and by Japanese workers. Speech has been transmitted 1,000 km. by radio methods by Vanni, and in one gigantic experiment conducted in the United States it was transmitted from Arlington, U.S.A.; to the Eiffel Tower, Paris; and also to Honolulu. Radiotelephony is, however, still in the experimental stage, and has not yet been brought into a condition for commercial and regular use. We are still looking for a more simple, cheap, easily managed yet powerful generator of undamped waves.

Side by side with the work of bringing to perfection the appliances for long-distance transoceanic radiotelegraphy there has been a progressive improvement in shorter distance apparatus. The adoption of telephonic reception, of a high-speed 300-500 per second spark frequency, better means for tuning and the regulations introduced by the International Convention have largely overcome all the early difficulties. The highly efficient radiotelegraphy of the British Navy is not a little due to the work of Admiral Sir Henry Jackson, who was a very early worker in this field. Marconi's Wireless Telegraph Co. brought to great perfection, many years ago, an inter-ship and shore exchange radiotelegraphy; and the General Post Office took over in 1910 the coast stations, and connected this ship communication with the General Post Office telegraphic system.

Referring, then, for one moment to scientific researches in connection with radiotelegraphy, it may be noted that these interesting problems have attracted to their study a large number of eminent men. The mathematicians have endeavoured to determine how far true diffraction can account for the propagation of electric waves round the earth. Radiotelegraphic waves can be detected at least a quarter of the way round the globe if of suitable wave-length. Prof. Macdonald and Prof. Love have shown that diffraction may possibly account for nearly all the effect during daylight. There is, however, an abnormal range at night, and the only theory which seems to explain this, and also the diurnal and irregular variations, is that of ionic refraction, proposed by Prof. W. H. Eccles. Meanwhile, very large scale experiments have been made by Dr. Austin and Mr. Hogan with the aid of two United States cruisers, by means of which an empirical law of variation with distance for daylight propagation over sea up to about 2,000 miles, has been determined. There are curious absorptive effects over land, due to soil or to vegetation, and great irregularities in the nocturnal signal strength.

Much research has taken place on the atmospheric stray waves. Senatore Marconi, Dr. Eccles, Messrs. Round and Tremellen and a host of other workers have contributed knowledge. At a meeting of the British Association at Dundee the writer proposed the formation of a B.A. Committee on radiotelegraphic research. This suggestion was adopted, and a strong Committee formed, but the outbreak of the European war has restricted its work. In most countries there are now special institutions or societies devoted to research in wireless telegraphy, and many periodicals are published in various languages as a result. The great increase of amateur and national radiotelegraphy, combined with the fact that there is only one æther for us all, has compelled the Governments of all great Powers to enact legislation to control it. Three great International Conventions have been held

in 1903, 1906 and 1912 in Berlin and London for the discussion and settlement of regulations for radiotelegraphy.

In 10 years it has become an absolutely indispensable means of intercommunication between ships and the shore, and for naval signalling and scouting. At least 5,000 persons owe their rescue from a watery grave in shipping disasters to its operation, and every passenger vessel is now compelled by law or public opinion to carry wireless apparatus.

All this constitutes a great achievement in the short space of little more than two decades. At the beginning of that time electric waves were the interest only of philosophers concerned in exploring the hidden things of Nature or the mechanism of rays of light. To-day the same ethereal waves, increased ten thousand or a million fold in wave-length, ferry our messages across the great oceans of the world: give to every ship a life line by which to call for help; furnish every battleship with an ear and voice ranging over 1,000 miles; and permit an aeroplane or dirigible balloon floating far above the clouds to converse with its base of operations as if it were only a dozen yards away. But these great feats are not merely the result of scientific invention or engineering skill. They are partly the product of business ability and organising power. Everyone who, like the writer, has been closely in contact with the industrial applications of scientific invention for 30 or 40 years will have had abundant opportunity of observing how essential is that indefinable quality we call business ability to their practical success. This business acumen, resource and organising power is absolutely necessary if permanently useful results are to be obtained from scientific discoveries or inventions. We are by no means yet at the end of the possibilities of radiotelegraphy. The effect of this great war, and the victory we trust it will bring in good time to the arms of the Allies in our fight for right and freedom against an immoral militarism, must be to increase the cohesion of the self-governing nations which form the British Empire. That closer union will necessitate more and better facilities for intercommunication. It implies amongst other things—the extension of long-distance radiotelegraphy. The daughter nations (Canada, Australia, New Zealand, South Africa), which have sent their sons to bear such an heroic part in this stupendous struggle for life or death with the Teuton and the Turk, will henceforth demand a larger voice in Imperial affairs, and to be in more direct touch with the Government of Great Britain on all these matters. An essential condition is that our means of instant communication between the periphery and the centre of the Empire by wireless and by cable must be multiplied and cheapened.

These great Dominions must be bound together into a coherent and mighty Empire, not only by a common language, commerce, literature and political ideals, but their means of intercourse across wide oceans must be secured by the utilisation of all the resources of science, and the perfecting of our methods of telegraphy, whether by guided or unguided electric waves.

Technical Research.

By J. SWINBURNE, F.R.S.

Since the beginning of the war much has been said and still more has been written about the importance of encouraging scientific research in this country. We have been told that we are far behind Germany in research, as in most other matters and that we must copy her methods in commerce and technology. Some who have studied the matter, and, what is important, give reasons for all they urge, say that Germany before the war was in a perilous way financially. It is said that she had brought this about by a policy of restraining her foreign trade through ignorance of economics, selling her goods abroad very cheap, thus subsidising the purchasers at her expense; and giving credit to an abnormal extent. It is also said that the rotten state of trade resulting from this was causing much misery and discontent, and the country was getting ripe for revolution, and that internal difficulties of this sort coerced those in power to plunge Europe into war, much as somewhat similar circumstances caused France to go to war in 1870. I do not say on my own authority that this is fact. I am a student of such matters, with no right to speak authoritatively. I may be quite wrong. However, here we have Germany fighting an insane war, which anyone who knows anything at all about economic realities must involve her in loss, directly or indirectly, of several thousand millions, even if victorious, and could not possibly leave her any sort of compensating good whatever. Surely this is enough to shew that we should not take Germany as an example. It is possible that there are many things done better there, and we ought to copy from and improve upon them in special cases, but it is absurd to assume that we have everything to learn from our enemies. We may, for example, copy their clean and orderly factories, and their courage in investing money in the development of scientific technical processes, because there are outside reasons for supposing well-organised factories and vigorous development based on the knowledge of able technologists is sound. We may, on the other hand, avoid the Government interference with commerce, which is so marked in Germany, because there are outside reasons for considering it pernicious. We may copy the Germans in not investing our savings in the ordinary limited companies that waste such a large proportion of this country's wealth: but whether the German "banking" system, so called, is worth transplanting is a question for financial experts to decide. By a financial expert I do not mean necessarily an English banker. He may be a very successful banker understanding his practical business thoroughly, and yet he may know little of the theory of banking, and may be uncertain whether he is really a creator of credit, or a pawnbroker of securities. Neither is a student of the theory of money the right person. Still less are the irresponsible dicta in newspaper articles to be considered. It is really a question for the various manufacturing and financial houses to settle. If the German banking system is good it will probably be introduced here by the experts concerned without the help of uninformed outside opinion, however freely and generously expressed.

There seems to be a fundamental confusion regarding two different things in the advocacy of scientific research. Physical and chemical science are a fabric of inter-connected and organised knowledge. We are always increasing this complicated structure by finding new parts, and tracing the interconnection of the parts already found. Such a fabric of knowledge might conceivably exist without being utilised at all by man, except as a means of satisfying his scientific cravings and at the same time sharpening his appetite for more. This fabric is what is sometimes called pure science. The knowledge may be applied to the practical uses of man, and the part so utilised is often called applied science; and

such applied science is generally specially developed because of its utility.

If science were developed solely with a view to practical utility it would soon stop. It would begin by getting uneven, with swellings wherever it happened to be useful, and atrophy everywhere else. It is therefore best that, as a whole, it should be developed by a special type of man working with the single-hearted endeavour to develop a wonderfully complete fabric with all its interconnections and interlacings beautifully laid out. But when this is done, what is the good of it? Is it, like one of the old systems of philosophy, merely an interesting exercise for the mind with no ulterior use? It may be said it provides a splendid training for the mind. No doubt it does. We are told that the sham Latin and sham Greek of the public schools are splendid training for the mind; surely no scientific man degrades science to the level of bogus Latin verse. The real value of science is in enabling man to cope more successfully with his environment. We thus get two types of research; involving different objects, largely different methods and different training, knowledge and experience. Yet they are both commonly called scientific research. Thus Maxwell's theory of light led Hertz to prove its truth experimentally. Hertz's work was made without any idea of any sort of direct practical utility. This is one kind of scientific research. I met Hertz about 25 years ago, and found he did not know what a transformer was. Very soon afterwards Hertz's work led to wireless telegraphy. In connection with that we have researches made on all sorts of crystals of ores for detectors. Here we have technical research. The knowledge obtained did not increase the sum of pure or raw scientific knowledge, but it was valuable commercially. In numberless cases purely scientific knowledge has unexpectedly become useful to man; but it generally serves as the starting point of elaborate technical research, which demands quite a special kind of knowledge and experience. Yet it is generally taken for granted that the two kinds of research are substantially the same, except that the technical advance can be made by an inferior type of man; and that the knowledge and experience of the votary of raw science enables him to do the technical work with no difficulty if he condescends to tackle it. Take as an example a moulding material now largely used as an insulator. An Austrian technical chemist was trying to evolve a new scent or disinfectant; it does not matter which, as they are so similar. He produced a body accidentally, which he found he could work up into an amber-like material; it is a condensation product of formaldehyde and phenol. But to make this body commercially meant a great deal of very tedious and uninteresting work, involving much fume and smell, and the undesired solidification of masses of hard insoluble mess, choking the apparatus or boiling over and choking the premises. It also involved an incredibly sticky material which spread itself over everything with even more pervasion than marmalade worked by a competent child. Of what use would a professor of organic chemistry be in such a case? He might give a list of all the condensation products of all the aldehydes, and all the phenol and kindred bodies. That information would be of no use, and is already obtainable in books of reference. As to the control of the process with phenol and formalin the technical experimenter would be far ahead of him in a week. This kind of work has no purely scientific interest, and would not raise any enthusiasm in one who had not the instincts of the practical inventor.

Take another example. Prof. Remsen, in a search for knowledge, produced a body with an extraordinarily sweet taste. He was not aiming at anything to do with taste. This he called "saccharin," and it has come to be of great commercial value. The original methods of getting from toluol to saccharin were all right for laboratory purposes, as cost was unimportant, but an immense amount of investigation has been carried out in getting cheaper methods. Such work is technical research. It is of little or no purely scientific importance or interest; but it is very valuable all the same.

To settle what ought to be done to further technical research we must discuss its object. Do we want to do good to mankind at large, civilised man, or only to our countrymen? If someone makes a discovery like the dynamo, and publishes it so that all can make generators, it is conventional to say that he has conferred a great benefit on mankind. The sociologist may object: "No; owing to the pressure of population the only result is that a few more people can live, but each individual is no better off." It may be answered that civilisation involves beside a higher standard of comfort, increase of knowledge, and that as man becomes more sensible he gets happier. But few really take much interest in the remote chance of making man generally more sensible when they are inventing dynamos. The general idea is that we should develop technical research so as to benefit England either in comparison with, or, more generally, at the expense of other nations. The ordinary so-called educated man, who has the usual newspaper nightmare negative knowledge of everything connected with sociology and economics, is, of course, quite positive that we can benefit only at the expense of other nations. It is impossible to discuss such matters with him. A few, however, will urge that what is wanted is to benefit England in comparison with other nations. The sociologist may say: "The pressure of population will merely increase the number of Englishmen without increasing the welfare of each, so what is the good?" The answer will be almost unanimous. It will be, "Bother the sociologist." As the sociologist, if his argument prevailed, would make my writing this article useless, and as I like writing it, I will tell him that it is of paramount importance to increase both the population and wealth of this glorious Empire, so that we can maintain to the full the resplendent heritage of our naval and military pre-eminence, which ensures that the sun shall never set on our smiling people. No self-respecting sociologist will discuss with anyone who talks like that; and I can continue on the assumption that the object is to help England without helping other countries at the same time.

To help England alone no research need be considered, unless the results can either be kept secret or patented abroad. Sir Norman Lockyer advocated the State devoting a million or a hundred millions or some other nice sum to science to help England. Apart from any confusion as to "science," such expenditure would all fall on England, while the benefit would be spread among humanity. Various schemes of endowment of scientific research are very popular among science teachers, and naturally so, because they would enhance their reputation and increase their incomes; but such endowment would not do the country any good, it would merely cost money.

It is now urged that we should have State assisted technical research. Consider an example. A cable maker would like to discover a new and better dielectric. He has spent £10,000, and is considering spending £10,000 more on technical investigation. The "publicist" comes along and says: "Don't do that; give £10,000 to State officials: they will form a committee and do the work for you." The cable maker knows exactly what he wants and what the difficulties are. He also knows all the men in the trade who could tackle such a problem. The Government knows nothing. It would appoint a committee of science teachers who had no knowledge of technology and no experience in technical research. Such a committee would be quite useless. The cable maker could do much better without it. If, instead of one case, we have a cable maker and a steel works each subscribing £10,000, the committee is just as little use; and it remains just as useless if all the industries are taken together. Neither does it help if the money is voted by the Treasury. It is true that the public think money voted by the State comes from the clouds without expense to them; they also think that the State is more efficient than individuals. Belief in the State is evidence of the uninformed mind. Any one manufacturer may think he may score by getting a benefit at the expense of the generality of taxpayers, but as a whole, Government research could be good only if done more efficiently than by private enterprise. It is vastly less efficient for several reasons.

Let us consider its origin and working. The English are considered modest because they belittle their country. Instead of pooling our vanity and saying everything English is good, we

display it on individualist principles. When an Englishman says that the English are ignorant of science, muddlers, unmusical, prejudiced, unenterprising, and so on, he always means that other Englishmen are inferior to him in these respects. When Carlyle wrote of thirty million people, mostly fools, he never for a moment realised that he might be one of the most considerable. We are, in fact, all fools in everything, but, at most, a bit of one subject each. It is generally the bit by which each gets his living.

It has become the proper thing for newspapers and publicists to say that English manufacturers are out of date. A publicist is a man with a ready tongue or pen who teaches the world how to roll. He may have considerable miscellaneous knowledge, often not digested or co-ordinated, but generally he has no qualifications. He may have made his name familiar as a novelist, and once his name is known he is an authority on everything. The next step is to call on the Government to take the matter up. Incompetent people always call on the Government. The politicians then fear they will lose some votes if they do nothing, so they appoint committees, and in the case in question the best plan was to make them up of science teachers, because they have been making a fuss, and because they and the public think they are technologists. The result is that a number of men who are very able in their own sphere generously give a great deal of time to matters which are outside their knowledge, training and experience. They will have a very difficult task. In the first place they will not have any idea what researches to make. Though that is an admission of the absurdity of their position, they can ask technical societies what they are to do. Unfortunately technical societies are not manufacturers; but they will no doubt make many suggestions, and help as far as they can. But why not ask the manufacturers? Probably because the manufacturers do not know either; however willing they may be to give the committee every chance. Imagine a manufacturer approached by a committee, who says: "You do not understand your business, and you are effete and out of date. We are appointed by the Government at public expense to put you right. We have no knowledge of your business, but we are so scientific that we can teach you it, and put you right. Just tell us all about your work, and, in particular, tell us the research you want made." It would be put more politely, of course. The manufacturer will say: "No practical knowledge. P.R.S. means 'full of raw science' to the exclusion of technology and common-sense. But as the public pays, I might get something for nothing, so I'll help. Please, therefore, produce a good accumulator without local action. I have done some work on it; you shall have the results in confidence; and if there is any progress I must have the patent here and abroad; no rival English manufacturer may know. The work must be confidential, and you must publish nothing. No papers before learned societies, please, and no kudos for you." The next man would like an incorrodible steel on similar terms. No one who has had any experience of the development of inventions would dream for a moment that committees of science teachers could do anything to help.

It may be said very fairly that I am merely criticising what is being done instead of saying what ought to be done. It is not necessarily my business to tell the manufacturers what they ought to do. I would be trespassing on the province of the newspapers and the publicist, not to speak of the science teacher; and I am disqualified, as I have had a little to do with manufacture; enough in fact to teach me that the manufacturers are much more able to manage their affairs than I am. There is one common-sense course which it does not require great knowledge to point out. The publicists and the newspaper writers might confine themselves to matters they know about and understand. This would dessicate the inky output of many. All the better. Then science teachers might devote their attention to teaching their students instead of manufacturers. Why have not their pupils taken command of technology by this time, and driven all the old-fashioned ignorant manufacturers to the wall? That they have not done this shows either that science, as taught, is wanting, which I for one do not believe; or that manufacturers are competent. Generally, what appears to be needed is that we Englishmen should stop shouting about everybody's inferiority to each of us, and each of us should put his whole energy into his own business. I will therefore close, and, like Voltaire's hero, will go and do some work.

But just as a final diversion I would suggest that though we are told our trade is all rotten, and that Germany was wiping us out, it might be well before believing it to look up the returns as to British home and foreign trade as far as available, making diagrams comparing us with America, France and Germany. We might find that the whole outcry is due to the ignorance and conceit of clamorous and irresponsible scribes, and that the world was going very well with us, and that we were really thriving. But I make no statement; I am not an authority. I merely suggest that such matters are worth examination before assumptions are made and policies based on them.

Development of Electric Power Stations.

By P. V. HUNTER.

A retrospective view of the progress of electric power station development is one of the pleasantest subjects that can engage the attention of electrical engineers. At no time could such a review be more opportune than the present, when as a result of the war the whole of our industrial activities are under critical consideration.

Contemplation of the consistent, rapid and sound progress which has marked the stages of development is an inspiration for the present and reassurance for the future. It makes a peculiarly personal appeal to each of us in a manner most difficult to define and elusive in its origin. Not the least interesting part of the appeal is a curious feeling of the unreal, similar to that experienced when looking at near-by objects through the wrong end of a telescope. We seem to have advanced so far since power station loads were computed in terms of eight candle-power lamps, and yet most of us remember brightly the excitement experienced when the necessary number matriculated each year to produce a crescendo curve of maximum load.

A feeling of personal interest is also given by the fact that power station development, as we know it, has not been the work of an individual, although Parsons' development of the reaction turbine has had an important influence. No one stands, however, in quite the same relation to power station development as do Newcomen and Watt to the industrial application of steam, and Stephenson in its application to railways. We feel, therefore, that power stations have developed rapidly and soundly because of the co-operative effort of elec-

trical engineers as a whole, in which each can take a personal pride.

Nothing would be easier than to produce flattering statistics comparing our present position with an earlier one. Whatever date we might chose for the basis of the comparison the result would be the same, as progress has been both rapid and continuous. Statistics are, however, at their best a somewhat mechanical means of self-congratulation, even when expressed in those graphical forms with which our confrères in the United States of America have made us so familiar. The graphical representation of how much electric light a dollar will now buy, or the number of units produced per cubic foot of power station, or per ton of coal, compared with the conditions of 10 or 20 years ago may, in capable hands, convey a striking impression, but seldom an entirely correct one. Such comparisons tend to magnify the present at the expense of the past. They engender a sense of self-satisfaction atrophying in its effects and completely out of consonance with the spirit of the present times.

The work of our pioneers deserves a great deal more thoughtful consideration than can be deduced from comparisons on a superficial statistical basis. It will be found on examination that their methods were usually admirably adapted to the requirements of their circumstances, often, it would appear, more so than those of the present day.

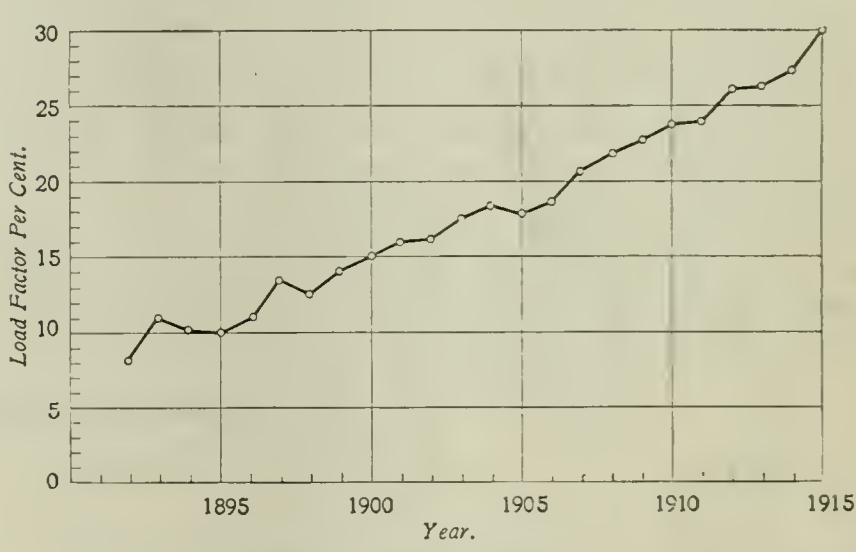
The builders of these early stations were faced with the condition that the cost of coal was one of the least important items of their expenditure, and the cost of capital the most serious. As a result, the early power station was characterised by simplicity in conception. In general it presented some degree of complication in appearance due to the requirements of a site whose principal merit consisted in a central situation with respect to the load and whose greatest disadvantage was a high cost per square yard. The coal was carted, the boilers were hand fired, the draught natural, the prime movers simple steam engines working at low pressures and exhausting to atmosphere, and the generators belt-driven. Their load was purely lighting, and had an annual load-factor of 8 to 10 per cent. Even to-day such apparatus as superheaters, condensers, economisers, mechanical stokers and railway sidings would be expensive luxuries with such load-factors. With the gradually extended use of electricity the load-factor improved, and these useful aids to economy in coal and labour were adopted, but in each case only when the load-factor justified it. Also steam pressures and temperatures were raised when the economy obtained more than balanced the cost. Long after condensing was established it did not pay to move power stations to distant riverside sites. The cost of transmission at the pressures available was prohibitive, while a comparatively small and cheap cooling tower would produce on any convenient site all the vacuum that a reciprocating engine could usefully employ.

There are many early power stations existing to-day the designers of which are criticised for their choice of site, although under the conditions existing at the time the sites were the most suitable. All that can be urged against them is that the designers did not anticipate the development of the steam turbine coupled with high-tension transmission.

The advent of the steam turbine produced a revolution in power station siting and construction, largely because high-tension transmission was at the time sufficiently developed to allow considerable freedom in the choice of site. As a result, power stations were erected in situations which suited the characteristics of the turbine, namely, those offering a plentiful supply of condensing water. Power station progress consequently entered upon an entirely new line development, the general lines of which have not been departed from up to the present.

Our pioneers had developed on the lines of improving the thermal cycle. From the simple steam engine taking steam at 100 lb. pressure and exhausting to atmosphere, which best suited the load-factor of the pioneer station, they passed to higher pressures, compound, triple and even quadruple expansion, superheated steam and adopted condensing. Each of these steps marked an improvement in the thermal cycle The steam turbine found conditions at the stage when all these improvements were in common use. In the fact that it could successfully employ a higher vacuum than the steam engine the turbine was itself responsible for an improvement in the thermal cycle. During the last 10 years or more no further step in advance on the lines of improving the thermal cycle has been made in power station practice. Engineers have been content to develop in the direction of improving the internal efficiency of the turbine and reducing its capital cost per kilowatt by the development of sets of increasing size and speed.

The economical advantages obtained in this way have led to the cheaper production of electricity, increased sale and improved load-factor, which in their turn have permitted the use of still larger turbines. These conditions have mutually reacted on each other in a manner which has produced an extraordinary development. Some indication of this is given in the accompanying curve, which shows the annual load-factor of one of the larger supply undertakings from its beginning to the present time. The large power stations which were thus rapidly evolved sought further and further afield for their load. With each extension diversity improved, and as a consequence of the cheaper cost per kilowatt of the larger plants, and the greater use made of them due to high load-factor, the cost of producing electricity fell rapidly. Engineers come to look upon the cost of transmitting electricity as unimportant, since their experience showed that the further they transmitted the larger the load, the higher the load-factor and the better the result.



At the present time, although the condition has not actually been reached, it is possible to see approaching the end of this line of development. Experience with the larger units both of boilers and turbines which have been built in the last few years shows that with the present thermal cycle the curves of steam consumption and capital cost per kilowatt become very much flatter, and there is obviously a size of unit beyond which it will not be economical to go. There is evidence of this in the fact that the largest sizes of turbine are already built as two or three separate high and low pressure machines, each with its own alternator. The reason that these limitations have only recently become apparent is that in the past the smaller units did not permit of the materials being used to their fullest advantage.

The approach of this condition is of the greatest importance, as it will mean a reconsideration of the whole of our present day lines of development. With the limitation to the most economical size of unit, using economical in the sense of the one which gives the best result both as regards capital expenditure and operating costs, it will no longer be possible to obtain improvement by increasing the size of power station ; in fact, at a certain point such procedure would be the reverse of economical as any increase in the size of power station would incur the disability of increased cost of transmission as compared with, say, two power stations supplying the same network from different points. As a number of power stations supplying the same network in parallel have the same load-factor as a single one running under similar conditions there

will be a tendency to increase the number of power stations supplying a common network. We are, therefore, now in sight of the limits of the advantage to be obtained by increasing the size of unit and size of power station. If we are to progress in the future as in the past we must seek another outlet. It is possible that this will in the initial stages take the form of a return to the improvement of the thermal cycle.

Theoretically we can improve the thermodynamic efficiency of the process of converting the chemical energy of coal to mechanical work to a figure approaching 90 per cent. This compares with a theoretical efficiency of only 45 per cent. attainable with steam plant, even at pressures much in excess of those at present in use. It is this enormous margin which is the inspiration of gas engine and gas turbine research, but so far the difficulty of dealing with the vastly increased temperature range with the materials at our disposal has made progress slow. The gas turbine is still an ideal, and even the great progress which has been made with internal combustion engines is in special directions where relatively small units of power are required. Present indications show that long before the combined capital and running costs of large turbo-alternators can be approached by internal combustion engines constructional difficulties intervene which increase the cost per kilowatt and cost of operation and thus much more than neutralise the increased thermal efficiency.

It seems more probable therefore that developments in the immediate future will be in the direction of improvements in the thermal cycle of steam turbines. Dr. Ferranti has already shown the way with his reheating proposals which were conceived in the true spirit of the pioneer. In considering these and similar schemes it must be remembered that under present load-factor conditions coal is a much larger item in the total cost of production. This, coupled with the steady increase in the market price of coal, means that any material reduction in the coal per unit would justify appreciable increase in capital charges if these should prove necessary.

The precise form which will be taken by any permanent advance in the thermal cycle will depend purely on the relative cost of the various alternatives or combinations of them, and will be settled only by experience. With the magnitude of the annual coal bill as an ever present incentive we may reasonably expect to see some substantial improvement materialise in the course of the next few years.

When the limit has been reached in this direction, and conditions are such that even with 100 per cent. load-factor the cost of improving the thermal efficiency is not balanced by the saving in fuel, we shall still not be at the end of our resources. It will then be necessary to widen our fields and utilise coal to greater economic advantage, recovering from it those constituents which are of greater value for other purposes than as fuel, and utilising only the balance of the constituents for the production of electricity. It is indeed probable that such processes will be developed concurrently with improvements of the thermal cycle. In any case improvement of the thermal cycle will tend greatly towards their adoption. A substantial difficulty with such by-product processes in the past has been the limited quantity of waste heat available from each ton of coal coupled with the inefficient methods of producing electricity from heat. As a consequence a large power station run in this manner would require a by-product works so large that the capital cost and commercial risk involved would deter even the boldest. It is important, therefore, to remember that every improvement in the thermal cycle brings such schemes nearer realisation. In fact, the one may be regarded as complementary to the other.

Another difficulty in the application of such by-product processes has been that for economical working they require to be continuous. They thus suited exactly the conditions of gas works, which owing to the ease of storage can run at a constant output. Since the storage of electricity in bulk is not a commercial proposition the only way in which power stations can attain similar running conditions is by improvement in load-factor. Recent development in this direction has been so rapid that the combination of the power station and the chemical works is even now a commercial possibility. In any case we may rest assured that in many directions electrical engineers will have an outlet for that spirit of enterprise and co-operation which the war has excited, and which we all hope will be of lasting benefit to the community, and bring some compensation for its destructive effects.

Boiler Development, 1882-1916.

By D. WILSON.

To engineers who have passed through the Darlington station there is probably no better reminder of the tremendous progress in steam engineering than the old Stephenson engine there exhibited. This represents the first locomotive used in England, being built about the year 1824, and the evolution of the steam boiler as a separate unit is equally impressive when traced back to the "Origin of Species."

About the year 1882 an electric light exhibition was held at the Crystal Palace, and a large number of engines and boilers were assembled, both for exhibition and for running the electric light. The type of boiler that seemed to be gaining most favour at this time for electric and for lighting purposes appears to have been the locomotive type, combined with an engine.

In the early days of electric lighting such a plant was used under the arches at Cannon-street station, a Ferranti alternator being belt-driven from a new compound engine with boiler combined, the latter being supplied by Messrs. John Fowler & Co., of Leeds, and considered the latest thing for the purpose. But even prior to this date, viz., 1881, an electric light station, about which too little has been written, was founded at Brighton as an outcome of the Public Health Exhibition held there, Mr. Arthur Wright, who had charge under the old Hammond Electric Light & Power Supply Co. (Ltd.), converting the old engine shed in North-road into a primitive electric light station.

A picture of this station used to be attached to a certain old catalogue. It showed the interior of the station, consisting of a heterogeneous mass of combined loco engines and boilers of various sizes, dynamos, belting and countershafting, in the midst of which there was a solitary figure of an engineer, who appeared to be unable to extricate himself from the tangle, or was undergoing a sort of pillory punishment.

At the Eastbourne station, controlled by Messrs. Lowrie, Hall & Kolle, loco engines and boilers were used to run the dynamos, but at the Hastings electricity works, started about the same time, three Lancashire boilers were used.

Apart from the electric light industry, however, the Lancashire boiler, with its counterpart the Cornish boiler, was very largely used wherever any other plant of large power was installed, so that this type, gradually improved from year to

year in the method of its manufacture, in the bending, drilling and rivetting of its plates and in the quality of its material, &c., came to be considered the only unit capable of generating steam on sound lines, until a competitor appeared in the shape of the water-tube boiler.

Engineers were generally well aware of the attempts that had been made for many years prior to this period, to put on the market a thoroughly practical water-tube boiler, and some of them may have come to the conclusion that it was more of an engineering fad than a fundamental improvement. In spite of this feeling, the Lancashire boiler is not so much the senior of the water-tube boiler in its origination, for it was only in 1844 that the Lancashire type arrived, whereas Stephen Wilcox took out his patent for water-tube boilers in 1856.

In America, water-tube boilers were steadily gaining ground, and about the year 1885 were sufficiently powerful to throw out an offshoot which took vigorous root in this country, and began to appear in the very home of the Lancashire boiler, and in Scotland.

At this period the electrical industry, which had been retarded by the disastrous Electric Lighting Act of 1882, was

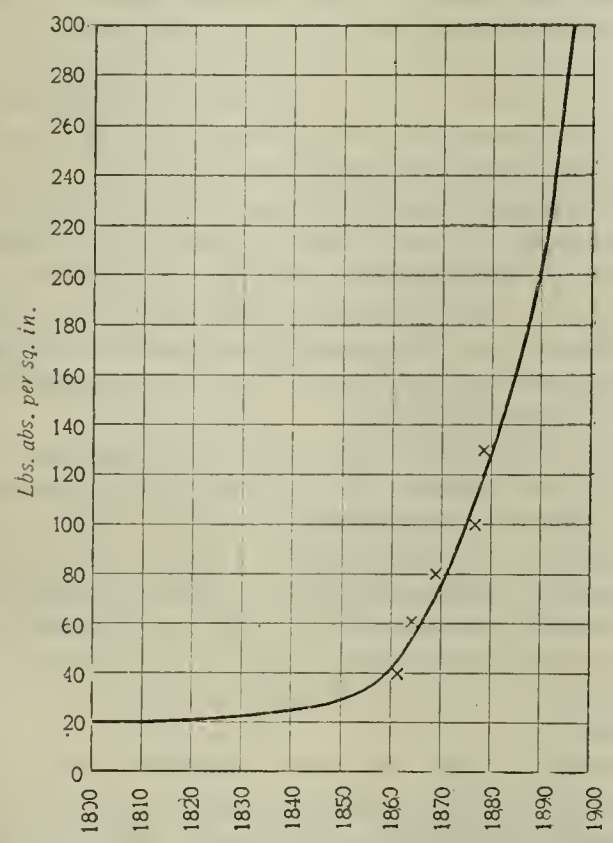


Fig. 1.—Progress in Steam Pressures from 1800 to 1900.

struggling for the position which it was destined to occupy in the future, and amongst the first installations in connection with a modern power station, put down by the House-to-House Electric Supply Co., the water-tube boiler appeared, this station being intended as a model of future electricity works in this country.

Another principle prominent in connection with the water-tube boiler was meantime steadily working in the engineering world to the advantage of the water-tube boiler as compared with the Lancashire boiler, viz., the question of steam pressures.

From the diagram, Fig. 1, it will be seen that the pressure of steam had gradually advanced from atmospheric in the early days of Watt, to 25 lb. to 35 lb. per square inch in 1860, 65 lb. per square inch in 1870, 120 lb. in 1880, and even 200 lb. was being considered in 1890. This principle undoubtedly assisted the rapid growth in number of water-tube boilers used in sundry industries, but especially in electricity works and the early power stations, where improvements in steam engines and electrical machinery were being specially studied with a view to obtaining the highest economy and the lowest working costs.

About the year 1888, the maximum normal rating obtained from the largest of the water-tube boilers probably did not exceed 10,000 lb. of steam per hour, while that of the largest loco and Lancashire boilers at the same period would not exceed 7,000 lb. per hour actual.

Mr. Hiller, in a Paper read about the year 1896, gives the proportion of boilers in use at that time as 62 per cent. of Lancashire and Cornish combined, and 1·8 per cent. of water tube. This small colony of water-tube boilers, however, was constantly and steadily convincing engineers of their greater evaporative efficiency as compared with the Lancashire type.

At this time, the commonly accepted proportions of grate area to heating surface were between 15 to 25 to 1 for Cornish and Lancashire boilers, and from 30 to 40 to 1 for water-tube boilers.

From some of the contemporary papers of this time, one gets such items as the following :—

> The writer has seen grates (Lancashire, of course) 7 ft. 6 in. long with 50 per cent. air spaces, burning 7 lb. to 10 lb. of coal per square foot of grate per hour, working with dampers full up, and sufficient draught of air to burn 24 lb. to 30 lb. per square foot of grate. (E. J. Duff, 23/1/1897.)

In the year 1904 the "Electrical Review" published on December 30th an article by Mr. F. H. Davies on the "Tendency of Practice in Power Station Engine and Boiler Plant," in which they showed a curve illustrating the relative use and trend of water-tube boilers and miscellaneous types, which is here reproduced (Fig. 2), and from which it will be seen that very soon after the year 1898, when the water-tube boilers and Lancashire boilers in power stations appeared to run side by side, the water-tube began to out-distance its rival in the race, so that in 1904 there was a good distance between them, and

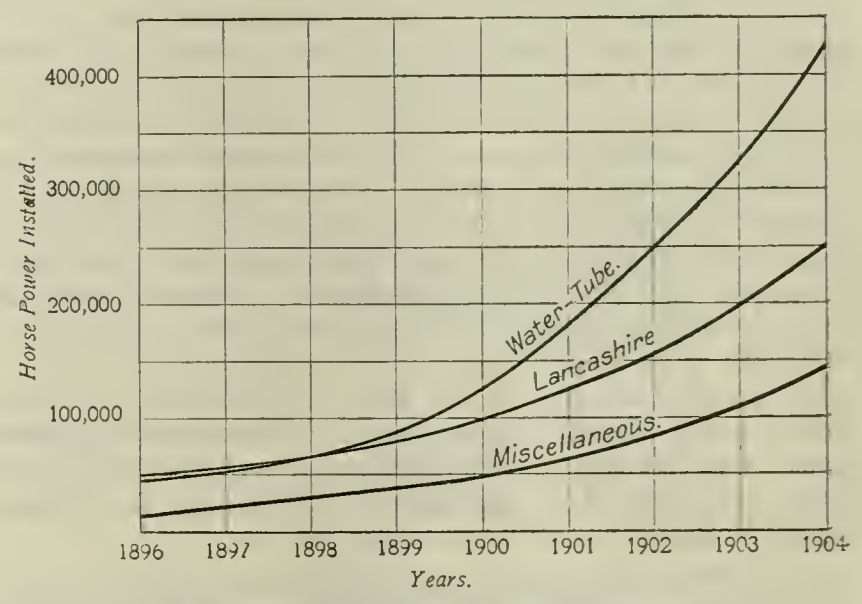


Fig. 2.—Boilers in Power Stations.

the water-tube boiler curve was rapidly rising, as the above article pointed out :—

> The feature of interest in this figure is not so much the very large general interest that it shows, as the marked increase in popularity of the water-tube boiler, evidenced by a rapid ascent of its curve in a manner out of all proportion to the increase in other types.
>
> Starting slightly under the Lancashire boiler in 1896 and probably lower still in preceding years, it has now passed it by nearly 75 per cent., and this despite a very fair increase in the horse-power of its rival.

Another principle which began to work in favour of the water-tube boiler was due to the growing activity in the matter of the electric lighting industry since the remedial electric Lighting Acts of 1888; this was the continual demand on consulting engineers for new designs for electric light stations, and the comparison between the older works of the kind in this country with those on the Continent and in America. It was found that if water-tube boilers were employed the space at the disposal of the engineer could be more efficiently utilised than with Lancashire boilers.

In one particular instance where a range of Lancashire boilers was put down by the side of a range of water-tube boilers of approximately the same capacity, it was found that the former required about 2½ times the space of the latter, and this naturally influenced engineers and continued to do so when the question of extensions of their plant had to be considered and when they had to make the most of the room at their disposal; this principle is still an active feature, and has been discussed

from time to time in important Papers, such as those by Messrs. Merz & McLellan in their important Paper on "Power Station Design," April, 1904, and also by Mr. Parshall and other authorities on this subject.

Another principle which undoubtedly led to the preference for water-tube boilers in power stations, was the question of superheated steam. As electrical machinery improved, the employment of superheated steam gradually became a necessity. The water-tube boiler, from its very construction, was adapted for the inclusion of superheater tubes in its design, and in fact superheaters were constantly being supplied before even the year 1897 in combination with the water-tube boilers manufactured by one prominent firm.

Among the pioneers in connection with superheating, the name of Mr. Hirn in 1873 is naturally prominent, but there were other pioneers of superheating, notably Dr. Haycraft, Mr. Howard, Mr. J. M. Ryder and the Hon. J. Wethered, all of whom communicated their experiences to the various institutes.

The water-tube boiler was the medium by which this important improvement was brought into more practical use for engineers, and in fact the water-tube boiler makers were really the means of leading the engine makers to improve their types so as to make them able to work with highly superheated steam and thus gain the saving of from 10 per cent. to 20 per cent. which was effected.

Superheaters were not extensively used in the year 1888 and Col. Crompton, in his Paper on "Cost of Electric Energy," read before the Institution in 1894, remarked that "in the days of low pressure steam at 15 lb. pressure, such superheating was a reasonably easy matter, but the same is widely different when the high pressure steam leaves the boiler at a temperature of 375° F., as is now the case. Any future superheating is very much in the nature of passing this steam through pipes at a temperature which nearly amounts to red heat, so that it is little wonder that not many engineers have cared about tackling such a difficult and risky problem." At the present day steam temperatures of 660° F. are quite common, and experiments are being made even with higher temperatures.

The engine makers were not slow to follow the lead given, and gradually higher class engines, and finally steam turbines, began to appear and to assume the important place which they have now obtained in engineering practice, so that Messrs. Merz & McLellan were able to say in 1904 :—

> Steam turbines seem in every respect to be specially suitable for power scheme purposes, and although they have taken many years to develop, it is probable that had there been a demand 10 years ago for 2,000 kw. generating sets, the turbo-alternators would have been the only large size generating units in extensive use at the present day.

Side by side with the increase in the size of these turbo-generators another principle to the advantage of the water-tube boiler began to be prominent, viz., the power to expand the unit of the water-tube boiler almost indefinitely, in contradistinction to the limited size of the unit of the Lancashire boiler. This feature of the water tube boiler has enabled the steam-raising plant to keep pace with the rapid engine room developments, and in this country boilers are now installed having each an evaporative capacity of 40,000, 50,000 and even more per hour, whilst in America boilers have been built, such as at Detroit, for a peak duty of 400,000 lb. per hour each, and others are in course of construction for even higher evaporations. Mr. Stott, the engineer of the Buffalo General Electric Co., estimating that he will obtain from one of his units a maximum peak evaporation of as much as 157,000 lb. per hour from and at 212° F.

There has been no fundamental change in water tube boiler design during the last 10 years; the types have varied, but the higher efficiency of the water-tube boiler of to-day, as compared with that of yesterday, is almost entirely due to continued improvements in structural detail, and in the better assembling of boiler house plant generally.

The present-day thermal efficiencies would appear to be reaching a maximum for coal-fired boilers, and with this system of steam generation, any further progress will be more or less confined to increased capacity on reduced ground space. In 1894 Col. Crompton gave an average efficiency of 52 per cent. for nine important stations, whereas to-day efficiencies of 85 per cent. can be obtained on reliable tests and working back from a possible minimum for constant losses such as radiation and waste heat in the chimney; the margin for further improvements is indeed pretty limited.

The gradual concentration of steam generating plant has, however, improved the over-all boiler house efficiency by reducing the constant losses, and further development is taking place in this direction to-day, but one appears to be approaching finality in the designs which we now see in some modern stations where the total combined steam generating plant, including superheater, economiser, fan and chimney, is placed directly over the grate area.

It is now possible to evaporate 100 lb. per hour per square foot of net ground space and over, whereas, in some of the older existing stations the maximum evaporation per square foot of ground space covered by the equivalent plant probably does not exceed 35 lb. from and at 212°F. per square foot. Such concentration of plant has had a marked effect upon capital costs, and, basing upon pre-war prices, a complete 10,000 kw. station could be built at a cost not exceeding £8. per kilowatt.

Great improvements have taken place in the general design of boiler-house plant, and the modern station offers every facility for labour saving and efficient control.

Automatic stokers are essential, and enable a high efficiency to be maintained with any class of coal. Coal transport is more or less standardised for any quantity of coal, whilst storage of coal in some of the latest stations is being arranged external to the boiler house, reducing the large internal bunkers, and thereby making the boiler plant more accessible, and allowing ample natural light.

The adoption of suction ash-handling plant removes the horrors of the ash tunnel, and if only for humane reasons, will become general in all stations.

Induced draught plants with short steel chimneys are replacing the tall brick chimney, thereby giving a flexibility and margin of draught intensity which, considering the low temperature of present waste gases, could not be obtained with a natural draught chimney unless built to a height which would be prohibitive.

More attention is given to water treatment, and it is now generally recognised that a modern boiler should be used for evaporating water and not for purifying it, with the result that boilers can be forced to higher rates of evaporation without detriment to the tubes.

On the Continent a system of distilling the make-up water is developing, and with the absence of concentration in the boiler water, the necessity for frequent "blowing down" largely disappears, with a consequent reduction in the percentage of make-up.

The increase in boiler pressures has made it essential to dispense with all cast-iron parts, and the modern boiler is now constructed entirely of steel.

Superheaters are now conveniently installed inside the boiler casing, and any desired steam temperature can be obtained to suit the development of the steam turbine.

The over-all efficiencies of electric power stations have improved very considerably, and whilst the advent and ever-increasing efficiency of the steam turbine must be recognised as the chief reason for such improvement, the boiler house has done its bit in this direction.

In 1894 Col. Crompton gave a figure of 117 B.T.U. per watt-hour generated as an average for 23 English power stations, and mentioned 32·6 B.T.U. per watt-hour as a possible figure for "ideal works." In large modern works with a good load factor 27 B.T.U. per watt-hour generated is quite common, and in some cases the excellent figure of 20 B.T.U. per watt-hour has been established.

Col. Crompton also estimated that the average coal consumption in 1888 was about 24 lb. per unit sold, and predicted an ideal figure of 2½ lb. per unit sold for the future, when using

coal of 14,000 B.T.U.'s. We know of at least one modern station where the coal consumption is only 2 lb. per unit generated, although the coal has an average value of only 11,000 B.T.U.'s

Whilst the investigation work which is being carried on will doubtless lead to some further improvements in boiler house design, we cannot expect any further great advance so far as the more modern stations are concerned. Some of the latest stations, having good load factors, can show an overall efficiency, *i.e.*, from coal to units sent out, of 15 per cent., and an overall efficiency of 17 per cent. was recently claimed for an American power house; but as the average overall efficiency for electric stations in this country probably does not exceed 10 per cent. there is evidently room for a considerable general improvement before the advance of the whole line of the electric industry becomes urgent. Whilst it may be difficult to improve the present high standard of modern boiler plant, much may be done by increased supervision.

The effect of load-factor on station economy is well known, but it should be possible to raise considerably the average overall efficiency of stations having a relatively low load factor, and the writer believes that this can be achieved by having more expert supervision in the boiler house, the cost of which is of trifling importance, considering the possibilities offered for reducing the coal bill.

Contractors' efficiency tests are too often only accepted as representing figures which can only be obtained under ideal conditions, but there is really no reason why the test results should not be approximated to continuously, provided arrangements be made for a scientific staff to be present in the boiler house at all times, and the raising of the average boiler-house efficiency to the line of test efficiency would undoubtedly produce very marked economy throughout the country. In other words, the modern boiler is capable of working at a much higher average efficiency than that represented by many of the station results published. This fact should be recognised, especially at the present time, when the combined efforts seem to be more directed to the finding of cheaper fuel.

The present abnormal condition of the coal market no doubt makes these efforts urgent, but it is not simply the burning of low-grade fuel or coke breeze which is going to have any permanent effect upon the cheaper generation of electricity.

We have had the various systems of dust firing, from the "Schwartzkopf," which was tried many years ago, to the Bettington, which has been before engineers during recent years; yet, whatever success may have been achieved by this method of firing, the commercial results do not seem to have been sufficient to justify any important extension of the system.

In the future, we can probably look for higher steam pressures and steam temperatures, depending upon the requirements of the turbine contractors.

There is little difficulty in constructing boilers for pressures of 500 lb. per square inch if desired, and as a matter of fact, some high-pressure boilers have already been built for experimental works, but the test results are not yet sufficiently definite for publication.

Gas firing of boilers in electric stations is again receiving some attention, but its adoption in the majority of existing stations must necessarily be very limited.

From a national point of view, the generation of electricity from gas producers, with a recovery plant, by which all the valuable by-products can be recovered from the coal, seems to suggest the next really important milestone in the road of progress, but past experience in this direction indicates that such plant, if of any magnitude, would only be a commercial success if placed in the midst of our coalfields, where coal can be obtained at a low figure, and where ground is cheap, the space required for producer and recovery plant being some five times greater than that required for the present standard steam plant.

The larger question of centralisation of power supply must therefore be settled before we can expect to see any gas-fired scheme adopted which will produce any appreciable effect upon the cheaper generation of electricity for lighting and power purposes throughout the country. Still, the day will probably come when we shall see the mechanical stokers transferred to the producers, and the boilers fired by simply turning on a tap.

Electrically-Driven Coal-Handling Plant.

By H. H. BROUGHTON.

In the United Kingdom the amount of coal raised in 1913 was 287-million tons, as compared with 126-million tons in 1874. According to "The Engineer,"* it is highly probable that the annual tonnage raised will continue to increase until it has reached the figure of 350- or 400-million tons. Of the 287-million tons raised in 1913, 98-million tons were exported as cargo and used for steam navigation. Figures such as these serve to show how imperative it is that the coal raised should be handled economically.

The question as to whether it would not be wiser to cease exporting our coal at the rate of 100-million tons a year in order to leave it for our successors, or to use it for developing our own industries, is one we do not propose to discuss. In business some regard as *alpha* and *omega* the idea of getting rich quickly and at any cost, but it is for the economists to determine the effect on the community of what is looked upon by many as improper use of the natural wealth of the country.

Both the economical handling and efficient consumption of coal are engineering problems, and it is with machinery and appliances for promoting the former that we propose to deal.

* August 25, 1916.

Less than 30 years ago Lord Armstrong, speaking in a discussion at the Institution of Civil Engineers,* said he "felt satisfied that in point of safety, controllability and adaptability to various purposes electricity had little chance of ever rising to the level of hydraulic power."

At the Cardiff meeting of the Institution of Mechanical Engineers† in 1906 the writer ventured to criticise the arrangements that had been made for the mechanical handling of coal at certain of the Welsh ports, and the late Mr. T. Hurry Riches, in reply to the criticism, "had no hesitation in saying that (electrical engineers) would have to talk to him for a very long time before (they) would convince him that electrical machinery was better than hydraulic for coal-tipping."

Under the heading "Hundred-ton Electric Cranes" a note appeared in these columns about two years ago§ to the effect that two 100-ton electrically-driven cranes were being installed at one of the new coal docks on the Great Lakes. It was stated that the new cranes would be capable of lifting direct from the

* "Proceedings" Inst. C.E., Vol. XCIV., p. 64.
† "Proceedings" Inst. Mech. E., July, 1906.
§ Vol. LXXIII., p. 475.

tracks a coal truck of 100-ton load and emptying it into the hold of a vessel at the rate of about one truck per minute.

If it be accepted as an axiom that no business man wastes time in criticising a rival unless he fears that the latter is in a position to compete with him, then the fact that since the beginning of the century hydraulic engineers have brought their whole strength to bear in drawing attention to the weaknesses of the electric system must be regarded as one of the best testimonials to the efficiency of the electric drive. From the criticism offered by the hydraulic engineer it would appear that the electrically-driven crane is one of the worst appliances devised by man; but, notwithstanding its imperfections, at the present time the electric crane is used to the exclusion of all others when a supply of energy is available.

The more one considers the matter the more is one at a loss to understand what appears to be the lack of enterprise on the part of our electrical engineers and crane makers in not conducting a vigorous campaign with the object of convincing railway companies and harbour authorities of the many and important advantages of the electrically-operated machine. Seeing that during the last decade every railway and dock company of note has extensively adopted the electric crane it will be easier now to obtain a hearing than it would have been 10 or 15 years ago.

Although no one would advocate wholesale scrapping of such of the hydraulic equipment as still represents a considerable sum on the books, and which would have to be debited against modern equipment, the author is, nevertheless, strongly of the

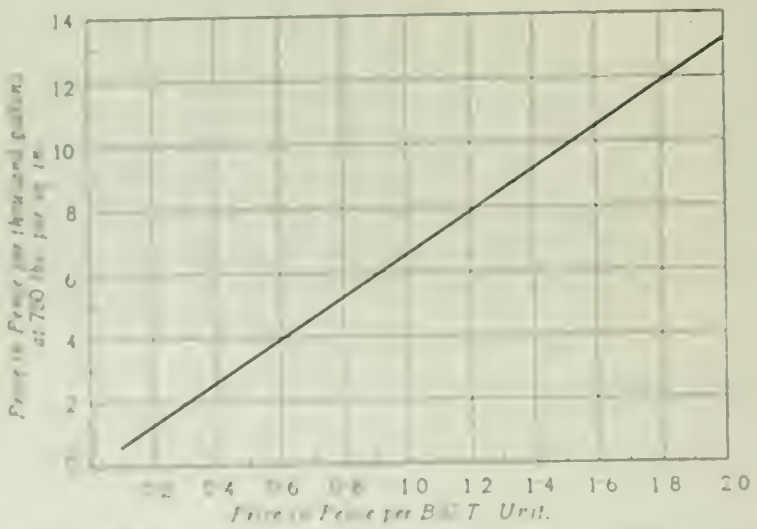


Fig. 1.—Curve Connecting Cost of Electrical Energy and Equivalent Cost of Pressure Water.

opinion that there are many cases where immediate electrification of the pumping plant could be undertaken with profit to the owners, and there are several instances where entire electrification of the equipment would show not only an immediate and considerable saving in working expenses but also a greatly increased output.

In comparing the cost of energy by the electric and hydraulic transmission systems it is desirable to be able quickly to convert from one set of units to the other, and the curve (Fig. 1) connecting the cost of the one and that of the other has been prepared from the well-known relation that 1,000 gallons of water at 750 lb. pressure per square inch are equal to 6·53 Board of Trade units. The curve, which is self-explanatory, serves to show how erroneous are many of the extravagant claims that have been made concerning the cost of pressure water.

One of the greatest advantages of the hydraulic system is the ease with which pressure water may be stored. The flywheel is the mechanical equivalent of the hydraulic accumulator, and to the flywheel load equaliser is due the application of the electric drive to machines which at one time it was thought could never be so driven. Examples of such machines are the colliery winder and the rolling mill. A vitally important point, and one that is often overlooked in discussions on the two systems—hydraulic and electric—is that the load-equaliser is an ingenious and *temporary* expedient as far as the electric system is concerned. As power stations increase in size the more will they be able to take charge of heavy and widely fluctuating loads, and the less, therefore, will be the necessity for load equalisation.

The performance of their plant is highly creditable to hydraulic engineers. As illustrations may be mentioned the putting of 4,000 tons of coal into a ship in 6½ hours with two tips, and the putting of a like amount into a ship by one tip in 12 hours.* Although these figures must not be regarded as record performances, they, nevertheless, serve to indicate the nature of the service demanded by dock companies with the existing railway facilities. As the latter are brought into line with present-day requirements, conditions of greater severity will be imposed on the coal-handling appliances.

Messrs. W. Dixon and G. H. Baxter in an informative Paper† on "Modern Electrical Dock Equipment, with Special Reference to Electrically-operated Coal Hoists," gave a description and recorded the working results of the two 32-ton hoists installed on the Clyde at Rothesay Dock.



Fig. 2.—Electrically-operated Coal-hoist at Glasgow.

It appears that during a period of 12 months the total coal and other material shipped by the two hoists was 556,419 tons, the energy consumption being 80,164 units, and the number of wagons dealt with 70,604. Including all distribution losses, and also the power necessary for the working of all auxiliary apparatus on the hoist, the energy consumption over the whole period only averaged 1 unit per 6·94 tons of coal shipped. It will be noted that 70,601 wagons were handled in shipping 556,419 tons of coal, or an average of only 7·88 tons of coal per wagon, and this emphasises the adverse conditions under which the hoists were being worked in 1910.

From Fig. 2 it will be seen that the design of the structural work and arrangement of shoot, jib cranes and other auxiliary apparatus is on usual lines, the essential difference being that all the mechanism is at the top of the structure. The reader is referred to Messrs. Dixon and Baxter's Paper for further information concerning these hoists.

* Proceedings Inst. Mech. Engineers, January 20, 1911.
† *Ibid.*

It is elsewhere that one has to turn for numerous examples of electrically-driven machinery for the handling of coal in considerable quantity. The coal production of the United States in 1915, as announced by the U.S. Geological Survey, was 443-million tons of bituminous coal and 89-million tons of anthracite. In the development of machinery for the economical handling of this enormous weight of coal there has been close co-operation between the financier, civil engineer, shipper, naval architect and railway engineer, as well as the crane builder and electrical engineer. Notwithstanding the geographical and climatic disadvantages, such co-operation has enabled the United States in a relatively short period successfully to compete in the markets of the world with more favourably situated countries, and, judging by the broad outlook of those who have the best interests of their country at heart, it would appear that even more successful in the future is the United States likely to be.

The following brief notes from a Paper, entitled "Application of Electricity to the Ore-handling Industry," by Mr. C. D. Gilpin,* serve to give a good general idea of the several kinds of equipment in use in the Great Lakes district for the handling of coal and iron ore :—

Fig. 3 shows a side elevation of a dock equipped with one or more crane-type unloaders in combination with a rehandling gantry crane.

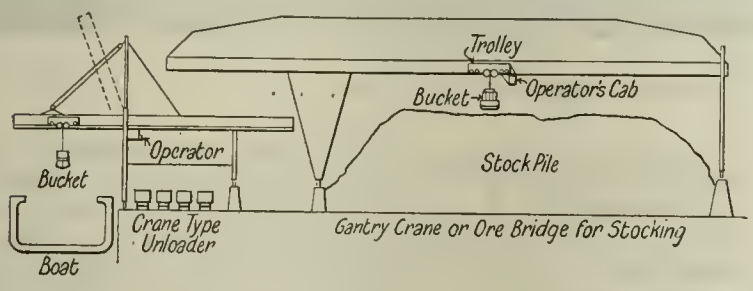


Fig. 3.—Crane-type Unloader and Rehandling Gantry Crane.

The unloader is provided with a trolley which runs out over the hatches of the vessel ; a grab-bucket is then lowered into the hold, and the loaded bucket is hoisted and traversed back either to a bin which feeds the railway wagons, or to a space in the rear of the unloader, from which it is picked up by a bucket carried on the gantry crane trolley, and is placed in storage. From this storage-pile ore is eventually reclaimed by the stock-pile gantry crane, and is loaded on to railway wagons. The crane-type unloader is essentially the same as the stock-pile gantry, and the principles which apply to one will apply to the other.

Fig. 4 shows a Hulett unloader in conjunction with a gantry crane.

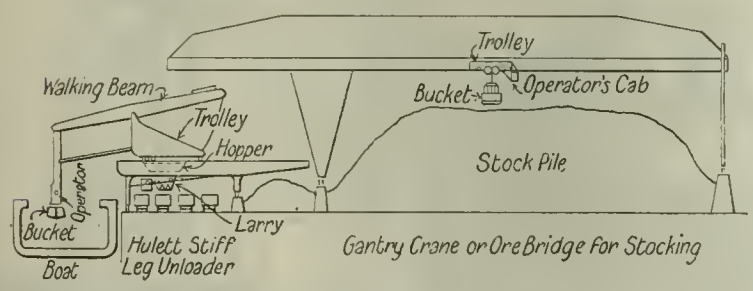


Fig. 4.—Hulett Unloader and Rehandling Gantry Crane.

In this type of unloader the bucket is suspended from a walking-beam by means of a stiff structural leg, the operator riding directly above the bucket. This leg is held steady by means of an equaliser, and may be rotated at will. The walking-beam is carried on a large trolley which moves the loaded bucket back over a bin, into which the ore is dumped. From this bin the ore is fed as desired into a lorry car, which carries it either to a point above an empty railway wagon or else deposits it on the ground in the rear of the unloader, there to be cared for by the gantry crane.

A movable car dumper is depicted in Fig. 5. With this type of dumper the wagon is pushed up a short incline by means of a locomotive until it rests on the L-shaped rotatable member. When this member is turned over, the contents of the wagon slide down a chute into the stock-pile, the wagon being held in place by means of counter-weighted clamps. The empty wagon is then rotated back into its former position, from which it is displaced by the impact of the oncoming wagon. The machinery for operating the L-shaped member or cradle, and also for imparting longitudinal motion along the track, is located in the house at the top of the dumper.

A fixed car dumper is shown in Fig. 6. The wagon is dumped in the same way as with a movable dumper, but with this type of machine it is necessary to haul the loaded cars up an incline and on to the cradle by means of a "mule," which consists of a small carriage running on a track between the standard-gauge permanent way. The mule may be lowered into a pit at the bottom of the incline, from which it emerges after the loaded wagon has passed over it. The machinery is generally located in a house beneath the incline on which the mule operates.

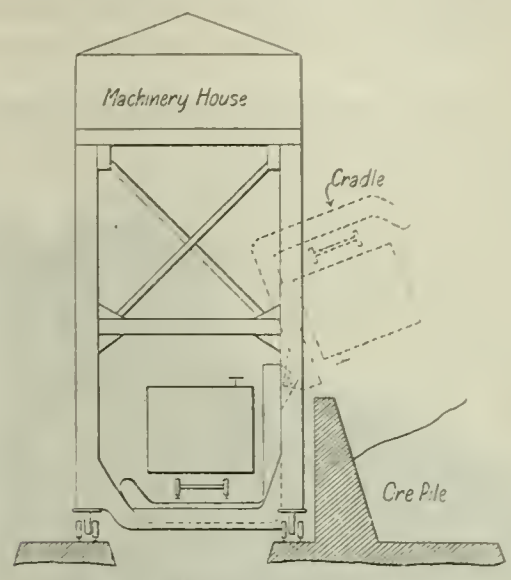


Fig. 5.—Movable Car-dumper.

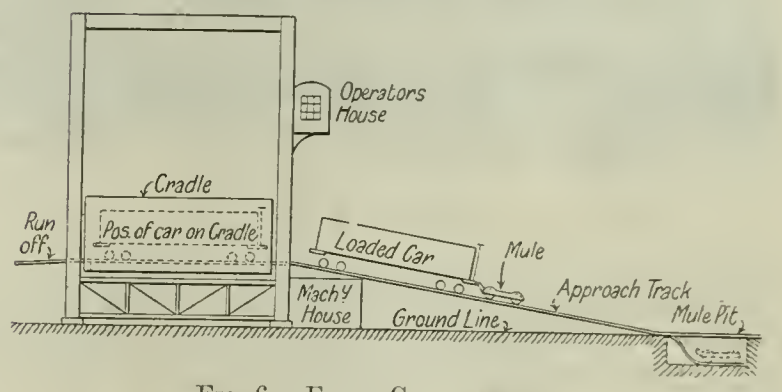


Fig. 6.—Fixed Car-dumper.

The same authority, in an address to the Association of Iron and Steel Electrical Engineers, described a new style of coaling

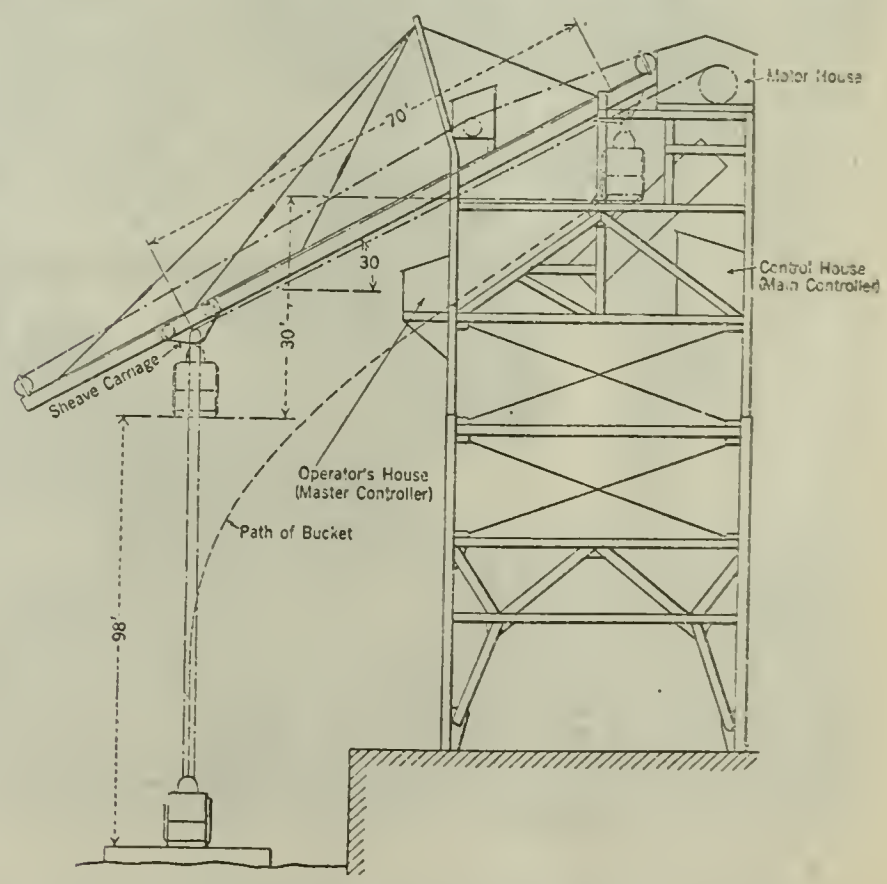


Fig. 7.—High-speed Coal-hoist.

dock, in which the flexibility of the bin system is secured at greatly reduced cost. Part of the description follows* :—

The dock carries a runway next to the water edge and not very much above water level ; on this runway travels a loading tower. Behind this is another runway, elevated above the first by means of

* "Proceedings" Am. Inst. E.E., March, 1915.

* "Engineering News," July 27, 1916.

a trestle, and carrying on its rails a turnover car-dumper of the movable type. Beyond the car-dumper runway is a return track for empty cars. The loaded cars are pushed on to the dumper by means of a locomotive, and the coal is dumped into a 100-ton hopper on the rear of the loading tower, the dumper having been brought into line with the latter. The tower hopper is provided with a gate, through which the coal is fed into a scraper conveyor. The latter carries the coal up a pivoted mehned boom, which extends out over the boat when loading, and carries a telescope chute at its outer end, so that the coal may be directed where desired. The conveyor on the boom is the largest ever built of this type, having a capacity of 3,000 tons per hour when the boom is approximately level.

In a later section of the article further reference will be made to this most recent development in coal-handling machinery.

of 70 cubic ft. capacity, weighing 6,200 lb. empty. The average weight of coal per lift is 1¼ tons, making a total average load of about 9,000 lb. Each hoist is driven by a 300-H.P. continuous rating compound-wound 500 revs. per min, 230-volt continuous-current motor, which is geared to a drum on which is the closing cable. To this drum through a solenoid-operated friction-clutch is connected the steel cable drum.

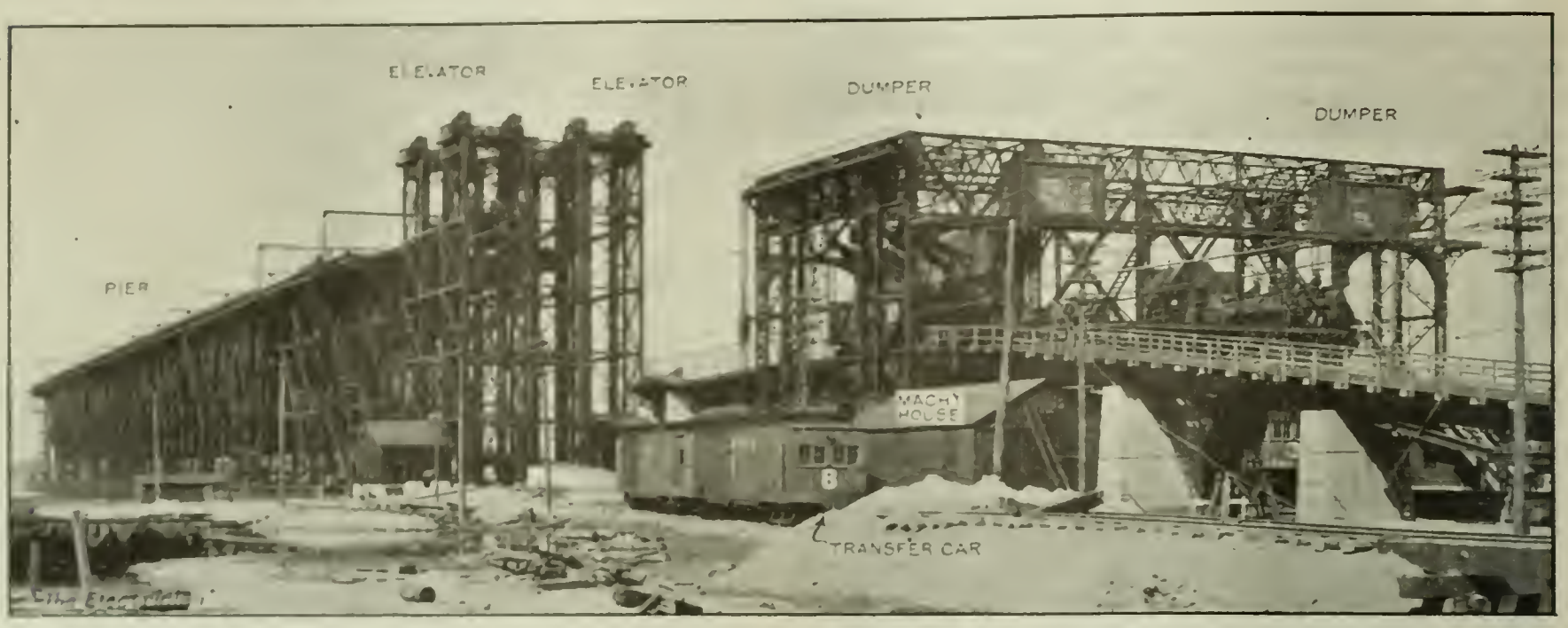


Fig. 8.—Coal-handling Plant of Norfolk and Western Railway at Norfolk, Va.

The solenoid which operates the friction-clutch is controlled by a push-button switch in the handle of the operator's master-controller. After the bucket is closed and the stress on the cables is equalised, the friction-clutch operates, connecting the shell and closing cable drums together. While the bucket is being hoisted, the sheave-carriage is moved by an auxiliary drive up an incline, the path of the bucket describing a parabolic curve, the total vertical lift being 128 ft.

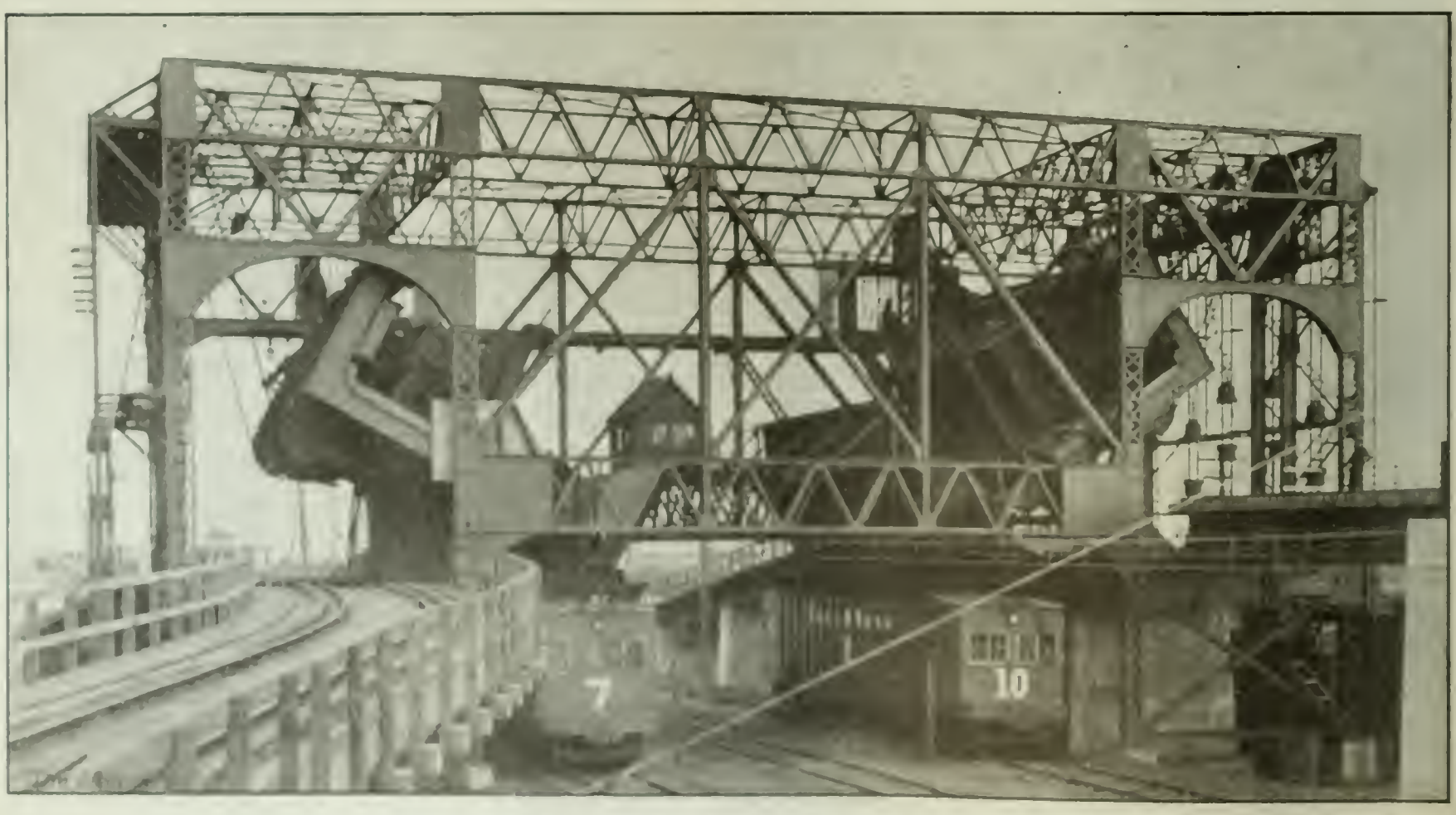


Fig. 9.—Double Car-Dumper in Operation.

Another type of machine is the high-speed coal hoist. An outline diagram of such a hoist is shown in Fig. 7 on the previous page. Mr. W. T. Snyder,† in a Paper on "Direct-current Control for Hoisting Equipment in Industrial Plants," gave the following description of this hoist:—

> This hoist is provided with two independent lifting mechanisms, each capable of hoisting 100 tons of coal per hour with a grab bucket

† "Proceedings" Am. Inst. E.E., May, 1915.

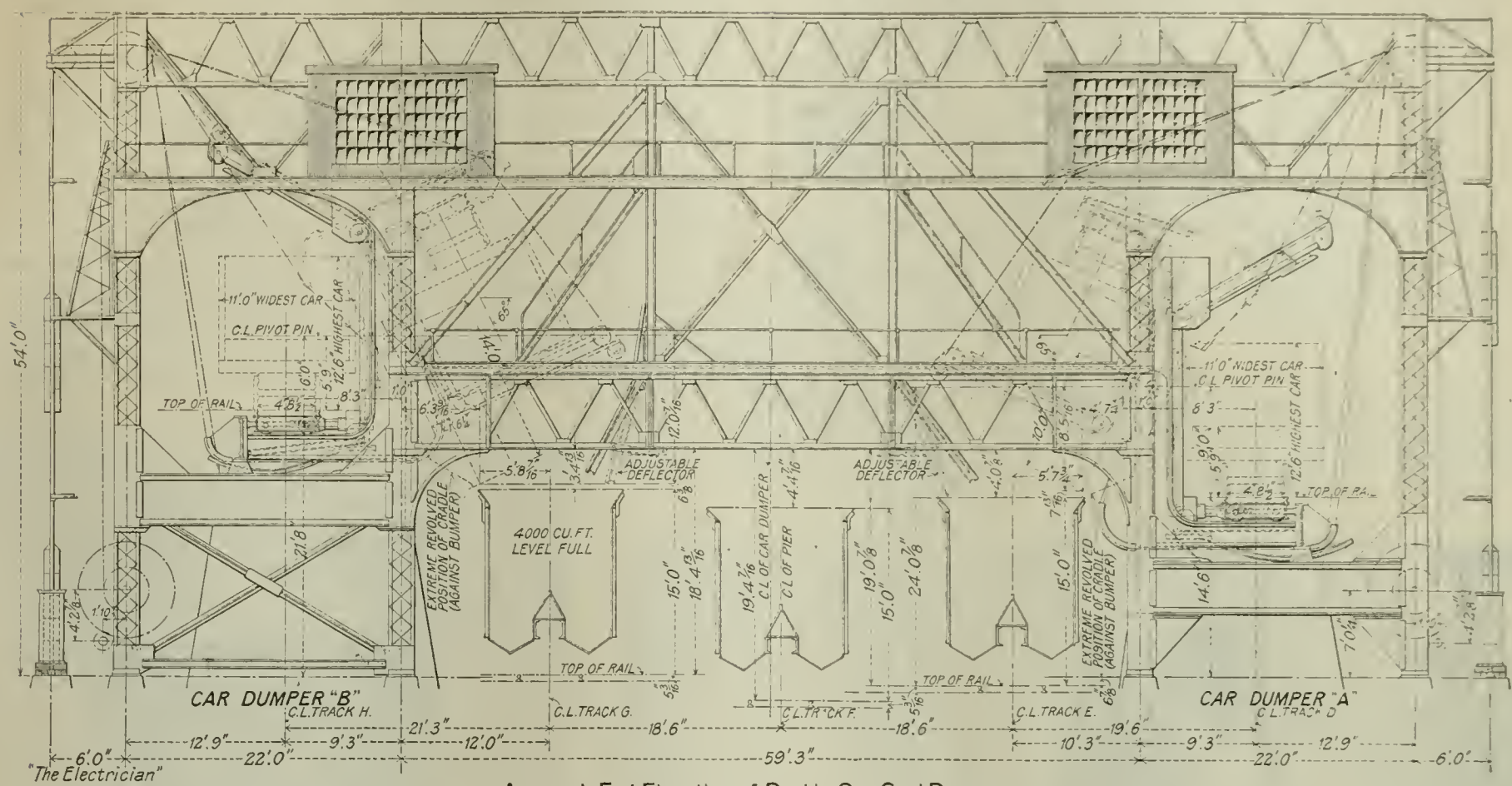
When the bucket reaches the dumping point the friction-clutch is released, a band-brake . . . is applied to the shell drum, power is applied to the motor and to the closing cable drum in the reverse direction, and the coal is dumped into a chute, and the bucket continues lowering and moving down the incline at the same time. The hoist motor is retarded by dynamic braking, with the shell and closing cable drums locked together and the bucket in the open position. The actual time required to complete a round trip is 35 seconds, the permissible time per trip, based on 100 tons of coal hoisted per hour and 1¼ tons per lift, being 45 seconds.

As stated above, there are two duplicate equipments on a common structure operating as one unit, hoisting coal from the same boat. To provide against heavy current surges . . . the hoist controllers were interlocked electrically to prevent both hoisting at the same time, but allowing one to hoist while the other is lowering. In addition to the benefits that were expected. this arrangement has resulted in lower maintenance cost on the hoisting plant, brought about by more even stresses on the structure, and a more even pace on the part of the operators, there being less tendency to reckless operation, since one operator cannot hurry unless the other does likewise, and one cannot slow down without affecting the other. The result is that capacity is maintained while stresses on the hoisting equipment and structure . . . are less severe.

In connection with certain of the above plants, the conveyor plays an important part, and a number of conveyor equipments are giving satisfactory service at home ports.

Detailed descriptions of the crane-type unloaders in combination with re-handling gantry cranes and of Hulett unloaders in conjunction with gantry cranes were given in THE ELECTRICIAN about 12 months ago.* In this article, which may be regarded as a continuation of the previous one, descriptions will be given of modern fixed and movable car-dumpers and their equipments. Other notable examples of electrically-driven coal-handling plant will be dealt with in due course, and if these arouse the interest of those whose business it is to handle coal the articles will have served the purpose for which they were written.

The coal-handling plant installed by the Norfolk & Western Railway Co., at Hampton Roads, is clearly shown in Figs. 8, 9 and 10. This consists of two large car-dumpers built into one frame, transfer cars for the transferring of coal from the dumpers to the pockets on the pier, and two elevators built for elevating the transfer cars to the top of the pier. The plant is electrically-operated throughout. The double car-dumper, Figs. 9 and 10, consists of a steel framework supporting two separate tipples. Each tipple consists of a cradle, supporting a platen, carried on pivot pins supported by heavy cradle posts carried on the foundations. The cars are brought up an incline approach to the cradle by means of separate mules controlled from the operators' houses. The cradle is tipped by means of ropes passing around the underside of the cradle and over sheaves at the top of the framework, and around upon drums located in the framework at the outside of the dumpers. These drums on each dumper are operated by electric motors wound for 550 volts continuous-current. The mule haulage mechanisms, also motor driven, are located in the same houses as the cradle mechanisms. The ropes from the haulage drums pass around deflecting sheaves under the approach tracks. and the ends are anchored to the mule cars. In the operation of this plant the loaded cars are discharged by gravity to a point between the dumper and the mule pit. The mule then hoists



Approach End Elevation of Double Car Coal Dumper.

FIG. 10.—ARRANGEMENT OF DOUBLE CAR-DUMPER AT NORFOLK, VA.



FIG. 11.—CAR-DUMPER AND LOADING TOWER AT CHARLESTON, S.C. (TOWER SHOWN WITH BOOM COMING INTO POSITION OVER BOAT.)

* Vol. LXXV., pp. 575 and 617.

them up the incline approach on to the platen, and the cradle hoist mechanism inverts the car to the dumping position.

Car clamps automatically operated by heavy counterweights act so as to return the empty car and cradle to the original position, ready to receive another car. The incoming car pushes the empty car out of the cradle, and it then descends over the gravity discharge to the empty storage yard.

The cradle hoist mechanism for each dumper consists of two 200-H.P. motors, connected through proper reductions of spur gear to the cradle hoist drums.

Dynamic braking is used for lowering the cradle after dumping. Solenoid brakes are also provided for emergency use and to stop the motions instantly in case of failure of current, holding the loads in any position.

The mule haulage mechanism is located in the same house as the cradle, and consists of two 22·5-H.P. motors geared to a drum. This drum is governed by a brake operated by a foot lever in the operator's cab, and is also governed by a solenoid brake.

The speeds of this machine are so regulated as to give a capacity of 30 cars an hour to each dumper. The dumpers are also designed to handle cars from the minimum road size up to the new 100-ton cars now in use.

Figs. 11 to 16 show the arrangement and design of the movable car dumper and loading tower recently installed for the Southern Railway Co. at Charleston, South Carolina. The car-dumper is mounted on wheels, and is designed to travel along a runway elevated above the dock on a special trestle system. Intermediate between the dumper runways is a standard-gauge railroad track, upon which the coal cars are brought to the dumper, and which serves as a discharge track for the empties after they have been dumped. The car-dumper proper travels over the standard gauge track, and is provided at each end with movable approaches, up which the loaded cars are pushed by a locomotive or electric car pusher.

After the dumper has been properly placed opposite the loading tower the incoming loaded car is placed on the cradle in the position for dumping. At the first instant of rotation of the cradle the car moves sideways on a rolling platen, until its side rests securely against the side of the cradle. The cradle is then rotated to an angle of 70 deg. with the horizontal. As the cradle rotates the car clamp beams automatically clamp the car securely in position by means of heavy counterweights that travel in guides at the rear of the dumper frame. The clamps depend simply on the counterweight system for operation, and release automatically as the car is lowered to its original position. After the car has been dumped, the next loaded car pushes it out of the cradle, and it runs down the discharge on the empty storage track. The dumper is designed to handle any ordinary type of open top car, and has a specified capacity of 35 cars per hour.

All of the machinery is contained in a large house built on top of the framework. The hoisting mechanism consists of two 200-H.P. motors geared to drums on which the hoisting ropes are wound. This mechanism is provided with both band type and solenoid brakes. The car-dumper is carried on six four-wheel trucks, one under each corner, and two additional trucks under the pivot-post of the machine. The wheels on the four corner trucks are geared by means of spur and bevel gearing and shafting to a 100-H.P. motor in the machinery house. This mechanism is supplied with a suitable mechanical brake set by a weight and released by a foot lever in the operator's house. This brake gives sufficient power securely to lock the wheels and skid them on the rails. All motions of the dumper are controlled by one operator in the cab on the main frame.

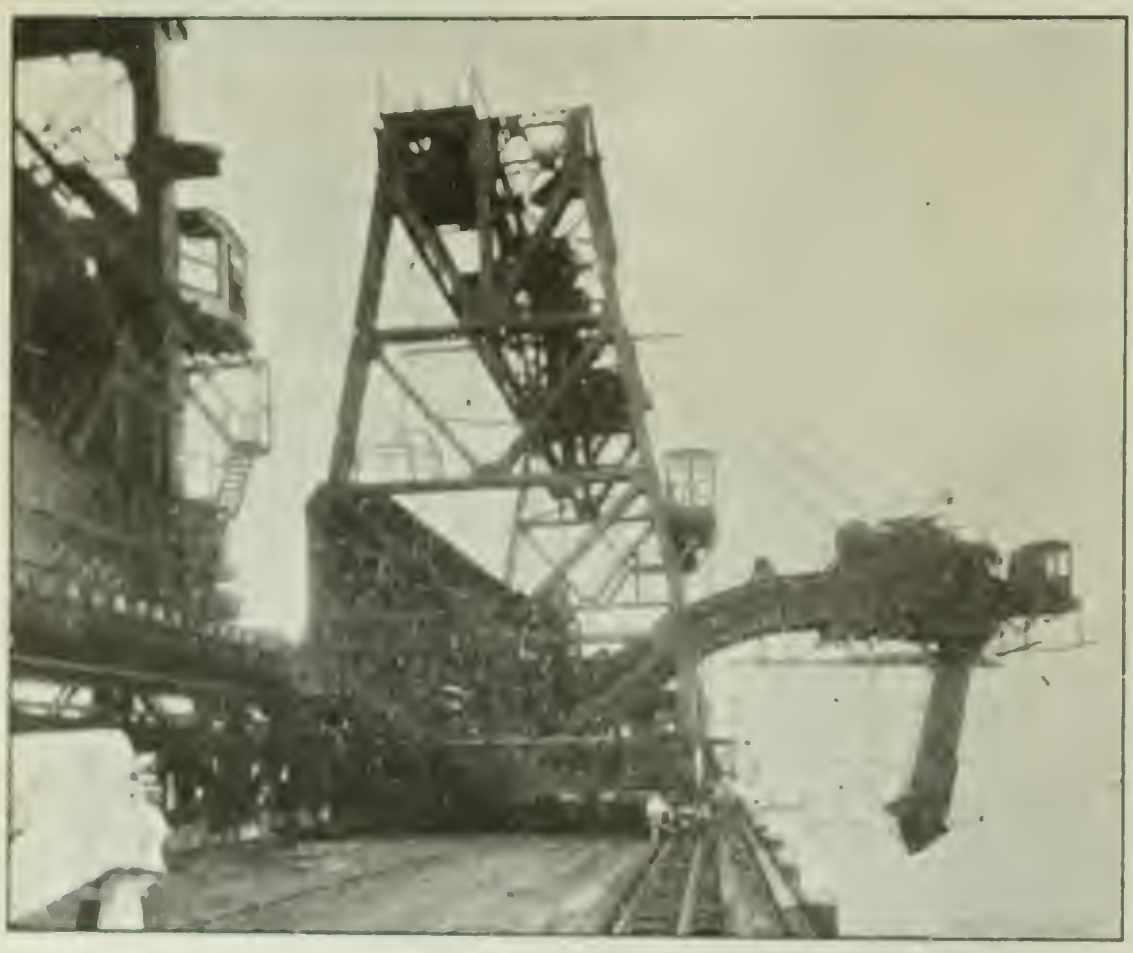


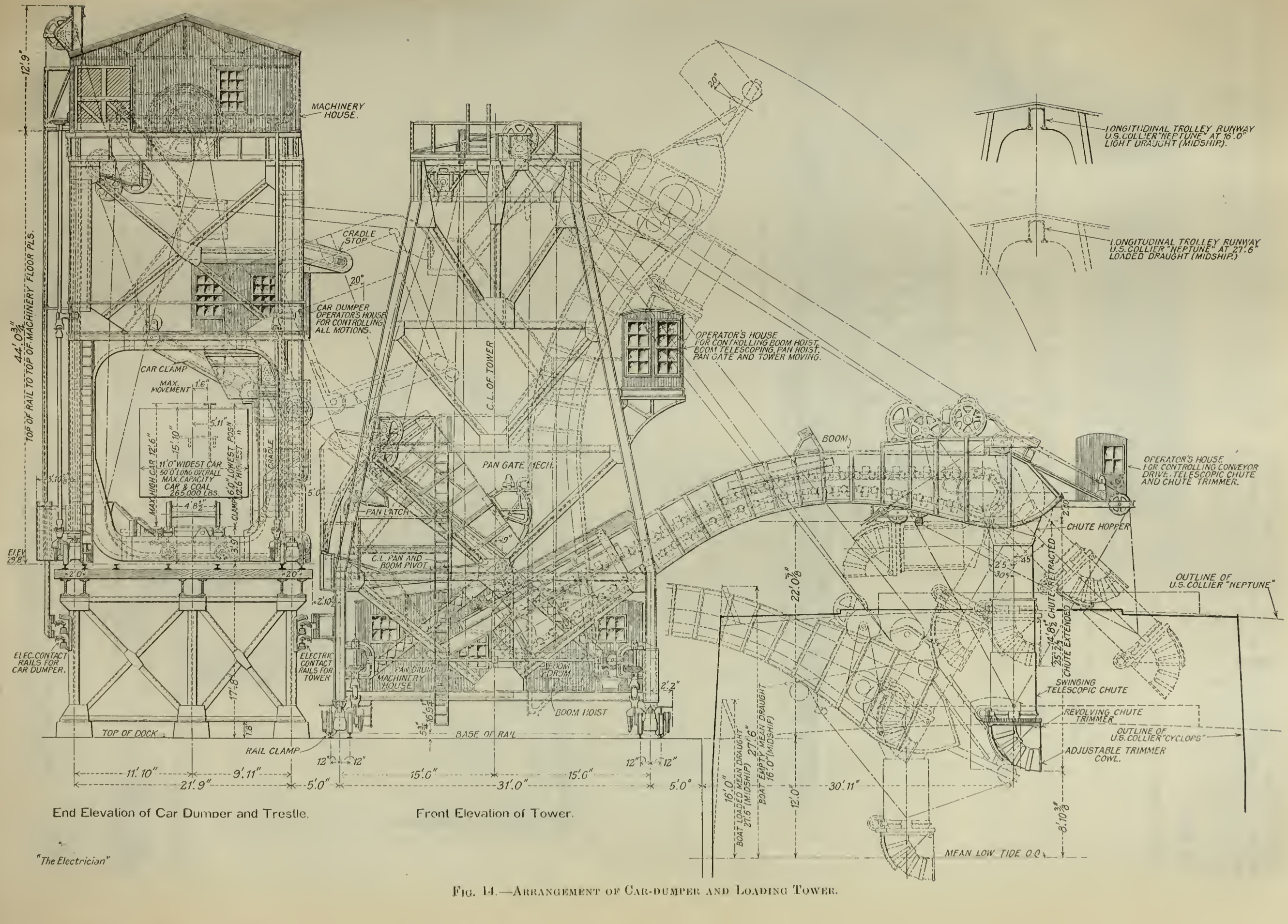
Fig. 12.—Movable Loading Tower.



Fig. 13.—Movable Car-dumper.

The dumper empties the coal into a large pan on the loading tower. This pan has a gate at the lower end which may be closed, thus using it as a storage hopper. The pan is hinged at the forward side directly over the boom, and may be either lowered to a horizontal position or raised so as to act as a chute from the dumper to the loading boom. It is actuated by means of ropes passing around sheaves at the top of the framework and wound on a drum in the machinery house at the base of the tower.

The boom, which is hinged directly below the pan, carries the coal by means of a scraper conveyor to the outer end, and discharges it through a swinging telescopic chute equipped with a retracting trimmer into the boat. The boom may be raised or lowered by means of ropes passing around sheaves at the outer end and then over sheaves in the framework, and wound on a drum in the machinery house. The boom also has a retracting



"The Electrician"

FIG. 14.—ARRANGEMENT OF CAR-DUMPER AND LOADING TOWER.

motion in order to accommodate boats of small beam. This motion is accomplished by means of screws connected to a 33-H.P. motor on the heel of the boom. The mechanism for operating the chute is located on the outer end of the boom, and the operator for controlling the chute motions is placed in a cab, also on the end of the boom.

The operator for the boom hoist, pan hoist, gate, retracting and tower-travel mechanisms is placed in a house on the front

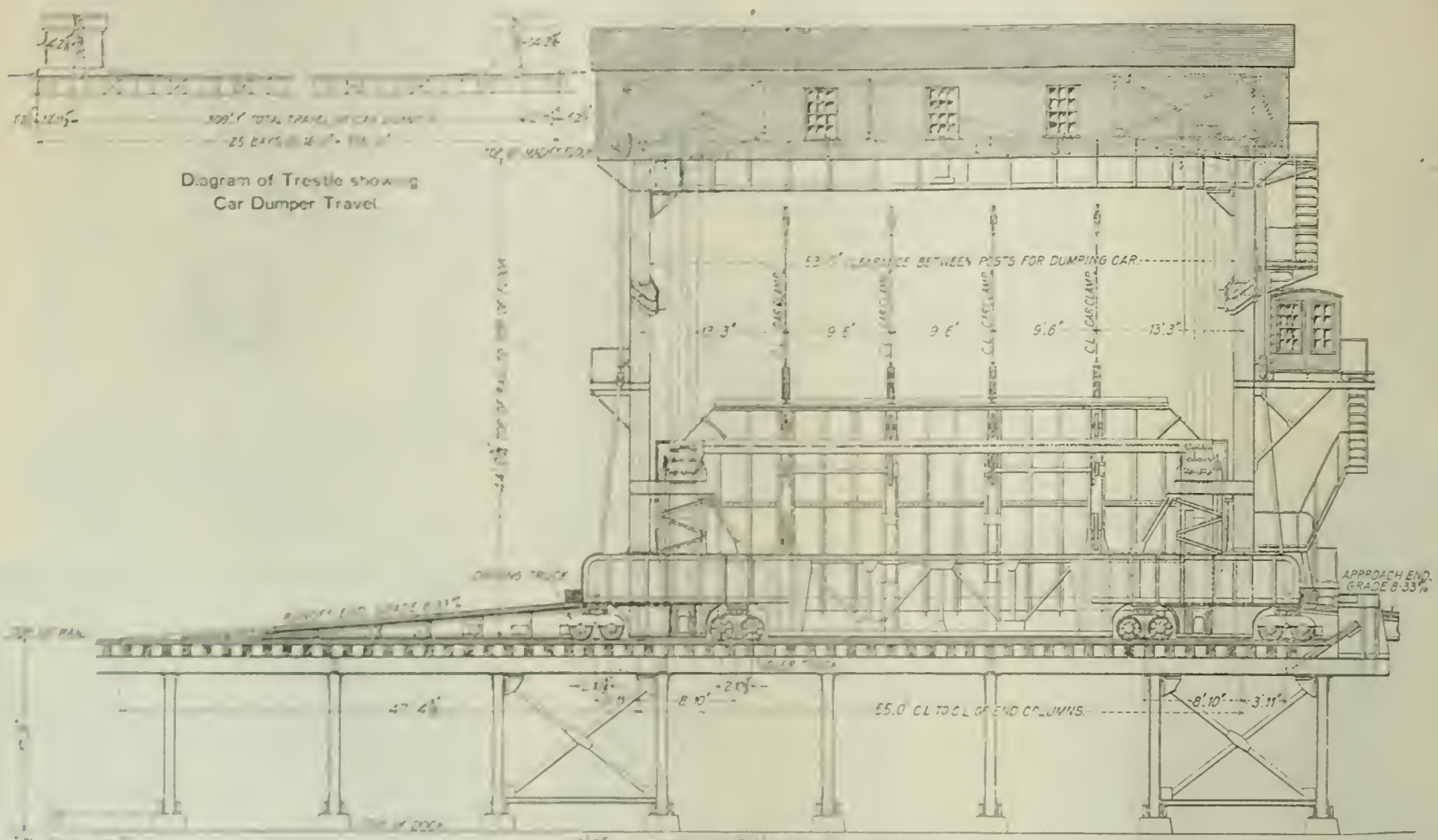


FIG. 15.—ARRANGEMENT OF CAR-DUMPER.

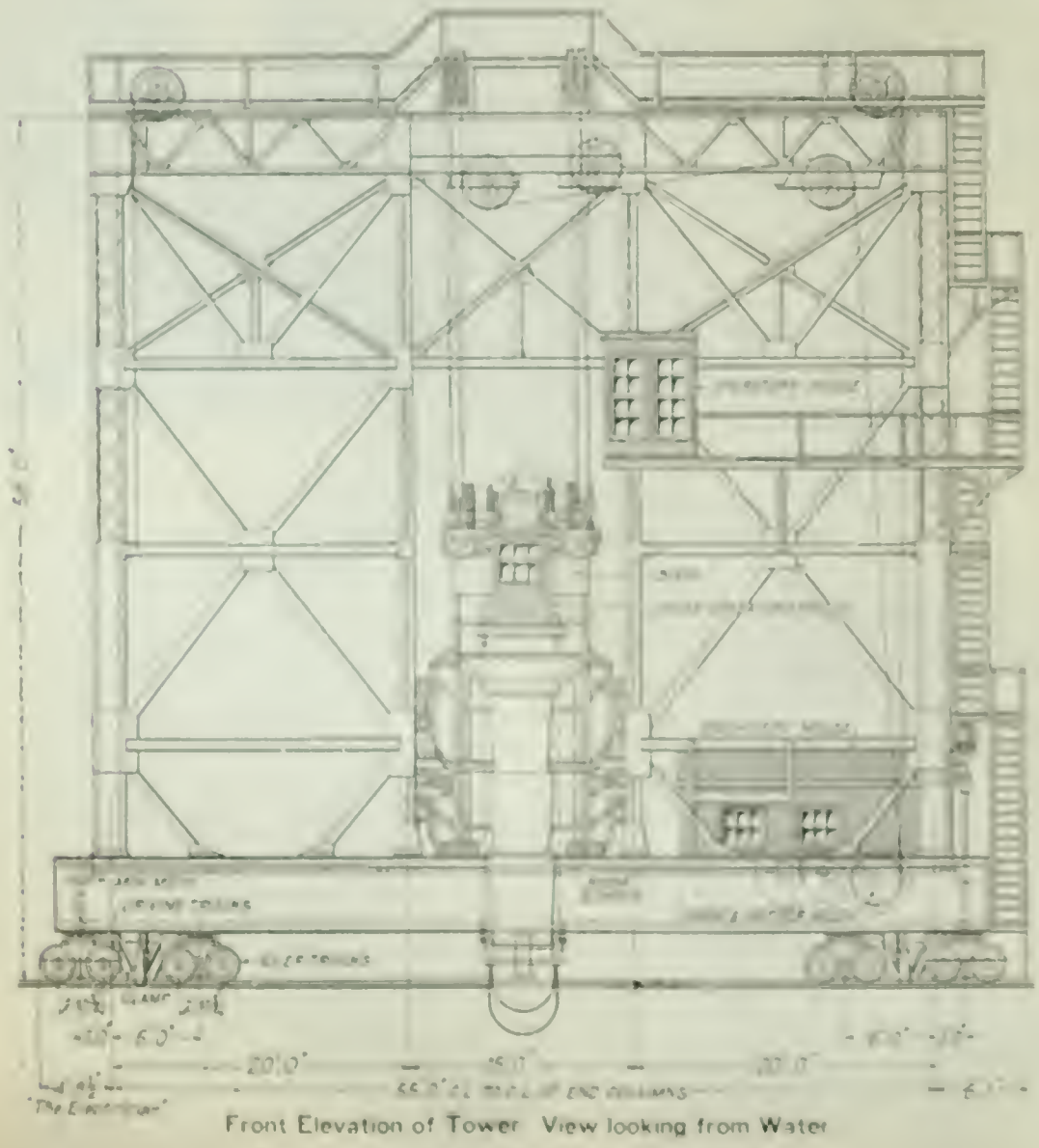


FIG. 16.—ARRANGEMENT OF LOADING TOWER

of the main frame. Switchboards and machinery for all motions, except the chute, gate and retracting mechanisms, are located in a large house built into the framework at the base of the tower. The trucks are similar to those used on the movable car-dumper, and the moving mechanism is so geared as to give the machine a travel of 75 ft. to 100 ft. per minute along the runway.

Both the fixed and movabled umpers described above are of American design and construction, and have been put into operation by railway companies in the United States. In common with the cranes and unloaders described in these columns 12 months ago they may be taken as typical examples of the most recent American practice, and it must not be forgotten that in America electrical energy is regarded as indispensable for the handling of coal and ore.

The attention that has been paid to the handling of material accounts in large measure for the rapid development of the heavy engineering industries in the United States. As regards the handling of material we are, in some respects, in much the same position as we were 15 or 20 years ago in connection with polyphase electrical machinery, and we need not remind our readers that the enviable position of many of the large electrical engineering firms on the Continent is due to the eagerness with which these firms developed machinery to meet the new conditions before their trade rivals had even mastered the elementary principles of the subject.

To the Wellman-Seaver-Morgan Co. belongs much of the credit for the phenomenal development of the steel trade in the United States, and the labour-saving machines made by the British branch of the firm are to be found in most of our principal steelworks. An inspection of the drawings herewith shows that the coal-handling plant is characterised by the same excellence of design and attention to detail—structural, mechanical and electrical—as that which marks the steelworks machinery. For this reason, in concluding, we venture to suggest that those interested in the subject would do better to study the new machinery than to assume that because there is very little electrically-operated coaling plant at home, electrical energy must *per se* be unsuitable as a motive power for coal-handling plant.

Improvements in the Sensitiveness of Apparatus at the B.O.T. Electrical Standards Laboratory.

By A. P. TROTTER.

As the tooth of a horse or the scale of a fish may be used to estimate the age of the animal, an apparently minor point, namely, the sensitiveness of measuring apparatus, affords an indication of the development of electric science and engineering. To deprive a horse of its teeth or a fish of its scales would be as grave an act of inconvenience as to rob an electrical engineer of his measuring instruments. During the period of the first volume of the present series of THE ELECTRICIAN, Sir William Thomson was working on his balances with the assistance, amongst others, of Mr. J. Rennie, who for 26 years has been in charge of the Board of Trade Electrical Standards Laboratory. The Thomson graded galvanometers were then ready as practical workshop instruments, and I used them as the best available apparatus in 1884.

On page 99 of this first volume Prof. Rowland describes his research on the absolute unit of electrical resistance, working with a tangent galvanometer having a probable error of ± 1 minute of arc, and a high resistance galvanometer with which "it does not seem probable that this error can be more than one part in two or three thousand." The final probable error was estimated to be $+0{\cdot}04$ per cent., or about half that of the British Association. At that time (p. 236) Desmond Fitzgerald had not given up the weber for the ampere. One of the most practical men in this country at work on electrical measurements other than those used in telegraphy was Mr. J. T. Sprague. He was probably the first to graduate an ordinary galvanometer in direct reading. He used a unit of his own, called an equi-volt, which was the unit of energy.

In 1882 Lord Rayleigh and Mrs. Sedgwick determined the value of the ampere in terms of silver deposition, and, almost simultaneously, Aryton and Perry, who had recently returned from Japan, brought out their ammeters and voltmeters. In 1890 the Board of Trade Electrical Standards Laboratory was established, and, though the choice of 100 volts as the legal standard rather than 1 volt indicates that the laboratory was intended to provide standards for industrial and commercial, rather than for scientific, purposes, great care was taken to secure apparatus capable of high precision.

Although no instruments are sent to the Board of Trade Electrical Standards Laboratory for verification which are capable of the precision of the legal standards (standard cells and resistance coils being excepted), the demands made in recent years for high accuracy has led to a general advance in this direction. Makers of electrical measuring instruments are now sending for test apparatus of a much higher quality than of old. At one time the tolerated error for commercial instruments, such as voltmeters, was one part in a hundred, or 1 per cent. This does not mean that the average instrument was good for making measurements to that degree of accuracy, but this was the limit considered suitable for that class of work. The demand for higher precision was anticipated at the laboratory before it was made, and new methods and sub-standard instruments have been provided. But in "screwing up" accuracy all round, it seemed that a difficulty might occur in connection with current. In resistance work, comparisons of ohm coils at the Board of Trade Laboratory have been carried out for many years to one-fifth of a microhm, and differences of temperature of one-thousandth of a degree are noted. In voltmeter work, the standard cell and potentiometer exceed in precision any indicating voltmeter that is likely to be submitted for test. But the ultimate legal standard for the unit of current, the ampere, did not give so high precision above the instruments for which it is the standard, as was desired. Officially the limit of accuracy is declared to be one-tenth part of 1 per cent.

The following is an account of steps which have been taken to modify the two instruments, the ampere standard balance and the auxiliary 1-ampere balance, to obtain greater sensitiveness without interfering in any way with the essential parts of either instrument or of the quantity measured by them.

1. THE AMPERE STANDARD.

The ampere standard at the Board of Trade Electrical Standards Laboratory consists of a coil of wire surrounded by a marble cylinder on which are wound two other coils. The central coil is suspended from one arm of an Oertling balance, and from the other arm a counterpoise is hung. The whole is mounted on a massive stone pillar resting on a thick bed of concrete a few feet below the level of the neighbouring street. A downward pull on the suspended coil can be balanced by a brass weight of $16{\cdot}77522_3$ grammes (in vacuo), and an upward pull can be balanced by the difference between an iridio-platinum weight of $33{\cdot}54713_9$ grammes on the left arm, and the brass weight on the right arm. The two weights being of nearly the same volume the displacement of the air is approximately the same for both. The current was led into the suspended coil by three silver wires and out of it by three others, 3·5 mils diameter. The total length of the beam of the balance between knife edges is 16 in. (406·4 mm.). A slender brass pointer about $12\frac{1}{2}$ in. (316 mm.) long, moves in front of a scale engraved on ivory. The distance between the divisions is 1/20 in. (say, 1·3 mm.).

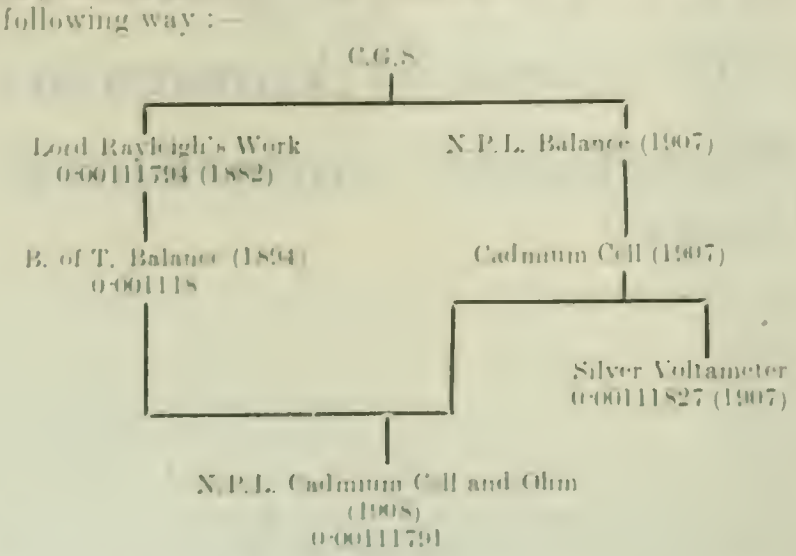
This apparatus, standardised in 1894 by repeated use of the silver voltmeter, represents the imperial standard for current, the ampere. The sensitiveness of such a balance depends largely on the leading-in wires, which, by their bending in a process of weighing, impose a restraint on the swings of the beam. These swings were observed and readings noted to one-tenth of a scale division of the engraved ivory scale, equivalent to 0·000065 of an ampere.

Before the balance had been standardised it was found to be largely sensitive to changes in the moisture of the atmosphere, and to keep the instrument in order for observation

at any time, and also to prevent any undue access of moisture to the coils, a current of about 1 ampere has been continuously passed through the coils, day and night, year by year.

The basis of the standardising is the value 0·00111794, arrived at by Lord Rayleigh and Mrs. Sedgwick in 1884 for the weight in grammes of silver deposited in 1 second by 1 C.G.S. ampere. Discarding the last two figures, the value adopted was 0·001118.

In January, 1908, a comparison was made between the Board of Trade ampere thus measured, and the ampere determined by the National Physical Laboratory directly from the centimetre-gramme-second. The comparison has been set out in the following way :—



The balance at the National Physical Laboratory is used for determining the value of a cadmium cell, which acts as an intermediary in determining the electrochemical equivalent of silver. In making the comparison, the cell was brought to the Board of Trade Laboratory and was used with a 1-ohm coil, having two coils of 0·01 ohm in series and a resistance box as a shunt, adjusted to the value determined at the National Physical Laboratory. The value obtained by the comparison viz., 0·00111791, differed only by 0·00000003 from Lord Rayleigh's original value. It was possible, therefore, with this ampere balance to obtain six significant figures. Assuming that the values of the cadmium cell and of the resistance in series with it were known exactly, the precision of the comparison depended (1) on the weighing of the silver wires which, of course, largely diminished the sensibility of the balance, (2) the difficulty of maintaining a steady current during a set of readings, say, for half an hour at a time, and (3) the difficulty of reading the indication of the pointer on the graduated scale.

The comparison was highly satisfactory. But during the last five years it has been necessary to press for greater precision, and by attention to two details, the leading-in wires and the graduated scale, the sensitiveness has been increased more than thirty-fold.

Owing to the heavy traffic along Whitehall, the street being only about 10 ft. (3 metres) from the instrument, the pointer is often set in vibration, and it did not seem worth while to apply a microscope to it. Experiments were made with photographed scales hung by aluminium wires from the end of the beam, but these took up strong transverse vibrations. A scale photographed on a glass disc about $\frac{3}{4}$ in. (20 mm.) diameter was hung by two parallel chains of the thinnest kind used for eye glasses, and this almost entirely got rid of street vibration. The chains are about 12 in. long and are attached to a bracket projecting beyond one end of the beam, at two points about $\frac{3}{4}$ in. (16 mm.) apart, on a line parallel with the knife edges of the beam, and 14$\frac{1}{2}$ in. (375 mm.) from the knife edges. About 11 divisions of the photographed scale are equivalent to one division of the old engraved scale. The new scale is observed through a microscope with a 2 in. objective, and one-tenth of a division can be estimated more easily than in the case of the old scale, so a gain of more than ten-fold has been made in this direction. The photographed scale, its mounting, and the special microscope were supplied by Messrs. R. & J. Beck.

The next matter taken in hand was the replacement by Mr. P. Webberley of the six leading-in wires by finer ones. Silver wire 1 mil diameter was procured, and experiments were made with an ordinary chemical balance. It was found that annealing the wires largely reduced their damping effect. Two screwed rods were held in a frame 100 mm. (say, 4 in.) apart, and the silver wire was wound nine times round them, with a space of about 2 mm. between the turns. This gave 18 wires per pair of rods.

When it was attempted to make these red hot for annealing purposes by passing a current through them, difficulties arose due to air currents, but these were eventually overcome. I wish to take this opportunity of expressing the appreciation of the laboratory for the excellent work of Mr. Percy Webberley, and for the care, skill and perseverance which he expended on the preparation and mounting of these connections to the standard balance, and of my regret in losing his services when he retired owing to ill-health in 1915.

This opportunity was taken for dismantling, cleaning and adjusting the balance by the maker, Mr. L. Oertling. On reassembling, and before attaching the leading-in wires to the suspended coil, the sensitiveness of the balance was determined, and it was found that the weight of 1 milligramme caused a displacement of two divisions of the new photographed scale. The angular movement of the beam was about 2′ 45″ : an angular movement of about one-twentieth of this can be estimated. The period of one complete swing when the current has been switched off, 57 seconds. The attachment of the two sets of 18 wires, as was anticipated from the preliminary experiments with the chemical balance, have a scarcely appreciable effect on the sensitiveness. The mean displacement is about 1 per cent. less when the wires are attached. The current required to bring the wires to a red heat was about 11 amperes, and no attempt has been made to measure the rise in temperature due to the passage of 1 ampere. It is inappreciable compared with that due to the heating of the main coils of the apparatus. A thermometer hung above them just within the marble cylinder shows a difference of about 3° C. higher than that of the laboratory, when the ampere is passing.

With the original two sets of three silver wires, 1 milligramme caused a deflection of 0·01 division of the ivory scale, or about one-third of the present deflection. The sensitiveness of the ampere standard balance has, therefore, been increased more than thirty-fold.

But full advantage cannot be taken of this, since the mechanical zero is found to wander. This is no doubt due to vibrations set up by the street traffic, but the nature of the inconstancy has not yet been discovered.

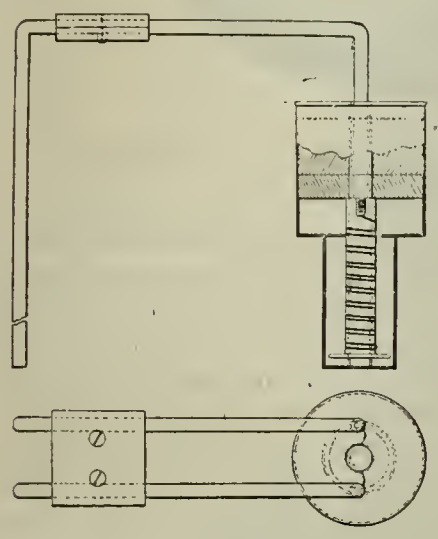
2 The Auxiliary Ampere Balance.

The auxiliary ampere balance is a Kelvin balance mounted on a stone pedestal. It is more suited than the standard balance for ordinary work, since the period of a complete swing under current is about 6 seconds instead of 46. With the usual pointer and scale one quarter of a division corresponds to 50 millionths of an ampere. In the comparison with the National Physical Laboratory ampere in 1908 this instrument was used as an indicator and was provided with an optical magnifying arrangement. This has been developed. A lens about 18 mm. diameter has been fixed on the beam, near one end a counterpoise being used at the other. A small electric lamp is placed on a holder capable of easy adjustment in any direction, and at a distance of 26 mm. from the lens. An image of the filament is thrown on to a scale at a distance of 9 ft. 5$\frac{1}{2}$ in. (2,832 mm.). A movement of the lens is indicated by a movement of the image through a distance 110 times greater. The scale on the wall is graduated in centimetres, and a change in the zero of the instrument through 1 cm. corresponds to 15 millionths of an ampere. This arrangement, which was supplied by Messrs. R. & J. Beck, enables the current to be observed from any part of the room with more than twice the precision of the old arrangement, which had to be minutely examined through a lens.

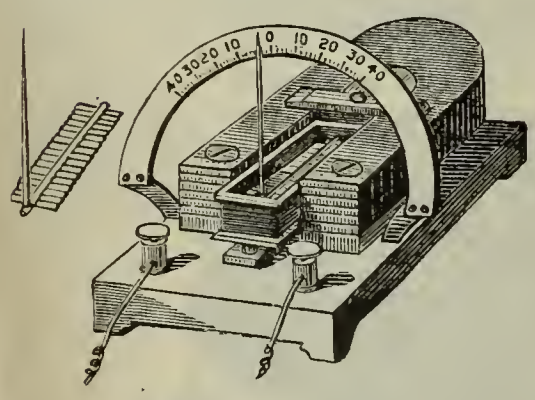
Measuring Instruments.

By C. V. DRYSDALE, D.Sc.

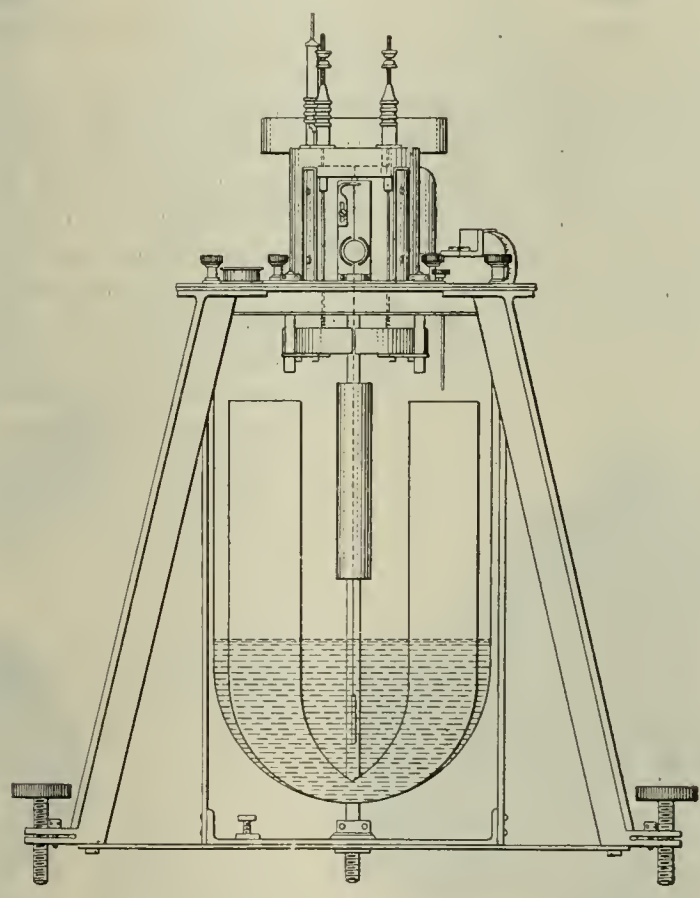
There is probably no department in which our country may be more proud of its pioneers than in the domain of electrical measurement. The formation of the British Association Committee on Electrical Units and Standards in 1861, with its reports of 1867, 1881, &c., was in itself a magnificent service to science; and if we had no other names in connection with the development of electrical instruments and measurements than those of Wheatstone, Lord Kelvin, Profs. Ayrton and Perry and Lord Rayleigh there would be no question as to our pre-eminence in this sphere. Few indeed are the types of instrument that have not owed their existence to British inception and to the pioneers of electrical instrument manufacture in this country, and although we have less reason for satisfaction at our developments during the last few years, the realisation of the place which these pioneers won for us, and the lesson taught us by the war, should be sufficient stimulus for us to be determined to regain that place.



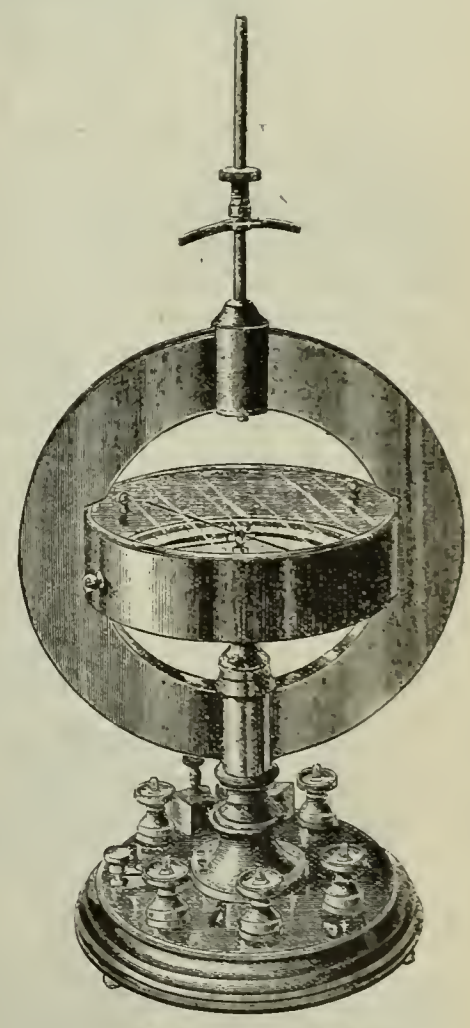
B.A. Standard Coil.



Deprez Galvanometer.



Lord Kelvin's Quadrant Electrometer.

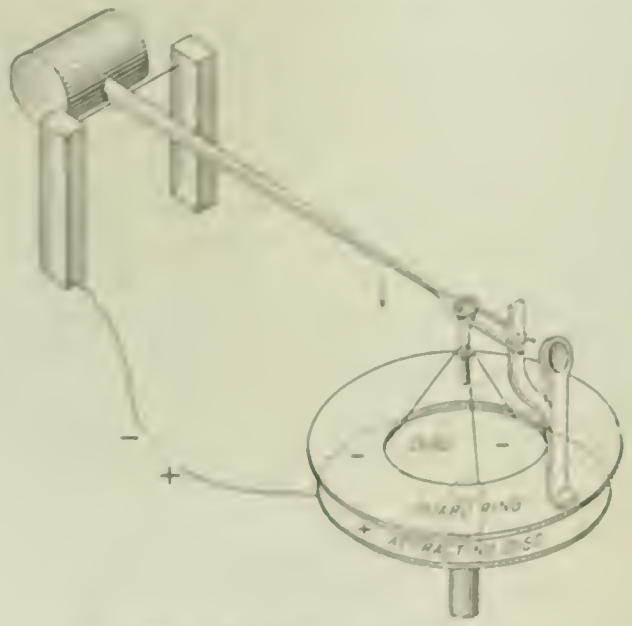


P.O. Tangent Galvanometer.

When we contemplate the array of electrical measuring instruments described in catalogues and shown at scientific exhibitions in recent years, it is difficult to realise that when The Electrician first made its appearance 38 years ago, measuring instruments, in the modern acceptation, had hardly any existence. Exception to this statement must be made in the case of sensitive galvanometers and resistance measuring apparatus which had been developed by our telegraphic pioneers from the early form of bridge suggested by Christie in 1833 and adopted by Wheatstone ten years later, and from the first mirror galvanometer devised by Sir William Thomson (Lord Kelvin) in 1856, to a degree of perfection which has been but little surpassed since that time. At the Conversazione of the Society of Telegraph Engineers (now the Institution of Electrical Engineers) in 1878, and at the Paris Exhibition of 1881, Messrs. Elliott Bros. and Messrs. Clark, Muirhead & Co. showed resistance standards of the B.A. form, four dial and other types of Wheatstone bridges, with platinum silver coils, the valuable Thomson and Varley slides, marine and other mirror galvanometer, standard mica condensers, and quadrant electrometers based upon the types of electrometer described by Sir William Thomson at the British Association of 1867. But there were no direct-reading indicating instruments of any kind, no ammeters, voltmeters, wattmeters, or supply meters; and current measurements were conducted by various forms of tangent or sine galvanometer. Perhaps the first general testing instrument for current P.D. and resistance was the Schwendler tangent galvanometer described in the first volume of The Electrician, which consisted of a portable tangent galvanometer with two coils of thick and thin wire respectively, and provided with auxiliary resistance coils. The question of electrical units and standards was also still unsettled, although astonishingly good work had been done by the B.A. Committee, with the limited facilities at their disposal.

For those who believe in the dictum that "science is measurement" the commencement of general electrotechnical science may perhaps be dated from the year 1882, when Profs. Ayrton and Perry read a Paper entitled "Measuring Instruments Used in Electric Lighting and Transmission of Power," before the Institution of Electrical Engineers. On that occasion they described and exhibited 14 instruments and devices for electrotechnical measurements, including direct-reading permanent-magnet ammeters and voltmeters (somewhat on the lines of the Deprez permanent magnet controlled galvanometer

devised in 1880), with or without series-parallel commutators, the first dynamometer wattmeter (which they termed a "power meter," and Lord Kelvin an "ergometer"), an electrostatic voltmeter, an ohmmeter, a mechanical transmission dynamometer, a dispersion photometer for arc lamp testing, and a "coulombmeter" with permanent magnet and fluid friction brake.* At the discussion on this Paper Dr. Obach described the first form of Siemen's electrodynamometer, which had just been introduced.



Lord Kelvin's Absolute Electrometer.

and also the Hefner Alteneck belt transmission dynamometer. It is interesting to see in the Paper and discussion how thoroughly Profs. Ayrton and Perry had already grasped the essential principles of good instrument design, the reduction of the moment of inertia and periodic time to a minimum, the attainment of "dead beatness," of good balancing to avoid errors of position, of strong internal fields to avoid disturbance by stray fields, &c. They were also quite alive to the question

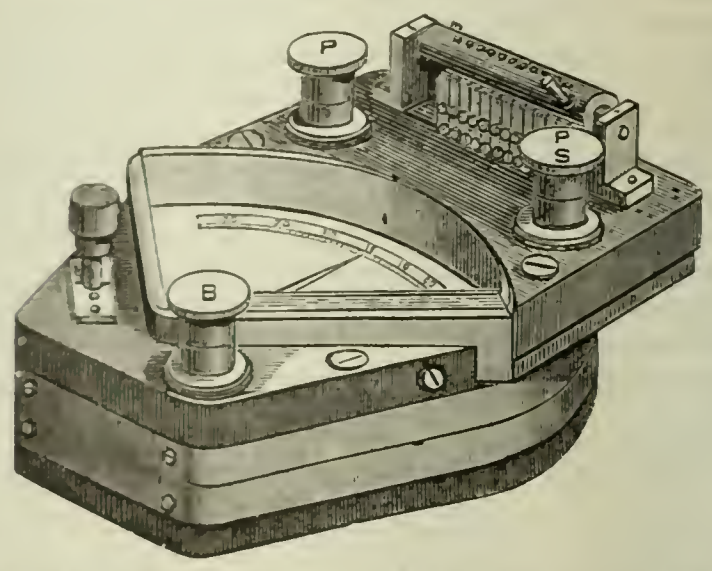


Siemens Tangent Galvanometer.

of suitable instruments for alternating current measurement, and the square root of mean square law.

Earlier in the same year Prof. C. V. Boys had read Papers at the Physical Society on integrating mechanisms, with application to electric supply meters, and had foreshadowed the clock meter, while in The Electrician for March 4, 1882, he described two "mangle motion" meters, one of the quantity, the other of the energy type, in which the deflection of an ammeter or of a dynamometer wattmeter was integrated by a revolving drum. The pioneer hot-wire voltmeter was devised by Major Cardew in 1883, and the next year saw the first "soft iron" measuring instrument in the "twisted strip" ammeters and voltmeters of Profs. Ayrton and Perry.

From this time onward, progress was rapid, and within a few years Lord Kelvin and Profs. Ayrton and Perry



Ayrton and Perry Commutator Ammeter and Volt-meter.

covered nearly the whole field of electrotechnical measurements. In April, 1883, Lord Kelvin took out the first patent for his renowned electric balances, which from that time to the present have held the field as current standards. At the British Association meeting in 1887 he was able to describe six grades of these balances from the centiampere to the kiloampere balance, an engine room voltmeter of the dynamometer type, and a soft-iron "marine voltmeter." At the Glasgow Philosophical Society the same year he described his high-voltage electrostatic voltmeter, 400-10,000 volts, and in 1890 his multicellular low-range voltmeters. In a letter to Helmholtz in 1885 he had stated that "My aim is a two-branched chain to measure current from 10^{-9} of an ampere (*i.e.*, a mikro-



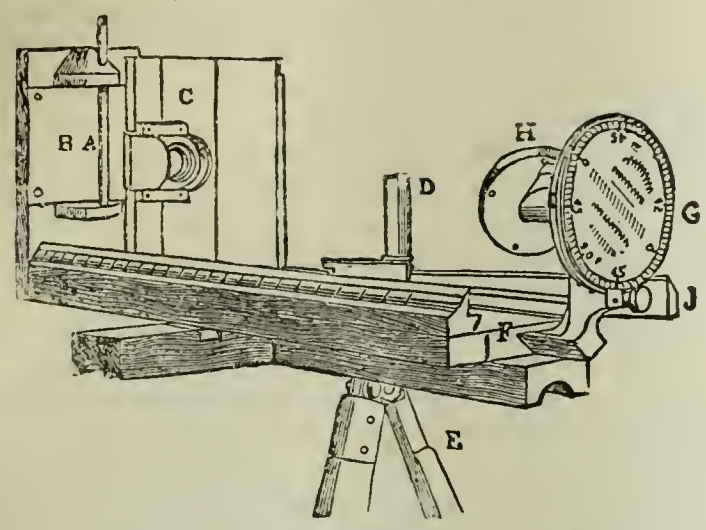
Ayrton and Perry Wheel and Pinion Electric Power Meter.

milliampere ?) to a 1,000 amperes, and from 1/10,000 volt (or as much less as you please) to 80,000 volts, all connected by proper standardisers and comparers, and susceptible (I hope) of an accuracy of 1/10 per cent. in every case, when the requisite care is given." This programme he may be said to have fairly realised.

To Profs. Ayrton and Perry we owe not only the first ammeters and voltmeters, and the first practical clock meter

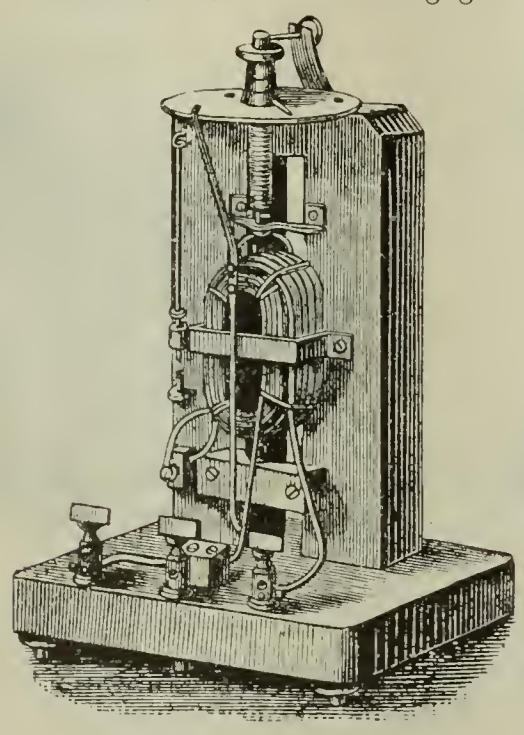
* This pioneer motor meter was found by Profs. Ayrton and Perry to have been patented by Edison some time previously, but there was no record to show that it had been made or that he had fully understood the conditions for accurate registration.

(to be revived later as the Aron meter), but a vast number of improvements in moving needle and moving coil galvanometers, and testing instruments of all kinds.



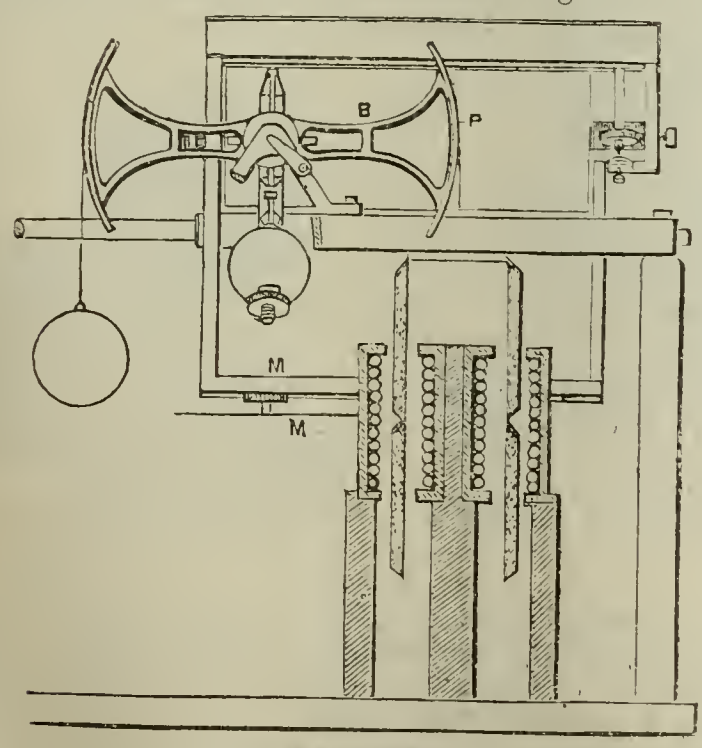
Ayrton and Perry Dispersion Photometer.

The permanent magnet moving coil instrument may be said to owe its inception to Lord Kelvin's Siphon Recorder of 1867, but it was first introduced as a reflecting galvanometer by



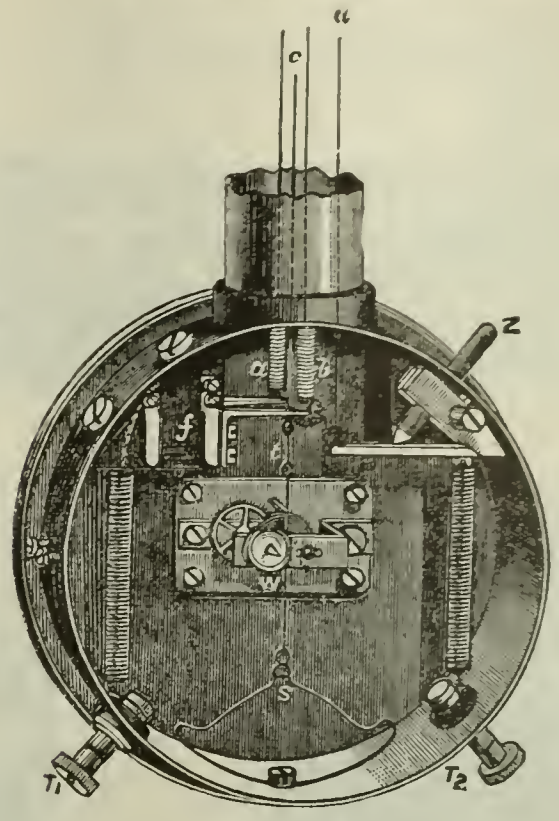
Siemens Dynamometer.

d'Arsonval in 1882, although a moving coil galvanometer had been used by Sturgeon as far back as 1836. We may, however, claim the introduction of the moving coil voltmeter



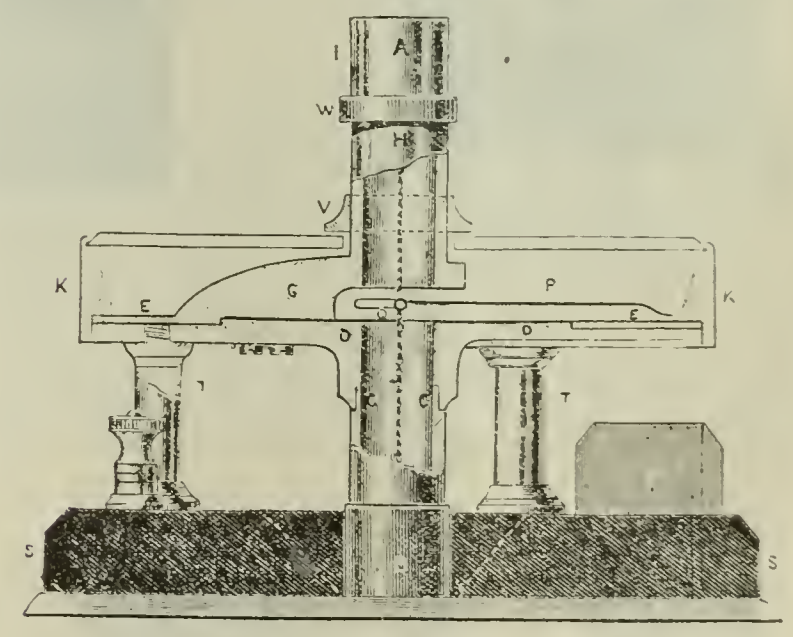
Boys Mangle Meter.

and ammeter by that remarkable English-born pioneer of accurate electrical instruments, Dr. Weston, in 1888, and the long line of precision-indicating instruments which he has developed in the United States have set up a standard of excellence in instrument construction which it is difficult to rival. To him we also owe the first indicating dynamo-



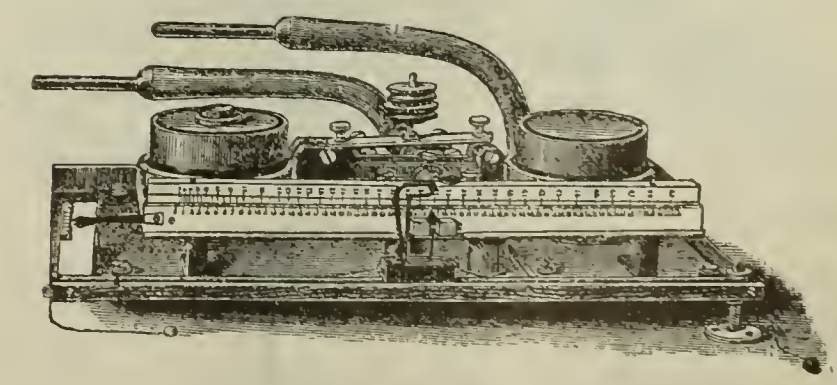
Cardew Voltmeter.

meter voltmeters and wattmeters introduced in 1890, as well as the important modern achievements of the Cadmium standard cell, and the resistance material of lowest temperature variation combined with high specific resis-



Ayrton and Perry Twisted Strip Voltmeter.

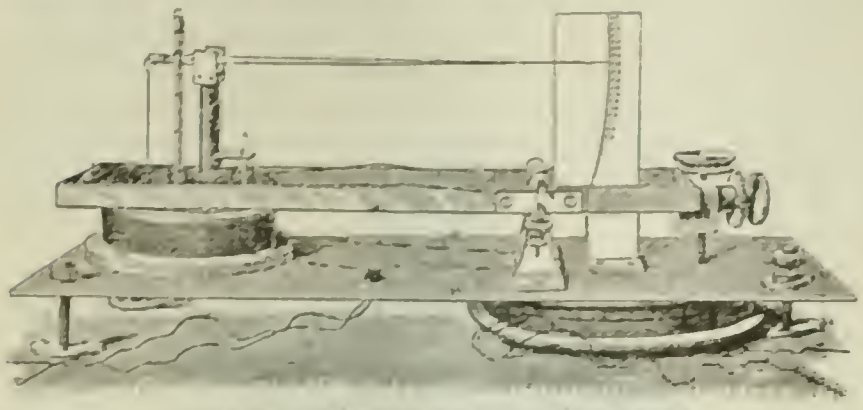
tance and low thermo E.M.F. (afterwards christened "manganin" by the Germans). On the standardising side the most important achievement was that of the potentiometer devised by Messrs. Fleming and Crompton in 1893 on the



Lord Kelvin's Standard Balance.

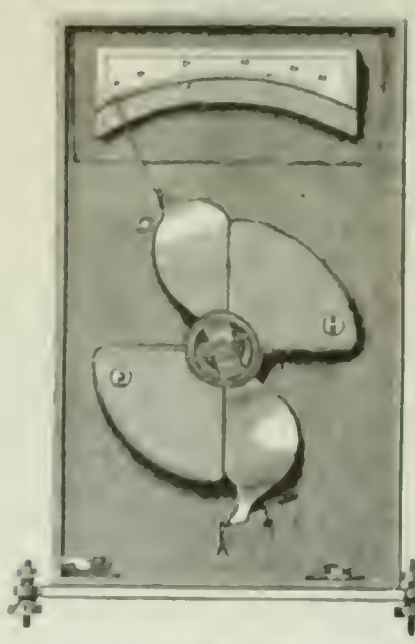
old principle of Poggendorf (1841). With the aid of the standard cell devised by Latimer Clark as far back as 1872, they developed this into the most useful, accurate, and universal

of continuous-current measuring instruments. The illustration shows the first form of Fleming-Crompton potentiometer, as described in THE ELECTRICIAN in May 1893.



LORD KELVIN'S ENGLISH ROOM VOLTMETER.

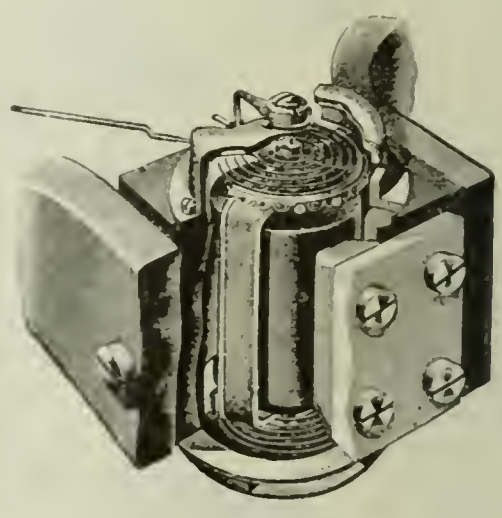
A mere classification of the instruments which exist at the present time will suffice to show the immense progress which has taken place in the 40 years we are reviewing, and may give some indications as to the possibilities of future progress.



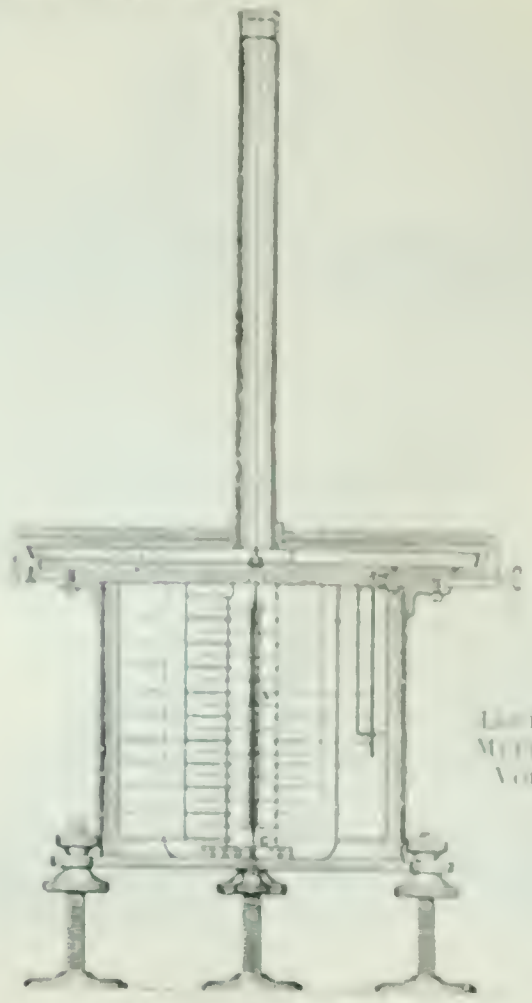
LORD KELVIN'S VERTICAL SCALE VOLTMETER.



LORD KELVIN'S AMPERE GAUGE.



WESTON VOLTMETER.



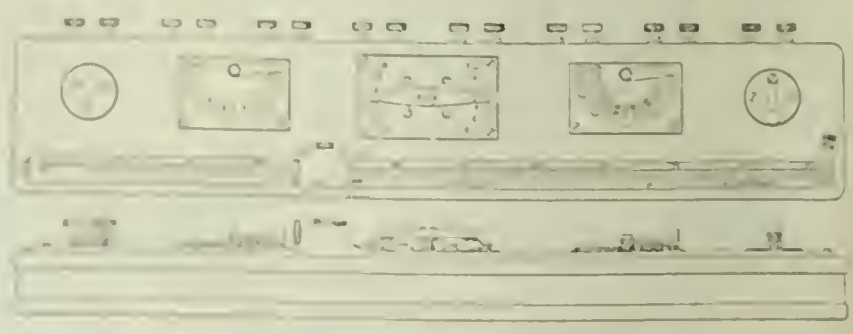
LORD KELVIN'S MULTICELLULAR VOLTMETER.

As regards indicating instruments, we have ammeters and voltmeters of the electromagnetic type, including permanent magnet, soft iron, dynamometer and induction principles, and also of the thermal or hot wire type. Electrostatic voltmeters, although better suited for high voltages, are satisfactory down to 100 volts or less. Indicating wattmeters are available of the dynamometer and induction types, and hot-wire wattmeters have been suggested by M. B. Field and by Irwin. The use of the electrometer as a wattmeter suggests the possibility of electrostatic wattmeters for high voltages, but there are several difficulties yet to be overcome.

The number of supply meters both of the quantity and energy type has become legion, and every kind of electromagnetic, electrochemical and electrothermal device with every variety of integrating mechanism has been pressed into the service. Specially worthy of mention are the Edison (1883) and Bastian (1900) chemical meters: the Faure (1882), and Ferranti (1889) mercury meters: the Elihu Thomson motor energy meter, 1891: and the Schallenberger (1888) and Ferranti-Wright (1890) induction meters.

Alternating-current supply has required a great extension of instruments, and we have frequency meters of the deflectional type (Westinghouse and Weston), and resonance type (Campbell, Hartmann and Braun, Frahms). We have also power factor and phase meters, idle current ammeters and synchroscopes.

Turning to standard instruments, Dr. Weston has developed the permanent magnet moving coil instrument into a remarkably accurate and convenient standard, but its indications naturally depend upon the constancy of the permanent magnet, and the instrument is unfortunately unsuitable for alternating currents. The Kelvin balances have been improved and extended in range, so as to cover direct or alternating currents from 0·01 ampere to 2,500 amperes, and the composite balance

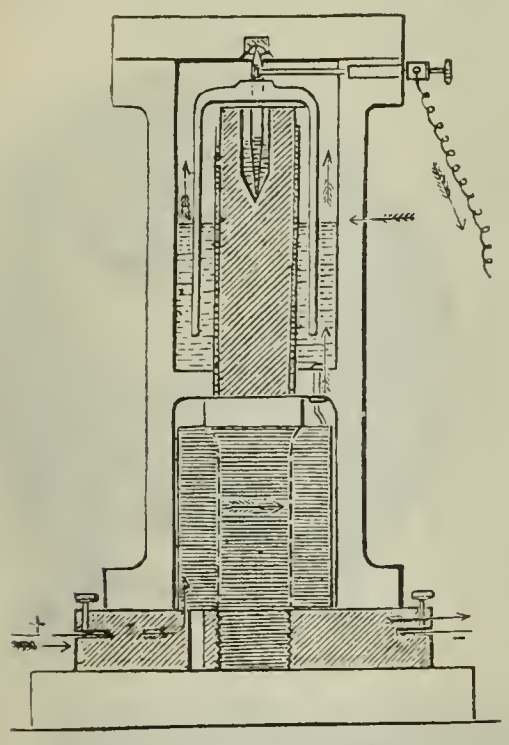


CROMPTON POTENTIOMETER (EARLY FORM).

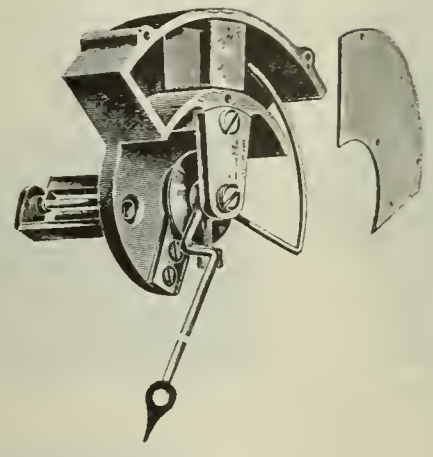
serves also as a wattmeter. Attempts at substitutes for these balances have been made by the Germans, notably by the use of pyrometers, but without any great success. On the other hand, Dr. Northrup in the United States has produced a highly ingenious instrument based upon the "pinch phenomenon" or tendency to contraction of a mercury stream carrying a current, which appears very suitable for heavy current measurement. Crossed wire thermo-junctions with sensitive moving-coil indicators have been favoured by the French instrument makers.

Coming to testing instruments, little advance has been made on the Kelvin mirror galvanometers of 1856. The

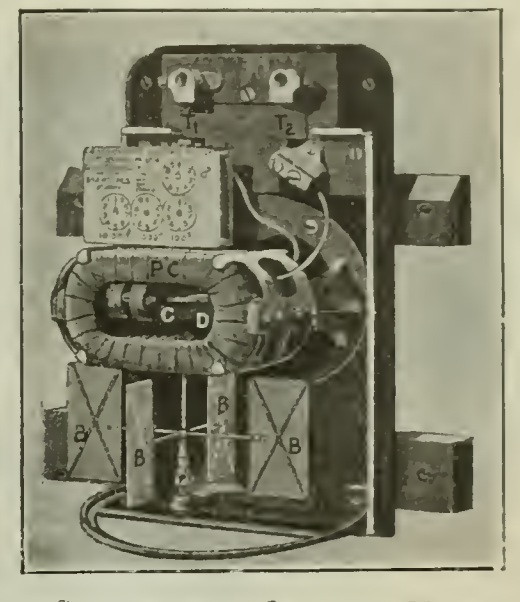
moving-coil galvanometer was, however, considerably improved by Profs. Ayrton and Mather in 1890 by the introduction of the narrow coil giving the maximum ratio of torque to inertia and thus reducing the periodic time. For the highest possible rapidity combined with sentiveness the Einthoven string galvanometer of 1903 was a decided advance, and it has proved of considerable value in electrotherapeutic work. Again, the demand of alternating-current testing have had to be met, and oscillographs have been produced, both of the moving iron form (Blondel, 1893) and moving-coil form (Blondel, Duddell, 1897), and also of the hot-wire form (Irwin), electrostatic



Faure's Mercury Meter.



Nalder Ammeter.



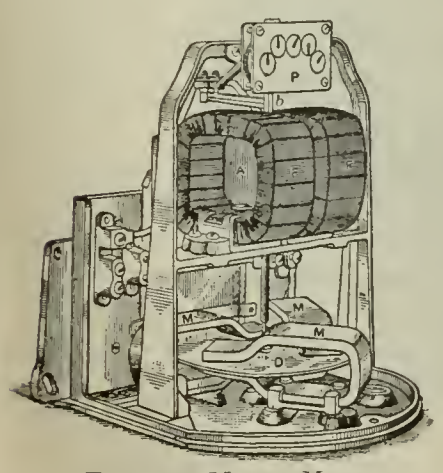
Shallenberger Induction Meter.

form (Ho and Koto, 1913) and vacuum tube form (Braun, Gehrke). For detection purposes, vibration galvanometers of the moving-needle form (Rubens and Drysdale-Tinsley) and moving-coil form (Campbell and Duddell) have come much into use, and for special purposes the moving-coil shunt electromagnet form of Dr. Sumpner, while for considerable sensitiveness at radiotelegraphic frequencies the thermo-galvanometer of Duddell, consisting of a Boys radiomicrometer, heated by a fine wire carrying the current to be tested, has proved of great service.

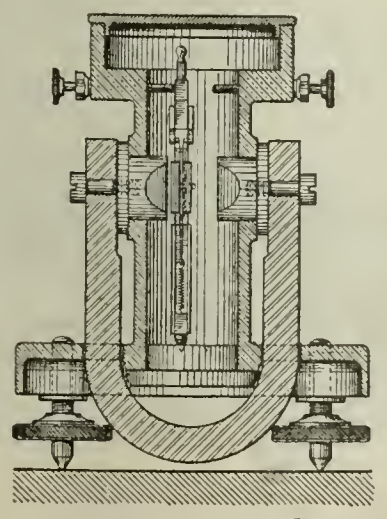
As regards resistance testing apparatus, the modifications of the Wheatstone bridge alone would fill a volume. Apart from improvements in the design and construction of the ordinary plug and switch bridges the principal developments from the original bridge are the Carey-Foster slide wire standardising bridge, the Kelvin double bridge for accurately measuring low resistance, the Reichsanstalt bridge for standardising both high and low resistances and the combined Kelvin-Carey-Foster standardising bridge of the writer. The resistance coils have been steadily improved from the german silver or platinum-silver wax-covered coils to the annealed and varnished manganin coils wound on thin-walled open tubes, thus allowing considerable surface for cooling. Where high-frequency alternating-current testing is required the coils are frequently wound on flat mica plates, or the resistance wire is woven into a cloth with asbestos (Ayrton and Duddell). For insulation testing purposes the ohmmeter principle has proved very useful and has been developed by Evershed and by Nalders.

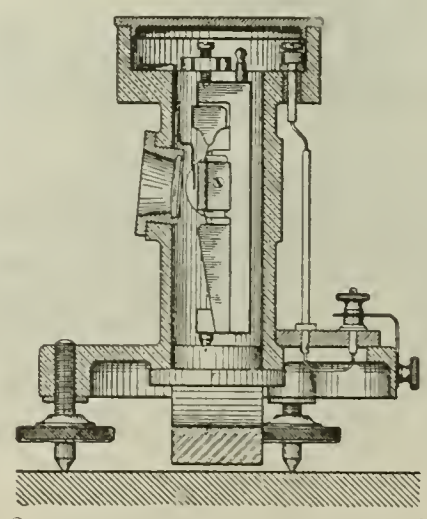
The development of the potentiometer has also been very rapid and has been very greatly studied in Germany, notably as regards low resistance, thermo-E.M.F.-free, elements for thermo-couple pyrometry, which ought to be better known in this country. As in some other instruments (*e.g.*, the Kelvin double bridge), the course of British and German development has gone on different lines, our standard form having been the Fleming-Crompton instrument with one resistance dial and a slide wire, while the standard German form has been the Feussner five-dial type. A compromise of two dials and a slide wire is probably the best arrangement.

Capacity and inductance measurements have become of steadily increasing importance, and many devices have been brought out to facilitate them. Standard condensers have been brought to a high pitch of perfection in this country, the paraffin paper condensers commonly used for cable work having an insulation resistance of 20,000 to 30,000 megohms per microfarad.

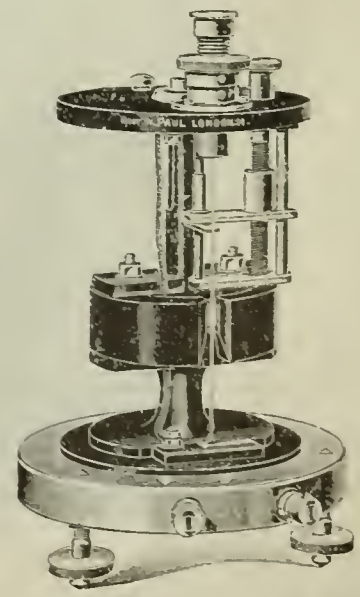


Thomson Motor Meter.





Duddell Oscillograph.

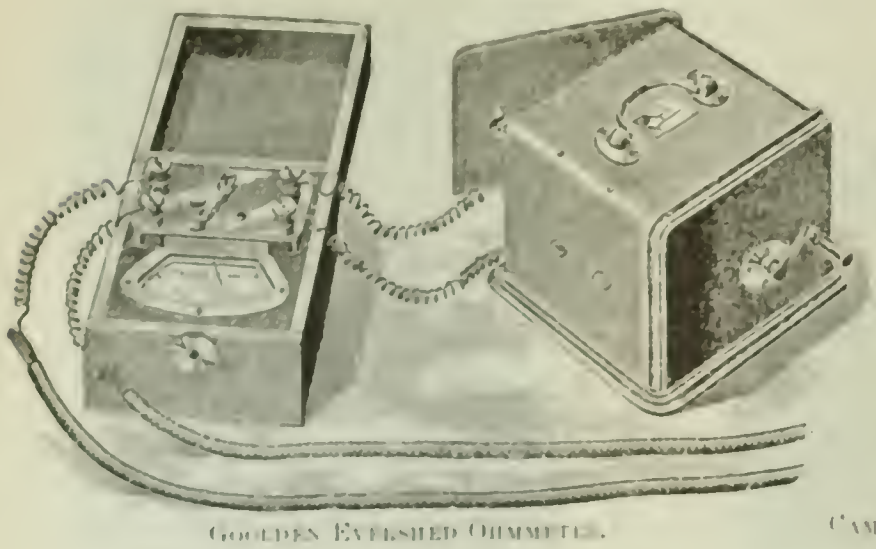


Campbell Vibration Galvanometer.

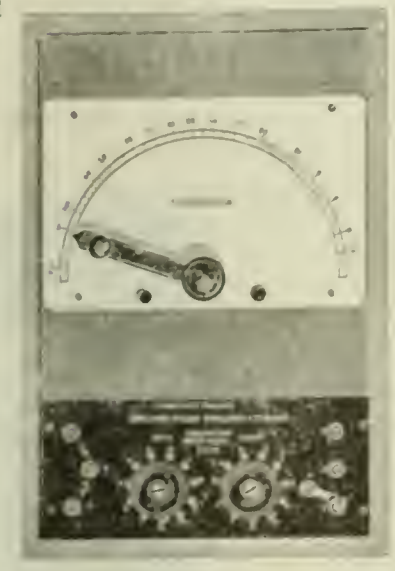
The pioneer work in inductance and capacity measurement after the theoretical work of Maxwell and others was done by Profs. Ayrton and Perry in the introduction of their secohmmeter and variable inductance standard, while the Fleming commutator has proved of great value for condenser testing, especially with small capacities. Mr. Campbell's form

of mutual inductance standard is also very useful. As regards high-frequency testing, Prof. Fleming's cymometer holds the first place for general work, and we also have the forms of spark counter devised by Dr. Fleming and by Mr. Campbell. In the region of radiotelegraphic measurement it may be said that our country is fully holding its own.

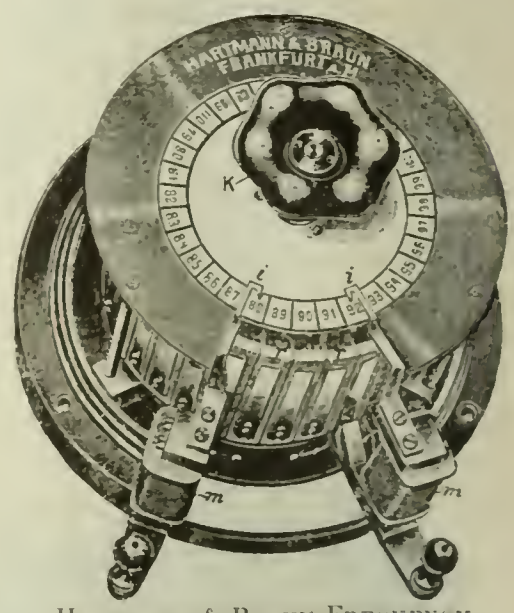
Iron testing is another branch in which considerable development of measuring instruments has taken place. Since the first permeameter of Hopkinson there have been the traction permeameter of Bidwell, Kapp and S. P. Thompson, the magnetic balance of du Bois, the Ewing magnetic bridge, the deflection permeameter of Siemens & Halske, the plug permeameter of the writer, and the friction permeameter of Murdoch. We have also had the Grassot flux meter, and the hysteresis meters of Ewing and of Carpentier.



Goolden Enfield Ohmmeter.



Campbell Mutual Inductance Standard.



Hartmann & Braun Frequency Meter.

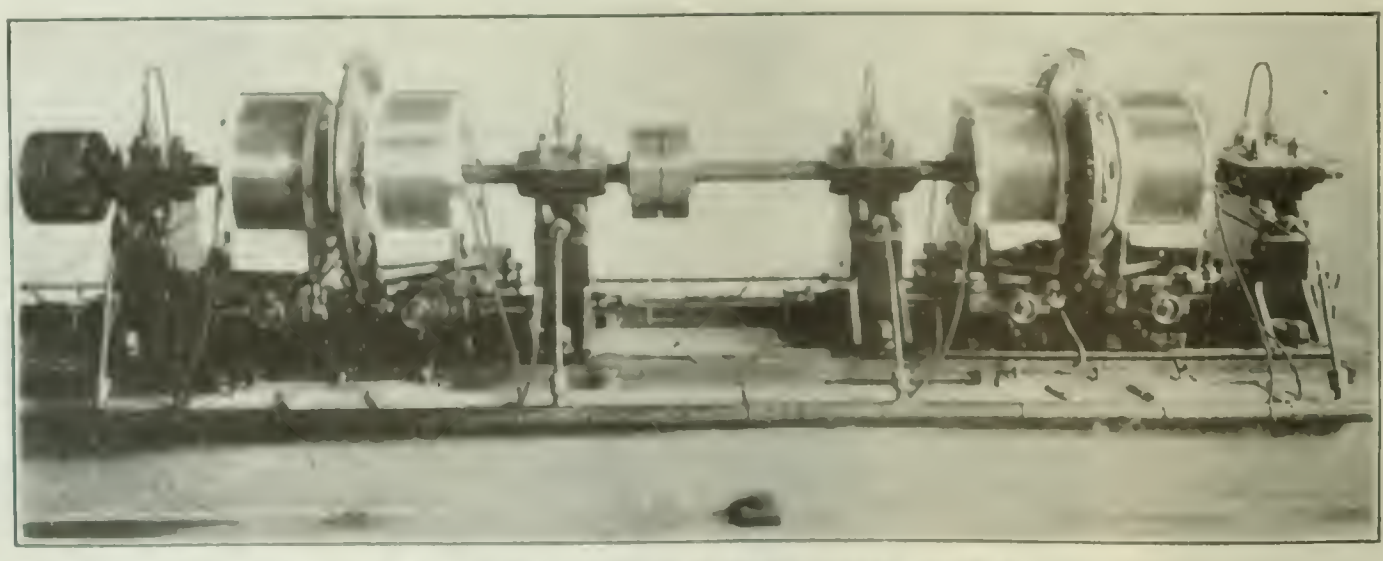
And in addition to all these we have had the numerous instruments which have been developed either as adjuncts to electrical testing or as employing electromagnetic principles. Electrical engineers, as being especially concerned in the accurate testing of rotating machines, have been obliged to devise special forms of dynamometers and speed indicators, and the bulk of the tachometers used at the present day are of the eddy-current form, or of the resonance form first introduced by Campbell and by Hartmann and Braun for frequency measurement. The development of electric lighting has also caused electrical engineers to take the leading part in photometric measurement, and we have consequently seen a remarkably complete series of photometric instruments, some of which, like the Fery photometer, give direct indication electrically. Most important of all has been the great rise of electrical thermometry from the resistance pyrometer of Siemens (1881) to the accurate platinum thermometers of Callendar and Griffiths, the thermoelectric pyrometers of Le Chatelier and others, the radiation pyrometers of Fery, Holborn and Kurlbaum, &c., all of which have been of the greatest possible value in metallurgical and other furnace operations.

As regards standards, the pioneer work of the B.A. Committee and the Board of Trade, reinforced by the recent excellent apparatus and measurements of the National Physical Laboratory, has certainly maintained British prestige, although for a certain period it was threatened by the Reichsanstalt. Except in the matter of radiation measurement, however, the latter institution has been quite outclassed in recent years by the Washington Bureau of Standards, by the International Bureau at Sèvres and by the National Physical Laboratory.

The foregoing account of progress up to recent times, although necessarily very incomplete, will suffice to indicate the immense ground which has been covered, and it will be well to review the present position and the prospects for future development.

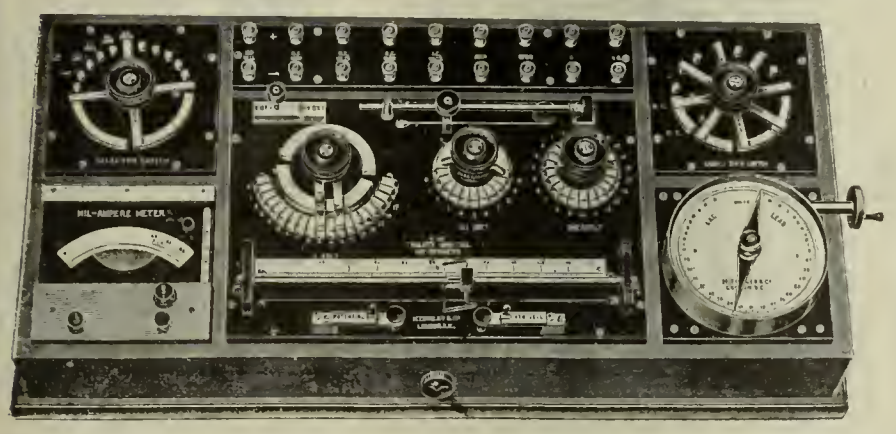
Standards of P.D., Current and Power.—The question of working standards of P.D., current and power has become a very difficult one in recent times, and it should come up for discussion as soon as circumstances permit. So long as direct currents only, or even single-phase currents of moderate amount and frequency, were concerned, the bulk of the necessary standardising of an ordinary supply station could be effected without great difficulty by means of a potentiometer or by a few Kelvin balances and electrostatic voltmeters: but with the modern extension to polyphase supply of great P.D. and current range with balanced and unbalanced loads at various power factors, and with the added complication of P.D. and current transformers, the battery of apparatus required for effective testing is formidable in magnitude and cost, and as a result few power stations appear to be equipped in any way adequately for their needs.

The Use of the Potentiometer.—In view of the great convenience and flexibility of the potentiometer for nearly all continuous-current measurements, there can be no question



National Physical Laboratory Lantern Apparatus.

as to the desirability of extending it, if possible, to deal with alternating-current measurements. In 1909 the writer obtained a solution of this problem by the application of a phase-shifting transformer and a dynamometer to an ordinary potentiometer, with the result of obtaining an instrument which is capable of making P.D., current and phase measurements, of a high degree of accuracy and of the highest possible range, on circuits having a good sine wave supply at a steady frequency. It does not profess to be accurate on other than sine waved supply, but the errors due to the presence of small harmonics is not great (0·12 per cent. for a 5 per cent. harmonic), and the absence of inductive and eddy-current errors make its indications in many cases more accurate than those of heavy current dynamometer instruments, especially at the higher frequencies. In combination with a volt box and a set of non-inductive "shunts" or low-resistance standards, this potentiometer is capable of measuring, in terms of a standard cell, either continuous or alternating-current voltages or currents of practically any range and frequency (up to 1,000 or 2,000 $\sim$ per second). And as it indicates the phase of each P.D. or current within 0·1° or 0·2° it will check power or phase measurements on single-phase or polyphase circuits. It may fairly be described as the most universal electrical measuring instrument which has yet been devised, and the only question is as to its accuracy and convenience in practical working. It has been adopted by several standardising laboratories and works, and the result appears to be favourable, despite the fact that steadiness of the circuits is necessary and that the P.D. and current readings are taken successively instead of simultaneously.



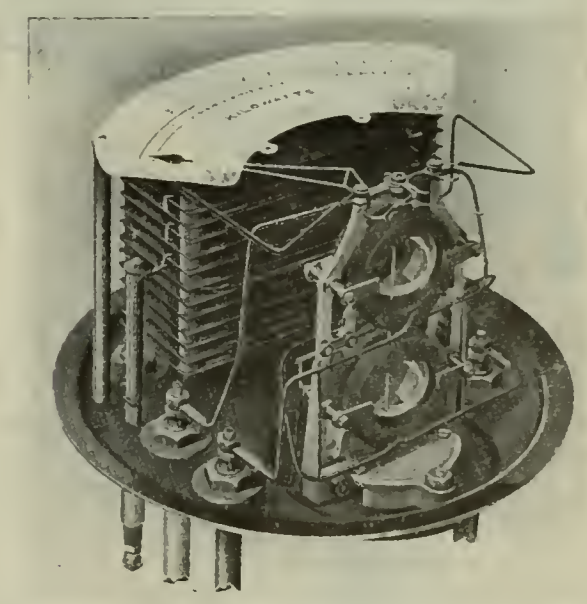
A. C. Potentiometer.

Wattmeters.—For the most accurate measurements of power, however, the wattmeter will still be necessary, and opinion in this country is still divided between the relative merits of the dynamometer and electrostatic wattmeters. Both have their advantages, and where a fairly large space is available for permanent installation, and loss of power at high currents is no object, the electrostatic form will very likely be used; but where robustness and some degree of portability are essential the dynamometer type holds the field. The difficulties as regards very high currents have been very neatly surmounted by Mr. P. G. Agnew, at the Bureau of Standards, by making the main circuit in the form of concentric tubes.

Standards of Resistance.—Considerable and steady progress has been made in the production of resistance standards since the introduction of the first form of standard by the B.A. Committee in 1867 with its platinum silver coil embedded in paraffin wax, and with its long thin copper electrodes. The improvements have lain in reducing the temperature coefficient by using manganin wire or by compensation, in increasing the current capacity by using open-wound coils in an oil bath, and by making the copper terminals short and stout and with separate current and potential or bridge terminals. Permanence is secured by silver soldering the wire to washers which are screwed and soldered to the electrodes by rigid mounting, by careful annealing after winding, and, in the case of the higher value resistances, by sealing the oil chamber to protect the coil from moisture.

The adoption of the potentiometer has brought into prominence standard resistances of low value and of high current carrying capacity, and for this purpose manganin plate resistances were first introduced by the Reichsanstalt in 1895. For many years the Germans have had almost a monopoly of the highest grade of resistances of this kind, but the advent of the alternating-current potentiometer has evolved a need for non-inductive resistances of this class, and has thus led to a new series of designs with improved terminals, &c., described in The Electrician on August 11 last. These designs, in conjunction with the resistance alloys, which the war has induced at least one British firm to produce, ought to do something towards challenging the German monopoly.

Indicating Instruments.—It is not easy to make any special predictions or recommendations in this matter, as each of the various types of instrument has its own fairly definite sphere of usefulness which makes it difficult to discard. Soft iron instruments are not only cheap, but are almost the only practicable type of instrument for ordinary alternating-current measurement. Moving coil permanent magnet instruments are unrivalled for accurate continuous-current testing, dynamometer and electrostatic instruments for accurate alternating-current work, and hot-wire instruments, although least satisfactory from the point of view of accuracy on ordinary circuits,



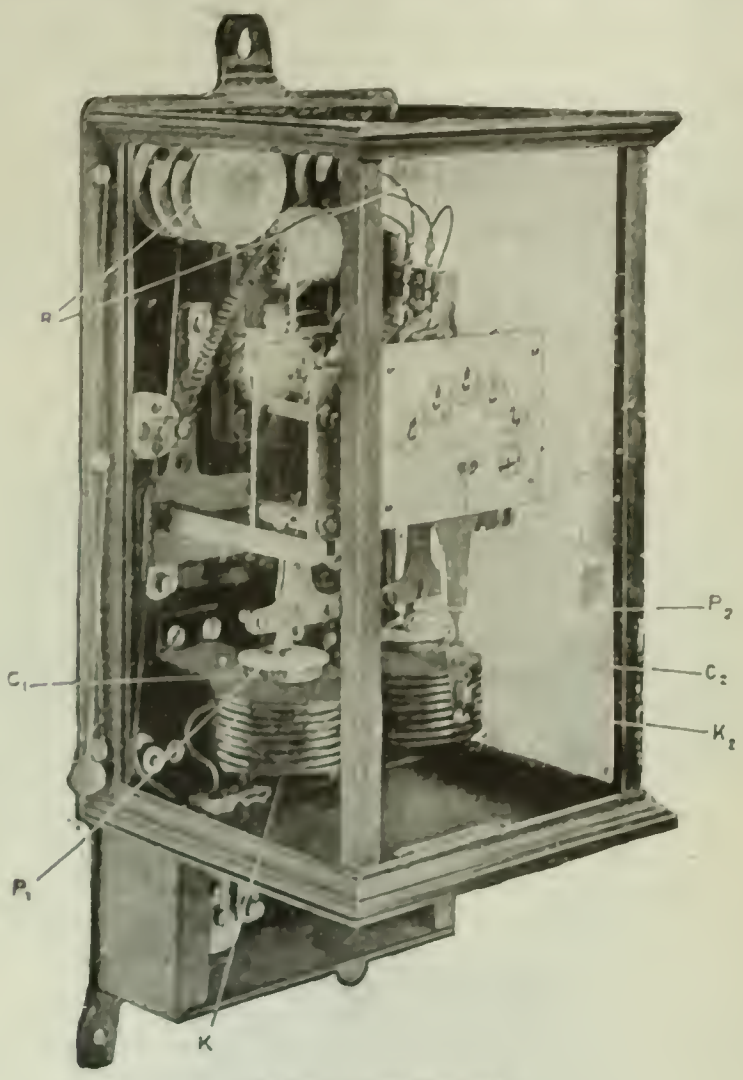
Weston Three-phase Dynamometer Wattmeter.

are essential for high-frequency tests. On the other hand, each of these types has one, or perhaps two, most suitable forms, and a great deal of useful elimination could be done which would help greatly towards better construction. Perhaps the induction pattern of indicating instrument is least suited for survival, except in the case of cheap indicating wattmeters and power factor indicators (especially for polyphase circuits).

Radio-Telegraphic Measuring Instruments.—The need for satisfactory measuring instruments is greatest in this direction, and, in fact, beyond the Fleming cymometer and spark counter, and the Marconi wave-meter, little has been effected. The difficulty here lies not only in the small amount of power usually available, and in the extreme risk of error from interference, eddy currents, &c., but in the fact that the very meaning of inductance and capacity in circuits of large dimensions at high frequencies is open to question, and many erroneous measurements have been made in consequence of these difficulties.

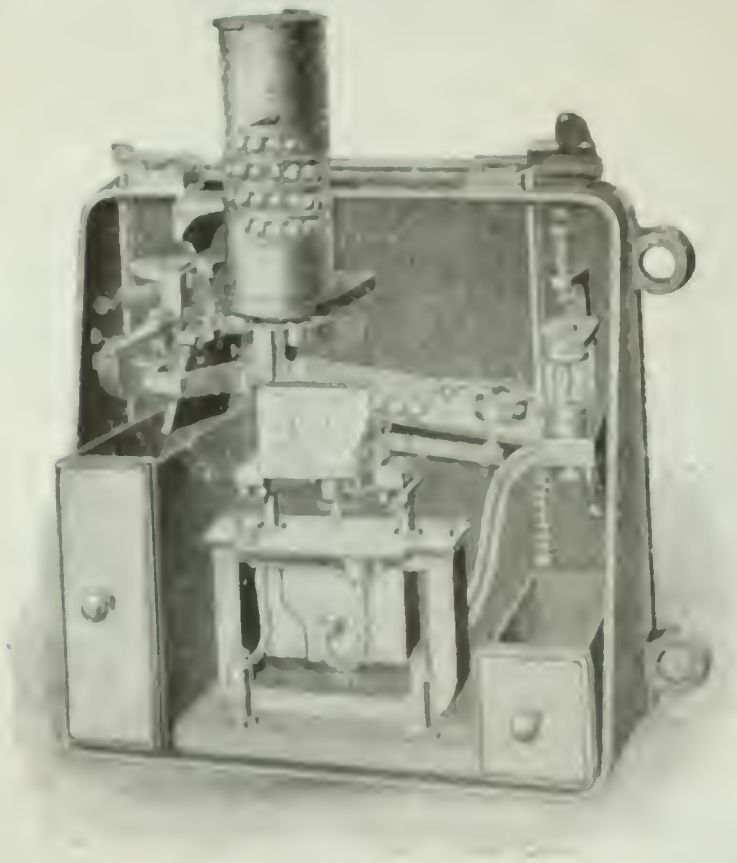
Electric Supply Meters.—As electric supply is a supply of energy it follows that the instruments which record the total energy supplied to a consumer in a given time are of the greatest practical importance. For this reason the amount of attention which has been given to supply meters by inventors is remarkable, and it is impossible even to indicate the course of their development. The tendencies as regards the future,

however, are fairly clear. The only surviving types of universal meters for continuous or alternating-current supply are the motor meters of the Thomson type and the controlled pendulum type, which has maintained its place through the strenuous efforts of Dr. Aron. Although the latter type has



Aron Clock Meter.

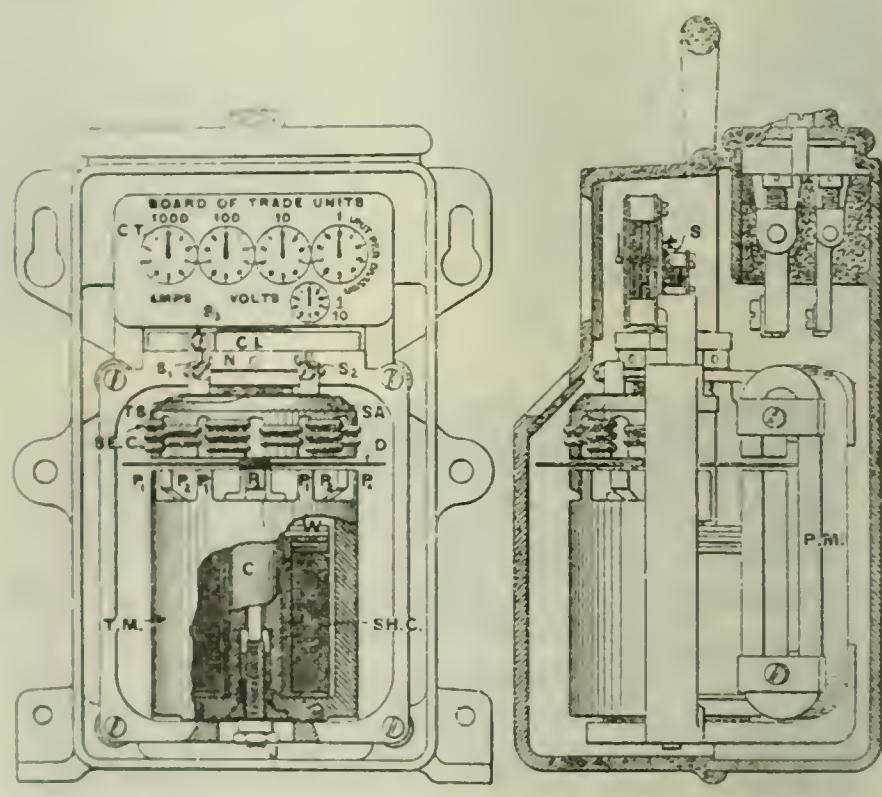
the advantage of avoiding the principal difficulty of the motor meter—the sliding contacts—its complexity and difficulty of satisfactory checking militate considerably against it, and it may be fairly confidently predicted that the continuous-

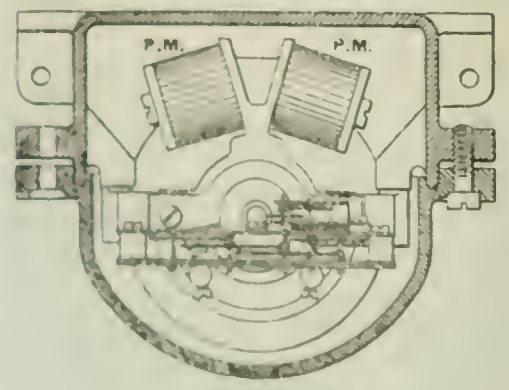


Prepayment Meter (Hookham & Hookham).

current energy meter of the future will be of the simple motor type, incorporating the leading features of Mr. Evershed's excellent design. Attempts have been made, notably by the A.E.G., to eliminate the commutator and brushes by allowing the shunt coil to oscillate between contacts, but no light touching contact appears to be satisfactory for long in our humid climate.

Although the commutator motor meter must become the standard type, quantity meters of the permanent magnet motor type are likely to retain their place for traction work where robust construction is essential, and for cheap service and prepayment meters, which latter appear likely to become of increasing importance. The survival of the electrolytic type of meter is, however, more doubtful, in spite of its cheapness. As regards alternating-current and polyphase supply, the induction pattern of energy meter appears to stand absolutely without rival, as it combines all the essentials for correct working with the maximum of simplicity. Almost every maker of meters for alternating-current circuits has now adopted some form of induction meter, and the only points to be settled are details concerning the compensation of the small phase and frequency errors, which occur in the uncompensated instrument. We may expect in a few years to see the alternating-current meter as standard in design as the polyphase motor.

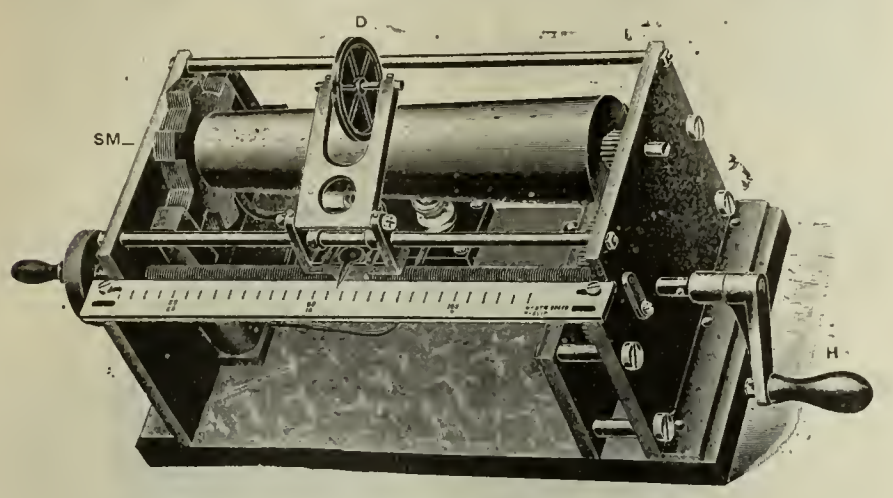




Ferranti Induction Meter.

Apparatus for the Mechanical Testing of Electrical Machinery. Although this hardly appears to come under the category of electrical measuring instruments, the writer attaches the greatest importance to it, and it is in this direction that most yet remains to be done. One of the most regrettable features concerning the electrical industry in this country is the neglect of thorough electrical and mechanical testing of motors and generators, and of the experimental analysis of the various losses. The problem of making satisfactory mechanical tests of such machines is a much more difficult one than that of the electrical testing, owing to the simple fact that no mechanical equivalent of the wattmeter has as yet been constructed. Brakes exist in plenty, although few are satisfactory from the point of view of convenient and accurate testing. The simple band brake of Messrs. Nalder, the eddy-current brake of Messrs. Morris & Lister, and the portable regenerative brake of the writer, are among the most convenient. For speed

measurement the resonance speed and frequency meters are most satisfactory, or the stroboscopic methods, which are also by far the best for the measurement of slip in induction motors and for standardising other tachometers. But the problem of a direct-reading indicating transmission dynamometer, or mechanical wattmeter, is not a difficult one, and it is hoped before long that it will have been solved practically,



Roller Strobcscope.

and that it will be possible to read the input and output of a motor or generator, or even its efficiency, directly on ordinary indicating instruments.

On the whole, however, although there is yet scope for entirely new developments, one is forced to the conclusion that progress in the electrical instrument industry will be principally in the direction of standardisation and of improving the design and construction of instruments which are already well known, and it is here that so much care is needed on our part. It has been the fate of this country to see the work of its pioneers in many directions (notably as regards the chemical and optical industries) taken up and developed successfully by other nations of less originality but greater perseverance and attention to detail; and although the British electrical instrument industry has not fallen so much behind its rivals as has some of the others, yet a mere glance at the scope of operations of firms like Siemens & Halske or of the Weston Company, or at the internal construction of their instruments shows the need which exists for immediate and concerted action on our part if we are to regain a leading position. Above all, the most crying need in this direction is the study and development of new materials, of alloys for resistances and springs, of insulators with good mechanical and electrical properties, and of varnishes and cements which are not only highly insulating, but non-hygroscopic, capable of withstanding high temperatures, and hard enough to prevent deformation. The discovery of a low temperature coefficient alloy of low specific resistance, if such were possible, would enormously improve instrument construction. We know that our rivals have devoted immense attention to the subjects, and until we can at least equal them in this respect we shall be seriously hampered. Fortunately, there are signs that the deprivation of these materials owing to the war has stimulated many manufacturers to action, and we may have some confidence that now we are awakened we shall not allow ourselves to be outclassed by any other nation.

Recent Progress in X-Rays and Radiography.

By G. W. C. KAYE, M.A., D.Sc., Capt. R.E. (T.).

It is a little over 20 years ago that Röntgen, so to speak, stumbled across a new radiation which possessed the most amazing properties, and to which he gave the name of the unknown or "X" rays. The name has stuck, for it is only within the last few years that the problem of the nature of the rays has been solved.

The application of the rays in surgery has always excited the popular interest to an astonishing degree, and even now there is probably no branch of physics that possesses a greater fascination for the general public which never loses its strange desire "to see its bones." The debt which the world of humanity owes the X-rays, to take the present war alone, is a heavy and increasing one. Incidentally, the curious popularity of the X-rays with wounded soldiers may be noted here. The average "Tommy" is always anxious to have his "picture taken" as often as possible, regarding the operation as clear evidence that the full resources of the hospital have been utilised on his behalf.

In the space available for this article we cannot do more than touch on a few of the more recent and important developments of the subject.

In common with a good deal of the scientific apparatus of this country, the manufacture of X-ray equipment had been largely permitted to pass into the hands of the Germans, who successfully exploited its possibilities. Since the war, English manufacturers have come into their own, and the very large number of X-ray sets which the war has rendered necessary has given a fillip to the industry generally.

From a research point of view, the study of the X-rays has been by no means neglected in this country, and we have the satisfaction of knowing that a large proportion of the fundamental literature has been contributed by the English-speaking races.

Radiography.

The art of producing shadowgraphs by means of X-rays is now being extensively practised in many directions not originally contemplated. One of its more recent developments is the detection of contraband copper and other munition metals when concealed in bales of cotton. The rays have also been turned to account in the discovery of blowholes in copper and steel ingots, and in the detection of faults in steel plates and rails.

X-rays have proved of service in distinguishing real from artificial gems and in locating pearls in oysters without opening the shells. By the use of extremely soft X-rays, radiographs have been obtained of the soft tissues of the body (showing the veins and nerves), the venation of leaves, and the structure of flowers. In conjunction with the microscope, pictures of tiny insects and minute shells have been taken which disclose the internal anatomy in a way that would be quite impossible by dissection.

But the all-important use of the X-rays is in surgical radiography, and with the varied experience that the present war has brought, we find that miracles are literally being wrought nowadays in the big hospitals. X-ray technique has improved so vastly as to give the diagnostic methods of physicians and surgeons a facility and exactness never dreamt of at one time. For example, in the surgery of the bone, we can not only see fractures, but we can examine the intimate

lamellar structure of the bone. Limbs are saved and cripples are uncrippled by the use of X-rays and the new antiseptic treatments. Bullets and shrapnel are found and removed, even from the lung and brain or in the region of the heart. We can detect and determine the position of tumours in the cranial cavity, even in the deepest part. The diagnosis of diseases of the alimentary system can be demonstrated by bismuth radiography, in which the required part is rendered temporarily opaque to the rays by mixing bismuth salts or emulsions with the food.



Fig. 1.—Shrapnel Bullets and Fragments of Shell in the Brain (N. S. Finzi, from the "Journal of the Röntgen Society").

Aneurisms, malignant growths, tubercle in the lungs, pleural effusions can be diagnosed with certainty and without pain or danger. It has also been noticed that X-rays have induced broken bones to knit faster and more surely, and surgeons have repeatedly reported that X-rays have given a patient relief from pain, though the part that suggestion plays in this connection must not be overlooked. We must not



Fig. 2.—Radiograph Showing Bullet at Hilum of Right Lung. (N. S. Finzi, from the "Journal of the Röntgen Society.")

leave the subject without paying a tribute to the medical profession for its unexampled devotion to its duties in the present war.

Radiotherapy.

As was anticipated, the X-rays have found a wide field of application in the treatment of malignant disease. As is the case with radiography, the technique of radiotherapy is being steadily improved. With suitable dosage the malignant cells disappear, leaving the healthy tissue quite unaffected. The treatment has been largely and successfully employed for ringworm and rodent ulcers. The question of dosage is all-important in view of the well-known danger of indiscriminate exposure to the rays, and it must not be forgotten that we are dealing with a vital and not a physical agency. The problem is biological, and the length and intensity of each of the doses into which a treatment may be divided require careful specification. The question of dosage is pressing, and no doubt X-rays will eventually be standardised with reference to some selected standard such as the British Radium Standard at the National Physical Laboratory.

Radiographic Equipment.

The modern installation of the radiographer has attained the accessibility and convenience which the apparatus of a growing subject would naturally assume.

The examination of a patient by X-rays may be carried out either by the use of a fluorescent screen or by the taking of photographs. In most cases it is usual to combine these methods, a preliminary screen examination being made to enable the photographic plate to be placed in the most advantageous position. In order that this examination may be



Fig. 3.—Fragmentation of Ulna. (Caused by Shrapnel.)

carried out rapidly and conveniently, it is necessary that the X-ray tube should be supported in such a way that it may be readily adjustable while the patient occupies some convenient stationary position. The various forms of apparatus by which this is accomplished may be divided into two classes—upright screening stands and horizontal couches. Certain of these stands are convertible from one type to the other, while other

more complicated forms constitute combined X-ray examination couches and surgical operation tables.

With an upright screening stand the patient stands or sits in contact with a vertical wood or canvas screen, behind which the X-ray tube is supported. In a horizontal couch the patient is examined in a recumbent position, the X-ray tube being either above or below him. Adequate adjustments provide for the proper setting of both X-ray tube and photographic plate.

The fluorescent screen should be properly protected with lead glass, and an adjustable diaphragm is of great assistance for stopping down the rays.

The various switches and measuring instruments are for convenience grouped on a portable switch-table which can be brought near the operator.

Localisation.

While an X-ray photograph is capable of revealing the presence of a foreign body it does not indicate the depth at which we should search.

The usual method of ascertaining this, is to take two photographs on the one plate, the two photographs being taken with the X-ray bulb in turn at each end of a short base line. The distance between the two shadows of the foreign body, and a knowledge of the other distances involved, gives us a simple exercise in trigonometry. Very many types of localisers have been introduced to solve the problem by some device calculated not to embarrass the medical man, who is prone to shy at mathematics.

X-Ray Tubes.

It is remarkable how slightly the design of the X-ray bulb has been changed from that introduced by Prof. H. Jackson in 1896. Leaving the Coolidge tube out of consideration for a moment, the chief changes are in the direction of robustness and the capacity to withstand heavy discharges. Tungsten is gradually replacing platinum as the material for the anti-cathode.

The numerous varieties of X-ray tubes differ only in details. They all possess a very low efficiency. The heat generated at the anti-cathode is ample proof that the energy of the cathode rays is mostly dissipated into heat; the X-rays are merely a small by-product. Under favourable conditions the ratio of the energy of the X-rays to that of the exciting cathode rays is of the order of 1/1000. The efficiency increases both with the speed of the cathode rays and the atomic weight of the anti-cathode.

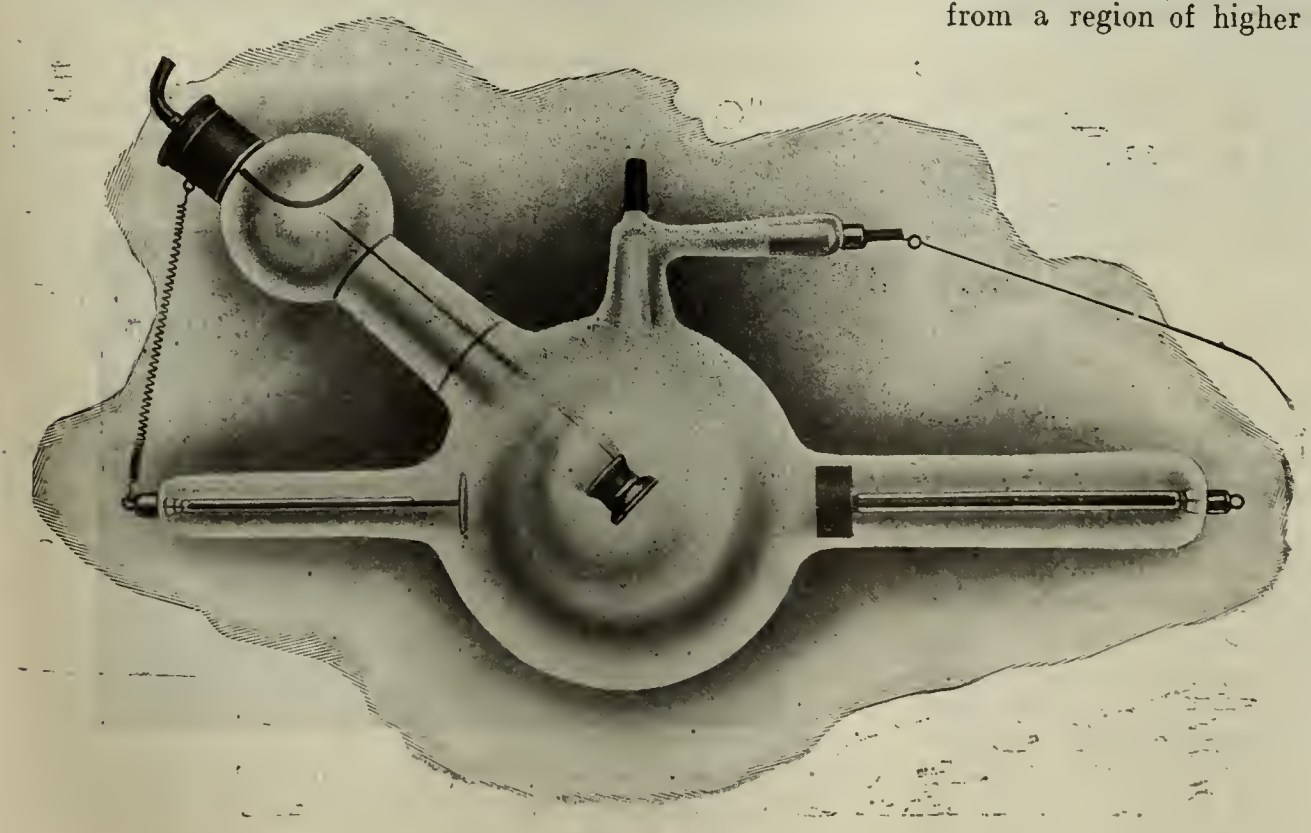


Fig. 4.—Modern X-Ray Tube.

With the latitude permissible in almost all X-ray work, it is sufficient to use the current through the tube as a measure of intensity, and the voltage across the tube as a measure of quality.

It is customary nowadays to keep a battery of tubes at one's disposal, as each tube possesses its own characteristics, and only experience can dictate the proper choice of tube for a particular purpose. Slight variations in the gas pressure are continually going on in most tubes, and a tube may become cranky in consequence. Tubes which are erratic are often the better for a month or two's rest.

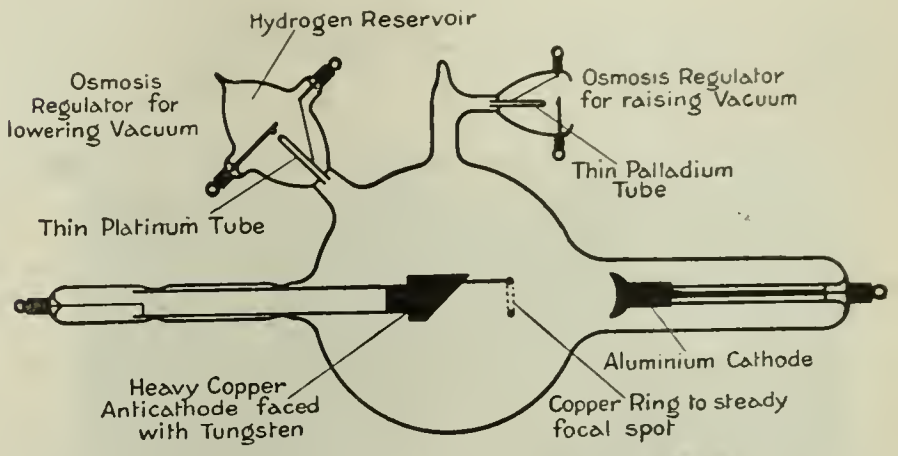


Fig. 5.—Snook Hydrogen Tube.

For most tubes there is some preferential value of the current, for which the tube will run for long periods without much regulation; but, in general, X-ray tubes tend to "harden" with use—*i.e.*, the pressure becomes lower and the driving voltage higher. The cause of this is even now not certain. In many cases it appears to be due to a reversible chemical reaction between the gas and the glass walls. The presence of a sputtered metallic deposit undoubtedly enhances the effect. To circumvent the hardening, "softening" devices are always fitted to a bulb, either of the osmosis or occlusion type, of which the latter type is the more popular in this country.

A neat adaptation of the osmosis device may be noted in connection with the Snook hydrogen tube. The osmosis method of regulating a vacuum de-pends on the fact that hydrogen will pass through red-hot platinumor palladium from a region of higher to one of lower hydrogen pressure. This diffusion takes place quite irrespective of the presence of other gases on either side of the metal boundary. In the Snook X-ray tube (Fig. 5) the residual gas is hydrogen, and two osmosis tubes are sealed into the bulb. Either may be heated to a bright red heat by causing a discharge to pass from the tip of the tube to an adjacent metal electrode.

The one regulating tube is exposed externally to the atmosphere. Now the amount of hydrogen in the air is negligible, and consequently when this tube is heated hydrogen passes from the interior of the bulb and the vacuum is raised. The other regulating tube is surrounded externally by an auxiliary bulb containing hydrogen at about atmospheric pressure, and the result of heating this tube is that hydrogen diffuses into the X-ray bulb and the vacuum is lowered.

The biggest step forward in recent years as regards X-ray bulbs is undoubtedly the Coolidge tube, the chief novelty of which is the fact that the vacuum is so high that the residual

gas plays little or no part in the "ionics" of the bulb. The electrons are provided by an incandescent cathode, the temperature of which controls the intensity of the X-rays. If the cathode is cold, the vacuum is too high to permit a discharge. When the cathode is hot, the bulb is excited in the ordinary way, and the X-rays produced are heterogeneous, just as with the ordinary type of bulb. The tube is remarkable in showing no fluorescence of the glass, so that it appearance affords little notion of the output or indeed of any activity at all. The worker should be protected by at least 3 mm. of lead or its equivalent.

In the Coolidge tube at present on the market (Fig. 6), the anti-cathode is of tungsten and unusually heavy. Recently

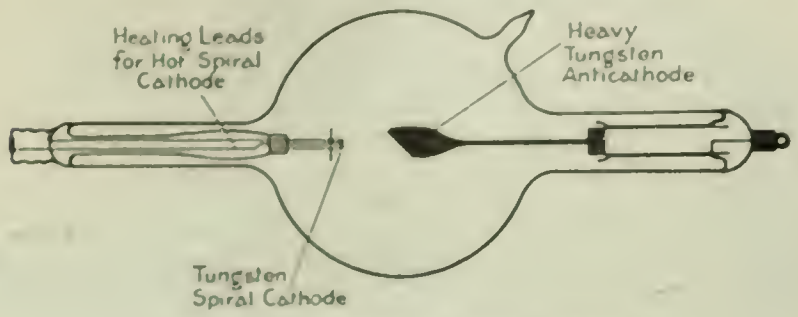


Fig. 6.—Coolidge X-Ray Tube.

Coolidge has experimented with anticathodes cooled by a rapid current of water. Such tubes permit enormous X-ray outputs. For example, one tube ran continuously for 68 hours at 100 milliamperes and 70,000 volts. Others have been run continuously at 200 milliamperes, the power supplied to the tube being 14 kw. It is anticipated that this figure will be shortly increased to 50 kw., a truly colossal value.

High-tension Generators.

The high-tension generator nowadays consists of some form of high-tension transformer, or more usually an induction coil designed specially for heavy discharge work. Interrupters are almost exclusively of the mercury-jet in gas type, although for instantaneous radiography a Wehnelt electrolytic break is very suitable. The installation generally has attained the high level of efficiency and convenience to which the electrical engineer is accustomed. In consequence, radiographic exposures have dropped from minutes—as they were in the early days—to seconds and small fractions of a second. The taking of X-ray cinematograph films is a thing accomplished.

Given a close co-operation between the medical profession and electrical engineering, extraordinary results may be anticipated. Even now flash currents of over 1 ampere have been sent through X-ray bulbs. Such discharges are capable of chiselling out a piece of metal from the anticathode and leaving a pit behind.

Very Soft X-Rays.

Ordinary X-rays are produced by driving voltages on the X-ray tube of from 10,000 to 100,000 volts or more, but it is possible to generate X-rays with much lower voltages. Such rays cannot traverse more than a few millimetres of air. As long ago as 1905 Wehnelt generated soft X-rays by the use of hot-lime cathodes excited by voltages as low as 100. Dember got very soft X-rays by bombarding platinum with the photo-electrons liberated by ultra-violet light. J. J. Thomson has recently obtained extremely soft X-rays by the impact of positive rays or slow cathode rays on platinum. The resulting X-rays were so soft as to be unable to pass through the thinnest aluminium or collodion films.

Very Hard X-Rays.

With high voltages on an X-ray tube, very penetrating X-rays are generated. Such rays have been detected at distances of over 100 yds. in air. On the experimental evidence at present available we cannot say with certainty that there is a limit to the hardness of the X-rays which may be generated by any particular anticathode. The relation between maximum hardness and voltage is of importance in connection with Planck's quantum-theory, from which we should anticipate that the maximum hardness would be reached with a voltage which diminishes with the atomic weight of the anticathode metal.

When the Coolidge tube was introduced it was hoped that by its means X-rays as penetrating as the γ-rays from radium would be possible, but so far this has not by any means been realised. Rutherford in some recent experiments cut down the rays from a bulb excited by 180,000 volts. Sufficient screens were employed to reduce the rays to 1 part in 10 millions, but even then the residual rays proved to be less than half as penetrating as the hardest γ-rays from *RaC*.

Characteristic X-Rays.

It was in 1908 that Barkla and Sadler first discovered that when a metal plate was bombarded by X-rays it not only scattered a proportion of these rays, but, if the conditions were favourable it emitted a homogeneous or monochromatic X-radiation of a quality characteristic of the metal. Further research showed that the quality of a characteristic radiation depended only on the metal; it was quite unaffected by chemical association or heat, nor was it dependent on the exciting X-rays. The only proviso was that the exciting rays should be harder (or more penetrating) than the characteristic radiation.

A few months later Kaye detected the characteristic radiation of the anticathode among the X-rays from a bulb, and showed that with a soft bulb the characteristic radiation might indeed constitute the bulk of the rays from the tube.

Up to now, two characteristic radiations, the K and L series, have been identified, but there is strong evidence of other series as well, which so far have received little attention. For most elements the K radiation is about 300 times as penetrating as the L radiation. Both radiations become harder as the atomic weight increases.

It is found that an element exhibits a maximum transparency for X-rays identical in quality with that of either of its own characteristic radiations. The absorption becomes abnormally large for X-rays slightly more penetrating. Under these conditions the characteristic radiation is generated, and at the same time corpuscular rays are given off in great abundance.

Ionisation by X-Rays.

It is now generally accepted that the ionisation produced by X-rays is an indirect one, and due solely to the corpuscular



Fig. 7.—Photograph by C. T. R. Wilson, showing the Track of an α Particle after Expulsion from Radium.

rays or electrons which the X-rays liberate. Bragg was the first to insist on the fact that X-rays spend little energy in their flight, and that they can, therefore, have little ionising action.

But indisputable proof of the correctness of the notion was provided by C. T. R. Wilson, who in his marvellous condensation experiments succeeded in rendering visible and photographing the tracks of the charged ions which are produced when X-rays pass through a gas. The photographs show no indication of any activity on the part of the X-rays other than in the production of electrons. The X-ray is, in fact, completely inoffensive and innocuous during its life, and only on its disappearance does the effective agent—the electron—come to life. Ionisation by X-rays appears, therefore, to be entirely a secondary process.

Diffraction of X-Rays by Crystals.

Many fruitless attempts have been made in the past to reflect and diffract X-rays. We now know that the stumbling block to such experiments was the extreme shortness of the wave-length. The specular reflection of light rays is only rendered possible by the fact that the irregularities remaining in a polished surface are negligible compared with the wave-length of light. But such irregularities are all important with X-rays, with the result that the rays are scattered in all directions instead of being regularly reflected.

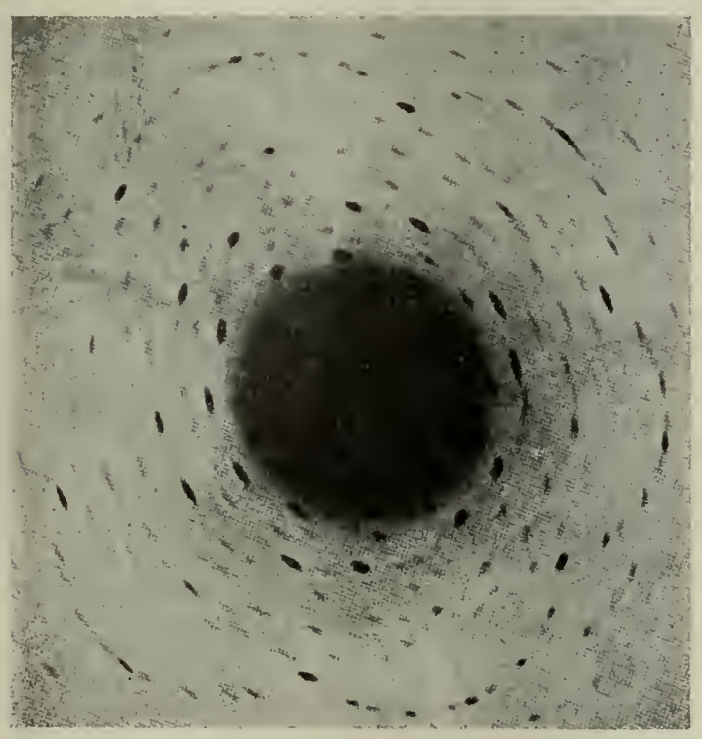


Fig. 8.—Diffraction of X-Rays by a Crystal of Beryl. (Friedrich and Knipping.)

But in 1913 Friedrich and Knipping put to the test Laue's suggestion that the regular geometrical grouping of the atoms in a crystal, which modern crystallography affirms should be capable of producing interference effects with the X-rays, in a way analogous to that in which diffraction gratings deal with light waves.

A narrow pencil of X-rays was transmitted through a crystal and received normally on a photographic plate. The experiment was an unqualified success, the plate revealing a group of diffracted spots, some of which were deviated as much as 40 deg. from the central undeflected spot (Fig. 8).

There was little doubt as to the meaning of such an epoch-making result; X-rays were undoubtedly waves, and crystallographers were justified in their conceptions of the regular atomic structure of crystals. The subject was at once actively pursued in this country by Bragg, Moseley and others. Results of the first importance followed. The Braggs (father and son) were led to interpret the Laue patterns from the point of view of the parallel and equidistant planes of atoms which can be pictured in a crystal. Attacking the subject on these lines, they devised the X-ray spectrometer in which the crystal is used as a reflection grating, and an ionisation chamber or photographic plate records the position of the reflected beam. By measuring the angle of reflection we can obtain the relation between the wave-length of the X-ray and the distance apart of the atomic planes which are parallel to the reflecting face of the crystal.

The presence of characteristic radiations in the X-rays from a bulb was immediately established, for each of them yielded a spectrum line which stood out amid the general radiation present. Different anticathodes yielded different spectra. In the hands of the Braggs the X-ray spectrometer has given us a measure of both the atomic spacings of a large number of crystals and the absolute wave-lengths of monochromatic X-rays. These wave-lengths have proved to have dimensions comparable with those of the atoms.

Moseley's Experiments.

The work of Moseley stands out pre-eminently in the recent literature of the subject. The early death of this brilliant young physicist, while serving as an officer in the Gallipoli campaign, is not the least of the tragedies of the present war.

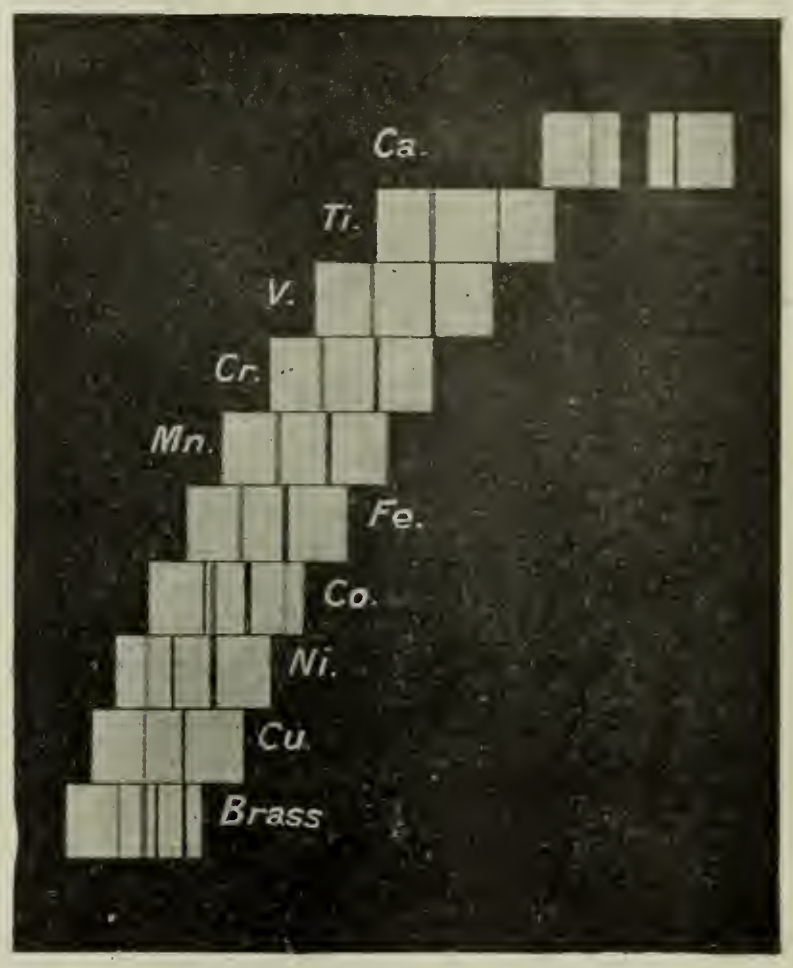


Fig. 9.—Moseley's Photographs of the X-ray or High Frequency Spectra from a Number of Metallic Anticathodes.

The spectra, which are in the third order, are placed approximately in register in the figure. For each metal, the more intense line, with the longer wave-length, is the *K* characteristic radiation. The brass shows the Zn and Cu lines; the cobalt contained both nickel and iron as impurities.

(From the writer's book on "X-Rays," by the courtesy of the publishers, Messrs. Longmans, Green & Co.)

Moseley in 1913-14 examined the X-ray spectra of a large number of elements and obtained remarkable and important results. Fig. 9 illustrates the X-ray spectra obtained by Moseley for some of the lighter elements which emit strong K characteristic radiations. It will be noticed that the wave-length increases as the atomic weight diminishes, and that the spectrum consists in each case of two lines. Later work has shown that the spectrum is a good deal more complicated than this.

But the outstanding feature of Moseley's work is the relationship which he established between the X-ray spectrum and the order of an element in the periodic table. In brief, he plotted the atomic number (*i.e.*, the number which represents the order of the element in the periodic table) against the square root of the frequency of the characteristic X-ray, and found that the points for the different elements all lay extremely well on a smooth line which was almost straight. In other words, the wave-length of the X-ray is inversely proportional to the square

of the atomic number. Fig. 10 shows the result in the case of the K radiations, the two curves referring to corresponding lines of the different spectra. Similar curves were obtained for the L radiations.

Moseley found that no element was unprovided for in the scheme, and the harmony of the relationship was such as to justify his assertion that the spaces which had necessarily to be left vacant were awaiting elements as yet undiscovered. He found that perfect regularity over the region extending from hydrogen to gold could only be retained by allowing spaces for three new elements. These elements should not be difficult to find.

The order of atomic numbers is that of atomic weights, except in the cases of argon, cobalt and tellurium. If in Fig. 10 atomic weights had been employed instead of atomic numbers, the relationship would not have been nearly so perfect.

It is apparent from Moseley's experiments that the atomic number is something more than a mere integer; it evidently represents some fundamental attribute of the atom. Now

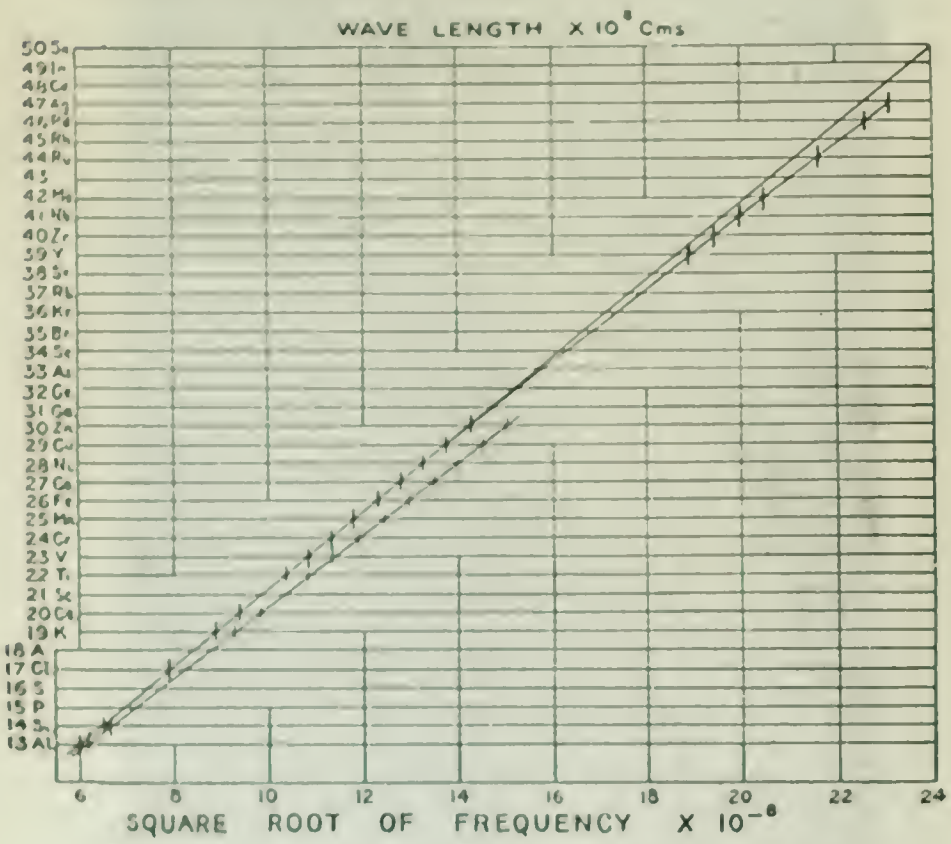


Fig 10.—Curves Showing Relation between Atomic Numbers and Frequency of K Radiations.

(From the writer's book on "X-Rays," by the courtesy of the publishers, Messrs. Longmans, Green & Co.)

several quite different methods of experimental attack (notably the scattering of X-rays) all agree in indicating that the atomic number agrees closely with the number of positive charges which are carried by the nucleus of the atom—adopting Rutherford's theory of atomic structure. We may well suppose that the wave-length of a characteristic radiation depends directly on the magnitude of the nuclear charge.

In passing we may note the development of the remarkable view that the same atomic number may be borne by each of several substances which may have different atomic weights, but which may be quite inseparable by ordinary chemical or physical means. Soddy calls the members of such a group of elements bearing a single atomic number and occupying, therefore, a single place in the periodic table "isotopes."

Wide Range of Electromagnetic Waves.

With the addition of X-rays to the list of electromagnetic waves already known, the table of wave-lengths is extended greatly in one direction. At the other end of the scale are the waves which were originally discovered by Hertz and are now used in wireless telegraphy. The longest wave-length generated up to the present is about 15,1881 metres, or a little over nine miles; the shortest is a few millimetres. The waves ordinarily used in "wireless" are a few thousand metres long—*e.g.*, the wave-length of the wireless time signals from the Eiffel Tower is 2,000 metres; of the Navy signals, from 600 to 1,800 metres, of trans-Atlantic signals, 7,000 metres or more.

Next to Hertzian waves, in order of magnitude, come the infra-red or heat rays, the greatest wave-length yet observed being $\frac{1}{3}$ mm. We pass from these right through the visible spectrum to the ultra-violet rays, which have been explored by Schumann and Lyman as far as wave-length 6×10^{-6} cm.; these are examined photographically.

Wave-Lengths of Electromagnetic Radiations.

Kind of wave.	Wave-length in cms.
Hertzian waves	10^{6} to 0·4
Infra-red rays	0·031 to $7{\cdot}7\times10^{-5}$
Visible light rays	$7{\cdot}7\times10^{-5}$ to $3{\cdot}6\times10^{-5}$
Ultra-violet rays	$3{\cdot}6\times10^{-5}$ to $6{\cdot}0\times10^{-6}$
X-rays	$8{\cdot}4\times10^{-8}$ to $1{\cdot}7\times10^{-9}$
γ-rays	$1{\cdot}4\times10^{-8}$ to $7{\cdot}0\times10^{-10}$

Next come X-rays with wave-lengths of the order of 10^{-8} cm., and beyond them the most penetrating of all—the γ-rays—whose wave-lengths have only recently been measured.

The various wave-lengths are summarised in the adjoining table; they cover, as will be seen, the amazing range of about one thousand million million fold. Virtually the only gap in the sequence is that between ultra-violet light and X-rays; and doubtless some of the very soft X-rays obtained by various experimenters find a place in this gap.

When we consider how tiny a proportion of these waves can affect the senses, we may perhaps regard the more kindly some of the speculations which the subject has inevitably inspired. If X-rays, it is argued, can traverse solid substances through which the sun's rays cannot pass, it seems logical to assume that sunlight also passes right through a number of things in space through which we can see, and of which we are therefore unaware. The inter-stellar spaces, the great outer ethereal nothing as it seems to us, may thus be a relatively solid mass.

So far as we know the human eye has not yet developed the faculty of detecting the many invisible kinds of light, but it may be that those gifted persons who rejoice in the occasional ability to see ghosts, or wraiths, are endowed with "super-eyes" to which a solid form or dress may appear transparent under favourable lighting conditions.

The Nature of the X-Rays.

For many years controversy raged as to the nature of the X-rays, but, as we have seen, they have proved to be a type of ultraviolet light of extremely short wave-length. There remains one outstanding difficulty. It seems certain from the extreme precision observed in the crystal-reflection experiments that X-rays are regular light waves and occur in trains of great length, yet the difficulty is that in many of their properties the rays behave strangely like streams of discrete entities, the effects of which are localised and confined. The energy equations are wrong quantitatively.

The difficulty is not, however, unique; it is now known to be common to all forms of radiation. The Newtonian laws implying perfect continuity, and infinite divisibility of time and space have, until recently, found complete credence, but they do not seem to be reconcilable with modern experiment, which suggests that energy radiation is essentially discontinuous and must take place by finite "jumps."

The problem of the transference of energy by ether-waves has accordingly led us to the conception of a "quantum" of radiant energy travelling undissipated through space. The reconciliation of Planck's well known idea with the older and well-founded conception of spreading waves remains. The experimental evidence seems to indicate that both theories are true simultaneously: that radiant energy is both concentrated and indivisible, and at the same time spreads, and is divisible.

We are left to hope for a compromise between the old and the new mechanics which will not involve concessions fatal to either.

Electrochemistry.

By F. MOLLWO PERKIN, Ph.D.

Although technical electrochemistry has made slow way in the United Kingdom, this has been largely a question of natural resources. Those countries which have had bountiful supplies of water located in such a manner that the potential energy can be comparatively easily harnessed and converted into direct energy have naturally taken advantage of their resources and developed in the first place an electrical industry and then an electrochemical industry. In the Tyrol, where streams of water flow hundreds of feet down the steep mountain sides, it was not a very difficult matter to build pipe lines and employ the energy produced by the fall of the water as motive power to drive dynamos. Hence long before larger towns were lighted by electricity, quite small towns and villages in mountainous regions used this source of energy for illumination. Gas would have been out of the question, and if it had not been for a beneficient Nature, aided by the skill of the engineer, these small towns and villages would probably, even to-day, be only illuminated by oil lamps. Perhaps in this country we have been rather too apt to consider that the attacking of electrochemical problems was not a feasible proposition simply because we have very little water power compared to some other countries. The cost of the electrical unit, however, is not everything in electrochemical processes.

If we glance back and examine the records of electrochemical research we find that much of the pioneering work was carried out in this country, and indeed that processes which have since then become of the greatest technical importance first saw the light of day in the chemical laboratories of Great Britain.

It was Priestley, in 1775, who first showed that when an electric spark was passed through air kept in a confined space over water, the air decreased in volume and the water became acid. Faraday, with the limited means at his disposal, mistook the nature of the acid which was formed, supposing it to be carbonic acid instead of nitric and nitrous acids. Shortly afterwards, Cavendish repeated the work of Priestley on a larger and more accurate scale and showed that the acid produced was nitric acid. He also showed that practically the whole of the air could be converted into this acid by the addition of excess of oxygen gas. More than 100 years later this work was repeated by Lord Rayleigh with the knowledge of modern chemistry to aid him and very greatly improved electrical apparatus. Rayleigh was able to show that, given cheap electrical energy, the process might be worked on an economic commercial scale. Incidentally, in conjunction with Sir William Ramsay, the work resulted in the discovery of the inert gas Argon, and later Ramsay, as a direct outcome of this work, discovered the other illusive inert gases helium, crypton, neon and xynon.

Rayleigh's work, by attracting attention to the subject, caused many other investigators to take up the problem with the intention of producing nitric acid on a commercial scale. MacDougal and Howles erected a small plant in England, but it was never worked on a commercial scale. Then the Atmospheric Products Co. at Niagara built a 2,000 H.P. plant; this was worked for a short time, but owing to the form of construction was not a commercial success. In the meantime, Prof. Birkeland and Prof. Eyde had been carrying out important experimental work in Norway which ultimately solved the problem, and in 1905 they were manufacturing nitric acid and converting it into calcium nitrate on a commercial scale at Nottoden in Norway. Since then great progress has been made and large quantities of nitric acid, nitrates and nitrites are being manufactured from the atmosphere by electrical means. There are other successful processes now in operation, notably the Paulin process. It will have been noticed that most of the initiative and pioneering work was carried on in Great Britain, and it is quite possible had we had cheaper sources of power that experimental work would have been carried further and that the industry might have been founded in this country.

Nitrogen is now won from the air in the form of cyanamide. In order to obtain cyanamide it is first necessary to obtain calcium carbide, a product produced in the electric furnace by heating carbon and lime to high temperatures. It is interesting to note that the first carbide—potassium carbide—was discovered by Davy in 1808. Wöhler appears to have been the first to produce calcium carbide, but it was Moissan who first produced it in quantity. Now it is made by thousands of tons. When nitrogen gas is passed over heated calcium carbide it is absorbed and calcium cyanamide is formed. The nitrogen is produced from the atmosphere by fractional distillation of liquid air. When calcium cyanamide is acted upon with water, ammonia is given off. The ammonia so produced can either be employed as such or converted into nitric acid by the Ostwald catalytic process. Whether, however, nitric acid is obtained directly from the atmosphere by direct oxidation or by the oxidation of ammonia, electricity is required to give the initial power.

In 1808 Davy discovered the alkali metals, sodium and potassium, by the electrolysis of fused sodium and potassium hydroxide. The method at present employed for the manufacture of sodium is based upon Davy's discovery, and the whole of the sodium manufactured to-day, amounting to many thousands of tons, is produced by the electrolysis of sodium hydroxide. One hundred years after Davy's discovery over 5,000 tons of this metal was manufactured annually. Lithium, another metal of the alkali group, also caesium and rubidium, are most easily manufactured electrolytically. The alkaline earth metals, calcium, strontium and barium, are prepared by the electrolysis of their chlorides. Calcium indeed is manufactured on a commercial scale. The bulk of the work on the isolation of these metals was carried out in Germany, but it followed from Davy's original pioneering work.

Without the dynamo there could have been no electrochemistry, and it was Faraday who first discovered the induction of currents in wires when they are moved across a magnetic field. This discovery suggested to him the dynamo, and he constructed the first dynamo machine in 1831. It was a long time before dynamos became perfect instruments, but now they are so universally used that few now imagine the enormous amount of experimental work which was necessary before the modern machines were possible. Further, Faraday gave us the laws of electrolysis which govern the yields and efficiency of any given process. An electrolytic preparation either inorganic or organic which does not conform to Faraday's laws will be inefficient and not of practical importance. Many chemical and physical theories have altered or been discarded with the evolution of knowledge, but Faraday's laws of electrolysis are fundamental; they have stood the test of time, and without prophecy we know they will stand as long as there is

an electrochemical science. Faraday's laws, of course, are not theories, they are based on most carefully worked-out experimental facts.

The greatest of electrochemical industries is the refining of copper electrolytically. Owing to its natural resources of copper ore, the United States of America is the centre of this industry, but the first electrolytic refinery for copper was erected at Pembury in Wales in 1869 by Elkington. It was, however, Charles Watt who first pointed out, in his master patent of 1851, the possibility of producing alkali hydroxides, chlorine hypochlorites and chlorates by the electrolysis of sodium chloride, and also described the refining of copper, silver and other metals by means of the electric current. He was before his time, because he had not the means at his disposal to carry out these reactions on a commercial scale. But he was a far-sighted genius and others have reaped where he sowed.

England was by no means behindhand in recognising the importance of aluminium. Davy, in 1809, attempted, although without success, to produce aluminium from alumina, and, in fact, suggested the name aluminium for the metal. It was Wohler who first obtained metallic aluminium by electrolysis of the chloride, and at the same time he was able to produce considerable quantities of magnesium by a similar process. Matthiessen in this country showed that magnesium could be more readily obtained by electrolysing three molecules of potassium chloride with four of magnesium chloride. While Bunsen in Germany got over the difficulty of the high fusing point of aluminium chloride by mixing it with sodium chloride. This mixture melts at a much lower temperature than pure aluminium chloride, and consequently is much easier to electrolyse. Shortly afterwards Gore suggested the electrolysis of a mixture of cryolite. Deville endeavoured to electrolyse cryolite and to regenerate the aluminium in the bath by means of anodes containing aluminium oxide. The great difficulty he met with was that of finding material which would withstand the high temperature necessary to melt the cryolite. This was particularly difficult because he applied his heat externally.

In 1881 the brothers Cowles endeavoured to obtain aluminium by heating in an electric furnace a mixture of carbon and aluminium oxide. This process was successful for obtaining alloys, but was not found satisfactory for the production of the pure metal. In 1886 the Cowles process was introduced at Milton in Staffordshire for the production of aluminium bronzes. In 1886, Hall, in America, patented a process in which aluminium oxide was dissolved in cryolite, sometimes with the addition of fluor spar. On electrolysis aluminium was given up at the cathode, and provided the voltage was not allowed to get too high only oxygen was given off at the anode, which was of carbon. The oxygen combined with the carbon with formation of carbon monoxide. Héroult, in France, patented a somewhat similar process and the Héroult process is the one universally employed in Europe.

In 1887 the Aluminium Co. was founded at Oldbury, near Birmingham, where the metal was manufactured by a chemical process. In 1891 the electrolytic process was commenced, and after passing through many vicissitudes the manufacture of aluminium has now for some years been a flourishing business. The value of aluminium for war purposes is enormous, and if we had been dependent upon foreign, particularly enemy, supplies we should have been in a very serious position when the war broke out. The country is therefore very much indebted to the supporters of the British Aluminium Co. for their energy and perseverance in the initial stages of the development, when men of less foresight and courage would have despaired of putting the industry on a firm basis. They not only had to evolve a new process but also had to meet severe foreign competition.

The quartz mercury vapour lamp with its wealth of ultra-violet rays was originally due to British inventive genius. It was Prof. Boys who first melted quartz in the oxyhydrogen blow-pipe flame and from it made threads as fine as silk which were used for suspending the needles of galvanometers. Later on Messrs. Johnson, Matthey & Co., with the help of the late Prof. Shenstone, commenced the manufacture of transparent silica apparatus, employing the electric furnace as their source of heat for fusing the silica. It was some time later that the manufacture of transparent silica was commenced in Germany: the pioneering work was carried out in England. For making large articles of silica we are indebted to the Thermal Syndicate who, by means of the electric furnace, are able to make large evaporating vessels for the concentration of sulphuric acid and articles of silica for a large variety of purposes.

Our tube railways are ventilated and the air kept pure by means of ozone. I believe this is not done in any other country. Now, ozone is being employed by our surgeons to sterilise the wounds of our soldiers in place of antiseptic dressings.

One most important use of the electric furnace is to melt steel, and it is now being largely used for this purpose. We were certainly slow in this country to introduce the electric furnace. The Faraday Society deserves much credit for having brought the importance of the various forms of furnace to the notice of the iron and steel trade. Papers were read before the Society by the foreign inventors of electric furnaces in France, Germany, Italy, Sweden and America, and through the journal of the Society all the latest developments were set forth. In the making of a shell the drillings and turnings are often greater in weight than the shell itself and all this scrap being of the finest steel must be recovered and melted down again. The electric furnace of the induction type is the best means of doing this, and is now being largely employed for this purpose.

In organic electrochemical research a considerable amount of work has been done in this country but more has been done on the Continent. The great difficulty in organic electrochemical reactions is to control the course of the action, it is either inclined to go too far or it is too slow in action.

In the commencement of this article it was mentioned that cheap power was of the utmost importance in electrochemical progress, and that other countries had made greater strides than we had done owing to their natural water resources. The question naturally arises can we compete with such countries—in other words, is it possible for us to obtain cheap power? I think it is possible. Up to the present we have been wasting our resources of coal in a most reckless manner. It is now being realised not only by the average business man, but by the Government that this waste of natural resources must not continue or the country will become bankrupt. But in saving this coal, that is to say, using it in a rational manner, large quantities of power gas will be produced.

If it were made compulsory to burn a smokeless fuel, that is, coal from which most of the volatile matter has been removed, a hot and comfortable fire could be produced, and the atmosphere of our towns and cities would not be polluted by smoke. Furthermore, this smokeless fuel can be burnt under locomotive and ships boilers. To produce a smokeless fuel the coal must be distilled at a low temperature. By this means the volatile matter is obtained in the form of tar which, upon distillation, yields valuable oils and paraffin wax. Sulphate of ammonia is also produced which is a most valuable fertiliser, and the gas formed at the same time is sufficient to heat the distilling retorts. If this process were carried out at the pit's head the fuel not required for domestic and other purposes could be burnt in a producer, thus giving extremely cheap power, because the other products produced would make the process practically self-supporting. By this means I believe it would be possible to obtain power for about 45s. per electrical horse-power per year. We should then be in a position to develop our electrochemical industry.

I have not written this article with the object of showing the actual progress of electrochemistry to date, but to show that to a large extent the pioneering work was carried out in this country, and so far as our resources have permitted we have actually developed the industry.

Metallurgy in Relation to Electrical Engineering.

The importance of metallurgy in the electrical industry cannot be over-estimated, for the metals play an essential part in both the electric and magnetic circuits. From the point of view of conductivity, copper is, of course, the metal which has been most closely allied with electrical engineering. Apart from its use, its refinement is one of the oldest and most important branches of electrochemistry, though in these days it does not figure prominently in technical literature. This is due to the fact that the refining process was worked out very fully many years ago ; moreover, copper refining is carried on more particularly in countries where the greater proportion of copper ores are to be found.

Although from the point of view of its monetary value copper may be said to occupy the first position, iron and steel are, of course, used to a much larger extent than copper in the construction of electrical machinery. The properties of iron, apart from the mechanical aspect, that are most important are the permeability, hysteresis and conductivity. It is impossible to obtain economical use of the material in the magnetic circuit unless the permeability is high, but, on the other hand, if the conductivity is high the eddy-current loss becomes large in an alternating magnetic field, and the hysteresis loss also is one that cannot be neglected. Some years ago it was generally considered that soft iron such as Swedish iron, was much the best material for magnetic circuits and that the purer the iron the better the result. The idea of using impure iron for the purpose was looked upon as quite out of the question if the most satisfactory results were to be obtained.

A change of thought in this respect was brought about by the work of Sir Robert Hadfield, F.R.S., who first showed that our ideas in regard to alloys were incorrect in the case of manganese steel. A small proportion of manganese produces steel that is brittle and, therefore, the assumption was very naturally made that the presence of manganese in larger proportion, must necessarily cause brittleness. Sir Robert Hadfield found, however, that when the manganese was increased to 12 per cent. the steel so produced was not merely non-magnetic, but when it was quenched from a temperature of 950°F. it could be bent cold, and showed a high tenacity and great toughness. There was, however, the difficulty that it could not be machined ; consequently, pieces of plant made of manganese steel were cast so that they did not require machining and could be used practically as they came from the moulds. This steel is largely employed in special work for tramway tracks, railways and mines ; and all our soldiers in the trenches are equipped with helmets made of this Hadfield manganese steel.

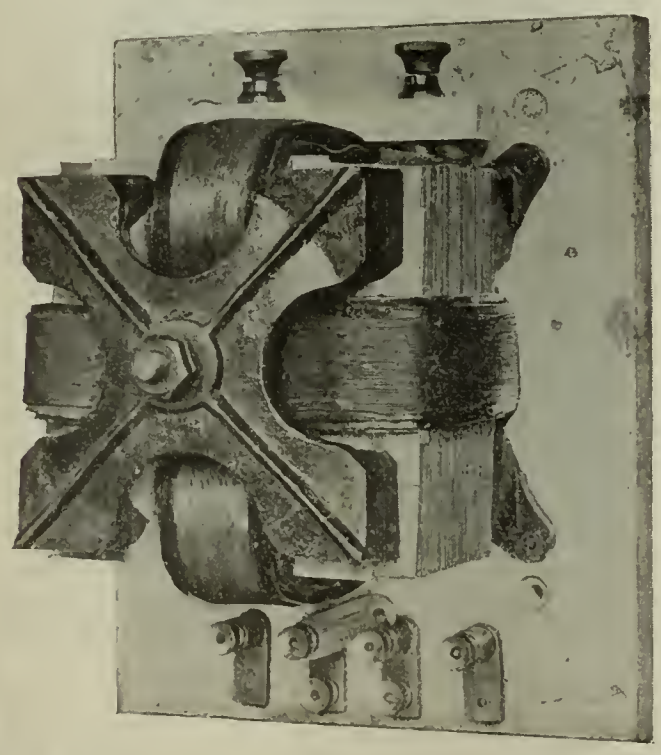


Fig. 1.—The First Transformer Made with Hadfield's Low-Hysteresis Steel (Stalloy).



Fig. 2.—Steel Casting by Hadfield for an Electric Generator.

The natural conclusion derived from this work was that the effect of adding other elements to steel could only be decided by experiment. The next element tried was silicon and it was found that a steel containing two per cent. of this element was an excellent tool steel.

This unexpected result led to further research work on steels

for electrical purposes, and thus Stalloy was produced, which is a steel low in carbon and manganese, but containing 3 to 4 per cent. of silicon. In this alloy the extraordinary result is reached that the permeability is higher than that of Swedish iron, and not only so but the hysteresis is lower and also the eddy-current loss. Thus Stalloy is particularly suitable for magnetic circuits in alternating fields. The first transformer made from Hadfield's low-hysteresis steel was completed in 1903: it weighed about 30 lb. and is shown in Fig. 1. This transformer was put to work by the Sheffield City Corporation Electric Light Department at Sheffield.

The importance of the properties of Stalloy are strikingly emphasised by Figs. 2 and 3. Owing to the high permeability a transformer made up with Stalloy is smaller than one of equal output made of the best transformer iron. Thus Fig. 3 shows a 40-kw. transformer made with the best transformer iron, and Fig. 4 a 60-kw. transformer made with Stalloy. Although the latter is 50 per cent. greater than the former as regards output the size is much about the same. By this means the core of the 40-kw. transformer weighed 830 lb. as against 1,120 lb. for a similar transformer using the best soft iron obtainable. Apart from the quantity of material there is the question of the saving of energy in magnetisation. Since the iron losses are approximately halved by the use of Stalloy it will be seen that the saving in electrical energy and, therefore, in coal is enormous when it is considered that the number of transformers in use is very large and they are continuously in circuit. In fact the saving amounts to many million pounds per annum. Another important feature of Stalloy is that it is practically free from ageing, that is, free from any serious increase in iron losses when kept continuously in use.

Fig. 2 shows a large steel casting of an electric generator.

From what has been said it will be realised that Stalloy is now very largely in use and that Sir Robert Hadfield has rendered a great service to the electrical industry by his work in this direction. Stalloy is handled by Messrs. J. Sankey & Sons, to whom much credit is due for the way in which it has been developed.

In recent years the electric furnace has been used very largely for the production of special alloys, for which purpose it is particularly suitable, owing to the easy means of control. Such alloys are playing a very important part in engineering and in the application of electricity at the present day. As an example, mention may be made of the alloy of nickel and chromium, which is commonly called "nichrome." This, owing to its high specific resistance, has solved many of the difficulties experienced in producing commercial resistances and heating elements required for electric heating and cooking apparatus. Special steels or ferro alloys, which are made exclusively by the electric furnace, are particularly used in the manufacture of motor cars, and in work where great strength combined with lightness is a necessity. The production of "crucible" steel is also being carried on increasingly by means of the electric furnace. It is unlikely that the electric smelting of iron ores will gain a footing in this country owing to the cheapness of coal, but in countries such as Sweden, where coal is not abundant, electric smelting is making headway.

In conclusion, attention may, perhaps, be drawn to the work of Prof. T. D. Yensen on the vacuum fusion of steel by means of the electric furnace, by which means the permeability of commercially pure iron is very much increased above 20,000 at the maximum point. It is too soon to say whether this treatment will be applied commercially, but it is an interesting example of how metallurgy is rendering service increasingly to the electrical industry and seeking to reduce the difficulties with which the electrical engineer is faced. As another instance, in a different line of work, we have the remarkable achievement of the tungsten drawn-wire filament for electric lamps. Tungsten is a metal with a very high melting point, and in the form of rods in which it is first obtained it is brittle. By mechanical treatment the molecular structure is changed, so that the metal ultimately becomes ductile, and can be drawn into the finest wire. Here, again, we see the importance of one branch working with another, and realising the difficulties with which either is faced.

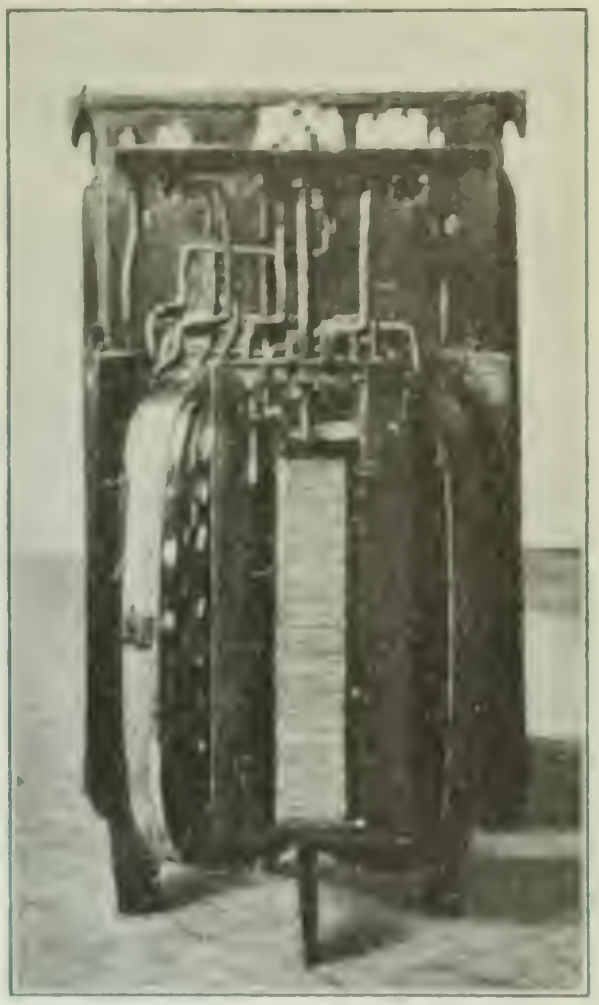


Fig. 3.—A 40-kw. Transformer Made up with Best Transformer Iron.

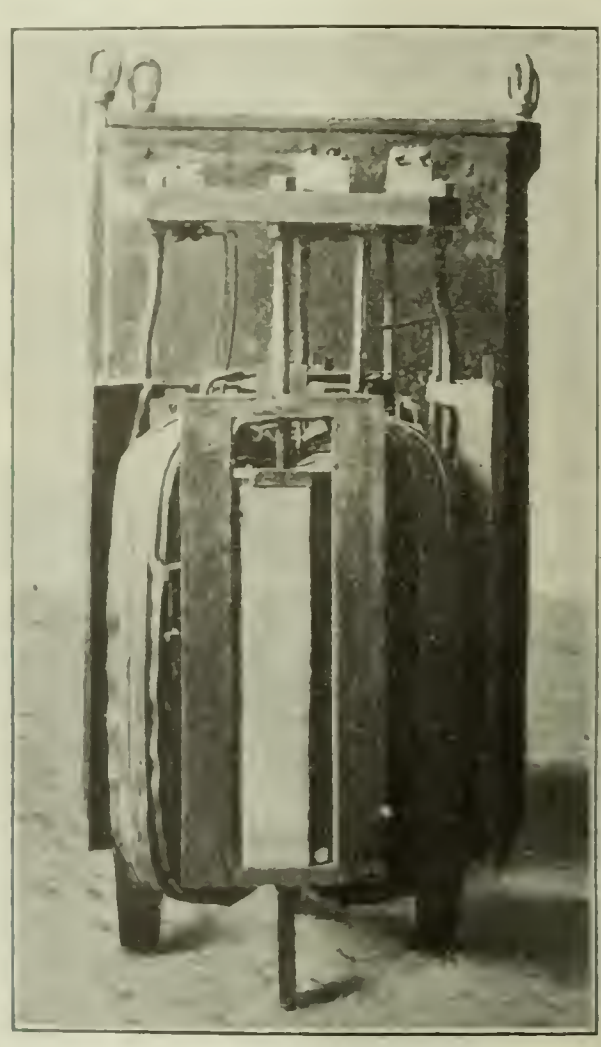


Fig. 4.—A 60-kw. Transformer Made up with Stalloy.

The Nation, the Apprentice and the Polytechnic.

By R. MULLINEUX WALMSLEY, D.Sc. M.I.E.E.

A consideration of the relations of the polytechnics and technical institutes with the nation on the one hand, and with those whom they train, or should train, on the other, naturally falls at the present time into two quite separate divisions. The first of these has reference to the period through which we are now passing—the period of the war—and cannot well be dissociated from that period. The conditions at present prevailing are very difficult ones, but will be succeeded by entirely different conditions, which will be not less difficult after peace has been declared and during the time of demobilisation of the large armies now in the field, and the return to their normal occupations of the great number of workers now engaged upon the manufacture of munitions.

With regard to the first period, the time has not yet arrived when the history of the contributions which the technical institutes are making to the prosecution of the war can be written. In August, 1914, the conditions of national life were suddenly profoundly changed, but when the educational session commenced at the end of September in that year there were not many in the country who realised how profound the change had been, and still fewer who could foresee its effect upon educational work. Still less was it realised in educational circles that the war was to be so long continued. The consequence was that in many respects the work of the session 1914-15 resembled that of an ordinary, but very seriously disturbed, educational session.

During that session, however, the technical institutes realised one by one that there was much work for them to do of a national character different from that upon which they had been hitherto employed, but for which they were well equipped and manned with both staff and students. As this fact was realised at different times and in different ways by the authorities controlling these institutions, and by the senior members of their staffs, and as there was no central authority to review the whole situation and to direct matters, it is not surprising that each institution in its efforts to do its best for the country developed work of a special kind. The result was much diversity both of effort and of achievement, the value of which will, let us hope, be recognised in due course by a grateful country. Most of the work, even at the present time, is special in each institution, and un-co-ordinated with work elsewhere, though naturally some of it in any particular institution is similar to work in other institutions. For the present it is doubtful whether it will be of any benefit to the country to attempt to co-ordinate this work, especially in view of the reasons to be given presently for considering that the time is close at hand for it to cease and be replaced, in the interests of the country as a whole, by regular educational work.

It will, however, be useful to place on record here, for future reference, a summary of the kind of work which has been done. In the first place, the manufacture of munitions of all kinds and the training of munitions workers bulk largely. At the polytechnics and higher technical institutes, as well as in the engineering workshops of the universities, the munitions work includes the manufacture of the more specialised articles required, such as inspectors' gauges and check gauges, the production of which demands the most highly skilled methods both of workmanship and testing. It has been a revelation to many practical engineers that such work should have been faced, and still more that it should have been successfully carried through, on commercial lines in workshops equipped primarily for educational purposes.

Next in importance, if not more important, has been the great amount of testing of materials of all kinds, both constructional and other, for naval and military purposes which has been carried out. Such testing was especially suited to the splendid equipment of many of the polytechnics and higher technical institutes, as well as of the universities, and probably the nation will never know the extent and importance of the aid which at a critical time these institutions freely rendered to it in this direction.

Side by side with all this, officers and men in the new armies have been trained by detachments in special subjects connected with their professional work. Amongst these subjects, taking London only, may be mentioned field telephony, range finding, saddlery, wheelwrighting, blacksmithing, coppersmithing, engineering fitting, carpentry, oxy-acetylene welding and other subjects; the list is far from exhaustive. In each case the particular needs of military service were kept carefully in view.

Further, the aftermath of the war is already making itself felt in the technical institutions, although the stress and strain of the after-period are not yet developed. Disabled sailors and soldiers, however, are already being discharged from the hospitals in great numbers, and in very many—indeed, in too many—cases it is necessary to fit the men for the battle of life in directions which they never contemplated before they joined the Army. This work is extending, but it will more properly belong to, and form a prominent feature of, the work which will have to be faced when peace has been declared.

The conditions which will then prevail cannot yet be realised in their entirety, but one thing is certain, and that is that the country will never return to the state, political, social or educational, which marked the epoch which came to an end on August 4, 1914. It is, however, primarily and almost exclusively to the educational aspects of the underlying problems that we must confine ourselves here.

Even so, the contemplation of some of the conditions which will arise brings us to one of the most urgent and important matters now pending. The engineering departments of the universities, the polytechnics and the technical institutes for the past two years have played up splendidly, but it has been at the cost of their normal work. It cannot be too strongly urged that the time has now arrived when the question of the resumption of that normal work should be seriously considered. A recent announcement in the press was to the effect that there are now under the Ministry of Munitions 4,212 controlled establishments. It may be assumed that these are all directly or indirectly engaged upon munitions work, and amongst them are the large new national munitions factories, each individually planned for an enormous output, and now actually at or nearly at its full productive capacity. The total amount of work which can be done in educational workshops must now be but a very small fraction of the whole output, instead of, as it was at the beginning, an important proportion of that output. If this be so, it can now, without serious detriment, be dropped, and it is of the utmost importance to the nation that it should be so dropped, and that the normal educational work should be resumed in the coming session as being at this moment of far more importance. Moreover it

has been publicly announced that our own production is now so well developed that the deliveries of munitions we have been receiving can be and are being diminished. This source of supply is therefore now becoming a reserve upon which we can draw if necessary.

For the past two years the outstanding aspect of the educational work in the polytechnics and technical institutes has been the depletion of the engineering classes, both day and evening. It is an under-estimate to say that in normal times we should be training in first-grade engineering day courses not fewer than 3,000, men who on the completion of their training should be qualified to serve on the technical staffs of our large engineering works and to assist in carrying forward the engineering industries of the country. But what is the present position? At the recent final examination for the degree of B.Sc. (Eng.) at the University of London there were only three internal candidates in electrical engineering from all the London University Colleges and Institutions connected with the University, and not one of these candidates was an Englishman. It is undoubtedly a noble thing that our students should have so sacrificed their careers for their country in her extremity, but was it best for the country that it should be so, and should it be allowed to continue any longer? We are being urged on all hands to prepare to capture the enemy's trade on the conclusion of the war, but how are we to do so or face the still more difficult task of meeting the competition of highly organised neutrals in the engineering trades if this state of things be allowed to continue? In this matter we cannot afford to be again "too late."

If anything worth doing is to be done during the coming session every engineering whole-time day student who can be traced should be at once brought back from the front, and every such student now engaged upon munitions work should be set free to resume his studies in the coming winter session, and be protected from being called up by the recruiting officer. The matter is not free from difficulty for, if everyone else be willing, many serving at the front may not wish to come, and many also have, alas, already made the great sacrifice, and can not come.

Moreover, all junior engineering students as they come within the military age should not be disturbed in their engineering studies, proper and easily-devised effective precautions being taken that the courses are not made a refuge for shirkers. The price we are paying and shall have to pay in the future for retaining these few thousands in our million-fold armies is altogether out of proportion to the services they can render to the country as combatants, and the same may be said of the munitions workers. The matter is *very* urgent. For two sessions our senior day courses, fourth-year, third-year and even second-year have been practically non-existent, and, if the war were to cease to-morrow it would take four years before the normal rate of output of fully trained students could be resumed, and during the first two of these years the output would be practically nil. When the havoc which the casualties have wrought in the pre-war staffs of all our big engineering firms is contemplated the outlook is gloomy indeed, even if no further time be lost, for one of the first problems which will have to be faced will be the re-conversion of the vast establishments now working on munitions into the thousand-and-one necessary varieties of commercially productive establishments. It is for such work that the services of a strong technical staff are specially required, and without such a staff we shall be disastrously delayed in getting into our manufacturing stride.

To enable the schools to re-start their normal courses it is also absolutely necessary to bring back to their proper work the members of the teaching staffs of the universities, polytechnics and technical institutes who have been allowed to join the Forces or to engage in other forms of war-service work. Here again, even if every man left be brought back there will probably be a serious deficiency which it will not be easy to remove, but without the return of the absentees it will, in most cases, be impossible to carry on the normal work of the engineering courses with only those members of the staff who are at present retained at home. The research and experimental work for the Government need not be interfered with, but could be altered and developed further with the assistance of enthusiastic senior students.

It is thus that even now the influence of the second period referred to above should be making itself felt. But when one turns to contemplate the problems to be faced during that period one is staggered by their variety and complexity, and even if only educational problems are to be dealt with volumes could be written. In a brief article like the present it is, therefore, only possible to take up a few of what appear to be the more salient points and to avoid detail, though in some directions detail is the essence of the problem.

As regards the polytechnics and technical institutes it would be well to consider first with respect to this second period the material in the way of students which will probably present itself for treatment. Early in the war period it was foreseen by some that the students who were fortunate enough to return from the front would have an outlook upon life very different from that which they had previously possessed, and would be far more likely to take matters more seriously than in former times. This was not a speculative opinion, but was based upon contact with fair samples of such men and upon discussions with them on various subjects. What was true early in the war is far more true to-day, or, rather, has a much wider application. The depletion of the day and evening classes in the polytechnics and technical institutes throughout the country shows that many of the men at the front are men who are actually within the period of life at which education for life work is not completed; others a little older are not far removed from that period. The contact which these men are having with stern realities is bringing a new spirit into all their relations with life, and their influence upon the rising generation who have not had their hard experience will be profound. It may be taken as axiomatic that the students who will be offering themselves for training, both in evening and in day classes in these institutions after the war will be in quantity greater and in quality equal to the best of those who came forward in pre-war time.

The students so offering themselves divide broadly into two distinctive groups, though there cannot be, and should not be, any sharply dividing line between the groups. In the first group will be those, and they will form the greater number, who, working at the bench, or its equivalent, are mainly concerned with the handling of material, in its different stages of manufacture and utilisation, and the shaping and adapting of it for the purposes in view. Such may be conveniently referred to as "workmen," and include in the higher grades the foremen and shop foremen. In the second group will be the technical assistants of all kinds from the juniors in the drawing office to the technical heads of departments responsible for planning, designing and directing the work going through the shops, and possessing in the higher grades a wide knowledge of the engineering and economic conditions necessary for commercial success.

Speaking quite generally, the juniors of the first group will, outside the workshop, obtain their technical training in part-time day and in evening classes, whilst those of the second group should preferably pass through whole-time day courses.

The educational work for the first group will be given in continuation schools, in part-time courses in technical institutes, and in evening classes in junior and in senior technical institutes. The last-named classes will, as in the past, be attended by students of all ages, but it is the conditions under which the work of students of immature age will be carried on which require the most careful consideration. The greatest asset we have in the engineering industries is the human asset, and yet this is the asset which we have unwittingly, but not the less certainly, wasted in the past. Though there are honourable exceptions, and they have been increasing of late years, it was before the war generally the fact that boys in the workshops between the ages of 14 and 16, or even later,

could only acquire a trade by the time-wasting and inefficient process of "picking it up" even though they might be, but usually were not, bound apprentices. In the majority of cases no provision was made for any real training, and still less for the welfare of the individual upon which the efficiency of real training so much depends.

The subject of apprenticeship is too wide to discuss in all its bearings here, but by whatever name the non-adult or adolescent be known ample provision should be made for his technical training during the early years in the works. The defects of our elementary and secondary school systems also cannot be discussed here, but they have a direct bearing upon the problems which have to be faced. Speaking quite generally, those who are being trained primarily as workmen, and who in large numbers will be drawn from the elementary schools, should be given time-off during working hours, and should be compelled to attend classes either in the works or in a neighbouring technical institute. It should be made impossible for any employer to avail himself of the services of anyone below the age of 17, or perhaps 18, except on such conditions. The principle should be applied universally, although we are only here concerned with its application in the engineering industries. As an alternative, if it be found that in certain specialised work a part-time attendance at the works is not possible, then whole-time leave of absence for the equivalent amount of time at full wages should be given at definite and periodic intervals, and educational arrangements should be made accordingly.

Provision should also be made by a carefully devised and sympathetically administered scheme of national and local scholarships for giving to the brightest and most promising junior members of this first group the wider educational facilities available for the training of the members of the second group. To go into details of such scholarships, or how the scholars should be selected, which should preferably not be wholly by examination, would lead us too far afield here.

The members of the second group should be trained in whole-time day courses combined with sufficiently long periods in works for all students who during the early part of their training in the schools show engineering ability and aptitude. All who fail in these essentials should be given short shrift early in the courses and advised to seek some other outlet for their energies. In the past excellent work, much appreciated by those employers who have come into contact with it, has been done in such courses in the more progressive of the technical institutions. With the widely extended assistance and direction from employers which may be expected in the post-war period this work should be largely extended and improved. The conditions for admission to the courses should be a good secondary school education, and the facilities for giving such an education commencing at a sufficiently early period of life to the best pupils of elementary schools should be extended.

The foregoing makes it all the more important that careful consideration should be given to the kind of education which should be offered to all the grades of students who may be expected to present themselves. We are, in this article, concerned chiefly, if not exclusively, with technological education, but it must not be overlooked that large numbers of the population will require and demand training in the liberal arts and in the humanities, perhaps to an extent never before contemplated. Full provision should be made to satisfy such a demand.

On the technological side the education to be offered is necessarily to a great extent, if not exclusively, utilitarian, but even so it must be recognised that without sacrificing the utilitarian character of the work it can be made an effective vehicle for the training of character and the highest qualities of the mind. After all it is not what is taught which tells in these directions, but how it is taught and the attitude of the teacher towards his work and towards his students. It goes without saying that research and the research spirit should dominate the higher courses in all technological day schools, and, if so, its effects will be felt in part-time day classes and in the evening work carried on in the same institution.

The splendid work done in the past in our technical evening classes, which have been second to none in any country, will have to be continued for many years to come, but it is to be hoped that the necessity for it will gradually diminish, for it is not fair to the individual that after a heavy day's work he should be called upon for further strenuous exertion, even though he may be perfectly willing to respond.

The actual work to be undertaken must be reviewed not only in the light of the experience acquired before the war as to the necessities of the locality and district in which each individual polytechnic and technical institute is placed, but also by more intimate contact with manufacturers and employers who as a class, it is to be hoped, will have awakened to the possibilities underlying sound technological education. In many technical institutes before the war such consultations were regarded as necessarily a part of the work of the higher teaching staff of the institute, but in practice the general experience was that there was a dead weight of apathy and indifference on the part of many employers which made it very difficult to ascertain their requirements and to mould the education accordingly. It may be fairly hoped that one result of the strenuous times through which we are now passing will be a large abatement, if not a complete disappearance, of this apathy and indifference.

If the engineering trades are to be organised against foreign competition, and it is gratifying to note that a start has been made in this direction, the employers and representative workmen must throw themselves whole-heartedly into the work of advising the polytechnics and technical institutes as to their requirements. The employers must go even further than this and be prepared to take from these institutes their products in the form of trained day-students at a wage very considerably in excess of what has been far too common in the past, namely, about the wage of an ordinary unskilled labourer. If this be done the engineering industry will command the best brains in the country. If it be not done, and there be no assured career for the best products of the schools, the last stage of the industry will be worse than the first.

Before the War, advisory committees, consisting of representatives of local authorities, of manufacturers and of labour organisations were much favoured in certain quarters and did some useful work. Their great defect was that they did not contain representatives of the senior teachers, with the result that, in educational technique, they had to trust to the advice of administrative officials not always cognisant of the best solutions for particular problems. Such committees should be reconstituted with the addition of teachers acquainted with the human material they have to handle and with the possibilities and limitations of the work under discussion. So reconstituted their usefulness would be considerably enhanced and they would form an important part of the educational organisation.

The great efforts which are being made in the United States to associate more closely the manufacturers on the one hand and the Technical Institutes and the engineering departments of the Universities on the other, are probably known to few in this country. To take one instance only, for space forbids more, the well-known Massachusetts Institute of Technology (the Boston "Tech."), besides removing to a new and greatly extended home during the past spring, is for its chemical engineering department establishing six new laboratories, each bearing the name of the institute and in charge of an institute professor, but each situated in a large and sometimes distant works in which an important chemical industry is being carried on. The students in chemical engineering, after passing through rather more than three years' training in the parent institute, will pass in rotation through these laboratories and see chemical work in progress under commercial conditions on a large scale. With this illustration of the spirit and energy with which similar work is being taken up elsewhere we leave the matter for the present.

Training of Apprentices.

By A. P. M. FLEMING.

SYNOPSIS.

This article deals with the methods of training for all grades of industrial engineering employment; the weaknesses of existing methods and some suggested remedies; the economic importance of the problem to industry and to the community, particularly under the industrial conditions likely to obtain in the near future; the responsibility of capital and labour in the training of workers, and the importance of the problem as a means of bringing about a greater degree of co-operation between these two bodies; the problem viewed from the standpoint of citizenship.

INTRODUCTION.

For the purpose of this article the term "apprenticeship" is broadly considered to apply to that period of preparation which precedes entry into full employment in any position in engineering manufacture, whether of bench workers or technically trained engineers. The former are usually termed "trade" apprentices, and the latter after completing a course of technical study may be rightly designated "college" apprentices.

In every industrial enterprise, the most important factor is usually the human one. From an economic point of view, this fact has clearly been demonstrated in connection with manufacturing conditions brought about by the war. It will be even more clearly in evidence in the industrial war that is to be expected. The importance of human service will be readily appreciated from the fact that of the three items constituting cost of production, namely, labour, material and indirect expenses, the first named is the one possessing the greatest possibilities for economic improvement. This improvement can be effected by suitable training.

Whether this training results in better productivity or in a better quality of workmanship, and whether it is brought about by more effective application of science in industry or by more efficient workmen, the result is a gain to the individual workers, to the industry and to the community.

The broader question of the relation between labour and capital is vitally affected by this problem of training, the solution of which may well be a factor in bringing about a closer co-operation between these two conflicting parties.

The method of training engineering workers has not kept pace with industrial changes, and, in view of its far-reaching importance, the time is opportune for a consideration of the problem in its various phases.

INDUSTRIAL CHANGES AND THEIR EFFECTS ON TRAINING.

The most important changes in the training required in the engineering industry are the following.

The change in conditions of manufacture, in which a high degree of manual dexterity has given place to less highly developed skill coupled with a broader knowledge and experience of tools and materials, ability to understand drawings, to use fine measuring instruments and an appreciation of the scientific principles underlying the practice of the trade. Thus this change is one which relates to the *character* rather than to the *degree* of experience required.

Modern conditions of intensive production and the consequent change in requirements of training, have eliminated the close personal relations that used to exist between masters and apprentices whereby the latter profited to a very great extent, both in character and experience. Modern apprenticeship is almost entirely lacking in this far-reaching influence.

Another change of note is that under the old system an apprentice rose to the position of a master largely by virtue of his skill, perseverance and latent business capacity, and there were no means of preparation for such a position other than through the channels afforded by apprentice training.

Under the present conditions, and particularly in the large engineering organisations, there are numerous grades of employment, and the higher ones demand preparation of an entirely different character from those of the lower. Hence it is not now essential that all apprentices commence their training on the level intended to produce skilled workmen, so long as they have the ability and means to profit by the opportunities afforded for training specifically for the higher posts. At the same time, it must always be possible for a youth to rise from the lower to the higher positions.

The other change of greatest importance is the increasing use of science in every phase of manufacture. This leads to the need for even greater refinement in all processes, which in turn renders the conditions of training for the workman, and, in fact, for every grade of employment, more exacting. The development of modern manufacture tends to standardisation, which brings about the need for repetition workers as distinct from the skilled craftsman. In turn, however, the new developments that are continually arising from inventions and applications of new scientific discoveries to a large extent counteract this tendency and bring about a continual demand for highly trained workers.

Engineering employment may be broadly divided into two classes, namely, that in which the work is essentially of a manual character and that for the higher positions in which no manual work is required.

THE MANUAL WORKER.

This group includes the skilled tradesmen, together with charge hands and supervisors; the repetition worker and the labourer.

In considering the problem of the labourer, the fact must be recognised that there must always be "hewers of wood and drawers of water," and it remains therefore to select those youths who, by physique and standard of mental capacity, are better adapted for this class of work than any other. Unfortunately, however, labourers are as a rule the product of blind-alley employment, and often youths inherently fitted for a much higher grade of employment are absorbed into this class, thereby involving economic waste to the community of the gravest importance.

In certain industrial centres in Germany an attempt has been made to counteract this tendency by compelling all but a small percentage of youths to learn a skilled trade.

In the United States economic conditions have brought about spasmodic efforts to train adult labourers to a higher state of efficiency by means of special instructors and the incentive of high wages. However satisfactory the results obtained in this way, the plan appears to be fundamentally wrong, in that the starting point should be *the correct selection of youths inherently fitted for the particular work they are called upon to perform*.

While it appears at the moment most necessary to pay attention to the training of higher classes of workers, it should be noted that no occupation is really unskilled, and that every job, however mean, can be performed methodically and efficiently.

The problem of the repetition worker has always presented

a difficulty because of the condition of mental atrophy it may tend to produce. The solution of the problem, as in the case of the labourer, depends on the selection of workers who are physically and psychologically inherently adapted to such work, that is to say, workers who can carry on repetition work continually without diminution of productive capacity and without prejudice to their mental development. Despite the pronouncements of various American writers on the subject, there does not yet appear to be any very satisfactory method of selection other than by trying the individual out on this kind of work, and thus making a practical test of his capacity. Fortunately, however, the influx of female labour into engineering works may to a considerable extent solve the problem, since such workers are inherently extremely well adapted to repetition work. The fact that a woman's period of factory working does not usually extend over more than a few years—although in the future this period may be very much extended—does not introduce a serious derangement, owing to the comparatively short time that is generally required to train for repetition work. As regards training of this division of labour, some good can be accomplished by means of instruction directed to giving a broad understanding of the principles of the processes or machines employed and the function of the products obtained, so as to widen the interests of the worker in his or her occupation, which in some cases may react to the reduction of physical fatigue and mental stagnation.

With regard to the skilled tradesman, here again *the inherent weakness of the present system is the lack of means of selection*. This is often due to the failure of those who guide the boy to his future occupation to appreciate the requirements and principles of industrial work, with the result that in some cases the most promising youths are directed to clerical work, and in others a skilled trade is taken up only after preliminary attempts at other employment. There is also a lack of attention in the final years of the primary school to education which is in any sense preparatory to industrial life; there is a want of continuation education of a character which has direct bearing on the everyday employment that the youth is following; means are generally lacking for a thoroughly sound, practical training during apprenticeship, and further, there is at present no standard by which this training is eventually gauged.

To remedy these defects and direct to industrial employment those boys inherently suited for it, close observation is necessary on the part of teachers prior to the age of, say, 12, particularly in connection with handicraft work, play, scouting, &c. (To this end it will be desirable to improve the status and standard of intelligence and personality of the teachers.) By this means it should be possible broadly to classify youths according to whether they are suitable for industrial or commercial work. From this time to the school-leaving age, the education of boys proposing to enter industry should be emphasised in those directions which will assist in the ready acquisition of a skilled trade. This instruction might be provided by a suitable modification of primary school curriculum or in junior technical schools, where these are available or the industrial conditions justify their establishment. It must be clearly understood, however, that this preparatory education is not intended to impart manual dexterity or in any sense to teach a trade, since in the engineering trades this can only be done effectively in works. It should, however, include the scientific principles underlying the engineering trades, afford experience in making sketches and reading a drawing, and the use of the simple tools should also be taught.

It is important that the school-leaving age be raised to 14 and preferably 15, and that continuation education be made compulsory. What is far more important, however, is that this education be of the right character. That is to say, it should apply specifically to the everyday work of the youth, and in this respect be quite different in character from that of the present evening technical classes, which in the main provides a means only for the few of outstanding ability and endurance to rise to the higher positions. The fact is not realised that the vast majority of youths in engineering industries will be manual workers all their lives, and the continuation education should be directed primarily to providing such instruction as will render these youths the most efficient workmen possible. By teaching them in the first place *how best to make a living*, a good foundation is laid for subsequent instruction in the *best way to live*.

This continuation education should embody what might be termed "trade" as distinct from "technical" instruction, and should preferably be given in working hours in a school attached to the works and staffed by works engineers and foremen who are directly in touch with the practices of the trades. This will ensure that the courses provided are of the right type and properly related to the practical work. In the case of small works, a co-operative school might be provided dealing with the apprentices from a number of firms in the same locality, or, if this is not practicable, a municipal school for a whole industrial district might be arranged and attended by apprentices during working hours. The most efficient plan is undoubtedly that of individual works schools, and through the channels these afford the youths of ability can be most readily selected for promotion and higher education provided for them. Such schools fulfil a most important secondary function, in that during the years immediately preceding young manhood, in which youths are very susceptible to outside influence, a strong bond of sympathy may be developed between employers and juvenile employees.

Far greater attention is necessary than is usually given to the practical training in the shops. In very many works an apprentice picks up his knowledge and experience in a haphazard manner, often copying the methods of inefficient workmen and obtaining very little assistance from really experienced tradesmen. The long view is seldom taken by employers that it is economically much more satisfactory to ensure a thorough all-round training for apprentices than to exploit them for immediate productive output. The present lax methods of training often lead to apprentices migrating from shop to shop in search of wider experience. This is a very undesirable state of affairs, and could be prevented by each employer taking steps to ensure better education and training and by introducing an apprenticeship agreement to differentiate boys who are specifically learning a skilled trade from those who casually enter the shop and move from works to works.

In order to determine a means of gauging the quality of training, the Continental plan of establishing a board of employers and work people, who examine an apprentice in the practice and theory of his trade at the completion of apprenticeship, might be employed, and provision could then be made to prevent unauthorised persons from calling themselves tradesmen.

It will be observed that in all the classes of workers dealt with under this group the point of fundamental importance is to direct youths by the best possible means to that character of work for which they are inherently best fitted. It is only by doing so that misfits, dissatisfaction and economic waste can be avoided.

Technical Staff.

This group includes designers, commercial engineers, works managers and research staff. The training essential for such men includes a thorough technical training and practical experience of a character intended to afford a broad knowledge of engineering processes and manufacturing economics rather than any special manual dexterity such as is necessary for the manual working group.

While most men proceeding to such positions are those who are financially able to follow a course of higher technical instruction immediately after leaving school, it is most essential that encouragement be given to every means whereby youths of ability who commence their careers as manual workers can also attain these positions. At present a small minority do so through the channels afforded by evening technical schools and part time courses. It is also important to increase the facilities for higher education by means of scholarships enabling boys to proceed from the primary

schools to the universities, and this must be supplemented by facilities provided by employers for such youths to acquire the requisite practical training at a living wage.

It is hoped that employers will in the future realise to a greater extent than appears at present to be the case, the far-reaching national importance of developing to the utmost the latent capacity of every individual in whatever grade of employment he may be found. The works school affords the most satisfactory means of disclosing such latent capacity, and in at least one large English engineering firm the opportunity thus afforded is utilised for the selection and advanced education of working youths who show their capacity to benefit thereby.

The works trade apprentice school should be of particular value in this respect for partly meeting the supply of men for intermediate technical positions such as draughtsmen, test assistants and the like. The lack of systematic training of men for such positions is a matter to which more attention should be given in this country, as is the case on the Continent. Such men at present mostly pick up their experience, as has been the case with trade apprentices, in a haphazard and unsystematic way. The resulting lack in uniformity or of a more or less well defined standard of ability does not make for efficiency.

There exist in this country a few so-called "senior technical schools" which are suitable places of training for men for the intermediate technical positions, but at present they form no integral part of a coherent scheme of education.

At the present time the educational facilities for technical positions are more comprehensive and satisfactory than those for the manual working group. At the same time, two weaknesses may be referred to, namely, the comparatively low standard of education—due principally to the lack of continuity in our whole educational system—in the first year of the technical course, and the general lack of instruction relating to manufacturing economics. The first of these can be remedied by raising very considerably the entrance requirements. In this case it will also be necessary to provide suitable improved preparatory training as a bridge between the secondary schools and the technical colleges and universities. This would have to be met by separate preparatory technical schools or by the systematic establishment of technical and industrial divisions in the secondary schools similar to the present commercial divisions.

The second weakness can be remedied by providing a course of lectures during the third and preferably also the second year relating to the problems met with in works, the methods of costing, production and general works management. These lectures should be given wherever possible by works managers of wide experience.

In this connection it may be noted that several of our best technical colleges have for some years arranged specialised courses of lectures of instruction by specialists in different branches of engineering. Such efforts should be developed to as broad an extent as possible. The usual technical educational curriculum generally gives the student too limited an idea of the conditions obtaining in industrial works and works methods.

Leaving aside the controversial question of the order of precedence of works experience and technical training, attention might be called to the fact that the technically trained man proceeding to works as "college apprentice" can acquire the requisite practical experience at a very much greater rate than one not so educated. So much is this the case that some large engineering firms consider a two-year course of practical training sufficient for the technically educated man as compared with four or five years for a non-technical apprentice. The tendency in a few of the largest manufacturing firms to pay a college apprentice a sum sufficient for maintenance during his apprenticeship period is a step in the right direction.

Though most "college apprentices" are not usually worth a living wage to their employers for at least a year, it is taking the long sighted view to attract the best men by such means, which will be generally quite compensated when the man becomes proficient in industrial engineering work.

The significance of the practical training for technical positions, especially in electrical engineering, is often misunderstood. For such purposes a long training is not necessary, excepting for those who intend to deal with works organisation, and a period of two years, about half of which may be spent in drawing, designing and commercial offices, is sufficient for most cases. In this connection it is interesting to note that one large American electrical firm has planned a course of training of one year's duration, during the first half of which the apprentice is expected to decide which branch of the organisation he desires permanently to follow. The subsequent experience is then directed specially to training in that branch. In the case of a designer, the apprentice is very carefully selected according to his mathematical ability, and for six months is given what amounts to a post graduate course, comprising practice in the solution of problems of design, directly under the supervision of the chief electrical engineer. Having covered broadly in this way the whole field of electrical design, the apprentice spends six months in the various testing departments, at the end of which time he is absorbed by the designing staff in one or other of the main divisions. The experience of two or three years working on this plan is said to have produced very satisfactory results, and while the method of training is of a very intensive character, the specialisation that nowadays appears inseparable from the electrical industry seems to justify its adoption.

With regard to commercial engineers, a good plan seems to be to select these men from those who have followed a two-year apprenticeship course in which they have had some designing experience. It is essential that they possess commercial instinct, and that suitable instruction be given in commercial procedure.

A field of growing importance is that of works management, which possesses promising possibilities for technically-trained men. The opportunities for economy in manufacture, particularly under modern conditions, in which there are so many scientific processes employed, are very great, and this division of technical employment appears to be becoming more and more a province of the scientifically trained man who, in addition, has works experience and an innate capacity for dealing with labour.

With regard to the research staff, this body is at present in this country unfortunately in little demand. There appears every reason to believe, however, that in the largest works such staffs will be recognised as essential in the near future. The present plan of training such men is for them to pursue a post-graduate course at the universities, in which they carry out some special research under the guidance of their professor. While such a plan is commendable in that it trains the student's capacity for observation and logical deduction, the research is often not of very great industrial value. An alternative plan that has been proposed by one of the large engineering concerns, is to take from the universities carefully selected students who have shown a natural bent for research, and to afford them facilities in the works for studying some of the urgent industrial problems on which research can profitably be carried out. Having selected the subject for investigation, the students can then conduct this work either on the firm's premises or at their university, according to whichever affords the best facilities. These students would be paid a sum sufficient for their maintenance, and their work carried out under the joint supervision of the firm's staff. In this way work of real industrial importance would be done, and the students brought all the time into contact with industrial conditions.

Directly associated with technical engineering employment is that of so-called chemical-engineering. Thus far there has been little provision for training men for manufacturing positions in chemical works, in connection with which a good deal of engineering experience is required, and a scheme recently proposed for adoption at Harvard University (Massachusetts Institute of Technology) is of interest. This scheme provides

for a series of eight experiment and research stations being installed, one in each of the large centres of chemical industries and equipped with laboratory facilities, in which students will spend six weeks in each station. These stations will deal with such industries as dyeing, paper manufacture, iron and steel industry, cement manufacture, glue, fertilisers, &c., petroleum distillation and electrochemical products. This portion of the course will occupy the fourth year of a five-year period of training, the first three and the last years being spent at the university.

There are two marked features of training in connection with the technical staff that may be noted, especially in regard to electrical engineering. The first is the fact that suitability for the different divisions of technical employment in manufacture are determined very largely by the inherent characteristics of the man, as, for instance, mathematical ability and broad judgments, for design; commercial instinct in addition to technical capacity, for commercial engineering; sound mechanical training and innate capacity, for understanding and controlling labour by the works organiser; in the case of the research worker a bent for investigation and a thorough training in mathematics and physics. The other is the need for the large works to develop courses of higher instruction applying to those different branches of employment which will in fact serve as a post graduate course for college apprentices in works. These courses would be conducted by the works engineers, and have special application to industrial requirements.

The deplorably short-sighted policy that has enabled our supply of technically-trained men to be depleted in connection with military service, has introduced the need for considering the possibilities of employing university trained women in technical positions. Experiments in regard to the employment of such women students and the special training they require have been made in one large engineering works, and the results thus far appear to justify this departure.

Future Developments.

Among the future developments affecting apprentice training, the most far-reaching are those which bear on the relationship between capital and labour. The differences between these two conflicting bodies are the result largely of a mutual ignorance each of the other's aims and interests. To a considerable extent the mistrust that this condition produces can be dispelled by the close connection that it is possible to bring about between juvenile workers and employers during the apprenticeship period. Adequate provision along the lines of promotion suggested also affords a means whereby what has been aptly termed "the upward mobility" of the youth can take place, and by thus democratising engineering employment a considerable step will be taken towards the solution of this problem. The urgent need of the future will be the turning to account of every means which will facilitate industrial production. An important factor in this connection will be the development of every industrial worker to his highest capacity and the reward of every worker in proportion to his attainment.

This is particularly important in view of the keen industrial competition that will exist in the future. The necessity for each individual worker to attain the highest efficiency in the present crisis and in view of future conditions is just as great as that of the soldier in the field.

The responsibility which rests on both employers and representatives of labour in the matter of effective education and training of juvenile manual workers has not yet been realised. This matter should not be left entirely in the hands of the professional educationist, but a far greater share in the direction of suitable instruction should be borne by employers and workers. This perhaps can best be done by their better representation on the committees of local educational authorities. The economic importance of affording facilities for practical training of men for the technical staff has not been sufficiently realised by manufacturers. In this connection the latter should be represented on the governing bodies of universities and technical colleges.

Attention is called to the bearing which apprentice training has on preparation for citizenship. There is from time to time a demand for the teaching of what has been termed civics, or the principles of citizenship, in the public schools. Such instruction is of comparatively little value unless accompanied by some training which will develop the will to apply these principles. Apprenticeship training in the case of the manual worker is the most effective means of developing the character required for this purpose. In fact, the underlying characteristics of a good workman are precisely those of a good citizen. Hence any efforts that result in producing good workmen react to the ethical benefit of the community, in addition to any direct gains through increased industrial prosperity.

Similarly, it is equally important that men being trained for higher staff positions should realise their ultimate duty in the matter of citizenship, especially in regard to their responsibility to industrial workers.

THE BRITISH ASSOCIATION AT NEWCASTLE.

(From our Special Correspondent.)

Tuesday, September 5th.

The British Association meets this year under probably the most adverse conditions in its existence. The number of members is smaller than for many years, but this is to some extent compensated by the absence of lighter elements of the garden party kind, and, judging by the "Journal," the volume of solid scientific work achieved will, in many sections, be little less than usual.

The Inaugural Meeting was opened by the singing of the National Anthem. The Presidential Address of Sir Arthur Evans dealt entirely with "New Archæological Lights on the Origins of Civilisation in Europe," a subject of great human interest, and one that can be quite as technical as any of the more exact sciences. In referring towards the close of his address to the scientific side of education, the President remarked: "It is not so much the actual amount of science taught that is in question—insufficient as that is—as the installation of the scientific spirit, the perception of method, the sacred thirst for investigation."

Wednesday, September 6th.

Section A (Mathematics and Physics) this year is singularly barren of subjects of electrical interest. A note by the Rev. A. L. Cortie on "The Efficiency of Sunspots in Relation to Terrestrial Magnetism," and a remark by Mr. E. Cunningham that magnetic phenomena might possibly be better explained by gravitation than gravitation by magnetic phenomena, were the only references of this kind.

In discussing gravitation Prof. Eddington said that the principle of relativity had been recently generalised by Einstein, and in this new form accounts with arithmetical accuracy for the motion of the perihelia of mercury. The significance of this is that the principle of relativity has become of supreme importance to astronomers. The discussion was continued by the Astronomers Royal for England and Scotland, Dr. Dyson and Dr. Sampson, and by Dr. P. E. Shaw.

Section G.

A large audience gathered to hear the Presidential address by Mr. Gerald Stoney, F.R.S., which we gave in abstract in our last issue. Mr. Stoney's thoughtful analysis of the present industrial conditions gave rise later to active private discussion—the President's address in any section not being discussed as a Paper.

Dr. R. T. Glazebrook, F.R.S., then gave an account of the methods developed at the National Physical Laboratory for dealing with limit gauges, a branch of the work of the Engineering Standards Committee which has within the last two years become of the first importance. He mentioned that over 5,000 gauges passed through the laboratory per week. We hope to give the Paper itself at some length in our next issue.

Sir Charles Parsons in the discussion said that the work of the National Physical Laboratory had greatly increased the efficiency of output of munitions. At the outset there was some deficiency in the number of gauges available. Men from the district were sent to the National Physical Laboratory, and were shown everything; they returned, failed, went again, and in the end succeeded. The men enjoyed the work. "It was like serving their apprenticeship over again." He wished that the National Physical Laboratory was ten times bigger, and after the war he would like to see very much larger laboratories. Prof. J. E. Petavel congratulated Dr. Glazebrook on the rapidity with which the work was organised. Mr. W. A. Price said that the National Physical Laboratory had done what the British Association Small Screws Committee failed to obtain 15 years ago, and with an accuracy never then contemplated. Prof. H. Louis suggested that the micrometer methods used with limit gauges might be used in Brinell hardness tests. Dr. Stromeyer asked for instruction to be given how such gauges are to be used, and quoted striking examples of misuse. Prof. Howe asked who settled the limits required.

Dr. Glazebrook, in reply to the last, said that the limits were assigned by the Chief Inspector at Woolwich (so that presumably the values at present worked to and under discussion refer only to armaments). He thought that Prof. Louis's suggestion might simplify hardness testing, and in conclusion said that much of the success of the work was due to two of his staff from Newcastle, Mr. J. Sears and Mr. W. A. Price.

Thursday, September 7th.

Disappointment was felt in Section A that Prof. G. E. Hale, of Mount Wilson Observatory, was unable to be present to give an account of his work on "The Magnetic Phenomena of Bipolar Sunspots."

Prof. J. C. McLennan, of Toronto, gave a resumé of recent work on ionisation potential.

In Section G, Dr. T. Stanton, F.R.S., read a Paper on "Principles of Similitude" chiefly in reference to the employment of small scale models to predict the performance of ships, beams, structures, propellers, projectiles, &c., under working conditions.

In the discussion the President referred to this principle as commonly used in the design of turbine blades, and of alternators. Sir Chas. Parsons illustrated it by the behaviour of the impact of projectiles. Prof. Thornton remarked that the principle was the basis of the construction of all "lines" of electrical machines, but that there it was found necessary to use a coefficient of performance which varied in magnitude with the size of the machine.

Mr. C. D. le Maistre read a Paper on "Standardisation and its Influence on the Engineering Industries," in which reference was made to standardisation of electrical machinery and apparatus.

Mr. H. T. Newbigin gave an account of recent developments of the Michell principle of oil film lubrication, especially as applied to thrust bearings. The Chairman referred to the fact that higher pressures were obtainable than the author had given. For example, he had obtained 4,000 lb. per square inch at 53 ft. a second, and in America he believed 9,000 lb. per square inch had been used successfully. The limit was not the oil but the deformation of the white metal. The method might revolutionise ordinary bearings.

Sir Chas. Parsons referred to the great improvement in marine thrust bearings which had been made by the use of the Michell principle, but thought that it had not much future in journal bearings.

Prof. Weighton asked what happened when the rotation was reversed when the bearing blocks were pivoted. Did the oil film adjust itself sufficiently quickly to take the pressure. Mr. Merz asked whether there were any high-speed journal bearings of the Michell type in use.

Mr. Newbigin, in reply, said that the blocks could be pivoted centrally so as to give satisfactory results with either direction of rotation. There were journal bearings moving on vertical pump shafts in Australia, and some on marine shafting.

Prof. W. M. Thornton then read a Paper on "The Influence of Pressure on Electrical Ignition," which was given in our last issue.

In the discussion Dr. Dugald Clerk asked whether the results varied with the size of the vessel. Prof. Petavel said that it would be an advantage to know the criteria of magneto ignition, and gave examples of the great difficulty in igniting gases at pressures of 2,000 lb. to 4,000 lb. per square inch. Was it voltage or current that caused ignition? Dr. Marchant asked how self-induction in the circuit affected ignition.

In reply, Dr. Thornton said that ignition, as distinct from pressure reached in explosion, did not appear to depend upon the dimensions of the explosion vessel. The fusing-wire ignition, used by Dr. Petavel, was, he thought, active on account of the stream of electrons which came from a metal at the point of fusion. In some cases ignition depended on voltage, in others on energy. The only self-induction used was that of the leads.

At the afternoon meeting Prof. G. W. O. Howe read a Paper on "The Calculation of the Capacity of Aerials, including the Effect of Masts and Buildings," which is concluded in our present issue. This was briefly discussed by Dr. Marchant, who complimented the author on the accuracy and convenience of the results obtained.

Mr. N. W. McLachlan then read a Paper on "Some Characteristic Curves for a Poulsen Arc Generator," which also appears in our present issue.

In Section B (chemistry) Prof. Thornton gave an address on "The Stepped Ignition of Gases," followed by a demonstration of the formation of a step in the electrical ignition of hydrogen.

Friday, September 8th.

In Section A, Sir E. Rutherford gave an account of recent work in neutral countries on the X-ray spectra of the elements. He remarked that the cost of a single research—over £1,000—was now beyond the reach of any one university, and gave the example of the development of the Coolidge tube by the General Electric Co. of America to illustrate the necessity for co-operation between manufacturers and colleges in higher research. He first spoke of the work of Prof. W. H. Bragg and his son on X-ray spectra and the nature of crystals, and secondly, of the work of Mosley on the fundamental connection among the elements, accounts of which have already appeared elsewhere.

Papers were also read by Dr. R. T. Beatty of Dublin, and Prof. W. M. Hicks, F.R.S., on spectra.

Section G.

A joint discussion between the engineering and chemical sections was held to-day on the Report of the Committee on Fuel Economy, Utilisation of Coal and Smoke Prevention. This took place in the rooms of Section G at the Mining Institute, Mr. G. Stoney in the Chair, and was one of the best organised and carried out discussions held for many years, a high level being maintained both in the morning and afternoon meetings.

Prof. W. A. Bone, F.R.S., reviewed the work of the Committee and sub-Committees, and said that there was every

prospect of important steps being taken in the near future with regard to fuel economy.

Dr. J. T. DUNN, as Chairman of the Chemical and Statistical sub-Committee, said that analyses of coal gave hardly any information as to its chemical nature and asked for collaboration of workers on this subject.

Dr. J. E. STEAD, F.R.S., in reviewing the work of the Metallurgical, Ceramic and Refractory Materials sub-Committee, said that all steel industries would not co-operate in an inquiry. Those who were in advance would not give their methods and those behind were ashamed to give theirs. It was desirable to know how much coal was being used in iron and steel industries and to have a heat balance of a furnace.

Mr. H. J. YATES, of the Domestic Fuel sub-Committee, briefly revised its work, and by the aid of the lantern showed incidentally the use of gas furnaces in the manufacture of munitions. He said that war had affected great economics in such furnaces. One plant alone used 500,000 cubic ft. per hour for annealing.

Sir HUGH BELL opened the discussion. He showed how Lord Armstrong's estimates, made 53 years ago, and his own of 1893, of the increase in coal consumption had been falsified by time. He thought, however, that the remarkable increases in coal consumption before the war could not be continued after it. Sir William Ramsey's extraordinary imaginative faculty led him to suggest the combustion of thin seams of coal in situ. This was being put to practical trial on one of his (the speaker's) mines in Durham at the time of Sir William Ramsey's death. He said that Mr. Merz regarded the electrical transmission of energy as the chief use to which coal could be put.

Prof. H. LOUIS said that coal was all raised for making money, not a ton a year raised for scientific purposes. Was it well to spend large sums on expensive recovery plant when chemists might at any time invent a new process making it obsolete, by synthetic methods ? He considered that they would have to have legislative power to put their suggestions into effect.

Sir CHARLES PARSONS said that the war had changed everything, had made everybody think. Things were in the melting pot and now was the time to go into large questions. The decision of chemists was wanted now, and the utility of the suggestions made with regard to bye-products had to be proved.

Dr. DUGALD CLERK remarked that civilisation was based now on coal and oil fuel. At the average rate per man in the world our supplies would last for 5,000 years. At the rate in England it would last 500. We *must* reduce the rate of fuel consumption. Engineers had from the time of Watt been alive to this question.

Dr. DES VŒUX, of the Smoke Abatement Society, gave a vivid and interesting account of the steps taken in London to prevent the smoke nuisance. By these the " London particular " fog was a thing of the past. Stokers were not now paid as formerly by the amount of coal they could fire in a day but by the amount they saved. The improvement was made by the use of mechanical stokers and by educated stoking.

Dr. E. F. ARMSTRONG advocated scientific management of large establishments, with fuel experts.

Mr. STROMEYER said that the smoke trouble from works arose from the fact that the boilers were usually too small. It was impossible to keep steam under these circumstances with dirty coal and this was one reason why it was left in the mine.

Colonel BLACKETT, speaking as a colliery manager, said that coal owners would gladly sell the small coal to the chemists and leave it to them to get the finest results. Collieries burned rubbish and gave out their best coal.

Prof. HENDERSON said that by low temperature distillation a coal could be obtained for domestic purposes free from smoke and with the valuable volatile gases removed.

Prof. BONE, in reply, said that Prof. Louis was unnecessarily insistent in pressing the amount of coal wasted, and pointed out that the Committee had not overlooked it in the Report. He welcomed any suggestions and invited those who had them to make to send them to the Committee for consideration.

The CHAIRMAN humorously referred to other possible sources of energy besides fuel. Maxwell's sorting demon might one day be discovered, by which we could tap the energy of the atmosphere.

The morning sitting, though exceedingly interesting to follow, had not resulted in definite proposals being made. The afternoon discussion, at which Dr. Dunn, as Chairman, was full of suggestions for future work, and was of special interest to electrical engineers. It was opened by Mr. C. H. Merz with a Paper which we hope to give in our next issue. Mr. Merz advocated the concentration of supply in each of the great industrial areas. That is, the Midlands, West of Scotland, North-east Coast, Lancashire and Yorkshire, with great electrical " road " mains, interconnecting generating units of the largest size.

Mr. R. P. SLOAN, manager of the Newcastle Electric Supply Co., gave examples of the use of electricity in the North-east district. In colliery work it was estimated that at least 75 per cent. of the coal previously used for power purposes had been saved as a result of burning it at the economical stations of the power companies instead of each pit generating its own power. This was equivalent to the saving of a million tons a year. Waste heat utilisation now amounted to some 150,000 tons per annum.

Mr. W. B. WOODHOUSE, manager of the Yorkshire Power Co., said that the great stimulus to fuel economy was the increase in the price of coal. What was wanted was co-ordination between the producers and users of coal for power purposes. There must be some incentive to progress, and he suggested the imposition of a tax on the use of raw coal, the proceeds to be used for the purposes of the Committee. This had a precedent in the petrol tax, devoted in pre-war days to the road Boards. Low-grade fuel could only be used in the coalfields. This called for distribution of energy by electricity ; carbonisation must go hand in hand with electrical production. In the Yorkshire district there were 400 collieries raising 30,000,000 tons a year. If the carbonisation were pooled with the power companies, all power at present used could be supplied, and in addition all the textile industries. This could well be done with low-temperature distillation of coal supplying a smokeless fuel for domestic purposes, the gas being used by the power companies.

Mr. MACLAURIN, of the Glasgow Corporation, said that fuel economy was an engineer's problem and it was up to them to co-operate with the chemists. He disagreed with Prof. Louis with regard to the recovery of nitrogen. If 1·4 per cent. of nitrogen could be recovered it would mean, with sulphate of ammonia at 1d. a pound 12s. a ton. This had, however, not yet been realised. Then with regard to oils, from 15 to 40 gallons were realisable. He quoted an example of where 100 tons a week of poor fuel, unmarketable on account of the ash, which amounted to from 2 to 30 per cent., were used in a producer method, and which could not be burnt in a boiler. Using 80 tons a week gave 40 gallons of oil per ton and 40 lb. of ammonia. In addition to which two boilers did the work of three. With ammonia at 1d., 5s. a ton had been realised. With oil at 3d. another 5s. could be obtained, making 10s. in all from bye-products. The method of distillation used was not by external but by internal heating. Hot gas from the producer was passed through the fuel in a tower and carried the oil over. These condensed in the upper parts, but were not allowed to run back on to the hotter parts and be " cracked " ; they were drained away. The oil obtained was quite different from anything he had found before, more like crude oil from a retort. It dried on wood or glass making a polish like linseed oil. In distillation it yielded 6 per cent. of light oil below 170 deg. for petrol, with no benzol or toluol or any aromatic hydrocarbons. By treating the residue with dilute sulphuric acid or paraffin oil a portion was obtained good for lubricants, selling at 8d. a gallon if the flashpoint was high enough, and 6 to 10 per cent. of cresolic acid. A heavy tarry portion fell to the bottom of the weak acid. This could be used as a varnish and sold at 1s. to 1s. 4d. per gallon. All this tar had the peculiarity that it was solvent in caustic soda and was, there-

fore, resinous, but its nature was still obscure. It might be possible by distilling resin at low temperature to compare the results with those now obtained in order to determine the nature of coal. In reply to Mr. Merz he said that the capital cost of the plant per ton per hour was about £1,500. There was a saving at the end of the year by this method of distillation, of 20 per cent.

Mr. W. A. CHAMEN, of the South Wales Power Co., said that the areas of operation of the municipalities of power companies must be respected in any scheme of co-operation. Linking-up could be quite well done, but the action must be spontaneous not compulsory. It was a disgrace that the electrical companies should require anything of the nature of coercion. There were powers already available. Let the municipalities and company schemes bury the hatchet and get some of the desired economies by connecting up existing systems. One thing requiring legislation was the need for absolute powers to run electrical "main roads." Landlords at present had a veto. The Post Office had an act putting their position right, and public supply should be on a similar footing.

Mr. R. A. CHATTOCK, of Birmingham, pointed out that to start gas production and recovery of bye-products would require a good deal of handling of the coal. More labour and land would be required and more expensive works. Every bye-product would be a business in itself. It was hardly fair to ask the electrical industries to take on that in addition to power supply. There should be a primary body concerned with the handling of coal apart from power purposes, working in close touch with them—financial and operating. The most economical method of transmission was electrical, and electricity was applicable to all processes for which coal was used at the present time. Stations fifty times larger than the present were conceivable and the cost of production of electrical power would then fall far below its present value. Some low temperature distillation might be used to provide smokeless fuel where it was necessary, and where electricity was not suitable. He pointed out that there were other factors. The condensing water of the Birmingham system ran to a million gallons a day. The whole supply of water to Birmingham was only 25 million gallons, and if very large stations were to be used there might not be sufficient water in many of the coal-fields. The change to the large schemes might be made by a slow process of natural development or by compelling all users of energy to take their supply from some central station. The Institution of Electrical Engineers had appointed a Committee to consider these questions from an engineering point of view.

Mr. J. S. HIGHFIELD said that it was now seen that large scale operation was necessary. Legislation had hindered progress since Mr. Ferranti in 1888 advocated concentration. The question of bye-product recovery was simply an economic one. If coal was cheap it was wasted, and economy was left to coal users. Were we to keep coal in the future at the cost of the large capital required to put up bye-product plants? No large sum of public money should be spent on this coal-saving question unless it was perfectly clear that full interest could be earned on the whole.

Dr. DUGALD CLERK, in a vigorous speech which came as a relief after the strenuous afternoon, said that he had listened to the debate with mixed emotions. Fuel economy was desirable, but if Mr. Merz succeeded, the gas engine would be wiped out along with gas production, and the coal for industries also. But too rigid logic was not common to Englishmen. We preferred to "wait and see." After comparing German and English mental processes he agreed that the human orchid as a whole preferred compromise to logic, and expressed the opinion that gas and steam engines would continue to work alongside for a long time to come.

Prof. BONE, on behalf of the Fuel Economy Committee, thanked those who had contributed to the important debate. The Association should be satisfied with the result of the first year's work of the Committee. Any suggestions submitted to it would receive close attention, and he looked forward to a fruitful year's work.

THE CALCULATION OF THE CAPACITY OF RADIO-TELEGRAPH ANTENNÆ, INCLUDING THE EFFECTS OF MASTS AND BUILDINGS.*

BY PROF. G. W. O. HOWE, D.SC., M.I.E.E.

(*Concluded from p.* 762.)

THE EFFECT OF MASTS.

The method of calculating the effect of masts and buildings will now be considered, commencing with the simple case shown in Fig. 2, where a single vertical wire runs parallel to a cylindrical mast.

Let l = the length of mast or wire, r = radius of wire, r_m = radius of mast, D = distance between wire and mast.

If the wire be assumed to have a uniform charge of 1 unit per centimetre of length, it will induce on the mast a negative charge of q units per centimetre, which we assume to be also uniformly distributed. Their images in the earth will be equally and oppositely charged. The value of q can be determined from the fact that the resultant potential of the mast must be zero, since it is connected to the earth. Having determined q, the potential of the insulated wire can be found, and thus also its capacity. In most cases the value of l/D will not be large enough to enable the approximate logarithmic formula to be used, and it will be necessary to employ the accurate formula for the potential of one conductor due to the charge on a parallel conductor—viz. (THE ELECTRICIAN, Vol. LXXIII., p. 859):

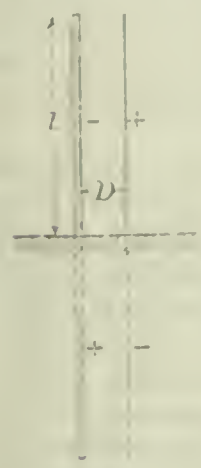


Fig. 2.

$$V_{av.} = 2\left(\sinh^{-1}\frac{l}{D} + \frac{D}{l} - \sqrt{1+\frac{D^2}{l^2}}\right).$$

On substituting r for D this formula can also be employed to find the potential due to the charge on the conductor itself, even if the ratio of its length to its radius is not exceedingly great. The values of this expression for different values of l/D are given in the following table and are plotted in Fig. 3.

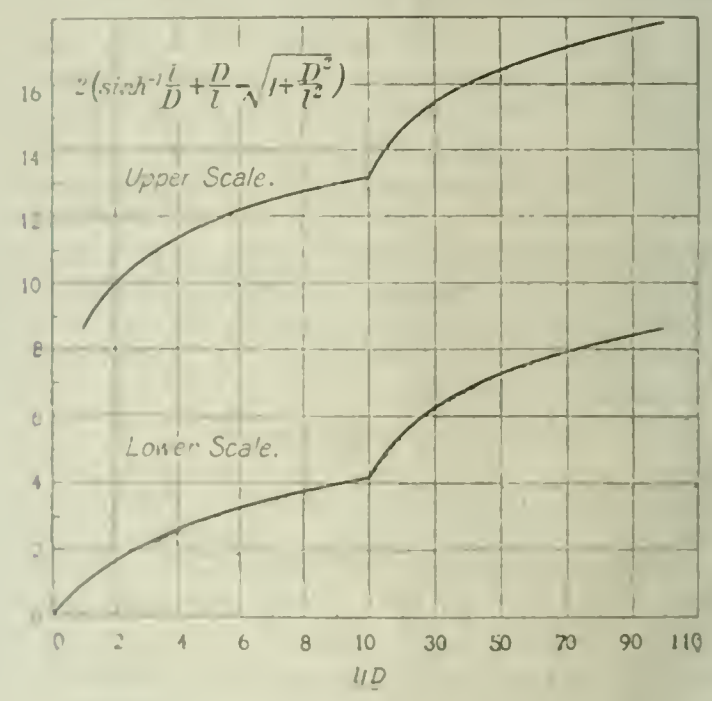


Fig. 3.

l/D	$V_{av.}$	l/D.	$V_{av.}$	l/D.	$V_{av.}$	l/D.	$V_{av.}$
1	0·830	15	4·93	100	8·62	1,300	13·72
2	1·648	20	5·48	200	9·98	2,000	14·58
4	2·196	30	6·27	350	11·1	4,000	15·97
5	2·986	40	6·81	500	11·81	8,000	17·18
7	3·564	50	7·26	750	12·62	...	...
10	4·186	75	8·05	1,000	13·20	...	...

In our example (Fig. 2), let l = 200 ft., r = 0·05 in., r_m = 6 in. D = 10 ft., so that l/r = 48,000; l/r_m = 400 and l/D = 20.

The potential of the mast

due to its own charge	=	− 11·34 q
.. its own image	=	+ 1·38 q
.. the charge on wire	=	− 5·48
.. the image of wire	=	− 1·33

* Abstract of a Paper read before Section G of the British Association at Newcastle.

Of these four component potentials, the first and third are read off the curves in Fig. 3, the second was determined on page 907 of the original Paper, while the fourth is found from the following considerations. If the wire and mast were both twice as long—that is, as long as themselves plus their images—l/D would be increased to 40 and $V_{av.}$ to 6·81. This would be the average potential of the whole or of either half of the 400 ft. mast due to the 400 ft. wire; hence it is the potential of the actual 200 ft. mast due to the 400 ft. wire. Now the potential of the actual mast due to the actual 200 ft. wire is only 5·48, and the difference—viz., 1·33—must be due to the charge on the image of the wire.

Seeing that the mast is earthed, its resultant potential must be zero, and therefore

$$5{\cdot}48-1{\cdot}33-(11{\cdot}34-1{\cdot}38)q=0,$$

or $q=0{\cdot}417$ units per centimetre of length. Hence the potential of the wire

Due to its own charge	=	20·9 (*see* Fig. 3 in original Paper)
,, its own image	= −	1·0 (*see* Fig. 21 *et seq.*)
,, charge on mast	= −	2·28 (=0·417×5·48)
,, image of mast	=	0·56 (=0·417×1·33)
Resultant potential of wire	=	18·2

Hence the presence of the mast lowers the potential of the wire from 19·9 to 18·2, thereby increasing its capacity 9·3 per cent. The effect of altering the distance between the wire and the mast is shown in Fig. 4.

It should be pointed out that the capacity here considered is that which would be measured by electrostatic or low-frequency methods,

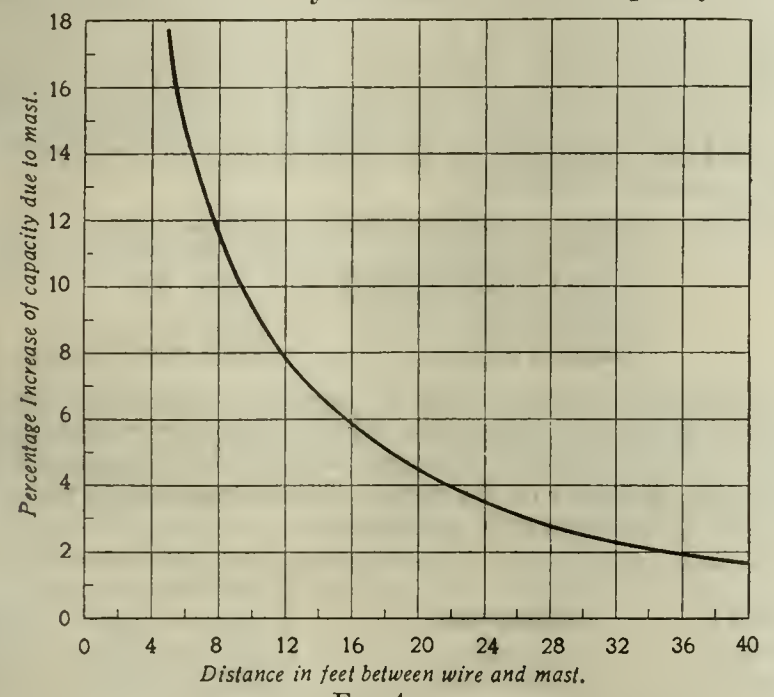


FIG. 4.

and is not necessarily the same as the effective capacity at radio frequencies. The latter will depend on the wave-length employed and on other factors which are beyond the scope of this Paper. To electrostatic measurements a wooden mast will act as an earthed conductor, whereas at radio frequencies its high resistance will considerably modify its effect on the capacity of the aerial. If the masts be of iron or steel and not insulated, and if, as is now common, the wave-length employed is considerably greater than the fundamental wave-length of the aerial, the effective capacity will agree closely with that calculated by the method here described.

We shall now apply the method to the inverted conical aerial of 160 wires, to which reference has already been made. We shall assume that it is supported by a ring of 10 masts 105 ft. high and 18 in. diameter, situated on a circle of 116 ft. diameter, as shown in Fig. 5. It is assumed, as before, that the induced charge on the masts is uniformly distributed and equal to q units per centimetre of length. To determine q, we have the average potential of the mast

due to its own charge	= −	9·27 q
,, the other masts	= −	11·74 q
,, the antenna	=	240
,, the image of the antenna	=	−135
,, the image of the masts	=	8·9 q

Of these five items, the first two and the last can be found accurately from Fig. 3 of this Paper; the other two are approximate, although they could be determined accurately if necessary. It is unfortunate that in this case the items which can be readily obtained with great accuracy are relatively unimportant. Since the mast is assumed to be earthed, its resultant potential must be zero, and therefore

$$(8{\cdot}9-9{\cdot}27-11{\cdot}74)q+240-135=0$$

and $q=8{\cdot}67$ units per centimetre.

We can now find the potential of the aerial, and we shall consider an average wire and not one situated close to a mast.

The average potential of a wire

due to the nearest mast	=	−22
,, all other masts	=	−117
,, the image of the mast	=	85
,, antenna without masts (previously found)	=	381
Total	=	327

Hence the effect of the masts is to lower the potential from 381 to 327, which will increase the capacity 16·5 per cent., *i.e.*, from 1,423 to 1,660 micro-microfarads. This is still only 62 per cent. of the measured value given for this antenna. Our calculation is based, however, on the assumption of 10 masts of 18 in. mean diameter; a greater number would, of course, still further increase the capacity We have here neglected any horizontal wire from which the 160 wires may be suspended; we have already seen that such a wire might increase the capacity by 20 per cent.

The Capacity of Wires Near Buildings.

We shall consider in the first place a single vertical wire running close to the wall of a building. If the planes of the ground surface and of the wall be continued, and three images drawn symmetrically with regard to their intersection as shown in Fig. 6, then, on giving these images charges equal to that of the wire and of the signs shown in the figure, the planes will be equipotential surfaces, and will consequently have no effect on the potentials of the system. The potential of the wire will be made up of four components, viz., that due to its own charge, and those due to the three images. That due to its own charge can be read off Fig. 3 in the original Paper; that due to the earth image we have shown to be 1·38, if the lower end is almost touching the ground, but about 1·0 if the lower end is

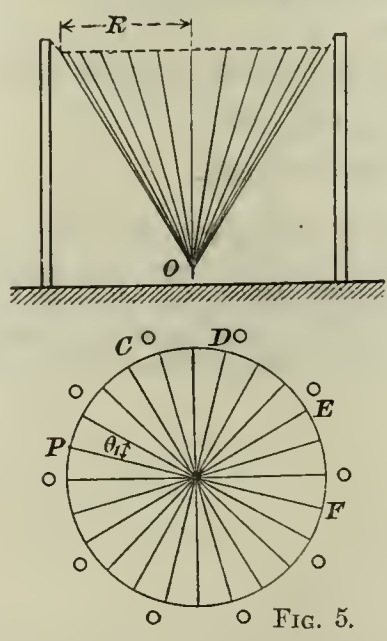


FIG. 5.

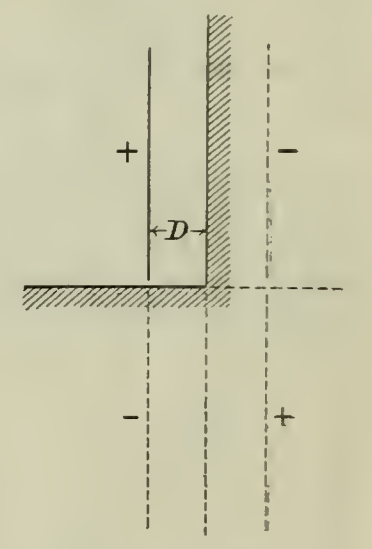


FIG. 6.

3 ft. or 4 ft. above the ground. The potential of the wire due to its image in the wall can be read off Fig. 3 in this Paper, while that due to the diagonal image can also be obtained from Fig. 3 in the following manner. If two parallel vertical wires of length $2l$ are separated by a distance $2D$, the average potential of one due to unit charge per centimetre on the other can be read off Fig. 3; it is a function of the ratio l/D, which we may write $f(l/D)$. From considerations of symmetry it is obvious that this is also the average potential of the upper half of the wire due to the whole length of the charged wire, whereas that due only to the upper half of the charged wire is $f(l/2D)$, which can also be read off Fig. 3. The difference, viz., $f(l/D)-f(l/2D)$ must be the average potential of the upper half of one wire due to the charge on the lower half of the other, and it is therefore the average potential of the aerial due to its diagonal image.

As an example, let $l=100$ ft. of 0·1 in. diameter, and let $D=6$ ft., then we have $l/r=24{,}000$; $l/D=16{\cdot}67$; and $l/2D=8{\cdot}33$,

and $V_{av.}=19{\cdot}53$ due to its own charge,
$-1{\cdot}38$ due to its earth image,
$-3{\cdot}85$ due to its wall image,
$+(5{\cdot}14-3{\cdot}85)$ due to its diagonal image.
$=15{\cdot}6$.

Hence its capacity is increased 16 per cent. by the proximity of the wall.

As a further example we may consider the case of four vertica wires 45 ft. long, 3 ft. apart, 0·1 in. diameter and 3 ft. from the wall.

$V_{av.}$ due to their own charge	=	29·9 $\left(=\frac{135{\cdot}6}{4{\cdot}5}\right.$, *see* Fig. 10 in original Paper$\left.\right)$
,, earth image	=	−4·0 (approx.)
,, wall image	=	−13·3 (Fig. 3 in this Paper)
,, diagonal image	=	+4·0 (approx.)
Total	=	16·6

The charge $=4\times45\times30\cdot5=5{,}490$, and the capacity is therefore

$$\frac{5{,}490}{16\cdot6\times0\cdot9}=368 \text{ micro-microfarads.}$$

If the distance from the wall be decreased to 1 ft., the capacity will be increased to 500×10^{-6} mfd.

This example is illustrative of an antenna mentioned by Prof. Fleming, viz.: "Four vertical wires 0·1 diameter, each 45 ft. long, placed fan-shape in front of a building 6 ft. apart, bottom ends 10 in. apart, connected to a copper 'bus bar—485 micro-microfarads." The distance from the wall and the details of the copper 'bus bar not being given, it is impossible to calculate the capacity accurately, but the above example shows that, given the necessary data, such cases can be calculated very readily.

As a further example of the method, we shall make an approximate calculation of the effect of the Eiffel Tower on the capacity of the antenna which is supported from it. The principal dimensions are shown in Fig. 7. The antenna consists of six wires of 7 mm. diameter. Each wire is about 330 metres long, and the average distance between adjacent wires is assumed to be 22 metres. Hence $l/d=15$ and $d/r=6{,}300$, and

$$C=\frac{16\cdot94n}{n\left(\log_e\frac{l}{d}-0\cdot31\right)+\log_e\frac{d}{r}-B}\times5\cdot2\times10^{-6} \text{ mfd. per foot.}$$

(For B *see* Table IV. in the original Paper.)

The capacity of the antenna, apart from the effects of the earth and of the tower, would therefore be $5{,}620\times10^{-6}$ mfd. If charged with 1 unit per centimetre of wire, its average potential would be

$$\frac{6\times33\cdot9}{5\cdot2}=39\cdot1 \text{ due to its own charge,}$$

and $\dfrac{6\times33{,}000}{27{,}500}=7\cdot2$ due to its image in the earth, giving a resultant potential of 31·9 and a capacity of

$$5{,}620\times\frac{39\cdot1}{31\cdot9}=6{,}900\times10^{-6} \text{ mfd.}$$

The proximity of the earth increases the capacity 22·7 per cent.

To form an estimate of the effect of the tower itself it is sufficient to assume that it is a vertical cylinder 300 metres high with a diameter of, say, 20 metres. (It is actually a lattice structure about 10 metres square near the top, 24 metres square in the middle, supported on



Fig. 7.

four legs each 15 metres square, the centres of which form a square of 104 metres side.) Let the antenna be charged with 1 unit per centimetre of wire, and let this induce a charge of $-q$ units per centimetre of height of the tower.

The potential of the tower

Due to its own charge	$=+5\cdot27\,q$ (*see* Fig. 3, $l/r_m=30$)
,, its own image	$=+1\cdot38\,q$ (*see* Fig. 21 *et seq.* in original Paper)
,, the antenna	$=-16\cdot5$ (approx.)
,, the image of antenna	$=-7\cdot0$ (approx.)

Since the tower is earthed, its potential is zero and $9\cdot5-4\cdot89\,q=0$; therefore $q=1\cdot94$.

The potential of the antenna due to the induced charge on the tower will be about $-2\cdot5\,q$, while that due to the image of the tower will be $1\cdot1\,q$, giving a resultant potential due to the tower and its image of $-1\cdot4\,q$ or $-2\cdot72$. The previously found potential of 31·9 will be reduced to 29·2, causing the capacity to be increased about 9 per cent. to $7{,}540\times10^{-6}$ mfd. *The actual measured capacity has been given as* $7{,}300\times10^{-6}$ mfd., but it must be remembered that the above calculation has only been carried out approximately upon very meagre data. To show the effect of a different assumption as to the equivalent diameter of the tower, it may be mentioned that, taking 10 metres instead of 20, merely reduces the increase of capacity from 9 to 7 per cent.

Experimental.

Seeing that the calculated values of the capacity differed very considerably in many cases from the values given as the result of actual measurement, and that sufficient data were not available to enable the effects of the masts, &c., to be allowed for in these measurements, it was thought essential to make some crucial tests to determine the accuracy which one might expect. For this purpose wires were stretched between insulators as shown in Fig. 8. The uprights and cross bars were of iron. The distance between the wires could be adjusted, and the separate wires could be insulated, earthed or connected together as desired. All the dimensions were accurately measured, and the capacity determined by a bridge method, using a

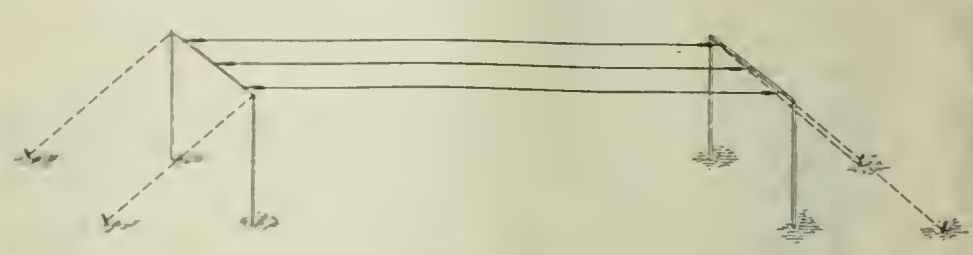


Fig. 8.

buzzer and a telephone. Two of the arms consisted of a Pau inductionless ratio box with 1.000 ohms in each arm, while the other two consisted of variable air condensers. The capacity to be measured was substituted for one of these air condensers which had been accurately calibrated.

Length between supports	=114 ft. 5 in.
Length of each wire	=113 ft. 6 in.
Width between uprights	= 6 ft. 8 in.
Diameter of supports	=2·2 in.
Diameter of wire	=0·085 in.=0·21 cm.

The effect of the supports on the capacity of the wires was calculated but found to be negligible. The height of the wires above the ground was measured at different points and the mean taken in calculating the effect of the earth. The average height was about 1 metre. The results were as follows:—

Distance d between adjacent wires.	Arrangement of connections.	Capacity. Calculated, 10^{-6} mfd.	Capacity. Measured, 10^{-6} mfd.	Percentage diff.
...	Single solid wire (0·072 in.).....	250	248	−0·8
...	Ditto, but only 73 ft. 2 in. long ...	164	162	−1·2
...	Stranded wire (7×0·028 in.)	256	260	+1·6
4·7 cm.	Two ditto connected	350	357	+2·0
4·7 ,,	Cap. of one, the other earthed ...	341	330	−3·8
0·745 ,,	Three wires connected.....	310	335	+8·0
0·745 ,,	Middle only, outers earthed	770	788	+2·3
1·65 ,,	Three wires connected.....	362	375	+3·6
1·65 ,,	Middle only, outers earthed	539	520	−3·5
2·8 ,,	Three wires connected.....	396	395	−0·25
2·8 ,,	Middle only, outers earthed	454	450	−0·9
5·55 ,,	Three wires connected.....	432·5	425	−1·7
5·55 ,,	Middle only, outers earthed	381	380	−0·26

It will be seen that the difference between the calculated and the measured value does not exceed 4 per cent., except in the very extreme case where the wires are only 7·45 mm. apart. Considering the difficulty of measuring such small capacities, the uncertainty introduced by connecting wires, and the difficulty of accurately determining the dimensions when stranded wires 113 ft. long are suspended in the open at distances of 1 cm. or 2 cm., the agreement must be considered very good with the exception of the case referred to. Here, however, the values of l/d and d/r are very extreme, and quite outside the range of the curves given in the original Paper for three wire antennæ. The assumption of equal distribution of charge between the three wires is, therefore, far from true; but it is a relatively simple matter to apply the method which we have already employed for finding the distribution of the charges in the cases in which the two outer wires were earthed. It is only necessary to determine the necessary distribution of charge between the three wires in order that they may all have the same average potential, as they must have, seeing that they are all connected.

Let the middle wire have a charge of 1 unit per centimetre, while

the outer wires have q units per centimetre length. The potential of an outer wire

due to its own charge $=20{\cdot}12\,q$ (Fig. 3 in original Paper)
„ the other outer $=14{\cdot}9\,q$ (Fig. 3 in this Paper)
„ the inner wire $=16{\cdot}28$ „ „
„ the earth image $=-5{\cdot}48(1+2q)$ „ „

(NOTE.—The average height above ground=87 cm.)

The resultant potential of an outer wire $=24{\cdot}06q+10{\cdot}8$.

The potential of the inner wire

due to its own charge $=20{\cdot}12$
„ the outer wires $=2\times16{\cdot}28\,q$
„ the earth image $=-5{\cdot}48(1+2\,q)$

giving a resultant potential of $21{\cdot}6q+14{\cdot}64$.

Since the two wires must have the same potential, we have

$$24{\cdot}06q+10{\cdot}8=21{\cdot}6q+14{\cdot}64$$

and $$q=1{\cdot}56.$$

Hence the charge on the outer wires has a density 1·56 times that on the middle wire.

The potential $=(24{\cdot}06\times1{\cdot}56)+10{\cdot}8=48{\cdot}4$, and the charge per centimetre run of antenna $=1+2q=4{\cdot}12$ units. Hence the capacity

$$=\frac{4{\cdot}12\times3{,}450}{48{\cdot}4\times0{\cdot}9}=326{\cdot}5 \text{ micro-microfarads,}$$

which differs by less than 3 per cent. from the measured value. A similar accurate calculation would also reduce the error of 3·6 per cent. found in the case of the three wires spaced at 1·65 cm. An accurate determination of the differences between the calculated and measured values obviously calls for measurements of far greater precision than those here recorded, but these are sufficient to show that, even in extreme cases, the author's method of calculating static capacity gives results of greater accuracy than is usually obtained in technical measurements of such small capacities.

SOME CHARACTERISTIC CURVES OF A POULSEN-ARC GENERATOR.*

BY N. W. MCLACHLAN, B.SC.ENG., A.M.I.E.E.

INTRODUCTION.

It has been shown by Mercer † that with a carbon-copper arc burning in an atmosphere of hydrogen, without a magnetic blast, having a condenser (the capacity not exceeding a certain limit) and a variable inductance shunted across its terminals, there is a certain inductance and, therefore, frequency, for which the shunt current is a maximum. The present investigation was undertaken to determine whether this condition is applicable in the case of a Poulsen-arc generator: (1) When energy is absorbed in the shunt circuit by a variable non-inductive resistance; (2) when the energy absorbed in the shunt circuit is as small as possible. In both these cases there is a loss in the Moscicki condensers, this being unavoidable, unless air condensers are used. (*See* Appendix.)

METHODS OF MEASUREMENT.

The main and shunt circuits of the Poulsen generator were arranged as shown in a recent Paper by the author.‡ The test ring and the rheostats were removed and a sandstone resistance moistened with copper sulphate solution was connected between the variable inductance and the primary of the current transformer (*see* Fig. 1 in Paper, *loc. cit.*). This type of resistance is constant in magnitude and inductionless at high frequencies.§ The resistance could be altered by varying the amount of moisture in the sandstone or the distance between the copper plates to which the terminals were soldered. An iron-cored (stalloy discs) current transformer¶ was arranged to obtain a transformation ratio of 100 : 3 or 100 : 1, so that shunt currents up to 10 amperes could be measured.

Voltages greater than 40 volts were measured by an electrostatic voltmeter connected across the terminals of the sandstone resistance. The capacity current of the voltmeter was small, and since it was 90 deg. out of phase with the current through the sandstone, its effect on the shunt current could be disregarded. For voltages less than 40 volts a hot-wire instrument was used, the small errors of which at the frequencies employed in these tests, were found by the method detailed in the author's Paper to which reference was made above. In this case the total power expended between the terminals of the sandstone resistance was taken—*i.e.*, power to voltmeter+power to sandstone. The frequency of the oscillations in the shunt circuit was measured, as in the other experiments (*loc. cit.*), by means of a Lorenz wavemeter. Frequencies between $1{\cdot}3\times10^6\sim$ and $8\times10^5\sim$ per second were employed, the range of frequency in any experiment depending on the magnitude of the capacity.

Keeping the frequency and the capacity constant, the following readings were taken for different values of the resistance in the shunt circuit (including resistance of connecting wires and inductance) :—

1. Direct current supplied to generator.
2. Current in shunt circuit (R.M.S.).
3. Voltage on arc (excluding ohmic drop in magnetising coils) (R.M.S.).
4. Voltage across terminals of sandstone resistance in shunt circuit (R.M.S.).

Sets of readings were taken of the same quantities at various frequencies. The whole of the foregoing procedure was repeated with several different capacities. The resistance used varied from 70 ohms to 6 ohms, and the capacity from 0·0009 mfd. to 0·009 mfd.

STRENGTH OF THE MAGNETIC BLAST.

The field strength at the centre of the gap where the arc was formed between the electrodes—*i.e.*, the strength of the magnetic blast—was measured by using a narrow search coil of small resistance wound on an annular groove cut in the centre of a wooden bobbin. The bobbin was securely fixed between the conical pole-pieces of the electromagnet, and the ends of the coil were connected to the terminals of a Grassot fluxmeter, the deflection being observed

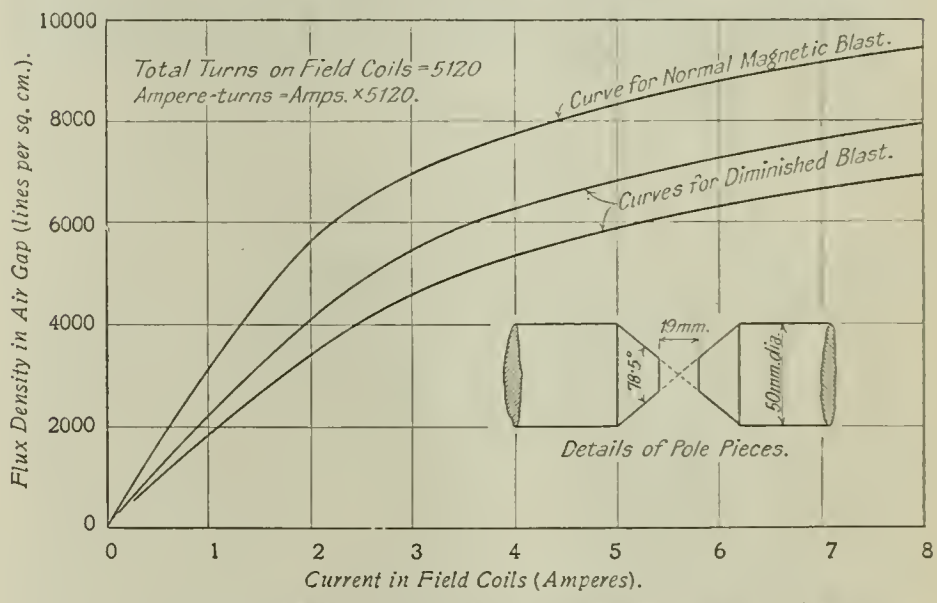


FIG. 1.—CURVES SHOWING THE RELATION BETWEEN THE FLUX DENSITY IN THE AIR GAP AND THE CURRENT THROUGH THE FIELD MAGNET COILS.

on reversal of the current through the field coils. The search coil was calibrated, using a mutual inductance and a ballistic galvanometer. Although the reading of a fluxmeter with a sufficiently long period and weak control is almost independent of the time taken for the flux linkages through the magnetic circuit to change, the time of reversal of the current was reduced by connecting the magnet-coils to a 240-volt circuit, the excess voltage being taken up by a non-inductive rheostat. Details of the conical pole-pieces and a curve connecting the field strength in the air-gap and the magnetising current in the field coils are shown in Fig. 1. The angle of the cones is such as to produce a fairly uniform magnetic field in the air-gap.*

ANALYSIS OF SHUNT CURRENT.

The current in the shunt circuit was analysed, using the method described in the author's Paper.† For the various capacities tested the most prominent harmonic was the second, other harmonics being comparatively small. With a capacity of 0·00924 mfd. the R.M.S. values of the second and third harmonics were, respectively, 30 per cent. and 9 per cent. that of the fundamental when the frequency was $3\times10^5\sim$ per second.

With capacities of 0·00924, 0·00368 and 0·00195 mfd. the second harmonic increased with decrease in inductance, and therefore increase in frequency. With a capacity of 0·00091 mfd. the second harmonic was practically non-existent at all frequencies. It was difficult to measure the harmonics to any degree of accuracy, especially when the ratio L/C was small. In this case the number of

* Paper read before Section G of the British Association at Newcastle.

† F. Mercer, "The Arc as a Source of Oscillations." "Proceedings" of the Physical Society, London. Vol. XXVI., p. 372. 1914.

‡ N. W. McLachlan, "An Investigation into the Magnetic Behaviour of Iron at very High Frequencies with the Aid of a Poulsen-arc Generator." "Journal" I.E.E., Vol. LIV., p. 480, 1916.

§ *See* Paper by author, THE ELECTRICIAN, Vol. LXXVI., p. 875, March 24, 1916.

¶ A. Campbell and D. W. Dye, "Proc." Roy. Soc., A, Vol. XC., 1914; also McLachlan, *loc. cit.*

* *See* J. A. Ewing, "Magnetic Induction in Iron and other Metals." Third edition, p. 148.

† *Loc. cit.*

turns of the variable inductance in circuit was small, and in order to obtain sufficient energy in the wavemeter circuit to secure reliable readings the coupling between the two circuits must be fairly close. Under this condition the maximum value of the current in the wavemeter circuit (as read on the thermoammeter) was not always sharply defined, and the frequency of the oscillations could not be definitely determined. Since the distance between the inductances in the shunt and wavemeter circuits was small, it is probable that the mutual reactions of the oscillations in these circuits would affect the frequency. Moreover, it was impossible in some case to analyse the shunt current. The magnitude of the harmonics compared with the fundamental depends to a certain extent on the length of the arc, the condition of the copper and graphite electrodes* and the ratio of the shunt current to the arc current.†. (This ratio for given conditions is partially dependent on the length of the arc.) This ratio increases with increase in capacity, and the magnitudes of the second and other harmonics, compared with that of the fundamental, increase with the capacity. Throughout the experiments the arc length was adjusted to obtain maximum current and power in the shunt circuit for good burning. The graphite was carefully ground up for each set of observations, so that the burning was as steady and quiet as possible.

Observations were also made of the effect of resistance in the shunt circuit on the harmonics—i.e., the effect of absorption of power in the shunt circuit. It was found that with a capacity of 0·00924 mfd. the resistance in circuit had no appreciable effect on the harmonics. With capacities of 0·00195 mfd. and 0·00368 mfd. the effect of resistance was to increase the second harmonic, chiefly at the higher frequencies.

Results of Experiments.

Figs. 2 and 3 show the power absorbed in the shunt circuit plotted against the frequency for capacities of 0·00195 mfd. and 0·00924 mfd.

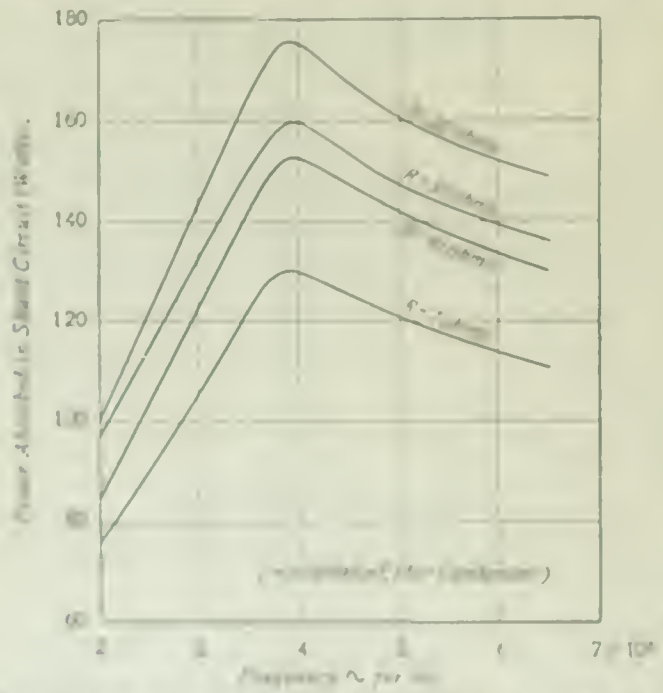


Fig. 2.—Curves showing the Total Power absorbed in the Shunt Circuit at Different Frequencies for Various Values of the Resistance and a Capacity of 0·00195 mfd.

and different values of the total resistance, including I^2r losses. In Fig. 2 each curve has a maximum ordinate, which shows that, with fixed capacity and resistance, there is a certain inductance, and therefore frequency, for which the power absorbed in the shunt circuit is a maximum. In Mercer's experiments the power absorbed in the shunt circuit was small (L/R and condenser losses), and the curve showing the relation between shunt current and frequency was peaked like a resonance curve, there being more than one peak in certain cases. The voltage on the arc was more than double that in the present experiments, being 475 as against 240 on the field coils and arc. The absence of a sharply defined peak in the current and power curves obtained in these experiments is probably due to the effect of the magnetic blast and to the fact that the direct current voltage across the arc is least when the shunt current and, therefore, the power is a maximum, owing to the increased volt drop in the field coils (*See* Fig. 5.)

With large values of the capacity, say 0·00924 mfd., the curves, as plotted in Fig. 3, have no maximum values for the range of frequency used in the tests; but the power gradually increases with the frequency. Curves showing the relation between the frequency and the power obtained from oscillations of fundamental frequency and the power obtained from oscillations of fundamental frequency for a capacity of 0·00924 mfd., appear to have a maximum value between $f = 2{\cdot}5 \times 10^5 \sim$ and $3{\cdot}5 \times 10^5 \sim$ per second. At the latter frequency, however, L/C was small, and the arc did not burn regularly, making it impossible to obtain reliable readings of current and voltage, or to analyse the shunt current accurately.

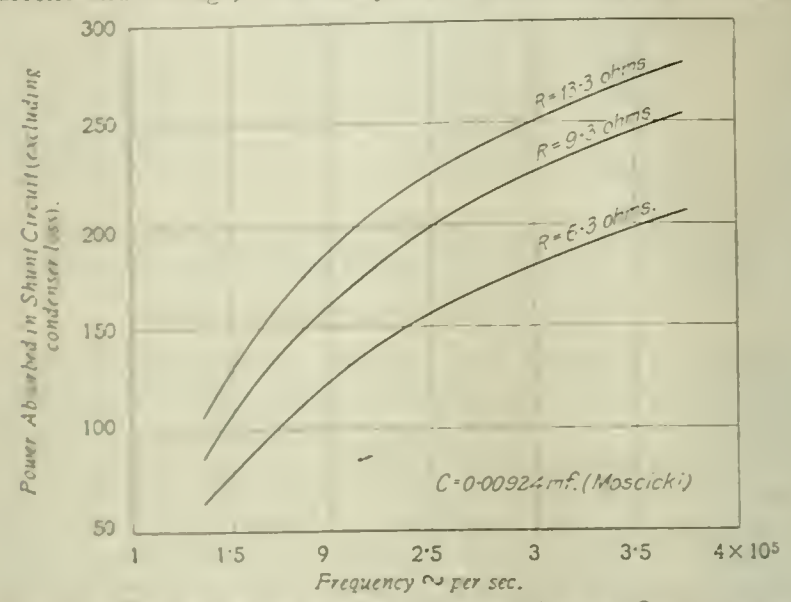


Fig. 3.—Curves showing the Power (from Oscillations of Fundamental Frequency and the various Harmonics) absorbed in the Shunt Circuit at Different Frequencies for Various Values of the Resistance, and a Capacity of 0·00924 mfd.

The curves in Fig. 4 show the power obtained with various resistances plotted against those resistances for different values of the frequency. When the resistance is small the curves rise quickly, reaching a maximum value; as the resistance increases the curves fall away more gradually. Hence there is a definite resistance, for which the power absorbed in the shunt circuit is a maximum. For large capacities (0·00924 mfd.) the curves are more flat topped.

With a fixed resistance in the shunt circuit the power absorbed at any given frequency increases with the capacity. If, however, the ratio L/C is small, the burning of the arc is not so regular as it would be with a smaller capacity and a reduced output.

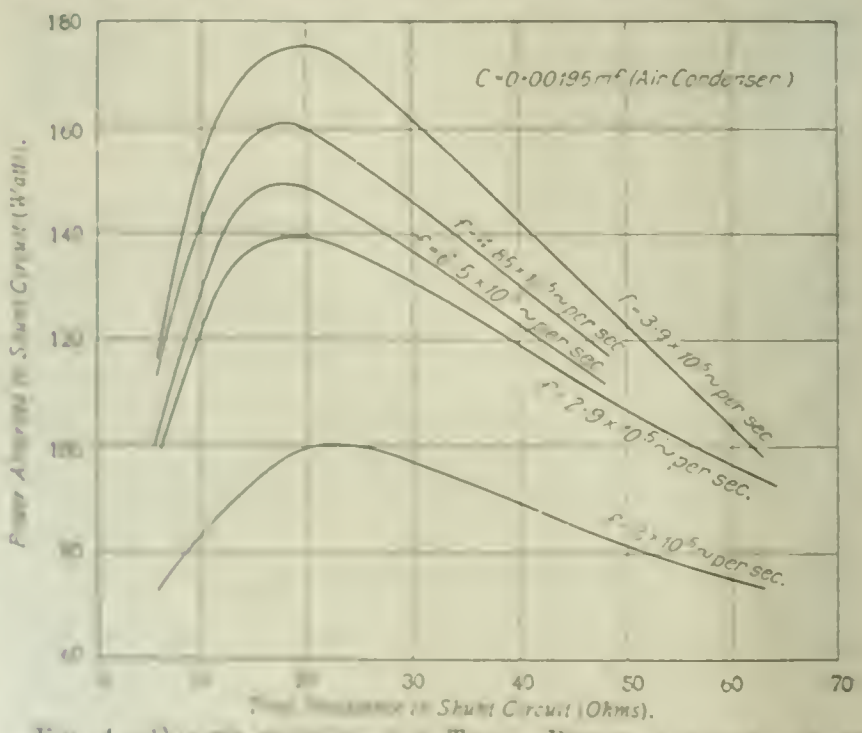


Fig. 4.—Curves showing the Total Power absorbed in the Shunt Circuit Plotted against the Resistance for Different Frequencies, and a Capacity of 0·00195 mfd.

The curves showing the relation between the direct current supplied to the arc and the frequency, for a given resistance in the shunt circuit, are similar in shape to those in Fig. 5. The maximum value of the direct current supplied to the generator corresponds to maximum shunt current and to minimum voltage across the arc. The reason for the simultaneous occurrence of maximum shunt current and minimum voltage across the arc is probably due to the increased ohmic volt drop in the field coils (which are in series with the arc), due to the direct current being a maximum, thus reducing the direct-current voltage across the arc.

* The second harmonic is more prominent when the graphite is badly burnt and the arc is burning irregularly. Both electrodes should have sharp edges.

† McLachlan, *loc. cit.*

‡ The curves showing the power obtained from "oscillations of fundamental frequency" for a capacity of 0·00195 mfd. are almost identical with those shown in Fig. 2, excepting that for frequencies greater than 4×10^5 ~ the ordinates of the former curves are slightly smaller than those of the latter. An agreement of a similar nature exists between the corresponding sets of efficiency curves.

The strength of the magnetic blast was lessened by making an air-gap between the top of the electromagnet, carrying the conical pole-pieces, and the two vertical limbs on which the field coils were wound. By this means it was possible to ascertain the performance of the generator with different strengths of magnetic blast, without altering the resistance of or the number of turns on the field coils. Two different field strengths were employed, the characteristics being shown by the two lower curves in Fig. 1. A diminution in the strength of the blast did not cause any appreciable alteration in the fundamental frequency of the oscillations in the shunt circuit; but there was an increase in the second harmonic with the larger capacities) 0·00368 mfd.) and small inductances. For any given resistance in the shunt circuit the power obtained at the lower frequencies was increased (owing to increased direct-current supplied to the generator), the maximum value occurring at a lower frequency than with the normal blast—*i.e.*, the curves in Fig. 2 were shifted horizontally backwards. The maximum power and the corresponding efficiency of the arc were almost the same as the values obtained with normal blast. It has been shown by Poulsen* that the amount of energy radiated is increased considerably by using a magnetic blast. No details, however, are given regarding the strength of the blast.

A resistance of 20 ohms in the shunt circuit with a diminished blast caused very unsteady burning at the higher frequencies. At the lower frequencies the burning was improved by diminishing the blast. If, however, the blast is diminished beyond a certain value the burning is unsteady. With normal blast the oscillations were irregular and the burning noisy when the resistance in the shunt

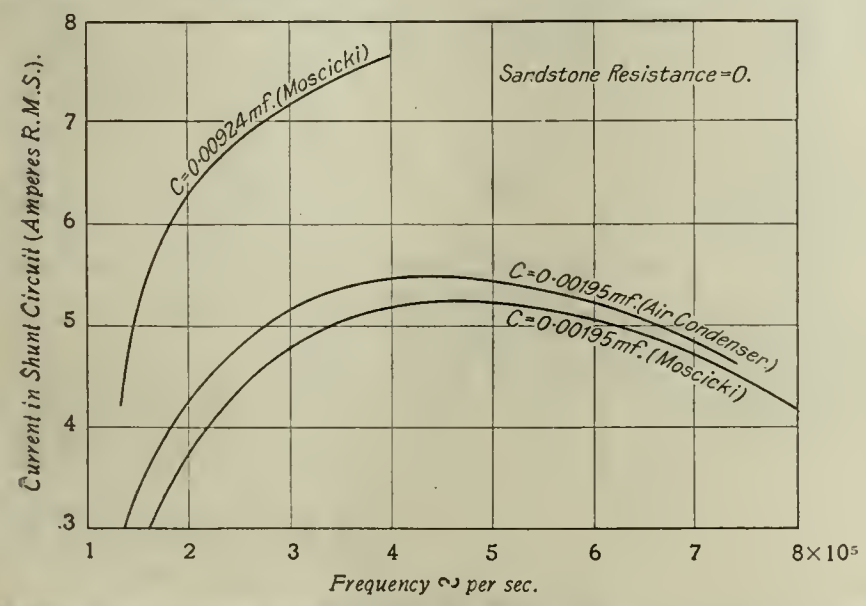


FIG. 5.—CURVES SHOWING THE CURRENT IN THE SHUNT CIRCUIT PLOTTED AGAINST THE FREQUENCY FOR DIFFERENT VALUES OF THE CAPACITY, THE RESISTANCE OF THE SANDSTONE BEING ZERO.

circuit was large enough to cause a substantial reduction in the shunt current. This was especially the case when the ratio L/C was small.† Without the blast, and with resistance in circuit, oscillations could not be obtained. This confirms observations made by Austin, using an arc without a magnetic blast burning in an atmosphere of hydrogen.‡ With diminished blast and zero sandstone resistance the maximum value of the shunt current (cap.=0·00195 mf.) occurred at a lower frequency than with the normal blast, and the curves showing the relation between the shunt current and the frequency were shifted horizontally backwards relatively to those in Fig. 5. There was only a slight difference between the maxima currents for different blasts. The burning of the arc was more regular at the lower frequencies, but less regular at the higher frequencies with diminished blast. At the lower frequencies the active length of the arc was greater, but the proportionate variation in the shunt current and the direct current with alteration in arc length was less than with the normal blast. If the blast was decreased beyond a certain value the burning was irregular. It is possible, therefore, to maintain the current approximately constant and the burning regular over a fairly wide range of frequency by suitably varying the strength of the blast.

(*To be concluded.*)

* V. Poulsen, "A Method of Producing Undamped Electric Oscillations and its Employment in Wireless Telegraphy," THE ELECTRICIAN, Vol. LVIII., p. 166, 1906.

†"On the Production of High-frequency Oscillations from the Electric Arc," "Bulletin" of Bureau of Standards, Vol. III., No. 2, 1907. Also THE ELECTRICIAN, Vol. LIX., p. 632, 1907.

‡ V. Poulsen, "Production of Continuous Electrical Oscillations," "Trans." Int. Cong. St. Louis, Vol. II., p. 963, 1905, also "Science Abstracts," 1,620 A, 1905.

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

(*Concluded from page* 770.)

The Sphere of the Universities and Technical Colleges.—The question of the part which universities can and should take in the application of science to industry is extremely important, but also extremely difficult. We know that the universities and technical high schools of Germany, Austria and Switzerland have played a leading rôle in the development of scientific industry on the Continent. Yet such an experienced observer as Dr. Mees is strongly of opinion that the fundamental theory of a subject upon which the development and maintenance of industry chiefly depend "cannot possibly be carried on to any large extent in collaboration with a university." The fact is that the increasing complexity and length of the research necessary for modern scientific manufacture is making it increasingly difficult for the professor or the university laboratory to take a dominating share in the advance.

The universities can and must be the main sources of research in pure science. Yet the universities will not be able to do their fair share of this vital service unless they can attract more students and larger funds. Until our universities are in the position to offer appointments which carry with them real freedom from financial anxiety, it is certain that their teachers will not, because they cannot, take the leading part which they should in the national contributions to knowledge.

The Possible Sphere of Special Research Institutes.—When the scientific bases of a whole trade are in question some other machinery must be devised. Dr. Mees in his pamphlet expresses the view that at this point the university ceases to be a suitable agent. In the case of research institutes connected with universities, it is important to keep the finance of such institutes distinct from the general university finance, for many reasons, and among them the fact that the State is already aiding the general income of the universities and colleges while the Committee of Council are restricted to aiding their research activities. It seems to us no less important to give the industry concerned a responsible share in the policy of the institute as much in the interests of the industry as of the research. Yet if the institute is to be connected with a university or other educational institution, the suzerain power must have an effective means of criticising the work in its broad and general outlines and must have control of at least the principal appointments. Otherwise the university or college connection will be meaningless.

Research and Government Departments.—We have confined our remarks so far to those aspects of our work which are specially emphasised in the White Paper and which are undoubtedly the most urgent: but scarcely less important than the encouragement of research in our educational institutions and our factories is a due correlation of the research activities of the Government, or—as we should rather say—of the Governments of the Empire. We believe this can best be achieved by the free exchange of information given in a spirit of hearty co-operation. Accordingly Mr. Henderson, realising that the activities of the Committee of the Privy Council and its Advisory Council might create serious confusion and overlapping—especially at the present time—if they proceeded in ignorance or neglect of the work done by the departments of State in the same field, announced in the White Paper that arrangements would be made by which the Council would "keep in close touch with all Government departments concerned with or interested in scientific research."

Research and the Empire.—The Victorian Government, in a despatch dated October 5, 1915, to the Secretary of State for the Colonies, stated that they were desirous that the scheme described in the White Paper [Cd. 8,005] should be "extended to the Dominions, in order that the State of Victoria may receive the benefit of this most important movement," a proposal which was endorsed by the Premier of New South Wales, and the Commonwealth Government at a later date decided to work out a plan for the whole of Australia. A strong committee, appointed by the Commonwealth Government, reported in favour of the establishment of a national research institute under the charge of three directors with an advisory council, and the Government accepted the proposal in its main outlines. Meantime the Committee of Council had submitted a memorandum to the Colonial Office for communication to the Dominions, containing suggestions as to the various ways in which the home organisation might co-operate with similar organisations in other parts of the Empire. In Canada a similar movement has begun, and an Order in Council was issued on June 6th establishing machinery similar to that in this country for the encouragement of scientific and industrial research. The New Zealand Government also have the matter under consideration for they have referred the memorandum of the Committee of Council to a board constituted under the Science and Art Act, 1913, "for opinion and advice." We have not yet had an opportunity of considering in detail the possibility of co-operation with the Indian Government, but the Messrs. Tata, the generous founders of the Indian Institute of Science at Bangalore, have assured us of their desire to co-operate in any researches which we may wish to initiate in India. The organisation of research within the Empire must inevitably be a plant of slow growth, yet we think it augurs well for the future, that thought should move in parallel lines in places so remote and under conditions so various. It is obvious that the existence of such organisations throughout the Empire would immensely facilitate our own task by enabling us to enlist the best brains for the attack on problems of Imperial significance irrespective of the researcher's domicile.

It seems probable that one of the first and most necessary preliminaries to joint research in the stricter sense will be found to be the making

of a systematic survey of the mineral and other resources of the Empire. Our attention has already been drawn to this need from many sides. The right organisation for the purpose is not easy to devise, and it is not yet clear where the responsibility should rest for co-ordinating the work of the several Government surveys and for collecting unofficial information which may often be of great value. We are disposed to think that no machinery less independent than that of a Government office would suffice, but the whole question will doubtless be considered by the committee under the chairmanship of Lord Balfour of Burleigh, appointed by the Prime Minister to consider the commercial and industrial policy to be adopted after the war with special reference to the conclusions reached at the Economic Conference of the Allies and to a number of other questions among which are: To what extent and by what means the resources of the Empire should and can be developed; and to what extent and by what means the sources of supply within the Empire can be prevented from falling under foreign control.

Conclusions.

We have not attempted in this report to describe or even to make reference to all the various researches which we have recommended the Committee of Council to aid, still less to detail the larger and more comprehensive plans which are under consideration, for it seemed to us more important in this our first report to explain the principles which have guided us in our work, to call attention to some of the difficulties which will have to be overcome and to record the spirit of good will and co-operation with which we have been met.

If we were asked to state the conditions that appear to us necessary for the success of our work in the shortest possible terms we should reply: First, a largely increased supply of competent researchers; secondly, a hearty spirit of co-operation among all concerned, men of science, men of business, working men, professional and scientific societies, universities and technical colleges, local authorities and Government departments. And neither condition will be effective without the other.

The first condition of success cannot be secured rapidly at any time, and for the moment is out of the question. It is often said that when the industries call for the research workers, they will be forthcoming. The demand will create a supply. No doubt it will in time, especially if the discoverer or inventor is adequately rewarded. But it is also true that a supply will create a demand, and since the Committee of Council was established in order to encourage a demand for research, we are anxious to see a sufficient supply of trained workers forthcoming to enable a reasonable start to be made on the new road when peace is restored. Before the war the output of the universities was altogether insufficient to meet even a moderate expansion in the demand for research. The annual number of students graduating with first and second class honours in science and technology (including mathematics) in the universities of England and Wales before the war was only about 850, and of these but a small proportion will have received any serious training in research. We have frequently found on inquiry that the number of workers of any scientific standing on a given subject of industrial importance is very limited.

It is in our view certain that the number of trained research workers who will be available at the end of the war will not suffice for the demand that we hope will then exist. We are too apt to forget in this country that with industry as with war a brilliant group of field officers, and even a well organised general staff, need armies of well trained men in order to produce satisfactory results. We have not yet learned how to make the most of modern ability—particularly in things of the mind—yet without the scientific rank and file it will be as impossible to staff the industrial research laboratories which are coming, as to fight a European war with seven divisions. There is as much place and need for plodding labour in scientific research as in other kinds of work.

The responsibility for dealing with the grave situation which we anticipate rests with the education departments of the United Kingdom. We shall be able to do something to encourage a longer period of training by the offer of research studentships and the like, but that will not suffice. It is useless to offer scholarships if competent candidates are not forthcoming, and they cannot be forthcoming in sufficient numbers until a larger number of well educated students enter the universities. That is the problem which the education departments have to solve, and on the solution of which the success of the present movement in our opinion largely depends.

As regards the second condition of success, progress in co-operative effort is undoubtedly being made in many directions and we have mentioned some instances of it. But we wish to point out that there are specially strong reasons for more co-operation between the various British firms in each industry and between the industries and the State in the furtherance of research. If the general level of manufacture can be rapidly raised by co-operative effort in the exchange of information between firms, and in the support of national institutes for research, as well as in the improvement of the conditions and efficiency of labour, the country will have gone far towards establishing its industrial prosperity on a firm basis.

The economic problem has entered on a new phase, but it is an important aspect of the great issue with which we are confronted, and we do not believe that peace can be met effectively unless co-ordinated advance is made simultaneously on the whole front. We think it possible that the voluntary efforts of manufacturers in friendly union which enabled the problem of munitions to be rapidly solved may lead to a new kind of reciprocity between firms which will avoid the evils of monopoly and of individualism.

Quite apart from this general and fundamental point of view, team work is needed, because when we come to deal with the great industries which have an output worth many millions sterling a year and employ labour in proportionate amount, the problems to be solved are too manifold, and too complicated, to be dealt with by individual firms, or even, we may add, by a Government Department. When co-operation has done all that is possible in the common interest, there will still remain a mass of research work to be done by individual firms in their own interests, which will amply repay the cost and effort.

LIST OF AIDED RESEARCHES.

Research.	Institution or body responsible for the research.	Institutions, laboratories, &c., at which the research is, or will be, conducted.
(i.) Researches which were already in Progress.		
Laboratory glass ...	Institute of Chemistry.	Laboratory of the Institute of Chemistry, King's College, London, and Prof. Jackson's private laboratory.
Optical glass	Do. do.	Do. do.
Refractory materials	Institution of Gas Engineers.	Stoke-on-Trent Central Schl. of Science & Technology.
Hardness test for journals and pins.	Inst. of Mechanical Engineers.	National Physical Laboratory. Certain firms are co-operating.
Properties and composition of alloys.	Do. do.	National Physical Laboratory.
Flow of steam through nozzles.	Do. do.	University of Manchester and Glasgow Royal Technical College. Certain firms are co-operating.
Heating of buried cables.	Institution of Electrical Engineers.	National Physical Laboratory and University of Liverpool. Certain firms and public electricity supply undertakings are co-operating.
Properties of insulating oils.	Do. do.	Manchester Municipal Schl. of Technology. Certain firms are co-operating.
Tool steel experiments.	Manchester Association of Engineers.	Manchester Municipal School of Technology.
Methods of notched bar impact testing.	Engineering Standards Committee.	National Physical Laboratory.
Corrosion of non-ferrous metals.	Institute of Metals.	University of Liverpool. From Oct. 1, 1916, the research will be transferred to the Royal School of Mines (Imperial College of Science and Technology), and the Brighton Corporation Electric power station.
(ii.) New Researches.		
Optical glass	National Physical Laboratory.	National Physical Laboratory.
Glass technology ...	Sheffield University Delegacy for glass research.	Research Institute attached to the University of Sheffield.
Hard porcelain	Joint Research Committe of the Stoke Central School of Science and Technology and the Staffordshire Potteries Manufacturers' Association.	Research Institute attached to the Central School of Science and Technology, Stoke-on-Trent.
Setting and disintegration of salts and crystalline substances.	Faraday Society ...	Guy's Hospital Medical School and Mr. Bousfield's private laboratory.
Degumming of silk	Silk Association ...	Imperial College of Science and Technology. Certain firms are co-operating.
Tin and tungsten ..	Inst. of Mining and Metallurgy.	Royal School of Mines (Imperial College of Science and Technology). privately owned laboratories and concentration works of certain companies owning mines in Cornwall.
Statistical work in preparation of field for research in iron and steel.	Iron and Steel Institute.	Offices of the Institute.
Rate of heat transmission from hot surfaces to fluids over them.	National Physical Laboratory.	National Physical Laboratory.
Deterioration of structures of timber, metal and concrete in sea water	Institution of Civil Engineers.	Various ports throughout the Empire, and laboratories (for special investigations) as may be required.

COMMERCIAL & INDUSTRIAL SECTION.

Publicity and Its Relation to Engineering Work.

By W. E. WARRILOW, A.M.I.E.E.

From time to time, during the past 10 years there have been many contributions to the writings on publicity, and of recent years journals have become established to represent the interests of the advertising industry from various points of view. The columns of these periodicals display a tendency towards the creation of a science of advertising and the growth of what should in the next decade prove to be one of the most flourishing branches of commercial and industrial activity.

The present Great War has demonstrated the importance of publicity in an international sense, albeit it has witnessed, on the one hand, its complete degradation by the agencies of Prussianism, and, on the other, an entire lack of appreciation of its merit by the Allied countries. That, however, by the way.

The subject of engineering publicity—and by that is meant the advertising in their respective markets of the products of all classes of engineering effort—does not appear to have received that serious consideration which its relation to sales would justify. The engineering advertisements of the past quarter of a century suggest that publicity has not been regarded by the manufacturer as an investment ensuring a definite and positive return.

The advertisements in the early issues of the pioneer industrial journals—technical, scientific, commercial and engineering—suggest that the "copy" was prepared by the secretary, the chief clerk or the "head of the stationery department." The managing director would probably instruct one or other of these individuals to "drop in a block" and a few lines of type, and would then forget all about the advertisement until a request arrived from the publisher—months or even a year or two later—requesting that the block, which was badly worn, should be replaced by a new one. If this demand caught the manager in a "liverish" mood he would indignantly reply, cancelling the advertisement! The publisher "got wise" to this possibility, and when the copy was not changed at any time, he replaced the worn block at his own expense!

It is only of recent years that organised attempts have been made to introduce into engineering advertising copy, types, illustrations and grouping which raise the announcement above the level of a newspaper placard, and make the advertisement of "selling" value. Advertising in the early eighties merely displayed a welter of large types and the hideous overcrowding with reading matter of the spaces purchased Some of the pages of the industrial journals looked as though the matter had been thrown in, shaken down "type high" and sent to press. Both advertiser and publisher were to blame for this sort of thing; the former for writing as his copy a lot of capital letters on odd scraps of paper, and the latter for instructing his printer to "follow that exactly." Happily for the engineering industry, this view is undergoing important and salutary changes, both in its relation to directive policy and to the class of men which is entrusted with the task of putting this policy into effect.

The alterations which have led up to the modern clean cut advertisement have mostly come from the side of the advertiser, who, utilising the improved type faces available, has modernised his catalogue styles, and has naturally wished to see similar typographical improvements in his trade paper advertisements; the printer has by degrees fallen in with these views, and now uses type founts which are mainly in keeping with the advertisers' ideas. The advent of the half-tone illustration, with the introduction of highly-finished and coated papers which this advance necessitated, coupled with many improvements in printing machinery, have materially assisted in the great change for the better which has accrued. Regular readers must have noticed with a sense of relief the more "open" advertisements in the industrial periodicals; a few bold headlines, one or two illustrations and a panel or two of neat text descriptive of the subject, make up an advertisement which is attractive, and is likely to produce inquiries. This style of trade announcement is becoming more general, and it is inducing the reader to take a keen interest in the business pages of the industrial press.

Improvements in engineering advertisement "copy" are also due, apart from progress in types and printing methods, to the more stable conditions under which manufacturing and, therefore, selling are now conducted, compared with the state of flux which characterised all pioneer engineering work. The early manufacturer could do little more than include in his advertisements his name and address, and a list of what he thought he could make if he was asked to do so. Nowadays there are more settled designs, standard types of product and specialised manufacturing to be taken into account. Automatic machine tools, with semi-skilled labour, prompt quantity production and such a policy accumulates large stocks, and requires selling methods which must ensure the disposal of these stocks before any new patterns can be begun. The rate of change in design is necessarily slow. This feature of modern manufacturing makes it imperative that advertisement copy shall be written with a definite sales purpose. In the electrical business it is especially true of small dynamos and motors, lamps, installation material and accessories, instruments, cooking utensils, wires and cables, dry batteries, conduit, illumination fitments, fans, magnetos, telephones, bells, car dynamos, motor accessories, ignition cells, and similar products which experience has proved can be turned out better and at lower prices, in large rather than small numbers. Central station plant, industrial power equipment, electric railway and tramway material, and much other special machinery, which is made only to order and is supplied to specification and against public tender, comes into quite another advertising category. The heavy art paper catalogue, elaborately illustrated and expensively bound, is one of the chief aids to publicity in this field of engineering enterprise. Considerable sums of money are frequently spent in the compilation and "illumination" of these monuments to the art of modern printing, for such a great many of them undoubtedly are.

Technical and trade newspaper advertising is consequently quite subsidiary to the publicity work done by the means referred to.

Since the manufacturer took his publicity seriously the advertising manager has been one of the knotty problems which he has had to solve. At one time the selection of the advertisement manager was chiefly decided by his knowledge of types, blocks, copy grouping and design, and the general paraphernalia of printing. This class of publicity man knew little or nothing of engineering. His copy had first to be submitted to the engineering department, in order that its technicalities might be approved. In himself he had not sufficient engineering ability to emphasise the chief features of the subject matter of the advertisement. An arrangement of this kind naturally involves a considerable expenditure of time in the consultation of the advertising with the engineering and technical departments. In those industrial undertakings in which the efficiency of individual departments is a desideratum it is becoming recognised that the work of publicity can best be entrusted to a man who has had technical and engineering experience, and who also has a keen interest in advertising from a sales point of view. Such men are now being given their opportunity, and are beginning to prove their worth. They can best direct the work of the artist and printer who have not in themselves felt confident to handle engineering advertising material.

The same process of evolution which has given the manufacturer an engineer in charge of his publicity will also in time furnish the engineering press with a similar type of man—i.e., a sales engineer—to have control of the business pages.

What, then, is to be looked for as the result of these changes in engineering advertising? The writer thinks that the publicity side of manufacturing should be given its correct place as an essential adjunct to the selling departments of every industrial organisation. The "sales engineer" has developed out of the commercial traveller (or drummer, as he is sometimes termed), and is a great improvement upon him, technically, commercially, socially. Similarly, out of the advertising manager there will develop a type which, for want of a better description, the writer will term "publicity engineers"—engineers, that is to say, who have been through the technical schools and worked at the bench and have proved their ability as salesmen, and have a bent for journalism. In a sales capacity they have also demonstrated that they are not without tact and diplomacy. At one time the engineer, as such, would have looked with disfavour upon the idea of training himself to sell the products of the works in which he served his time. He felt that he was taking up the business of engineering, and not that of a commercial traveller. But experience has shown that "sales engineering" is not only a highly interesting business, but also an honourable and profitable one. It is no longer derogatory for an engineer to go out and sell. He can employ his engineering experience and knowledge to the best advantage in this capacity, particularly if he has a natural aptitude for the work.

The writer submits that it is from this class of man that the "publicity engineer" is to be drawn. There are already men who can qualify for inclusion in the rank of publicity engineers. Engineering advertising is being raised to the distinction of a profession, and those engaged in it may derive satisfaction from the fact that they have been members of that profession for some years past. They can also feel gratified that the immediate future will bring to their ranks many brother engineers who have not feared to pass through a course of sales engineering as a preliminary to the fascinating work—technical and engineering withal, of advertising and trade journalism.

The need for advertising to the general public the merits of the Electric Service was not recognised in this country until about 10 years ago. In a sporadic kind of way the manufacturers have for a score of years prepared and issued pamphlets and leaflets describing what can be done with electric irons, kettles, small hot plates and similar domestic electric appliances. This literature was distributed in considerable quantities through the agencies of the central station engineers and the electrical contractors. To some extent it did useful work by informing present and prospective electricity consumers that electrical energy is suitable for other purposes than mere lighting. Some years ago the London Electricity Supply Companies co-operated on a general policy which had for its object the preparation and distribution of an "Electrical Bulletin." A considerable sum was spent in this way, but the publication was not long continued.

The advertising of lamps and illumination must be considered to occupy a position distinct from that of the advertising of domestic electric appliances. In the first place the electric lamp patents are now practically settled, the manufacturers are grouped into a powerful association, the lamp has been standardised for all voltages and candle-powers, and a scale of fixed prices, based on the quantity purchased, has been drawn up. With all these various elements in a stable condition, the question of advertising electric lighting is a comparatively simple one.

The domestic appliances which are intended for "the other uses" of the Electric Service occupy a different position from that of electric lamp manufacture and trade. American experience of this class of business is useful to take as a guide. After passing through various phases in the development in the design of irons, toasters, kettles, hot plates, small fires and other apparatus, U.S. manufacturers are now settling down to a policy of quantity production. Having agreed upon this, they are able to go to the trade and the public with a standardised article which is made in great quantities, and is put out at a moderate price. The manufacturer, in other words, realises that there is a certain market and regulates his "make" accordingly. The general scheme of advertising then fits naturally into the selling campaign.

The work of the Society for Electrical Development, which began in the United States two years ago, is conducted in co-operation with manufacturing, selling and central station interests, and is a proof of the principle that these interests must work together if advertising the Electric Service is to succeed.*

Hitherto, such electrical publicity work as had been done in this country has largely defeated its object—presumably that object was to sell apparatus—because the advertising was always ahead of design and manufacture, and, therefore, of selling. On the other hand, if the design of the apparatus possessed serious defects the resulting breakdowns would cause dissatisfaction, and largely deprive further advertising of its business-getting value.

At the present time the Electrical Development Committee, formed some two years ago by the Incorporated Municipal Electrical Association, and subsequently extended to embrace manufacturing and selling interests, has, unfortunately, been unable to come into operation owing to the war. In the meantime the makers of electric appliances must carry on in a moderate way with small advertisements in carefully-selected papers, and the electric lamp makers must bear the somewhat heavy responsibility of reminding the public of the existence of the Electric Service, in their newspaper announcements which are now a feature of the dailies and weeklies.

Most of the advertising of the subsidiary uses of the Electric Service has suffered from a too great insistence upon the luxurious. The illustrations in the pamphlets, showcards and posters generally depict a gorgeously-attired female turning on an electric lamp, using an electric vacuum cleaner or lifting dainties from an electric chafing dish. This form of illustration has given the impression that domestic electricity is intended for those in the higher stations of life. Then again much of the advertising has been planned from the point of view of the well-informed electrical man, rather than that of the obviously ignorant public. It seems to have been drafted upon the assumption that the general public must know that ironing, the heating of water, the making of toast, the boiling of eggs, the running of fans, vacuum cleaners,

* Some of the posters used in the Society's 'America's Electrical Week' for 1916 are reproduced in miniature on p. 180 of the Supplement preceding this Section.

sewing machine motors and innumerable other things can be done by electricity.

There is still an enormous amount of missionary work to be carried out even among people who have been electricity consumers for years past. The writer suggests that this missionary work can best be undertaken in a newspaper campaign of letterpress advertising—*i.e.*, by a form of announcement which is in itself a complete message and is conveyed by type alone, without recourse to illustrations of any kind. The wording of these "electrical messages" would not be difficult to agree upon, and each would relate to some specific use of the Electric Service. For instance, a few drafted at random :—

"ELECTRIC LIGHT IS SAFE, CHEAP, HYGIENIC."
"AN ELECTRIC IRON IS THE HOUSEWIFE'S JOY."
"YOU CAN COOK BY ELECTRICITY."
"YOUR POWER AGENT MUST BE AN ELECTRIC MOTOR."
"AN ELECTRIC BEDROOM FIRE SAVES DOCTORS' BILLS."
"ELECTRIC TOAST IS PERFECTION."
"HAUL IT BY ELECTRIC."

The type selected should be bold and artistic, with plenty of white space round it, and the advertisement should give the address of the local electricity works or show rooms and of local contractors. Matrixes of these advertisements should be prepared and supplied to the newspapers with a list of the dates upon which they are to be inserted ; or, as an alternative, the matrixes could be sent to the central station engineer and he would arrange for the appearance of the messages in due season. A small annual levy upon central station undertakings, and a contribution from the electrical manufacturers, factors and contractors would raise a sum of money sufficient to pay for a newspaper campaign similar to that sketched out above. Advertising of this kind would keep matters electrical alive in the public mind and be in keeping with the rate at which British manufacturers are now able to produce and market domestic electrical appliances.

Until the manufacture and selling of subsidiary electrical appliances can be undertaken in this country on a scale which will justify a national electrical campaign, the writer suggests that the missionary type of advertisement be employed. It will take at least two years after the peace to establish the manufacture of these appliances on such a scale, and in the meantime the press and the hoardings will remain silent upon the merits of the Electric Service unless something is done.

COMMERCIAL TOPICS.

The Metropolitan Electric Supply Co.

In another column we give the report of the Committee of Shareholders which was appointed at the meeting on March 22 last. The Committee state that the arrangement which they submit for confirmation is in the best interests of the shareholders—namely, the addition of new independent directors (Messrs. A. W. Tait, Geo. Balfour and Geo. Verity) to the board. They are also of opinion that no useful purpose can be served by referring to the matters of controversy raised at the meeting. Reports of experts employed by the Committee to investigate and advise upon certain points will not be published, but will be placed at the disposal of the reconstituted board. The course suggested seems to be a wise one and in the interests of all parties.

* * * *

Victoria Falls Power Scheme.

The Victoria Falls & Transvaal Power Co. appears to have made good progress during 1915, the gross receipts having increased from £573,600 to £757,300, and the net profit from £170,800 to £223,100, though administration and management expenses in Johannesburg advanced 61 per cent. and in London and Salisbury 38 per cent. The improvement is, no doubt, due to the increased volume of work on the Rand last year. The last arrears of the preference dividend have been cleared off, and the ordinary shareholders should soon receive a dividend, though debenture redemption service commences this year. The second large turbo-generator at Brakpan has been brought into commission, and the whole of the plant for all the power stations of the combined undertakings is installed, so that no further capital will need to be raised in the immediate future. This should prove beneficial to the interests of the ordinary shareholders.

* * * *

Preference in Electricity Contracts.

The importance of having a carefully-drawn agreement for the supply of electricity is clearly shown by an incident which recently occurred at Rochdale. Certain large consumers obtained their supply of electrical energy from the Corporation under special contracts, and one firm, whose agreement contained (in addition to a coal clause) a provision that "they must be supplied at as low a price as other large consumers in the town," contended that they were entitled to better terms than they had hitherto had. After discussion, the point in dispute was referred to Sir John Snell, who has now given his award in favour of the firm. This decision means a refund of over £300 for energy supplied up to March 31st last, and in future the firm will receive their supply on the same basis as three other large firms in the town.

* * * *

British Property in Enemy Countries.

A Royal Proclamation has been issued requiring returns to be made of British property in enemy territory and claims by British subjects against enemy persons and enemy Governments.

The Proclamation orders that all who are entitled to property of any description whatsoever in enemy territory or to any interest in such property, or have claims against enemy persons or enemy Governments, forthwith to make returns of their said property or claims. It is not necessary to make returns respecting property or claims whereof returns have already been voluntarily made. The officers appointed to receive the returns are : (*a*) In the case of property in enemy territory and of claims against enemy persons, the Public Trustee, Kingsway, London, W.C. (*b*) In the case of claims against enemy Governments, the directors of the Foreign Claims Office, Foreign Office, London, S.W.

Claims against persons in enemy territories and against enemy persons must make returns to the Public Trustee, Kingsway, London, W.C. Claims against enemy Governments must be sent to the Directors, Foreign Claims Office, Foreign Office, London, S.W.

* * * *

Enemy Goods in Australia.

The Commonwealth Government recently decided that enemy goods imported before the war must not be sold by wholesale houses after Sept. 30, nor retail houses after Nov. 30. These dates have now been extended to Oct. 31 and Dec. 31 respectively.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From Sept. 2, 1916, *to* Sept. 8, 1916.

IMPORTS.

FOLKESTONE.—*France :* Elec. carbons, 34 pkgs. ; glow lamps, 2 pkgs. ; unenumerated 19 cases, 12 pkgs.

GRIMSBY.—*France :* Unenumerated, 19 cases.

LIVERPOOL.—*U.S.A. :* Electrodes, 87 cases ; insulated wire, 42 brls. ; unenumerated, 9 pkgs.

LONDON.—*U.S.A. :* Insulated material, 5 brls. ; carbon candles, £519 ; wire and cable, £570 ; telephone material, £386 ; unenumerated, £4,701. *Holland :* Elec. lamps, 634 pkgs. ; elec. glow lamps, £6,315 ; unenumerated, £1,889—378 pkgs. *Japan :* Unenumerated, £1,517. *Switzerland :* Unenumerated, £28. *Sweden :* Glow lamps, £250

EXPORTS.

TO AUSTRALASIA.—*Auckland :* Elec. machinery, £30 ; unenumerated, £201. *Melbourne :* Wire and cable, £17,262 ; elec. machinery, £108 ; telegraph material, £32 ; unenumerated, £2,355. *Sydney :* Elec. machinery, £1,319 ; telegraph material, £80 ; wire and cable, £1,079 ; unenumerated, £1,376. *Wellington :* Elec. lamps, 860 n.o. ; wire and cable, £1,209 ; unenumerated, £11,300. *Lyttelton :* Wire and cable, £761 ; unenumerated, £144. *Dunedin :* Wire and cable, £298 ; telegraph material, £112 ; unenumerated, £10. *Adelaide :* Wire and cable, £266 ; elec. machinery, £780 ; unenumerated, £625. *Christchurch :* Wire and cable, £169 ; telegraph material, £400 ; unenumerated, £40. *Perth :* Wire and cable, £121 ; unenumerated, £168. *Hobart :* Unenumerated, £227. *Fremantle :* Unenumerated, £34. *Perth :* Unenumerated, £224. *Napier :* Unenumerated, £29. *Brisbane :* Unenumerated, £131. *Wanganni :* Unenumerated, £64.

AFRICA.—*Durban :* Elec. machinery, £123 ; wire and cable, £1,510 ; elec. lamps, 11,784 n.o. ; unenumerated, £1,209. *Cape Town :* Unenumerated, £653. *Port Elizabeth* Elec. machinery, £21 ; wire cable, £537 ; unenumerated, £105. *East London :* Elec. machinery, £50 ; unenumerated, £127. *Beira :* Unenumerated, £297. *Chinde :* Unenumerated, £25. *Basra :* Unenumerated, £3,490. *Zanzibar :* Telegraph material, £367 ; wire and cable, £22 ; unenumerated, £30.

EGYPT.—*Alexandria :* Unenumerated, £92. *Port Sudan :* Elec. machinery, £400 unenumerated, £613. *Suez :* Unenumerated, £67.

MALTA.—Telegraph material, £253.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Bombay :* Wire and cable, £478 ; elec. machinery, £63 ; unenumerated, £1,001. *Calcutta :* Wire and cable, £2,945 ; elec. machinery, £143 ; unenumerated, £2,173. *Madras :* Elec. machinery, £58 ; wire and cable, £1,213 ; unenumerated, £215. *Colombo :* Unenumerated, £59. *Port Swettenham :* Unenumerated, £459. *Penang :* Elec. machinery, £70 ; wire and cable, £157 ; unenumerated, £345. *Bankok :* Unenumerated, £22. *Singapore :* Unenumerated, £256. *Karachi :* Elec. machinery, £503 ; unenumerated, £12. *Kilindini :* Wire and cable £70 ; telegraph material, £268 ; unenumerated, £233. *Sourabaya :* Elec. machinery, £94 ; unenumerated, £52.

CHINA.—*Shanghai :* Wire and cable, £998 ; elec. machinery, £410 ; elec. lamps, 6,650 n.o. ; unenumerated, £234. *Tientsin :* Elec. machinery, £327. *Hankow :* Wire and cable, £76 ; unenumerated, £70.

CANADA.—*Toronto :* Elec. machinery, £38.

U.S.A.—*New York:* Unenumerated, £192.
South and Central America.—*Vera Cruz:* Wire and cable £154. *Buenos Ayres:* Unenumerated, £527. *Antofagasta:* Unenumerated, £153 *Surinam:* Unenumerated, £70. *La Police:* Unenumerated, £38.
Java.—*Batavia:* Unenumerated, £92.
Japan.—*Osaka:* Unenumerated, £174.
South Sea Islands.—*Fiji:* Unenumerated £279
West Indies.—*Demerara:* Unenumerated £134 *Trinidad:* Unenumerated, £89. *Barbados:* Unenumerated, £29 *St. Lucia:* Unenumerated £20
Holland.—*Amsterdam:* Wire and cable, £472 Unenumerated £116. *Rotterdam:* Wire and cable, £5 201: unenumerated £56 *Haarlem:* Elec copper wire £140.
Denmark.—*Copenhagen:* Unenumerated £62
Russia—*Vladivostock:* Unenumerated £20
France.—*Dieppe:* Unenumerated, £80 *Paris:* Elec machinery £349 *Bordeaux:* Unenumerated, £158 *Havre:* Unenumerated, £154 *Nantes:* Elec machinery, £22.
Gibraltar.—Wire and cable £25 Unenumerated £674
Norway.—*Bergen:* Elec cable, £1 061
Portugal—*Lisbon:* Elec machinery, £42 Unenumerated £5 200
Italy.—*Genoa:* Unenumerated, £179.
Channel Islands.—Elec. machinery £40
Spain.—*Barcelona:* Unenumerated, £190

FOREIGN GOODS (duty paid and free).

Sydney: Elec lamps, 900 rs *Melbourne:* Elec machinery £430 *Durban:* Wire and cable, £120. *Cape Town:* Unenumerated £42 *Port Elizabeth:* Unenumerated, £44. *Calcutta:* Unenumerated, £26 *Paris:* Unenumerated, £45 *Zanzibar:* Unenumerated, £12. *Bordeaux:* Unenumerated £16 *Patras:* Unenumerated, £20. *Wellington:* Unenumerated, £29. *Sydney:* Unenumerated, £27

IN TRANSIT.

Durban: Elec glow lamps, £2 21.

Note.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

EDUCATIONAL.

University of Manchester.—The session will begin on Oct. 5. Complete theoretical and practical training is provided for students preparing for the higher positions in the electrical engineering profession. At the end of a three years' course students may obtain either an ordinary or an honours degree of B.Sc. in electrical engineering. A special course, also extending over three years, prepares for a certificate in electrical engineering. The John Hopkinson Laboratories are fitted with modern electrical machinery and testing appliances, and excellent facilities are offered for educational and research work. Particulars may be obtained from the Registrar.

Armstrong College (University of Durham), Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Priest, M.A.

Royal Technical College, Glasgow.—The session 1916-17 begins on Sept. 26.

The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, &c. There are also full courses of instruction in the schools of navigation and wireless telegraphy, and both day and evening classes are held. The diploma courses extend over three or four sessions, and the average fee is £12 12s. per session. The college is affiliated to the University of Glasgow, and the degrees of the university in engineering and applied chemistry are open to its students. Prospectuses from the Director.

The calendar for the session 1916-17 has been issued and contains full particulars of the courses of instruction, fees, classes (day and evening), examinations, &c. The head of the electrical engineering department is Prof. Magnus Maclean, M.A., D.Sc., and the laboratories are well equipped for practical work. The calendar is published at 1s. (post free 1s. 4d.)

Northampton Polytechnic, London.—In the day engineering college full day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Ashbourn scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

Manchester School of Technology.—Full courses, leading to the Manchester University degree in the faculty of technology, are provided in mechanical, electrical and military engineering (including municipal engineering), the chemical and textile industries, tanning, architecture, &c. During the session 1916-1917, first year courses will be specially adapted to the requirements of students who may wish to take commissions in H.M. Forces.

The prospectus of the University courses in the 1916-17 session has been issued and gives full particulars of the instruction, fees, conditions of admission to classes, &c. The school of technology affords a systematic training in all branches of engineering, the chemical and textile industries, &c. There are part-time day courses for engineers' and other apprentices, and there are also part-time evening courses, the latter courses extending over five years. There are well-equipped laboratories for practical and research work.

Battersea Polytechnic.—At this Polytechnic there are day courses in the electrical engineering department for the B.Sc. (Eng.) of London University and for the Polytechnic diploma. There are also evening courses in direct and alternating currents, electrical design, generation and transmission, electrical costs, electric lighting and illumination and electric traction. Sectional calendar 1d. (post free 2d.). Calendar of evening classes gratis on application to the secretary.

South-Western Polytechnic.—This Polytechnic will reopen on Sept. 25 for day and evening classes. The Engineering Courses include lectures in electrical and mechanical engineering, physics, chemistry and mathematics, and practical instruction in the laboratories. There is a complete three years' day course (leading to a diploma or University Degree in electrical engineering), and also a four years' evening course suitable for electrical engineering and wiremen's examinations of the City and Guilds Institute.

Students are prepared by recognised teachers of the University of London for the B.Sc. degree in engineering, for the examinations at the Engineering Institutions and of the City and Guilds of London Institute. The evening courses also include classes in electric wiring and other trade subjects. In the electric wiring department an advanced course has been arranged for the preparation of candidates for the final wiremen's examination of the City and Guilds of London Institute. Arrangements have been made for placing students who have passed satisfactorily through the three years' day course in positions with large engineering firms, and hitherto such firms have offered more vacancies than the Institute has been able to fill with its students. Prospectuses may be obtained from the Secretary, Manresa-road, Chelsea, London, S.W.

West Ham Municipal Technical Institute.—The session 1916-17 will commence on the 20th September.

In the electrical engineering department there are full day and evening courses in electrical engineering in preparation for the B.Sc. degree of London University and for the City and Guilds technological examination in electrical engineering, telegraphy, telephony and wireman's work. There are also a shortened two-year day course and part-time day classes in electrical engineering arranged with the co-operation of local engineering employers, to enable students to obtain a training in electrical engineering under more favourable conditions than is possible in evening classes. Particulars may be obtained from the Principal.

BUSINESS NOTICES.

The Damard Lacquer Co. (Ltd.), of 98, Bradford-street, Birmingham, has taken over the works of the Bakelite Co. (Ltd.), which has been wound up by the Board of Trade, at Orb Works, Cowley, Middlesex, for the manufacture of "Formite" synthetic resin products. These premises will in future be known as Bridge Works, Cowley, and inquiries respecting these products will be treated at 98, Bradford-street, Birmingham, as in the past.

It is announced that W. T. Henley's Telegraph Works Co. have removed their Bombay branch from 7, Hummum-street to larger premises at 10, Fort-street.

Plant for Sale.—Messrs. Marshalls, Gainsborough, have a 2½ h.p. Wilson Hartnell electric motor and an E.C.C. compound-wound dynamo for sale.

ELECTRICITY SUPPLY.

EXTENSIONS.

Battersea (London).—The Electricity Committee proposes to purchase a spare armature from Messrs. Belliss & Morcom for £710.

Kirkcaldy.—The burgh electrical engineer (Mr. O. F. Francis) has reported on the capacity of the present electricity works and on recent applications for power.

The report also contains correspondence between the Fife Power Co., the burgh engineer, the town clerk and Messrs. Barry, Ostlere & Shepherd. The latter asked for an additional supply of power, which the Corporation is unable to give. The Fife Power Co. is willing to supply power, but it is prevented by a clause in its Act of Parliament.

The Town Clerk points out that the company practically asked that the clause be abolished by the Corporation, but he considered it a very serious matter, as it indicated a hostile attitude on the part of the company towards the burgh. What made matters more serious was that the company had acted on the invitation of one of the largest and most important users in the burgh. The town clerk considered that the demand by the company foreshadowed the promotion by them of a pro-

visional order. While he felt sure the Council would receive fair treatment from Parliament, they should take care that they were able to show that they had done all that was reasonable.

On Monday the Council decided to ask Sir John Snell to report upon the matter.

Rawtenstall.—The Council have been authorised by the L.G. Board to borrow £2,216 for mains in connection with the supply of electricity in bulk to Haslingden and for other purposes.

Sheffield.—Mains are to be extended at an estimated cost of £1,846 to supply energy to new consumers.

Instructions have been given for the free supply of current to various premises used as residences for Belgian Refugees to be discontinued.

Swansea.—The Electricity Committee is in negotiation with the Harbour Trust on the question of all the electrical energy required at the docks being supplied by the Corporation in the same way as it is now supplied to the tramways.

It has been decided to extend the electricity works at a cost of from £20,000 to £25,000, so as to enable the department to give the supply.

It has been agreed to grant increases of 3s. a week to employés who are members of the Amalgamated Society of Engineers and to decrease the hours worked, including a 12 o'clock stop on Saturdays.

GENERAL.

Aberdeen.—A proposal to give a supply of electric current, on a new five years' contract, to the North of Scotland Fish Guano Co. caused some discussion at the Council meeting last week.

Baillie FIDDES moved that the matter be taken back for further consideration. He asked if the Council were aware that the Fish Guano Co., although an insignificant user of electricity compared with Messrs. Richards, would get it at a much smaller price. They would get for £416 what Messrs. Richards paid £668 for. It was a departure from the ordinary charges, and demanded very careful action.

The convener (Councillor GIBB) pointed out that Messrs. Richards had but a 12 hours' load, and the other company a 24 hours' load.

The matter was referred back.

Coniston.—Electric supply was switched on here for the first time on the 21st ult. by the Coniston & District Electric Supply Co.

The company erected hydro-electric works at Miners' Fall, and current is conveyed by overhead mains to the village. The scheme was designed by Mr. Chas. Pullan, of Bradford, the turbine contract being entrusted to Messrs. James Cordon & Co. and the electrical work to Messrs. Cox-Walkers, of Darlington. The resident engineer is Mr. F. Turnbull.

Epsom.—At the meeting of the Council last week Mr. Langlands asked for an explanation of the electric supply failure in a part of the town on the previous Saturday evening.

In reply, it was said there had been a great deal of trouble owing to the wet weather, and it was quite possible they would have further trouble during the coming winter. The difficulty was the impossibility of carrying out the reconstruction required. The electricity department would like to do it, but they had no money and they could not get the cables.

Revised Charges for Electrical Energy.—Aberdeen Corporation has reduced its power and lighting rates by 5 per cent.

The *Notting Hill* (*London*) *Electric Lighting Co.* has decided to make a minimum charge of 10s. for current supplied through slot meters. *Eastbourne* Council is increasing its charges for current for lighting by ½d. per unit. *Hexham & District Electric Supply Co.* is increasing its rates from 6d. to 7d. per unit for lighting, 2d to 2½d. for power and 2½d. to 3d. for heating.

Rochdale.—The dispute between the Electricity Committee and the Tyre Yarns Co. as to the supply of electricity was again considered by the Council on the 7th inst.

The points at issue were submitted to Sir John Snell, whose decision should be binding on both parties. The award has now been issued and is in favour of the company, who are to receive a refund of over £300 for energy supplied up to March 31, 1916, and for this year they are to be placed on the same basis as three other large firms.

The chairman of the Committee (Councillor WALKER) said the contract with the company was the first to contain a coal clause, and compared with other large contracts that firm was at a disadvantage. It was, however, part of a bargain, and was accepted by the company, which was the biggest consumer.

Councillor SHAWCROSS, whose firm was one of those referred to, said so far as he was concerned he wished to goodness he had never seen the electricity of the Corporation, for the reason that during the first year the firm had been charged £300 for electricity that they did not use owing to the war.

Sir J. E. JONES said that in the Tyre Yarns Company agreement there was a clause that they must be supplied at as low a price as other large consumers in the town. They were surprised to find such a clause in the agreement, but even if it had not been there there was the same stipulation in the Act of Parliament.

Ald. BLOMLEY said that when the contract was entered into there was no thought of war in their minds, and they were of opinion that prices for coal and labour might be easier. Tyre Yarns asked to be put under a coal contract, and the Corporation would have benefited if prices had gone down, as was anticipated.

The minutes of the Committee were then passed.

South Shields.—The salary of the borough electrical engineer (Mr H. S. Ellis) has been increased from £450 to £500 per annum.

Stretford.—The Electricity Committee, which reports continued shortage of supplies of coal, has been in correspondence with the contractor, the Board of Trade and the Coal and Coke Supplies Committee.

The Committee is of opinion that every effort should be made to secure its rights under the coal contract, and recommends the Council to authorise the chairman and the clerk to take such action (legal or otherwise) as may be necessary.

Walsall.—The Electricity Committee recommends that the existing charges for current should not be increased.

The agreement with the Talbot-Stead Tube Co. for a supply of energy to their works at Leamore is to be cancelled and a new agreement entered into for additional supply for a term of three years, commencing on the date when the extra-high-tension supply from the new station is available Subject to a satisfactory guarantee, the mains are to be extended and the necessary switchgear and transformer installed to give a supply of current to the Electrical Conduits (Ltd.); and an agreement is also to be entered into with Eyland & Sons for giving supply of current.

TRACTION NOTES.

Birmingham.—The Corporation has applied to the Board of Trade for an extension until Sept. 6, 1917, of the periods limited by the Corporation's 1912 and 1913 Light Railway Orders for the completion of works authorised thereby.

Doncaster.—A portion of the Bentley tramways track is to be reconstructed by the Council.

Gateshead.—The Town Improvement Committee recommend the Council not to approve the promotion of the suggested Bill for linking up the tramways systems of Newcastle and Gateshead by means of tramways across the High Level bridge unless proper provision is made in it to safeguard the interests of Gateshead.

Ilkeston.—On the 5th inst. the Council decided by 14 votes to 3 to transfer their tramway and electricity undertakings to the Notts. & Derbyshire Tramways Co. for the consideration of £28,150.

Leeds.—The question of paying a war bonus to women conductors on the tramways was discussed by the Council last week.

Ald. WILSON pointed out that the women formed a temporary staff; they came into the Corporation staff after the war, and had therefore not been paid a bonus. He did not think it could be argued that they were underpaid when they received 27s. 6d. and overtime. The women got two uniforms a year, against the male conductors' one. The women were in a bit of a hurry to ask for an increase. They were talking of striking, but "Let them strike," he said, "although that would not be an easy thing to do, as the tramway undertaking was a controlled establishment. If they were dissatisfied they should leave. The annual cost of the increased war bonuses would probably be more than £8,000 or £9,000.

The increased war bonus as proposed by the General Purposes Committee was adopted, the question of extra pay to the women conductors being passed over.

L.C.C. Tramway Power Station.—Some of the boilers at the Council's generating station at Greenwich are being altered so as to adapt them for using cheaper coal than that hitherto used. Last year coal cost £75,000 more than the previous year.

North London Railway.—It is announced that the L. & N.-W. and North London Railway Companies will commence on Oct. 1 an electric train service between Broad-street and Kew Bridge and Broad-street and Richmond in lieu of the present steam trains, the services being accelerated by about 10 minutes in each case. Second-class bookings by the electric trains will be abolished, but will remain in operation by certain steam train services.

Portsmouth.—The Tramways Committee recommend that a bonus of 10 per cent. be granted to tramway employés whose weekly wages are under 30s.; 7½ per cent. to those under 40s., and 5 per cent. to those under 50s. Honorariums will be paid to all salaried officials amounting to 5 per cent. of their annual salaries.

Salford.—At last week's meeting of the Corporation the Tramways Committee recommended the payment of a further war bonus to the tramway employés (other than skilled artisans, where special arrangements already exist between the employers and the trade society).

The increase would be, to youths under 18, 2s. per week war bonus, instead of 1s.; to male employés over 18 who were not householders, 3s. instead of 1s. 6d.; to male householders whose wages did not exceed 37s. 6d., 4s. 6d. per week instead of 2s. 6d.; and to those receiving over 37s. 6d. and less than 42s. per week an amount which would make their total wages, including war bonus, 42s. The increased payment represented a further addition to operating costs of £2,774 a year for the men now working, and £1,804 a year for those in the forces, a total of £4,588.

Added to the war bonus at present being paid, that represented a total charge of £9,878.

The chairman (Ald. LINSLEY), who called attention to the matter, said there was grave doubt whether, after meeting these charges, the Committee would be able to keep their promise to the Finance Committee with regard to the relief of rates.

Councillor P. HAMPSON said it seemed to him to be a waste of public money to add to the already generous contributions which were made in respect of the people who had gone to the war. The Committee ought not to have made this concession.

Several members spoke in favour of the increase, which was agreed to.

Sheffield.—The Tramways General Sub Committee recommends that the resolution of the Establishment Committee granting a special allowance of 3s. per week to certain Corporation employés shall apply to tramway inspectors, foremen, cash clerks, &c., on weekly wages.

TELEGRAPH AND TELEPHONE NOTES.

American Submarine Cables.—The Mexican and Central & South American Telegraph Companies recently decided to lay a second submarine cable between New York and Colon direct. It is also proposed to lay two additional cables between Buenos Ayres to Rio de Janeiro and Santos.

Dudley.—On Saturday last a new automatic telephone exchange was inaugurated.

New York-Havana Telephonic Communication.—The "Wall Street Journal" announces that the establishment of telephonic communication between New York and Havana (Cuba) may be undertaken by Cuban Telephone Co. through cables between Key West and Havana.

MISCELLANEOUS NOTES.

Customs Decisions.—According to recent decisions the duty upon imports of incandescent bulbs for pocket electric torches into Southern Rhodesia is 3 per cent. under the general tariff, the whole of the duty being allowed as rebate in the case of goods from any part of the British Empire; and X-ray plates (British or foreign) are duty free.

According to a recent decision, electric cables in sets, with terminals attached, especially suited for use in connection with electric ignition of motor vehicle engines, are subject to 10 per cent. ad val. duty on importation into New Zealand if of British manufacture and 20 per cent. if of foreign manufacture.

Enemy Firms Wound-up.—The Board of Trade has ordered the winding up of 332 businesses controlled by alien enemies.

The latest are: Switchgear Construction Co. (Ltd.), Park-street, Southwark, London, S.E., electrical engineers. (Controller, J. H. Stephens, 8, Clement's lane, Lombard street, E.C.) Turner & Burger, 149, Farringdon-road, London, E.C., electrical accessories merchants. (This order is in substitution for one made on June 29 last, prohibiting the firm from trading after Sept. 29.) (Controller, J. E. Percival, 6, Old Jewry, E.C.)

Inquests.—At Hebburn last week an inquest was held on Geo. Dickson (21) munition worker.

A fellow worker stated that on the 6th inst. he went for a walk with Dickson, and when passing along the foot path opposite Hebburn Cemetery, Dickson touched an electric lamp-standard with the backward swing of his left arm. He was drawn towards the standard, and his arms went around it. Witness, who tried to release him, received a shock which threw him to the other side of the road. Witness then struck Dickson's feet from underneath but Dickson was dead when pulled away.

Mr. Alfred Dixon, assistant engineer with the Newcastle-upon-Tyne Electric Supply Co., stated that the electric current through the standard had been caused by one of the cable wires getting into contact with the switch chamber at the top of the standard. The current could not have been more than 240 volts, and he did not think that merely touching the standard would be dangerous. A person doing so would be thrown off and not drawn in. The vibration caused by road traffic might have caused the wires to contract. The company had adopted a new method in regard to switch chambers.

A doctor stated that he did not think that simply touching the post was sufficient to have caused death. He thought Dickson must have gripped the post.

A verdict of accidental death was returned, and the jury expressed the hope that the company would do all they could to prevent similar accidents.

An inquest was held last week into the death of a lad named William Atkins.

Deceased was a riveter at the works of Messrs. Thompson Ltd. The halves of a tank were being welded by electricity, and Atkins was working at a vice close by. A plater named Wilcox accidentally caught his foot against a piece of angle iron, one end of which was on one end of the tank, the other holding a leg of the vice. In this way the vice became charged.

HAROLD BROOK, electrical engineer, said voltage for welding purposes was 110; it was a low pressure, but sufficient under certain circumstances to cause death. He thought the youth was gripping a spanner, and probably the shock contracted his muscles so that he could not let go.

The jury found that Atkins died from shock caused by an electric current accidentally transmitted.

Linking-up Farm and Market.—In no connection is the development of Canada more manifest than in the extension of the use of the telephone, particularly on the farms.

The development of rural telephone systems in Saskatchewan has been very rapid during the last few months, and each issue of the "Saskatchewan Gazette" contains a long list of newly incorporated companies. Since Jan. 1 of this year 175 new companies have been added to the list. The examination of plans and proposals for building these new lines, and the answering of a large number of inquiries which will subsequently lead to the formation of still more companies has kept the staff of the rural telephone branch usually busy.

Swedish Chamber of Commerce Year Book.—We have received a copy of the 1915 Year Book of the Swedish Chamber of Commerce for the United Kingdom.

The book contains much useful information for British firms doing business with Sweden, including the annual report of the Council, particulars of measures taken in consequence of the war, the annual report of the Standing Arbitration Committee, the report of the annual general meeting of the Chamber, a list of the members, statistics of imports and exports, articles or British industries, including the electrical industry (accompanied by curves showing values of exports and imports), lists of Swedish consuls in the United Kingdom and the British colonies and British consuls in Sweden, a comparative table of British and Swedish weights, measures and money, &c.

Trade Union Congress.—The annual Trade Union Congress at Birmingham terminated on Saturday.

The following (among other resolutions) were considered:—

Labour Exchanges.—A resolution recommending a number of changes in the control and administration of the Labour Exchanges was rejected. One member said an attempt was being made to make these exchanges the only medium for obtaining employment. If, as he understood, reorganisation of this State Department were to come, it was unwise that trade unionists should put forward such incomplete recommendations.

Workmen's Compensation.—A comprehensive resolution embodying 14 amendments to the Workmen's Compensation Acts was carried.

Fair Wages.—A long resolution on fair wages was also adopted. The resolution strongly protested against the manner in which the fair wages resolution of the House of Commons had been administered, and instructed the Parliamentary Committee to endeavour to secure—(1) that all Government departments should be invited to supply to all authorised trade unions a list of firms invited to tender; (2) that no firm proved to be paying less than the trade union rate of wages or not observing the working conditions general in the trade should be allowed to tender; and (3) that contractors should furnish to the several departments names and addresses of all sub-contractors, or be struck off the list of firms allowed to tender.

Technical Education.—The development of technical education was urged in a resolution, moved by Mr. John Hodge, M.P., who declared that the war had demonstrated the need for serious attention being given to the educational system, and called upon the Government to reorganise the system, and to pay special attention to the establishment of a proper system of technical education and to the fullest encouragement of scientific investigation.

Food Prices.—A resolution was passed protesting against the indifference of responsible statesmen to the enormous and unjustifiable increase in the cost of living, and calling for steps to be taken to secure a revision of prices.

Trading with the Enemy.—The "London Gazette" of Sept. 8 contains further lists of persons and firms with whom trading by persons and firms in the United Kingdom is prohibited:—

These include: *Brazil*—Deutsch-Atlantishe Telegraphen Gesellschaft A.G. (Rio de Janeiro and Pernambuco); Siemens-Schuckertwerke (Rio de Janeiro, Bahia, Porto Alegre and Sao Paulo). *U.S.A.*—Electro-Bleaching Gas Co. (Niagara Falls and New York).

Tribunal Cases.—An electrician appealed at Burnley last week for temporary exemption for an electrical wireman.

He was the only qualified man left, three having joined the Flying Corps. His foreman had gone to work in a coal mine as an electrician.

Capt. SMITH said that men of this description could be got any day; they were only labourers.

Exemption granted until end of September.

At Blackpool on Sept. 8 11 employés of the Blackpool & Fleetwood Tramroad Co. were granted conditional exemption.

Walsall Chamber of Commerce Year Book.—We have received a copy of the first (1916) issue of this book, which is issued by Messrs. Pearson & Sons (Ltd.), of Midland-place, Derby, and London.

The Year Book is being distributed throughout the British dominions and allied and neutral countries with the view of opening up new business relations. The information given includes particulars of the constitution of the Chamber and a list of its members, the industries of the district, information relating to imperial and foreign trade, lists of consular officers abroad, a classified trade index of firms in the district (in English, French, Italian, Russian and Spanish), &c.

Women as Travellers.—Callender's Cable & Construction Co. (Ltd.) have adopted the novel plan of keeping open the situations of their travellers and representatives who are on active service by offering their positions to the wives of such men as and when called up.

Ladies have willingly come forward in these days of stress and strife to occupy almost any position under the sun whilst their menfolk are doing country's work, and it was this idea that Callender's had in mind when they requested the wives of their employés to "carry on."

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during August, 1916, and (*b*) the aggregate figures from Jan. 1 to Aug. 31, with increase or decrease compared with corresponding periods of 1915:—

Electrical machinery, (*a*) £73,696 (decrease £24,343), (*b*) £809,048 (decrease £311,443); including generators and motors other than for aeroplanes, motor cars and cycles, (*a*) £21,834 (increase £947), (*b*) £140,976 (decrease £46,030); and electrical machinery unenumerated, (*a*) £51,862 (decrease £25,190), (*b*) £668,072 (decrease £265,413); telegraph and telephone cables other than submarine, (*a*) £1,856 (decrease £1,970), (*b*) £55,190 (increase £34,463); telegraph and telephone apparatus, (*a*) £2,463 (decrease £4,299), (*b*) £201,692 (increase £152,177); other electrical wires and cables, rubber insulated, (*a*) £5,529 (decrease £2,119), (*b*) £82,925 (increase £18,412); with other insulations, (*a*) £1,833 (decrease £9,124), (*b*) £7,050 (decrease £24,775); carbons, (*a*) £5,278 (decrease £18,084), (*b*) £60,027 (decrease £35,561) glow lamps, (*a*) £30,611 (increase £19,637), (*b*) £192,315 (increase £101,346); arc lamps and electric searchlights, (*a*) nil (decrease £40), (*b*) nil (decrease £1,626); parts of arc lamps and searchlights (other than carbons), (*a*) £12,292 (increase £5,985), (*b*) £69,923 (increase £9,877); primary and secondary batteries, (*a*) £14,560 (decrease £1,362), (*b*) £129,897 (increase £46,088); meters and measuring instruments, (*a*) £10,116 (increase £9,330), (*b*) £35,024 (increase £15,923); switchboards, (*a*) nil (decrease £1,074), (*b*) £257 (decrease £4,832); electrical goods and apparatus unenumerated, (*a*) £24,917 (increase £7,403), (*b*) £233,914 (increase £88,094). Total of electrical goods and apparatus other than machinery and uninsulated wire, (*a*) £109,455 (increase £4,152), (*b*) £1,058,214 (increase £399,455).

Exports.—The exports of electrical machinery, material, &c. (*a*) during August, 1916, and (*b*) from Jan. 1 to Aug. 31, with increase or decrease compared with corresponding periods of 1915, were as follows:

Electrical machinery, (*a*) £148,560 (increase £61,079), (*b*) £934,318 (increase £19,764); including railway and tramway motors, (*a*) £2,133 (decrease £4,544), (*b*) £22,758 (decrease £70,353); other generators and motors except for aeroplanes, motor cars and cycles, (*a*) £85,119 (increase £49,274), (*b*) £515,337 (increase £87,860); and electrical machinery unenumerated, (*a*) £61,308 (increase £16,349), (*b*) £396,223 (increase £2,257); telegraph and telephone cables, submarine, (*a*) £117,393 (increase £70,756) (*b*) £371,607 (increase £97,018); other than submarine, (*a*) £17,334 (decrease £15,501), (*b*) £339,487 (increase £43,402); telegraph and telephone apparatus, (*a*) £21,812 (increase £9,259), (*b*) £174,551 (increase £45,840); other electrical wires and cables, rubber insulated, (*a*) £47,941 (increase £27,259, (*b*) £339,289 (increase £149,278); with other insulation, (*a*) £58,077 (increase £25,991), (*b*) £533,542 (increase £275,263; carbons, (*a*) £1,225 (increase £639), (*b*) £7,420 (increase £1,905); glow lamps, (*a*) £21,183 (increase £7,355), (*b*) £124,436 (increase £28,887); arc lamps and searchlights, (*a*) £327 (decrease £649), (*b*) £6,159 (increase £2,845); parts of arc lamps and searchlights (other than carbons), (*a*) £653 (decrease £4,502), (*b*) £12,049 (decrease £3,898); primary and secondary batteries, (*a*) £30,065 (increase £10,689), (*b*) £187,932 (increase £52,418); meters and measuring instruments, (*a*) £18,085 (increase £6,020, (*b*) £139,294 (increase £36,714); transformers, (*a*) £11,383 (increase £6,389). (*b*) £68,465 (increase £20,200); switchboards, (*a*) £4,585 (decrease £675), (*b*) £41,426 (decrease £577); electrical goods and apparatus unenumerated (*a*) £59,446 (increase £7,349), (*b*) £431,942 (increase £40,125). Total of electrical goods and apparatus, other than machinery and uninsulated wire, (*a*) £409,509 (increase £150,379), (*b*) £2,797,599 (increase £789,420).

TENDERS INVITED.

Coal Transporter Plant.

Tenders are invited for the supply, delivery and erection in MELBOURNE, of a Coal Transporter Plant of the travelling tower type and electrically operated. Tender form with specification can be obtained from the agents for the Melbourne City Council, Messrs. McIlwraith, McEacharn & Co. Ppty. (Ltd.), Billiter-square-buildings, London, E.C. Tenders, addressed to the Chairman of the Electric Supply Committee, Town Hall, Melbourne, by noon Dec. 11. *Further particulars are given in an advertisement.*

Telephone and Telegraph Material, Instruments, &c.

Tenders are invited for the supply to the Postmaster-General's Dept., State of South Australia, of Telephone Material in accordance with schedule No. 428, and tenders are invited (up to Oct. 4) for the supply to the Postmaster-General's Dept., State of Western Australia, of Telephone and Telegraph Instruments in accordance with schedule No. 501. Tenders are also invited (up to Nov. 15) for the supply and erection at the telephone exchanges of Glenelg and Brighton, State of South Australia, of Automatic Switchboards and all associated apparatus (as per schedule No. 426). Tender forms, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, Perth, requires tenders by 3 p.m. Oct. 4 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts for the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General, Perth, W.A.

Tenders are invited by the Deputy Postmaster-General, Adelaide, for the supply and delivery of Telephones, Telephone Material, Instruments and Parts. (Schedule Nos. 429 to 437). Specifications, &c., and sealed patterns may be inspected at the Office of the High Commissioner in London for the Commonwealth, 72, Victoria-street, S.W. Tenders by 2 p.m. Sept. 27.

The "Departamento de Fomento de la Mancomunidad de Cataluna," Barcelona, also require tenders by noon Sept. 25 for the installation of a Telephone System connecting the towns of BALAGUER, ARTESA, PONS and CALAF, at a cost of £2,850.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. Oct. 17 for supply of (1) Sleeves and Tapes (schedule 1,355) and (2) 3,100 Stay Rods with bow tighteners (schedule 1,359) for AUSTRALIAN COMMONWEALTH Postmater-General's Dept. Specifications from the Deputy Postmaster-General, Melbourne.

Electrical Goods, Fittings, &c.

EDMONTON Guardians invite tenders (by Sept. 20) for six months' supply of Electric Lamps. Tenders to the Clerk, Lower Edmonton, London, N.

WARRINGTON Guardians require tenders by 10 a.m. Sept. 20 for six months' supply of Electrical Goods. Forms of tender from the Clerk.

WESTMINSTER Guardians require tenders by noon Sept. 20 for six months' supply of Electric Lamps, Fittings, &c. Forms of tender from the Clerk, Princes-row, Buckingham Palace-road, London, W.

TOXTETH PARK Guardians require tenders by noon Sept. 18 for three months' supply of Electrical Sundries and Engineers' Stores. Forms of tender from the Clerk, 15, High Park-street, Liverpool.

KENSINGTON (London) Guardians require tenders for six months' supply of Electric Lamps and Fittings, Engineers' Fittings, &c. Forms of tender (until Sept. 20) from the Clerk, Marloes-road, Kensington, W.

Tenders are wanted for six months supply of Electric Lighting Sundries, Ironmongery, &c., to the Welsh Metropolitan War Hospital, WHITCHURCH, near Cardiff. Forms of tender from the Clerk and Steward. Tenders to Mr. J. L. Wheatley, town clerk, Cardiff, by 10 a.m. Sept. 21.

MERTHYR TYDFIL Guardians require tenders by Sept. 19 for six months' supply of Electrical Accessories. Forms of tender from the Clerk, 134, High-street, Merthyr Tydfil.

MANCHESTER Electricity Committee require tenders by 10 a.m. Sept. 22 for 12 months' supply of Fuse Boxes. Specification, &c., from Mr. F. E. Hughes, Town Hall, Manchester.

Tenders are required by Sept. 25 for six months' supply of Electric Fittings, &c., to the Midlothian & Peebles District Asylum, ROSSLYNLEE. Forms of tender from the Clerk and Treasurer, 19, Hercot-row, Edinburgh.

Cables.

Tenders are invited for the supply of various sizes of Insulated Copper Cables and bare Hard Drawn Copper Cables to the City of MELBOURNE. Specifications, tender forms, &c., from Messrs. McIlwraith, McEacharn & Co. Ppty. (Ltd.), Agents for Melbourne City Council, Billiter-square-buildings, London, E.C., to whom tenders by noon Sept. 29

Carbons.

The Victorian Government Railways Dept. requires tenders by 11 a.m. on Nov. 1 for the supply of 50,000 Yellow Flame Arc Carbons. (Contract No. 30,405.) Specification, &c., from the Victorian Railway Commissioners, Spencer-street, Melbourne.

Tramway Track Work, Material, &c.

The Madrid "Gaceta" of Aug. 4 notifies that tenders will be opened on Oct. 7 for the Construction and Working of an Electric Tramway in Barcelona, an extension to Sans of the lines of the Cia Nacional de Tranvias de Barcelona, which holds an option on the proposed concession. Minimum rolling stock required will be Two Motor Tramcars and Two Trailers.

Tenders will be opened on Oct. 11 for Construction and Working an Electric Tramway in Madrid, from the Calle de Alcala to the Calle de Diego de Leon. Minimum rolling stock Four Cars.

In both cases construction work must be commenced within three months and completed within 10 months and a year respectively from dates of concession. An option on the concession is held by the Sociedad Tranvia del Este, Madrid.

Cooling Tower.

Gisborne (N.Z.) Council require tenders by noon Oct. 2 for the supply and erection of a Cooling Tower at the municipal electric power station. Specification from the borough offices, or from Mr. E. J. Fenn, consulting engineer, Auckland (N.Z.).

TENDERS RECEIVED AND ACCEPTED.

Portsmouth.—The following tenders have been accepted by the Corporation for supplies to the tramway department:—

Fleming, Birkby & Goodall, crossovers, terminal clamps, splicing ears, &c., and trolley wheel bushes; F. Smith & Co., span and guard wire; Engineering Supplies Co., plain ears, frogs and 60 span section insulators, and controller fingers; Gabriel & Co., brake ratchets and lifeguard springs; F. W. Rowlands & Co., car gear wheels and pinions; West Bromwich Spring Co., springs and spring washers; Wm. Brunton & Son, armature binding wire; Smith Bros. & Hill, sand tubes, spring washers, motor springs, &c.; Anti-Attrition Metal Co., bushed and unbushed trolley wheels, axle box bearings and key plates; Bromell Patents Co., rubber and Blackley tape; H. Clarke & Co., fuller board and white tape; P. R. Jackson & Co., armature coils; Micanite & Insulators Co., mica, mica cloth, insulation sleeves and commutator rings; British Thomson-Houston Co., incandescent lamps; Mica Mfg. Co., oiled cloth, mica paper and micanite; British Westinghouse Electric & Mfg. Co., fibre sheet and mica; Carr Bros. (Ltd.), black adhesive tape; G. P. Wilson & Son, brake blocks, £6. 15s. per ton; Middleton Bros., asbestos millboard, black round asbestos packing, rubber insertion and asbestos insertion, pumice blocks, manganese compound, petroleum jelly, black and red lead, resin, paraffin, shellac, soda, &c.; Sutcliffe Bros., asbestos fibre; Newton & Nicholson, Taylor's rings; Thermofelt (Ltd.), asbestos composition, asbestos cord, jointing insertion and greased hemp packing; Stringer Bros., bolts and nuts, washers, rivets and stock hoop iron; W. Atkins & Co., tool steel and files and rasps; Pilkington Bros., car side and end glasses and sheet glass; T. H. Harvey, creosote oil and pitch; J. L. Duguid & Co., metal polish; Engelbert & Co., motor gear grease; W. B. Dick & Co., motor bearing, engine, cylinder and cleaning oils.

Walsall.—The Tramways Committee has accepted the tender of J. Parkinson & Son for supplying a 6½ in. centre lathe for £77. 15s., plus four-jawed chuck at cost price.

West Hartlepool.—The Council have accepted the tender of W. Brazell for the extension of the Seaton Carew power station and that of the New Conveyor Co. for a coal and ash conveyor.

Belfast.—For the supply and erection of two electric lifts at the sanatorium the tender of Craig & Paton (at £270) has been accepted.

Salford.—The following tenders have been accepted by the Corporation:—

Hadfields Limited, manganese steel crossings, £220; Lea Recorder Co., one steam recorder (including erection), £134; Royles Limited, one feed-water heater, £115.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Bradford.—The electricity department's accounts for the year ended March 31 show gross capital expenditure £990,865 (increase £56,581), of which £521,259 is outstanding.

Revenue was £167,177 (compared with £147,584 in previous year), and working expenses were £87,064 (£71,587). Interest required £29,049 (£24,491) and sinking fund £35,075 (£32,581), leaving net profit £15,989 (£18,956). Average price obtained was 1·110d (1·154d.) per unit, and total costs were 0·544d (0·520d.), or 0·997d (0·995d.) including capital charges. Units sold were 33,905,136 (28,743,718).

Capital expenditure on the tramways is £1,048,831 (increase £2,263), of which £42,562 has been redeemed. Total revenue was £341,623 (compared with £329,888), including motor garage, Bowling Hill depot, rail less traction and parcels, but excluding rents of property; and working expenses were £254,951 (£246,095). After providing for insurance, compensations, interest, rent of leased lines, repayment of loans and contribution to sinking fund, the net profit was £29,771 (£42,442), of which £4,536 (£14,469) has been transferred to reserve or renewals fund and £25,000 (£10,000) applied to relief of rates. Average fare charged per mile was 0·536d (as in previous year). Average total revenue per car mile excluding rents of property was 13·209d (12·425d.), and working expenses, including power but not parcels, Bowling Hill depot, rail-less traction and motor garage, were 9·425d. (8·774d.). Rail-less traction revenue was £8,779 (£4,315)—0·226d (5·830d.) per car mile, including interest and sinking fund. Passengers carried were 74,082,612 (70,077,271) and car miles run 5,877,192 (6,134,057), in addition to rail-less car miles—322,180 (177,654).

Mr. C. J. Spencer (general manager) says in his report £8,338 was paid to dependents of reservists and £4,360 to sailors' families. Permanent-way work showed a decrease of nearly £2,000, due to scarcity of material and labour. Women employed as conductresses number 49. The Committee decided that the women be dispensed with when sufficient male labour can be obtained. Parcels carried were 804,870 (decrease 82,244).

Salford.—The accounts of the tramways department for the year ended March 31 show total capital expenditure £713,263, of which £213,131 has been repaid and £92,070 is in sinking fund.

Revenue was £275,920 (compared with £202,454 in previous year), working expenses were £169,015, and allowances to employés in H.M. Forces required £13,135, gross profit was £92,868 (£85,706), and net profit £18,473 (£32,264). Passengers carried were 56,458,206 (543,343,908), car miles run 5,495,295 (5,828,232). Earnings per car-mile were 11·807d (10·577d.), and working expenses, including power were 7·42d. Units used by Salford cars were 9,724,788, the consumption per car mile being 1·793 units (increase 0·126). The length of tramway worked by the Corporation is 76 miles, and cars in stock number 210, besides tower wagons, salt wagons, lorries, &c.

South Shields.—The Corporation electric supply department's accounts for the year ended March 31 show gross capital expenditure £225,099 (increase £8,829), of which £99,091 is outstanding.

Revenue was £30,738 (compared with £34,482 in previous year), total costs were £17,223 (£17,534), leaving gross profit £13,515 (£16,948). Interest and sinking funds required £14,543 (£12,913), and other expenditure met out of net revenue account was £853 (£788), the net result being a deficit of £1,881 (compared with £3,248 profit). Total costs were 0·91d. (0·85d.) per kelvin. Kelvins sold were 4,423,154 (4,665,380). Maximum load was 2,247 kw. (2,503 kw.) and load factor 22·5. (21·2) per cent.

The engineer (Mr. H. S. Ellis) says in his report the reduction of revenue is due to restrictions of lighting and of the hours of licensed premises, the earlier closing of shops, economy on the part of private consumers, and the reduction of the number of tramcars available for service. The prices of current had not been raised. The consumption of current for power purposes increased 14·4 per cent. and for heating 34 per cent. The sales department, established November, 1915, sold apparatus representing an addition of 58 kw. to the connections.

Tunbridge Wells.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £101,042 (increase £658). Stock extinguished amounts to £34,038 and loans repaid to £11,243.

Revenue was £15,824 and gross profit £7,214, and after providing for interest, dividends on stock and redemption, £598 was carried to appropriation account, into which £1,678 was brought from previous year, and after providing for income tax £359, provisional order expenses £185, cooling tower £943, meters £311, sub-stations £214 and maintenance and improvement of machinery £2,010, there remained £1,747 to carry forward. Units generated were 1,475,679 (compared with 1,802,939) and sold 1,095,874 (1,334,729). Total maximum supply demanded was 775 kw. (987 kw.).

Warrington.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £132,498 (increase £4,698), of which £14,174 has been redeemed.

Revenue was £34,403 (compared with £25,419 in previous year), total costs were £24,213 (£16,858), gross profit was £10,189 (£8,561). Interest required £3,000 (£2,926), and sinking fund £4,895 (£4,184), and net profit was £2,394 (£1,818). Maximum load was 2,702 kw. (2,351 kw.)

Mr. F. V. L. Mathias (borough electrical engineer) says in his report

the sales department has been very active installing motors, the turnover being £4,540, by far the largest yet attained. Units generated were 6,630,060 (increase 1,100,161), and sold 5,129,214, or 4,578,294 (3,743,197) excluding tramways. Total costs per unit sold were 0·782d. (0·729d.)

Yarmouth.—The Corporation tramway accounts for the year ended March 31 show gross capital expenditure £126,452 (no increase), of which £112,200 is outstanding.

Revenue was £16,508 (compared with £22,367 in previous year), and working expenses were £13,758 (£16,660). Interest required £4,504 (£4,158), and sinking fund £2,951 (£2,883), the net result being a deficit of £4,704 (£1,294). Passengers carried were 3,138,724 (4,236,424) car-miles run 544,540 (677,153), and units used 503,598 (708,756). Average total revenue per car-mile was 7·27d. (7·927d.), and working expenses, including power, were 6·063d. (5·905d.).

COMPANIES' MEETINGS AND REPORTS.

BRITISH EMPIRE TRUST CO. (LTD.)—At the meeting last week the chairman's statement went at length into the position and prospects of the British Columbia Electric Railway, the Toronto Power Co. and other enterprises with which the trust is associated. Owing to conditions arising from the war, the efforts of the directors had been concentrated on protecting the company from loss rather than on seeking to secure profits. In regard to the British Columbia Electric Railway, the results of the operations were still very seriously affected by the depression prevailing in British Columbia, which was mainly the result of the war. During the first seven months of its financial year (from July, 1915, to January, 1916) it showed a decrease in net earnings of $598,790, compared with the same period of the previous year. Since the early part of the present year, however, the returns showed a decided improvement.

DUMBARTON BURGH & COUNTY TRAMWAYS CO. (LTD.)—Mr. George Balfour, who presided at the recent meeting, stated that the total receipts for the year amounted to £26,041, an increase of £2,737. Expenses had increased by £2,052, due to abnormal cost of material and labour. The report was adopted, and a dividend on the ordinary shares of 1½ per cent. (less tax) agreed to.

DUNDEE, BROUGHTY FERRY & DISTRICT TRAMWAYS CO. (LTD.)—The directors' report states that the profit (including £109 brought forward), after providing for interest on debenture stock and £785 in redemption of debenture stock, amounts to £2,595. After payment of an interim dividend on the preference shares at rate of 6 per cent. per annum, the balance is £1,344. The directors propose a final dividend on the preference shares at rate of 6 per cent. per annum, which will absorb £1,178, and to carry forward £165.

HONG KONG TRAMWAYS CO.—The net profit for 1915 (after writing £6,625 off for depreciation and including £6,897 brought forward) is £18,071. A dividend of 12 per cent. has been declared, and a further £2,000 has been written off the cost of the tramway undertaking, leaving £6,321 to be carried forward.

MANAOS TRAMWAYS & LIGHT CO. (LTD.)—The report for the year to April 30 states that the adverse influences which caused a decrease in the earnings during the preceding year have still been operative, although to a somewhat lesser extent, and indications of better trading conditions in the Amazon valley are not lacking. The depreciation of currency resulted in a loss of £13,093 on remittances from Manaos during the year. The gross earnings were £110,524 (against £110,420), operating expenses £76,172 (against £82,240), and net operating revenue increased from £26,180 to £34,352. After providing for debenture interest, sinking fund, interest on loan, London office expenses, &c., £1,661 is carried forward. The indebtedness of the State Government has been slightly reduced, and every effort is being made with a view to avoiding a further accumulation of unpaid bills for public lighting.

MANILA ELECTRIC RAILROAD LIGHTING CORPN. (LTD.)—The gross earnings for 1915 were $1,494,787, a decrease from previous year of $107,213; operating expenses and taxes were $762,958, decrease $55,455; net earnings were $731,828, decrease $51,757. Interest charges were $264,975 and sinking fund requirements $41,500, leaving surplus of $425,353. From the available surplus of $345,363, four dividends of 1½ per cent. (making 6 per cent. for year) were paid, leaving $45,353, which was transferred to surplus account. In the railway department the earnings decreased $107,801, and operating expenses increased $5,045; in the electrical department the earnings increased $22,138, and operating expenses decreased $42,568.

METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)—The report of the Shareholders' Committee, which was appointed at the meeting in March last, has been issued. The members state that they examined into the affairs of the company and the past and future conduct of the business. They held upwards of 30 meetings and interviewed all the present directors except Mr. Moncrieff, also the three directors who had retired, and Mr. Highfield and the company's other chief officials. They had also had placed before them numerous reports and minutes, and in particular the reports recently prepared at the instance of the board by Sir John Snell, consulting electrical engineer, and by Messrs. Jackson, Pixley & Co., chartered accountants. The Committee, who called in Mr. Charles P. Sparks and Mr. David H. Allen, C.A. (of Messrs. Harris, Allen & Co.), to assist them, state that, "Having concluded our inquiry and having carefully considered the evidence, it seemed to us desirable that, possible, some arrangement with the present board should be come to, so as to avoid the necessity of publishing a report dealing with various matters intimately connected with the company's business and affairs, which if made public might seriously interfere with the trading and future prosperity of the company. With this end in view we approached the directors, and are pleased to report that an arrangement has been arrived at which we believe will be satisfactory to all sections of shareholders and ensure harmony on the board." Mr. Harrison Cripps has placed his resignation of the chairmanship in the hands of the board. Mr. Andrew Wilson Tait, a member of Messrs. Geo. A. Touche & Co., and Mr. Geo. Balfour (of Messrs. Balfour, Beatty & Co.), and Mr. George Verity, chairman of Verity's Limited, whom we have suggested as suitable persons (the first named as chairman), will be added to the board, the number of which is for the present at all events to be limited to seven. The board as reconstituted will be as follows: Mr. Andrew Wilson Tait (chairman), Mr. George Balfour, Mr. Geoffrey Blackwell, Mr. W. Harrison Cripps, Right Hon. F. Leverton Harris, M.P., Mr. J. Carr Saunders and Mr. George Verity. "In view of this arrangement, we feel that no useful purpose can be served by referring to the matters of controversy raised at the last meeting of the shareholders. At the same time we feel it right to express regret that personal imputations should have been made on that occasion which in our opinion were not justified. We also wish to record our opinion that the services of Mr. Highfield, as engineer, have been most valuable to the company and should be retained. We would further add that in our opinion the board should direct their special attention to the energetic development of business in the western area. Under all the circumstances, we confidently recommend the shareholders to accept the arrangement indicated above, and if desired we shall be prepared to place before the new board such information as we have acquired, including the reports which have been put before us, and to give to the company any other assistance in our power." The report is signed by Messrs. Roger Gregory (chairman), R. Melvill Beachcroft and W. S. Poole.

UNITED ELECTRIC CAR CO. (LTD.)—The report for the year ended June 30 states that, after charging £5,229 for depreciation (including £4,500 added to reserve), the profit is £6,563, to which is added £4,707 from last year, making a total of £11,269. 13s. 6d. Deducting preference dividend for six months ended Dec. 31, 1915 (£3,000) the available balance is £8,269. 13s. 6d. The directors recommend payment of the preference dividend (less tax) for the half-year ended June 30 (£3,000), leaving £5,269. 13s. 6d. to carry forward.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.)—The report for 1915 states that the year's business has resulted in a profit of £729,661, which, with £106,446 brought forward, makes a total of £845,649. After providing for interest on debentures (£232,556) and for depreciation, income tax, excess profits duty, &c. (£274,024), the balance is £339,068. The directors declared a dividend in December last at rate of 6 per cent. per annum (less tax) for the 10 months ended Feb. 28, 1915, on the preference shares, and a further dividend on the preference shares also at rate of 6 per cent. per annum for the 10 months ended Dec. 31, 1915, was declared in May. These dividends have absorbed £177,499, leaving £161,568 to be carried forward. The second large turbo-generator at the Brakpan power station has been brought into commission, and the whole of the plant for all the power stations of the combined undertakings is now installed.

NEW COMPANIES, MORTGAGES & CHARGES.

NEW COMPANIES.

ALUMINIUM SOLDER CO. (LTD.) (144,725.)—Reg. Aug. 30, capital £150 in £1 shares, to take over the business of manufacturers of aluminium and other solders, dealers in metals and alloys, &c., carried on as the "Aluminium Solder Co." Private company. First directors are W. H. M. Burgess, A. Lees and H. F. Galpin, jun. Reg. office, 40, Glasshouse street, Piccadilly, W.

BRITISH UTILITIES (LTD.) (144,767.)—Reg. Sept. 5, capital £1,000 in £1 shares, to carry on the business of electricians, mechanical engineers and manufacturers, manufacturers and constructors of articles or things of general or domestic utility. Private company. Reg. office, 48, South Park-road, Wimbledon.

INSULATED CAP & RIVET CO. (LTD.) (144,808.)—Reg. Sept. 8, capital £5,000 in £1 shares, to carry on the business of engineers, founders, machinists, manufacturers and patentees of caps for electric lamps and rivets for all purposes, &c. Private company. First directors are W. L. T. Arkwright and W. F. Mohr (provisional directors). Reg. office, Caxton House, Westminster.

NEW UNION ELECTRIC CO. (LTD.) (144,775.)—Reg. Sept. 5, capital £2,950 in £1 shares (1,667 founders' and 1,283 ordinary), to take over the business carried on as the Union Electric Co. (Ltd.), to carry on the business of manufacturers of and dealers in electric lamps, contractors for the construction, erection and maintenance of electric lighting, central and other stations, electricians, electrical, mechanical, metallurgical and chemical engineers, &c., and to adopt an agreement with A. V. Tomlinson, R. Belfield and G. A. Knapton. Private company. First directors are A. V. Tomlinson, R. Belfield and G. A. Knapton (life directors). Secretary, G. A. Knapton. Reg. office, 53-57, Park-street, Southwark, S.E.

STEEL'S ELECTRIC & ENGINEERING CO. (LTD.) (144,969).—Reg. Aug. 23, capital £3,000 in £1 shares, to take over the business carried on as Steel Bros., and to carry on the business of electricians, electrical and mechanical engineers, contractors and manufacturers of and dealers in all apparatus used in connection with the generation, distribution and supply of electricity, steam, gas, or other power, manufacturers and repairers of and dealers in motor cars, &c. Private company. Secretary (pro tem.), E. Lee. Reg. office: 206, East India Dock-road, E.

S. G. SHEARD & CO. (LTD.) (144,750).—Reg. Sept. 1, capital £1,000 in £1 shares (500 preference), to carry on the business of electrical mechanical and motor engineers and contractors, manufacturers of agricultural implements and machinery, &c. Private company. Reg. office, 158a, Blythe-road, West Kensington, W.

MORTGAGES AND CHARGES.

ILFORD DRY BATTERY CO. (LTD.)—Particulars of £1,250 debentures, created Aug. 23, 1916, have been filed, whole amount being now issued. Property charged, company's undertaking and property, present and future. No trustees.

CITY NOTES.

MEMORANDA (Sept. 13).—Bank rate 6 per cent. (since July 13, 1916). Consols 60¼. Stocks and Shares Ticket Day, Sept. 28. Pay Day, Sept. 29. Price of silver, 32⅛.

BROWETT, LINDLEY & CO. (LTD.)—An interim dividend at the rate of 6 per cent. per annum has been declared.

CANADIAN GENERAL ELECTRIC CO. (LTD.)—The directors have declared a quarterly dividend of 1¾ per cent. for the three months to the 30th inst. (being at rate of 7 per cent. per annum) on the common stock.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)—The directors have declared an interim dividend for the quarter ended June 30 last of 4s. per share (tax free), payable on the 14th prox. The share register will be closed from Oct. 6 to 13 inclusive.

METAL PRICES.

Messrs. J. B. Cookson & Sons, 132, Upper Thames-street, London, E.C., quote under date Sept. 12, the following as the present basic prices of—

New Metals	per lb.
Solid Drawn Brass Tubes	15½d.
Solid Drawn Copper Tubes	16½d.
Brazed Copper Tubes	18½d.
Brazed Brass Tubes	17½d.
Brass Wire	14½d.
Copper Wire	13½d.
Rolled Brass	14½d.
Brass Sheets	13½d.

	Per ton.
Copper Sheets	£136 0 0
Spelter	52 0 0

	Per ton.
English Lead	£30 15 0
Antimony	Nominal.
Old Metals	**Per ton.**
Clean Copper Scrap	£98 0 0
Clean Brass Scrap	62 0 0
Braziery Copper Scrap	86 0 0
Old Lead	26 10 0
Old Zinc	35 0 0
Hollow Pewter	120 0 0
Brazed Pewter	80 0 0
Gun Metal	82 0 0

Mr. A. Joseph, Eastcheap, Liverpool, Scrap Leader, S.E., quotes under date Sept. 12, the following approximate prices of Scrap Metals:—

	Per ton.
Aluminium Cuttings	£110 0 0
Clean Mixed Brass	64 0 0
Clean Copper	102 0 0
Brassery Copper	93 0 0
Gun Metal	83 0 0

	Per ton.
Old Lead	£3 15. under English lead price
Old Zinc	36 10 0
Hollow Pewter	130 0 0
Brazed Brass Pewter	90 0 0

Mr. Joseph will supply either of the following prices for Plumber's Solder (in bar or ingot): Best, Commercial Tinman's Solder, £97. Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

We give below the latest prices at which actual transactions took place on or before Tuesday, Sept. 12.

Shrs.	Last Dividend	Name.	Price Tues., Sept. 12	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
5	8%	Bournemouth & Poole Elec. Ord.	6⅜	6 5 6	Feb, Aug
5	7%	Do. 4½% Cum. Pref.	5⅞	5 19 2	Feb, Aug
10	6%	Do. 4% Cum. 2nd Pref.	74	4 14 8	Jan, Dec
		Bromley & Addiscombe Ord.	73	6 3 3	Apl, Oct
		Do. Pref.	1⅜	6 14 8	Mar, Aug
1	4½%	Central Elec. Board 4½% Deb. Stk.	6⅜	5 10 11	Mar, Sept
1	4½%	Chelsea Elec. Supply & Deb. Stk.	4⅛	5 4 1	Jan, July
5	7%	Crompton Parkinson Ltd. Ord.	73	6 3 3	Apl, Oct
5	4½%	Do. 4½% Cum. Pref.	1⅜	6 14 8	Mar, Aug
1	4½%	Do. 4½% Deb. Stk.	6⅜	5 10 11	Mar, Sept
1	4½%	Do. 4½% Deb. Stk. (1903-5)	4⅛	5 4 1	Jan, July
5	7%	Do. 4½% Cum. Pref.	73	6 3 3	Apl, Oct
5	4½%	Do. 4½% Cum. Pref.	1⅜	6 14 8	Mar, Aug
1	4½%	Do. 4½% Deb. Stk.	6⅜	5 10 11	Mar, Sept
1	4½%	Do. 4½% Deb. Stk. (1903-5)	4⅛	5 4 1	Jan, July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	86	5 16 3	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	80¼	7 9 6	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	72	5 11 1	.. ..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	.. ..
St.	4½%	Do. 4½% Pref.	82¼	5 9 1	Jan, July
St.	4%	Do. 4% Deb. St.	76	5 5 3	Jan, July
St.	4%	City & S. London Deb.	74¼	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70¼	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord. †	2⅛	5 14 3	Jan, July
St.	4%	Do. 4% Pref.	65¼	6 1 8	Mar, Sept
St.	4%	Do. 4% Deb.	75¾	4 19 3	Jan, July
St.	1%	Metropolitan Ry. Com. Ord.	24¼	4 0 7	Feb, Aug
St.	3½%	Do. 3½% Pref.	62½	5 11 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	60½	5 16 6	Feb, Aug
St.	3½%	Do. 3½% A Debs.	66¼	5 5 11	Jan, July
St.	3½%	Do. 3½% Debs.	68¼	5 2 7	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18⅛	.. ..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75¼	5 6 4	May, Nov
St.	4½%	Do. 4½ First Pref.	73	6 3 3	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	109	5 10 1	Jan, July
St.	4%	Do. 4% Debs.	73	5 9 7	Jan, July
St.	4%	Do. 4% Debs. (1903-5)	75	5 6 8	Jan, July
St.	4%	Do. 4% Guar. Stock	70⅛	5 14 2	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	3⅛	4 18 0	Apl, Oct
1	6%	Do. 6% Pref.	1⅛	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅜	5 6 8	Mar
100	5%	Do. Prior Lien Debs.	93½	5 6 11	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12⅝	6 18 7	Aug, Feb
⅝	3⅓	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan, July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	⅞	6 8 0	Mar, Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2⅛	5 17 1	April
100	6%	Do. 6% Prior Lien Debs.	102½	5 17 1	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	67½	5 18 4	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12¾	8 1 6	Jan, July
5	5%	Do. 5% Pref.	4¼	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	June, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	⅞	7 2 3	Sept.
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	¼	.. ..	Feb, Aug
St.	4%	Do. 4% Deb.	59¾	6 13 11	Jun, Dec
1	7½%	Elec. Construction Ord.	⅝	8 5 6	May
1	7%	Do. 7% Cum. Pref.	1	7 0 0	Jan, July
St.	4%	Do. 4% Debs.	68	5 17 8	Jan, July
10	10%	General Electric Ord.	14¾	6 19 2	July
10	6%	Do. 6% Pref.	10⅜	5 19 3	June, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	16⅛	5 18 1	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4	5 12 6	.. ..
St.	4½%	Do. 4½% Db.	88½	5 1 8	Jun, Dec
10	10%	India Rubber, G.P. &c., Ord.	11⅜	8 9 4	Feb, Aug
10	5%	Do. Pref.	7¼	6 7 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39½	6 2 8	Mar, July
100	4%	Do. 4% Debs.	95¼	4 4 1	Jan, July
1	7½%	Vickers Ord.	1⅛	4 0 0	May, Aug
1	6½	Do. 5% Pref.	⅞	5 10 4	May, Aug
St.	4%	Do. 1st Debs.	81¼	4 18 3	June, Dec
100	4½%	Do. 4½% 2nd Debs.	99¼	4 10 8	June, Dec
St.	4½%	Williams & Robinson B. Cm. Pref.	40	10 6 3	.. ..
St.	4	Do. 1st Mt. Deb. St.	56¾	7 1 0	.. ..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	102	5 17 7	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	22⅛	6 14 5	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	71¾	5 11 11	Ja. Ap. Jly.O
1	5%	Cuba Submarine Ord.	8½	6 0 9	May, Nov
10	10%	Do. 10% Pref.	15	6 13 4	.. ..
5	5/0	Direct Spanish 10% Pref.	7¼	6 13 4	.. ..
10	4%	Direct United States	6¾	6 0 9	Ja.Ap.Jly.O
St.	8	Eastern Tel. Co. Ord.	145	5 10 4	Ja,My,Jly,O
St.	3	Do. 3% Pref.	66¾	5 5 10	Ja.My,Jly,O
St.	4	Do. 4% Deb.	79½	5 0 11	May, Nov
St.	4	Eastern Extension Tel. Co., 4% Debs.	78	5 2 7	Feb, Aug
10	..	Do. Ord.	14⅞	5 9 10	Ja.Ap.Jly.O
10	22	Gt. Northern Tel. Co. With Coup. 11	41¾	5 5 4	Ja. My. Jly
25	13	Indo-European	49¼	6 12 0	May, Nov
1	1½%	Marconi's Wireless Tel. Co.	3⅜	3 3 4	April
1	..	Do. Pref.	2⅜	2 14 0	July
1	1	West India & Panama Ord.	1⅛	9 0 3	May, Nov
1	6%	Do. 1st Pref.	8	7 10 0	May, Nov
1	..	Western Telegraph Co.	15⅛	5 6 3	Mr, Jly, O, Dec
10	4	Do. 4% Debs. St.	77	5 3 11	June, Dec
10	4½	Western Union Mexican Bds.	99¾	4 10 10	May, Nov
		Telephones.			
1	7½	Mackie Wilson Telegh. Ord.	8⅜	7 13 7	Nov
1	10%	Oriental Telephone Ord.	2⅛	4 18 6	Apl, Oct
10	4	Do. Do. Pref.	79	5 1 3	Jan, July
10	4½	Telegraph Constr. & Maint. Co. Deb. St.	83	5 8 5	Jan, July
5	6	United Indep. Pfd. Ord.	6⅜	5 17 5	Apl, Oct
5	5	Do. Cum. Pref.	4⅜	5 3 11	Jan, July
10	4½	Do. Deb.	85¾	5 5 3	Jan, July
		Financial and Investment.			
10	5%	Canada Trust & Trust	12⅝	4 13 8	Sp,Dc,Mr,Jn
100	5%	Do. 5% Pref.	10¼	5 12 7	Sp,Dc,Mr,Jn
100	6%	Mexican Light & Power Co. Common	85¾	5 17 6	Ja,Apl,Jly,O
10	4%	Do. 5% Pref.	70	5 14 3	Ja,Apl,Jly,O
100	10%	Ordinary Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, &c.			
5	5%	Anglo Argentine Tramways Co. 6% Pref.	4⅜	6 1 6	Mar, Sept
5	5%	Do. Ord.	94¼	5 5 10	Jun, Dec
100	6%	Bombay E. S. & T. Co. 6% Pref.	10⅜	5 15 8	.. ..
10	4½%	Do. 4½% Debs.	83	5 8 5	Jan, July
5	5%	Calcutta Elec. Supply Corp. Ord.	6⅜	7 1 2	May, Nov.
5	5%	Do. 5% Pref.	4⅛	5 15 1	Mar, Sept.

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 2,001. [No. 25. Vol. LXXVII.] FRIDAY, SEPTEMBER 22, 1916. PRICE SIXPENCE (by post, 7d.). *Abroad 9d., or 20 cents, or 1fr., or 90pf.*

CONTENTS OF THE CURRENT NUMBER.

NOTES	897
Arrangements for the Week	899
Some Characteristic Curves of a Poulsen-Arc Generator. By N. W. McLachlan, B.Sc. Eng., A.M.I.E.E. Illustrated.—*Concluded*	900
Limit Gauges. By R. T. Glazebrook, C.B., F.R.S.	901
The Air-Gap Field of the Polyphase Induction Motor. By F. T. Chapman, D.Sc. Illustrated.—*Continued*	904
The Laws of Variation of Resistance with Voltage at a Rectifying Contact of Two Solid Conductors, with Applications to the Electric Wave Detector. By D. Owen, B.A., B.Sc. Illus.	910
Fuel Economy. Report of the British Association Committee. Illustrated	906
Crown Mines Hoist Installation. By F. L. Stone. Illustrated	913
FUEL ECONOMY	914
Electric Power Distribution. By Charles H. Merz	915
Fuel Economy on the North-East Coast as a Result of Electric Power Supply. By R. P. Sloan	917
Trade After the War.—*Discussion*	918
LEGAL INTELLIGENCE	919
Educational	920
The "Electrician" Commercial and Industrial Section	921–930

NOTES.

Ruses de Guerre.

THE publication of quaint items in connection with the war by each of the combatants must be regarded by some people as the work of official jokers who, knowing their own limited intelligence, promptly adopt it as the standard without first taking the trouble to inquire whether the average intelligence of their audience is greater than the standard which they have set up. Although to us the "Made in Germany" war news is grotesque, it may be that such news suits the German temperament well enough, and since it deceives nobody but themselves, no harm is done. Yet we find it difficult to imagine any country serving out "funnier" news than our own. It is impossible to conceive the German Press Büreau solemnly declaring that a British ship, made of wood, which brave German sailors had captured in the North Sea, was evidence of our lack of steel. An examination of the whole of the facts might conceivably show that the ship in question was built prior to the declaration of war, or that there were good reasons why wood should be used for the purpose. Impossible as it is to conceive anything so ridiculous of our enemies, it is, nevertheless, exactly what our own people expect of us. The official notices of the splendid achievement of one of our airmen in bringing down an enemy airship were marred in this way. Not only is it possible that the devilish contrivance was launched before war was declared, but it is equally possible that wood was the best material for its construction. Well do the Germans understand the art of structural design, and our engineers know it to their cost. As examples of fiction which may be compared with present-day war news may be mentioned Mark Twain's telescopic method of climbing Mont Blanc and Tartaran's experiences as a hunter of big game. In one case, however, it is called fiction and in the other a *ruse de guerre*.

SHORTLY after the declaration of war there appeared in the Press an unofficial announcement "from a reliable neutral source" to the effect that tram lines were being pulled up in the German towns in order that they could be used for the making of shells. To keep the ball rolling, we venture to lend our support to the opposite theory, namely, that our enemies have metals in abundance. As evidence we give the following from the last report of the Governor of the Panama Canal, an informative official document recently published by the United States Government :—

> The new jib was completed at the works of the contractor on April 15 (1915). On May 8th, the structural steel for the jib was shipped from Rotterdam on the steamship "Cornelius," was reloaded at New York and arrived at Colon on June 10, 1915. The second shipment, including the wire rope and mechanical parts, left Rotterdam in May and arrived at Colon June 18th. The final shipment, consisting of the electrical parts and the main engine crankshaft, arrived on the Isthmus on June 24, 1915.

In many respects this official news from a neutral source is remarkable. It shows that for partly executing one contract our enemies in 1915 were in a position to export steel sufficient for the making of upwards of an eighth of a million high-explosive shells, and that enemy artisans in sufficient numbers were available for the execution of civil contracts at a speed at least equal to that which obtained prior to the war. It shows that to complete a small contract three boat loads of German machinery left the port of Rotterdam for America during May and June of 1915. That we now have engines of war all the world knows, and none know better than our enemies. If it be true that fools profit by experience, none should know better than ourselves that lasting victories in war, in commerce and in diplomacy are not secured by prevarication. We should like to feel that our engineers could carry out civil contracts in their own way without let or hindrance, and we should like to feel that official news of a technical character was the work of technical men.

Inspecting and Viewing.

As long as we allow all and sundry to become inspectors and viewers of munitions we have no right to complain when we find the war is costing us six millions a day. Nor ought we to hold up our hands in horror when we discover that those to whom we have paid salaries commensurate with their attainments have been tempted and have fallen. That we—the people of Great Britain—who are primarily responsible for the lack of common sense shall not escape will be generally admitted when it is remembered that our punishment will be to pay in taxes the money we are now wasting. Mr. Justice Low's discovery that a Government Inspector is a person who does not inspect has been common knowledge in the engineering world for a long time, and there are many engineers who affirm that viewers are incompetent to "view." If we are content to employ as inspectors men who do not inspect, and as viewers men who cannot view; and if we expect to induce

able men to undertake this highly important work at the beggarly wage now offered, we deserve to pay far more for an article than it is worth, and what is more, we shall continue to pay more. No wonder "war is waste" when we pay our indispensables 30s. per week, and no wonder that many in receipt of such wages have to be dishonest in order to live when the purchasing power of a sovereign is down to 11s. Inspecting and viewing, as far as engineering is concerned, is work for our engineering institutions, and we believe that these institutions could still supply all the inspectors and viewers likely to be required during the war. We hope that the authority who declared that "war is waste" may live to learn that "peace is penury."

Limits and Limit Gauges.

Dr. R. T. Glazebrook's informative Paper on "Limit Gauges" before the British Association was well-timed. Many of our old-fashioned engineering firms are just beginning to appreciate the value in the works of the so-called "new" system of measurement. We venture to think that the system is very much older than many imagine. A generation or more ago it was customary for engine makers to allow from $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. "travel of gauge" for every 20 in. diameter of piston, the gauge being a polished steel rod of length equal to the diameter of the piston. The enormous amount of work that has been done at the National Physical Laboratory to ensure accuracy in the delicate limits is apparent from the Paper, and engineering firms would do well to avail themselves of the facilities provided by an Institution which they have been inclined to neglect in the past. We should like to see published a number of Papers devoted to gauges and gauge making. These should be entirely practical, and the work could with advantage be undertaken by the Ministry of Munitions. Although there is little likelihood of firms reverting to the two-foot rule method of measurement there is a two-fold danger to be faced. The first and most important matter is to get those in the works who talk glibly in thousandths to realise what one-thousandth means and to show them how to measure *accurately* to one-thousandth. The second is the fixing of limits suitable for the class of work in hand. Both these subjects are imperfectly understood not only by engineering firms and their employés, but also by those in high places. A further matter to which attention should be given is the abuse of the decimal system in the dimensioning of drawings. As an illustration may be given the dimensioning of a radius in a cored hole of a casting to three decimal places such as 0·125 in. when the draughtsman means an eighth of an inch. In works measurement an eighth of an inch is very different from 0·125 in.

Naval Preparedness and the Civilian Engineer.—An informative address on this subject was presented some time ago by Mr. F. J. Sprague before the Western Society of Engineers (of America), and is published in a recent issue of the "Journal." The address, besides showing the influence of the civilian engineer on naval efficiency, gives some interesting information respecting the British Navy that will be new to many of our readers.

Water-powers of the World.—According to Mr. D. B. Rushmore, it is estimated that the water-powers of the world represent about seven hundred million horse-power, this estimate being based on the assumption that the water-power per square mile is approximately 14 h.p. To this total Africa and North America each contribute 150,000,000 h.p., South America 100,000,000 h.p., Asia 225,000,000 h.p., Australia 10,000,000 h.p., and Europe 65,000,000 h.p. Approximate figures place the minimum water-power of the United States at 31,000,000 h.p. and the maximum at 56,000,000 h.p.

The Sheffield Electric Furnace.—The electric furnace continues to make rapid headway in Sheffield, and, according to the Sheffield "Daily Telegraph," the enterprising experiment of offering to the trade an electric furnace designed and erected by local experts is proving highly successful. The furnace referred to is of the Greaves-Etchell type, the construction of which has now been taken over by the Furnace Construction Co. (Sheffield), Ltd. It appears that a dozen of these furnaces are in course of erection or on order, and a number of steel makers are said to be negotiating for the adoption of this system.

Adjustable Electric Pocket Lamps.—A new form of electric portable lamp, the light from which is adjustable, is being brought out in Germany. A small spiral resistance in series with the lamp and switch is mounted above the battery. The resistance can be readily varied by the motion of a small knob at the side of the case, the brightness of the lamp being thus altered within the limits of maximum intensity and a dull red glow. This enables current to be economised when only a small amount of light is needed, prolonging the life of the lamp and battery. The resistance is also useful in preventing the tendency to over-run the lamp unduly when a new battery is substituted for the old one.

Small Power Wireless Installation.—The growth of the use of wireless telegraphy on vessels of small tonnage and the need of a moderate power installation for emergency uses on large vessels, has induced the Marconi Company to introduce a $\frac{1}{4}$ kw. installation, in which the whole of the transmitting apparatus, including the motor alternator, is mounted compactly in a wooden cabinet, 27 in. high, 26 in. wide and 17 in. deep when closed. The cabinet is divided into two portions, the larger portion containing the motor alternator and disc discharger, and the upper and smaller portion serving to hold the condenser primary inductance, aerial tuning inductance, earth arrester terminal and wave-shortening condenser.

Preparedness.—According to the "Iron Age," more than 30,000 manufacturing concerns in the United States, doing a business of over £20,000 a year, are being inventoried by the Committee of Industrial Preparedness of the United States Naval Consulting Board, to say nothing of smaller plants having equipment peculiarly adapted to the production of material for the fighting line. The committee reports that its plans for the instruction of manufacturers now, in time of peace, through annual educational orders, how to turn out munitions and other military and naval supplies when needed, will be incorporated into law. It likewise seems probable, it says, that legislation will soon be passed adopting the committee's measure for an industrial reserve, so that in time of war the skilled mechanic will be kept at home on the job where his services are most needed to feed the firing line.

Electrically-Operated Lock Machinery.—The new barge canal of New York State, which, when completed, will amount to 730 miles of waterway, with 57 locks, will have all its lock machinery, &c., worked by electric power. All the machinery used to work gates, valves and capstans is electrically driven. Power is supplied at 250 volts, continuous-current, from a power-house at each lock, except in a few cases where the locks are very near each other, and one power station is made to serve two locks. Current is generated for the most part by the waste water of the canal. The only alternating-current station is at the Crescent Dam, near Waterford, which supplies a series of five locks and two guard gates. Power is transmitted at 2,200 volts, three-phase, 40 cycles, to sub-stations at locks 3 and 5, where two 35 kw. induction motor-generator sets supply continuous current for working the lock motors.

Scientific Research in the United States and Japan.—In a recent number of the "General Electric Review" Dr. W. R. Whitney contributes a summary of the chief steps taken in America and in this country since the outbreak of war for the promotion of scientific and industrial research. Even before the war there were in the United States many institutions engaged in industrial research, and in 1914 the American

Association for the Advancement of Science appointed a committee to promote co-operation between industry and the universities. In March of the present year the Royal Canadian Institute inaugurated a bureau of scientific and industrial research, and the scheme on similar lines before the Commonwealth of Australia has been widely noticed. An interesting statement was made by Dr. Takamine on April 7th at the Chemists' Club in New York—namely, that the Japanese Government has now set apart a million dollars for a laboratory for physical and chemical research, and that the Emperor has contributed an additional $500,000.

Standardisation of Electric Service.—The procedure of local authorities in imposing regulations for electric supply varies greatly in the different States of America, and in some cases adequate engineering staff and funds are not available to carry out investigations and supervise the testing and registration of meters. The amount of tolerance allowed in meter testing is particularly variable. With a view to promoting uniformity of action, the Bureau of Standards has undertaken a study of the whole question, the results of which are summarised in " Bulletin " No. 56. Suggested ordinances for the regulation of electric service in (1) towns and small cities, (2) cities generally, and (3) larger cities are included. The practice of a number of States is summarised, and there is also a *résumé* of laws relating to accidents and safety provisions.

Recording X-Ray Spectrometer.—In an article in the " Physical Review," Mr. A. H. Compton describes a recording X-ray spectrometer, by means of which a continuous record can be obtained of the ionisation produced by a beam of X-rays reflected from a crystal as the angle of the crystal is varied. A spurious and irregular current in the ionisation chamber was investigated and found to be due to a slight radioactivity within the ionisation chamber. Methods are described whereby the effect of this radioactivity may be considerably reduced. The X-ray spectrum of tungsten was examined in some detail. In addition to the seven lines already known, an indication was found of six others, two of which are, however, somewhat uncertain. The wave-lengths of the different lines were carefully determined. The relative intensities of the different order reflections of the same line are proportional to the areas under the humps produced in the record by the spectrum line ; and the relative intensities of the first three orders in the spectrum from rock salt were determined by measuring these areas. The observed intensities of the different orders indicate that polarisation occurs when a beam of X-rays has been reflected by a crystal.

OBITUARY.

Killed in Action.—The following deaths in action or as the result of wounds are reported :—

Lieut. N. L. Sissons (East Yorks. Regt.), aged 21, who was killed on Sept. 9, was prior to the war in the service of Sissons Bros., Ltd. (Hull), of which company his father is a director.

Sec.-Lieut. Geoffrey Thompson (Indian Reserve of Officers), attached R.E., who was killed on Sept. 3, was 27 years of age. He was a B.Sc. of the McGill University, Montreal, and an assistant engineer to the Burmah Mining Co.

Lieut. Ithel Davies (Royal Welsh Fusiliers), aged 24, who has been killed in action, was a service student at Armstrong College, Newcastle, before the war.

Capt. Jas. Hendry (Royal Scots), who has died of wounds, was formerly a consulting engineer at Rochdale.

L.-Corp. F. Cressall (Royal Warwickshire Regt.), who has been killed, was a partner in the Cressall Electric Co., Birmingham.

Second-Lieut. David Malloch (R.E.), who has been accidentally killed at the front, was 30 years of age. He was apprenticed as an engineer with Messrs. M'Onie, of Govan, and was afterwards in the service of the Mirrlees-Watson Co.

PERSONAL.

Mr. T. Bowen, who recently resigned his position as electrical engineer to the Llandilo Urban Council, has been reappointed at an increase of salary.

It is announced that Mr. Thos. Worthington will retire from the position of director of the Commercial Intelligence Branch of the Board of Trade at the end of this month.

Capt. J. Muir Donaldson (K.R.R.), who has been three times wounded since January last, is now living at Chepstow Rise, Croydon. Prior to the war he was an electrical engineer, and filled responsible appointments with the British Thomson-Houston Co.

Mr. H. W. Leonard, who for the past six years has held an important position in the G.E.C. publicity department, has recently joined up for service with the London Electrical Engineers.

Mr. G. Weymouth, of G. Weymouth Ppty. (Ltd.), electrical engineers, Richmond (Victoria), is on his way to England to volunteer his services to the British Government during the continuance of the war.

In view of his impending departure from West Ham to take up the general managership of the Belfast Corporation tramways, consequent upon Mr. Andrew Nance, C.E., retiring from the active management of that undertaking, the Metropolitan Association of Electric Tramways Managers entertained Mr. J. S. D. Moffet to dinner at the Municipal and County Club, Whitehall Court, S.W., on Friday evening last, the 15th inst. In addition to the guest of the evening, there were also present Messrs. Ullmann (East Ham), Schofield (Leyton), chairman and vice-chairman respectively of the association, Bruce (L.C.C), Harvey (Ilford), Hammond (M.E.T.), Mackinnon (L.U.T.), Goodyer (hon. secretary of Croydon), Littler (ex-chairman West Ham Corporation tramways), Blain (L.G.O. Co.), Rooke, Scholey, Walton, Wyld, Myers, Beal, Compton, Robson (Southampton) and Chisholm. Letters expressing regret for inability to attend were received from Messrs. Fell and Slattery (L.C.C.), Williams (Erith), Murray (Walthamstow) and Mason (South Met.).

APPOINTMENTS VACANT AND FILLED.

A company transacting electrical insurance requires a qualified electrical engineer to inspect, test and report upon electrical units. *See an advertisement.*

A man is wanted to take charge of electrical equipment. *See advertisement.*

Mr. A. L. MacAulay, B.Sc., a graduate of the University of Tasmania, and a son of Prof. A. MacAulay, who holds the Chair of Mathematics and Physics at that university, has been appointed demonstrator in physics at the University of Melbourne.

Mr. J. S. Nierses, assistant electrical engineer, Punjab, has been appointed to assist the Electrical Inspector to Government, Punjab.

ARRANGEMENTS FOR THE WEEK.

TUESDAY, Sept. 26th.

Association of Supervising Electricians.

7.15 *p.m.* At St. Bride Institute, Bride-lane, E.C. Presidential Address by Mr. A. P. Trotter.

1st LONDON ENGINEER VOLUNTEERS.

Officer Commanding : Lieut.-Col. C. B. Clay, V.D.

Orders for the Week :- -

Officer for the Week.—Platoon Commander C. H. C. Bond.

Next for Duty.—Platoon Commander Hughes Hallett.

Monday, September 25th.—Technical for Platoon No. 9 at Regency-street. Squad and Platoon Drill, Platoon No. 10. Signalling Class. Recruits' Drill, 6.25 to 8.25.

Tuesday, September 26th.—Range Practice.

Wednesday, September 27th.—Lecture by W. Eyles, Esq. (late R.E.), 6.15, " Demolitions " Platoon Drill, Platoon No. 2. Range Practice.

Thursday, September 28th.—Instruction Class, 6.45. Platoon Drill, Platoon No. 6. Range Practice.

Friday, September 29th.—Technical for Platoon No. 10, Regency-street. Squad and Platoon Drill, No. 9. Signalling Class. Recruits' Drill, 6.25 to 8.25.

Saturday, September 30th.—General Parade, 2.45, Uniform. General Meeting of Corps, 5.30. The Commandant hopes to see a large attendance.

Sunday, October 1st.—Entrenching at Otford. Parade Victoria (S.E. & C. Railway) Booking Office 8.45 a.m. Uniform, haversacks, water bottles. Midday ration to be carried. Railway vouchers will be provided.

Musketry.—For all Companies, see Notice and Tables A and B at Headquarters.

Note.—Unless otherwise indicated, all Drills, &c., will take place at Headquarters.

SOME CHARACTERISTIC CURVES OF A POULSEN-ARC GENERATOR.*

(*Concluded from page* 885.)

BY N. W. MCLACHLAN, B.SC.ENG., A.M.I.E.E.

Efficiency of Arc as a Converter of Direct into Oscillatory Current

The efficiency of the arc itself (apart from the loss in the field coils)† as a converter of direct current into oscillatory current can be dealt with from two points of view: (1) The efficiency of the arc in respect of the oscillations of fundamental frequency, this being important in wireless telegraphy from the standpoint of radiation from an antenna; (2) the total efficiency, including the energy derived from the oscillations of fundamental frequency and the various harmonics.

Case 1.—With a given resistance, the efficiency of the arc at any particular frequency increases with the capacity in the shunt circuit.

The curves in Fig. 6 show the total efficiency‡ of the arc plotted against the frequency for a capacity of 0·00195 mfd., and various values of the resistance. As in Fig. 2, each curve has a maximum ordinate, showing that, with fixed capacity and resistance, there is a certain inductance and therefore frequency, for which the efficiency of the arc is a maximum. This maximum corresponds to the maximum power and current in the shunt circuit under the same conditions.

Fig. 7 shows the efficiency obtained with various resistances for different values of the frequency and a capacity of 0·00195 mfd.§ For resistances between 20 and 60 ohms the variation in efficiency is small but the shape of the curves is such that at a given frequency there is a certain value of the resistance for which the efficiency is a maximum. This resistance, however, is larger than that corresponding to maximum power in the shunt circuit—*i.e.*, the maximum efficiency is obtained when the shunt current is slightly less than that giving maximum power for the given capacity.

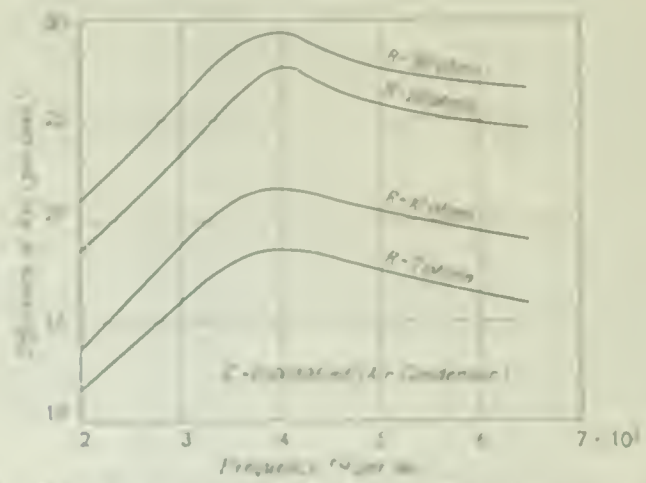


Fig. 6.—Curves showing the Total Efficiency of the Arc Plotted against the Frequency for Various Values of the Resistance in the Shunt Circuit.

It should be mentioned, however, that for given conditions the efficiency depends to a certain extent on the length of the arc, and it is sometimes possible (with large resistances and in general under conditions causing irregular burning), to vary this in such a way that the proportionate alteration in the current through the arc is greater than that in the shunt circuit. By increasing the arc length, with a capacity of 0·00195 mfd. and a resistance of about 50 ohms in circuit, the direct-current supplied to the generator diminished, the efficiency increased, but the burning was very noisy and irregular. Hence a very accurate determination of the efficiency in the case of a hand-operated arc is out of the question. The highest efficiency obtained for oscillations of fundamental frequency was approximately 38 per cent. (capacity 0·00024 mfd.), which indicates that a considerable amount of energy is wasted in heating the electrodes and in creating the arc itself by volatilisation of the copper and graphite, the latter material burning away very rapidly with large currents. Some approximate data bearing on these remarks are given in Table I.

Table I.—(*Moscicki Condensers*) *Oscillations of Fundamental Frequency with Normal Magnetic Blast.*

Capacity. (Microfarad.)	Maximum power absorbed in shunt circuit.* (Watts.)	Efficiency corresponding to maximum power. (Per cent.)	Power corresponding to maximum efficiency.* (Watts.)	Maximum efficiency of arc. (Per cent.)
0·00024	220	36	200	38
0·00368	175	26	160	30

Table II.—(*Moscicki Condensers*) *Oscillations of all Frequencies with Normal Magnetic Blast.*

Capacity. (Microfarad.)	Largest power absorbed in shunt circuit.* (Watts.)	Efficiency corresponding to largest power. (Per cent.)	Power corresponding to largest efficiency.* (Watts.)	Largest efficiency of arc. (Per cent.)
0·00024	280	39	268	42
0·00368	185†	28†	165†	31†

Case 2.—In Table II. approximate data are given with reference to the "total" efficiency of the arc. Since the power obtained from any harmonic depends on the square of the root-mean-square value thereof, the power obtained from the harmonics for capacities of 0·00091 mfd. and 0·00195 mfd. was small enough to be neglected. The figures in Table II., therefore, relate to the largest capacities only. It will be seen that the total power and efficiency are larger than the same quantities for oscillations of fundamental frequency, and that they increase with the capacity.

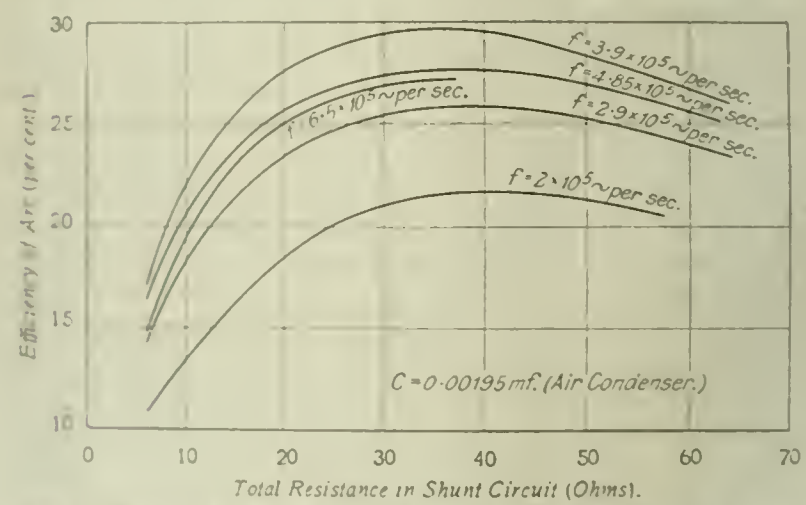


Fig. 7.—Curves showing the Total‡ Efficiency of the Arc Plotted against the Resistance in the Shunt Circuit for Different Values of the Frequency.

According to Barkhausen,§ to obtain the greatest possible efficiency, it is necessary for the voltage to rise very rapidly to the highest possible value after the arc has been extinguished. This is effected by water-cooling the copper electrode and removing the ionised gases quickly, the latter being accomplished by using a magnetic blast or a gas of high diffusion velocity, or both of these. Thus, if the copper electrode in these experiments had been water-cooled, the efficiency of the arc might have been greater than that indicated by the figures in Tables I. and II. and Figs. 6 and 7.

Conclusions.

1. With fixed capacity and frequency there is a certain resistance giving maximum power absorbed in the shunt circuit. There is also a certain resistance for which the efficiency of the arc is a maximum: but the resistance corresponding to maximum power is smaller than that corresponding to maximum efficiency.

2. With fixed capacity and fixed resistance in the shunt circuit

* Paper read before Section G of the British Association at Newcastle.

† The power supplied to the arc from the external circuit is a maximum when the direct current (assumed constant) $I = \frac{1}{2}E$, E being the supply voltage and R the resistance of the field windings—*i.e.*, when power supplied to arc = power expended in windings. The power factor of the arc, under working conditions, was measured by means of a wattmeter and obtaining the ratio watts/volt-amperes. This ratio was found to be practically unity. (See J. A. Fleming, "The Duddell Arc as a Means of Obtaining Continuous Electrical Oscillations," THE ELECTRICIAN, Vol. LIX., p. 914, 1907.)

‡ See footnote to Fig. 2.

§ Barkhausen, *loc. cit.*

* This does not include the loss in the condensers. The power absorbed in the shunt circuit and the efficiency of the arc will, therefore, be greater than the values given in Tables I. and II.

† These are maximum values.

‡ See footnote to Fig. 2.

§ See W. H. Eccles, "Wireless Telegraphy and Telephony," p. 201; also E. Rubmer, "Wireless Telephony," translated by J. Erskine Murray, p. 200.

‖ Efficiency based on oscillations of fundamental frequency or total oscillations. Both efficiencies occur with the same resistance.

there is a certain inductance, and therefore frequency, for which the power obtained from oscillations of fundamental frequency is a maximum. For capacities of limited value the total power from oscillations of all frequencies has a maximum value, but for capacities beyond a certain limit there does not appear to be any definite maximum value. The same conclusion applies in connection with the efficiency of the arc, but the resistance corresponding to maximum power is smaller than that corresponding to maximum efficiency.

3. With given resistance and frequency the power obtainable in the shunt circuit (both total power and that due to oscillations of fundamental frequency) and the efficiency of the arc increase with the capacity; but with larger capacities (of the order of 0·00368 mfd. and upwards) the burning, especially with small inductances, is apt to be irregular and noisy—*i.e.*, when the ratio L/C is small.

4. When the power absorbed in the shunt circuit is very small, the capacity being fixed and not exceeding a certain limit, there is a certain inductance, and therefore frequency, for which the shunt current is a maximum. For capacities beyond a certain limit there does not appear to be any definite maximum value. With diminished blast the maximum value of the shunt current occurs at a lower frequency than with normal blast, and it is possible to keep the shunt current approximately constant and the burning regular over a range of frequency by suitably varying the strength of the blast.

5. A diminution in the strength of the magnetic blast, as shown in Fig. 1, does not cause any appreciable alteration in the maximum power and maximum efficiency. The maximum power occurs at a lower frequency, and more power is obtainable at lower frequencies than with a stronger blast. It is possible to keep the power approximately constant and the burning regular over a range of frequency by suitably varying the strength of the blast.

6. A diminution in the strength of the magnetic blast does not cause any appreciable alteration in the fundamental frequency of the oscillations in the shunt circuit; but there is a tendency for the second harmonic to increase with capacities of 0·00368 mfd. and upwards.

7. The most prominent harmonic in the shunt circuit is the second, thereby showing the existence of an asymmetrical current wave. This harmonic for any given capacity increases with decrease in inductance, and therefore increase in frequency. For a given frequency the second harmonic increases with the capacity.

8. The insertion of resistance in the shunt circuit causes the burning to be less regular than it is without resistance. The irregularity of the burning increases with increase in the resistance. At the higher frequencies the burning is more irregular with diminished blast than with normal blast, but at the lower frequencies the reverse is the case. If the blast is diminished beyond a certain limit the oscillations are irregular.

The author's best thanks are due to Prof. E. W. Marchant, D.Sc., for reading over and criticising the MS.

APPENDIX.

Note on Condensers.

At the beginning of the Paper reference was made to the loss which occurs in the Moscicki condensers. That the loss in such condensers carrying large high-frequency currents is appreciable has been shown by Dr. Fleming and Mr. Dyke.* It is also shown, in the same Paper, that there is a loss with air condensers if the electrostatic force is large enough to cause appreciable ionisation of the air between the plates. In order to ascertain whether the loss in the Moscicki condensers had any considerable effect on the power obtained in the shunt circuit, an air condenser was arranged to have the same capacity at high frequencies as one of the Moscicki condensers. The capacity of the air condenser was adjusted until, with given inductance (comparatively large) and the least resistance possible in the shunt circuit, the same frequency was obtained with each condenser. A sandstone resistance (about 15 ohms) was connected in the shunt circuit and a series of readings of power and frequency taken with each condenser. It was found that the loss in the Moscicki condenser was sufficient to cause a diminution in the power expended in the shunt circuit (as found by voltmeter and ammeter readings), in some cases exceeding 15 per cent.; but this did not invalidate any of the conclusions given above. It was thought more satisfactory, however, to give results, as shown graphically in the diagrams, for an air condenser. The effect of the condenser loss was greatest when the current was largest for the given conditions—*i.e.*, when the sandstone resistance was not in circuit (*see* Fig. 5). In this case the voltage, and therefore the dielectric stress, especially at the lower frequencies, was greater than with resistance in circuit.

* "Proc." Phys. Soc., London, Vol. XXIII., p. 117, 1911; also The Electrician, Vol. LXVI., p. 658, 1911.

The capacity of each condenser was tested at 500 ∽ per second by Carey Forster's method, using a Campbell mutual standard and a Duddell vibration galvanometer. An air condenser was arranged so that the frequency of the oscillations in the shunt circuit was approximately the same as that obtained with a Moscicki condenser. The capacity of the air condenser was then measured at 500 ∽ per second, and its capacity at high frequencies assumed to be equal to this. From this value of the capacity and the frequency of the oscillations obtained with each condenser the capacity of the Moscicki condenser at high frequencies was calculated.

The capacities of the condensers were then found ballistically by charging up to about 210 volts, using 100 small secondary cells, and discharging through a ballistic galvanometer. The galvanometer was calibrated, using a Weston cadmium cell and a standard mica condenser having a capacity of 1 mfd.

As a check on the method, it was found that an air condenser 0·00175 mfd. had the same capacity when measured both ballistically and at 500 ∽ per second. The results of some of the experiments are given in Table A.

Table A.—*Moscicki Condenser.*

Capacity (microfarad).			Percentage difference between capacity at 500 ∽ per second and ballistically.
Ballistically.	500 ∽ per second.	$1{\cdot}75\times10$ ∽ per second.	
0·00354	0·00278	0·00272	21·5
0·00377	0·00295	0·00284	21·7

It is clear that the capacity found with alternating currents is much smaller than that found ballistically, the percentage decrease being almost the same in each case. There is, however, only a comparatively small difference between the capacities at 500 ∽ per second and $1{\cdot}75\times10^5$∽ per second. The decrease in the measured capacities is doubtless due to diminution in the dielectric coefficient which occurs with alternating currents of increasing frequency.*

One condenser, thought to be faulty, gave some remarkable results which are given in Table B.

Table B.—*Moscicki Condenser.*

Capacity (microfarad).			Percentage difference between capacity at 500∽ per second and ballistically.
Ballistically.	500∽ per second.	2×10^5∽ per second.	
0·00341	0·00185	0·00173	46

By allowing a short interval of time to elapse between breaking circuit with the charging cells, and making the galvanometer circuit, it was possible to obtain a rough estimate of the relative leak with various condensers. The rate of leak with the condenser in Table B was much larger than that with the other condensers, although the insulation resistance of each condenser, as found by an ohmmeter (using direct current), was "infinite."

The results in Table A confirm observations made some years ago by Dr. E. W. Marchant, using plate-glass condensers. The conditions were slightly different, since the condensers were charged up to about 9,400 volts by a Wimshurst machine, and then discharged through an oscillatory circuit having a free period of $\frac{1}{10000}$th second. Under these conditions the capacity was 15 per cent. less than that obtained ballistically.

LIMIT GAUGES.†

BY R. T. GLAZEBROOK, C.B., F.R.S.

The fundamental idea of limit gauging—that the dimensions of a piece of work should lie between certain definite values, and that the engineer should possess some means of measurement which would enable him readily to tell if this was the case—is probably quite old. Its importance has increased greatly of late, and during the past two years the growth has been enormous. The work of the Engineering Standards Committee in this, as in many other branches of engineering industry, has been of the utmost value, and it is to the reports of that Committee we turn for much of the information on the subject. It is impossible to speak on this subject without

* *See* J. A. Fleming, "The Principles of Electric Wave Telegraphy and Telephony," pp. 183-186.

† Abstract of Paper read before Section G of the British Association.

reference to the two men (Sir H. F. Donaldson and Mr. L. Robertson), whom we have recently lost, whose labours did so much to promote the cause of standardisation.

Report No. 27, dated June, 1906, deals with British Standard Systems for Limit Gauges (Running Fits), and was the result of much careful inquiry and discussion. From it is taken the following definition :—

Limit Gauges.—Gauges for ensuring that any given dimension is within the tolerance laid down for the class of work to be produced. In the case of cylindrical work, these gauges may be either double male gauges, one end of which *must* enter, and the other end of which *must not* enter, the hole to which it is applied, or they may be either two-ring or two-gap gauges, one of which *must* pass over, and one of which *must not* pass over, the plug or male piece to which they are applied.

To the Committee's list of gauges—namely, standard, reference and shop limit gauges—it is desirable to add "check gauges"—*i.e.*, gauges designed to check readily the dimensions of gauges in use either as reference gauges or as shop gauges, usually the inverse of the gauges they are employed to check—*i.e.*, for a hole the check gauge is a plug and *vice versa*.

It is proposed to discuss the use, permissible limits of accuracy and the methods of measuring or otherwise determining the dimensions of the various classes of gauges ; but before proceeding to this three other terms in common use need definition. These are :—

Tolerance.—A difference in dimensions prescribed in order to tolerate unavoidable imperfections of workmanship.

Allowance.—A difference of dimensions prescribed in order to allow of various qualities of fit.

Clearance.—A difference in dimension or in the shape of the surface prescribed in order that two surfaces or parts of surfaces may be clear of one another.

In dealing with gauges we may subdivide them usefully into three groups : (I.) Gauges for plain cylindrical work ; (II.) screw gauges ; (III.) form and position gauges.

Years ago Sir Joseph Whitworth aimed at standards which should be true dimensions, and he made no effort to specify plus or minus limits for each class of work. Accordingly, at the outset the Committee were faced with the necessity of determining the limits in order that interchangeability may be secured and what gauges are required for this purpose.

I. Cylindrical Work and Gauges.

In dealing with the work, it is clear that the tolerances and allowances must depend on its nature and the class of fit aimed at : different allowances are necessary for running fits, push fits and force fits.

As a result of measurements made by Mr. Attwell, the Committee were able to draw up a definite series of recommendations with regard to running fits, and the view was adopted that, wherever possible, the shaft should be the element more nearly approaching the true dimension and allowance be made on the hole according to the kind of fit required. The tolerances on the shaft are negative, so that it may never exceed its nominal dimensions. A minimum allowance, obtained by making the hole of larger than nominal size, is specified, and this cannot be encroached upon by either element ; above this a positive tolerance is allowed on the hole. This system the Committee call the shaft basis and the allowances applied to the shaft, the minimum diameter of the hole being its nominal size.

With a view to reducing the number of gauges required, the scheme has been arranged so that the maximum diameter of the hole for first class work is the minimum for second class work, and so on. Assuming, now, agreement has been reached as to the allowances and tolerances on the work, what as to the gauges ?

For a shaft we require two gauges, one corresponding to the maximum or high dimension, the other to the minimum or low dimension, and, as perfect workmanship is impossible, these gauges must be subject to tolerances. What is to be said as to the sign and amount of the tolerances ? And here a distinction has to be noted. So long as the work is within the limits allowed, interchangeability is secured, and it will pass inspection. In fairness, however, to the manufacturer, all work up to the limits should pass, the inspection gauges should not demand narrower limits than the production drawings. Accordingly, the tolerances on a high inspection gauge must be positive, those on a low inspection gauge negative. There is a point which the gauge maker should carefully attend to.

So far, then, we have found that for an inspection gauge the tolerance is positive on the high gauge, negative on the low. But on the workshop gauge, as will be seen, the reverse is the case. These are given out by the manufacturer to the workman to enable him to make work which will pass the inspector. Clearly, then, for safety he will arrange that the limits to which the gauges are rather narrower than those to which the work will be inspected. A high gauge will be a little too small, a low gauge slightly too large ; the tolerance on the high gauge is negative, that on the low gauge is positive.

As to the tolerances permissible, these depend on the class of work dealt with and for inspection gauges amounts of the order of one-tenth of the tolerances on the work are not unusual. For a workshop gauge the tolerances, as well as being of opposite sign, may wisely be large in amount ; the result of this is to contract somewhat the limits within which the workman has to work, but to increase the chance that his work will pass. Moreover, the "go" gauges wear, and a ring or a plug may easily in time become too large or too small respectively if when new they are very close to their nominal sizes.

We turn now to the measurement and testing of cylindrical gauges. For the purpose of merely testing a gauge to see if it is correct, two check gauges—a "go" and a "not-go"—may be used, and in some cases must be used. The difference between these will be equal to the tolerance on the gauge they are used to check, and their own tolerances will be much smaller ; but for cylindrical gauges in most cases check gauges are not necessary, and, indeed, are not desirable : the difficulties arising from inaccuracy of manufacture and wear are too serious. Besides, rejection by a check gauge gives no intimation of the error to the manufacturer, and thus it is unsatisfactory to him. Thus, cylindrical plug gauges are preferably checked by some form of accurate micrometer or measuring machine. To describe such machines in detail would fill a Paper by itself ; it must suffice to mention one or two leading points.

The original Whitworth form depends on the use of a feeler, a bar which is passed down between the jaw of the machine and the gauge under test, and while high accuracy can be attained by practice, the results are slow and depend on the skill of the observer. In another form the plunger presses against a spring and tilts a mirror. The machine is in adjustment when a ray of light reflected from the mirror occupies a definite position of a suitably placed scale.

These methods demand the employment of accurate standards of a large variety of lengths. Such are afforded by the now well-known Johansson gauges, and most of the test work at the National Physical Laboratory is now done by the aid of these gauges.

The checking of ring gauges or of snap gauges is a more difficult problem. For many purposes check gauges are used—a "go" and "not-go" plug, the external diameters of which can be accurately measured ; and, indeed, for small rings this is the only method. For larger gauges there are various forms of internal callipers available, but these do not lend themselves readily to high accuracy.

II. Screw Gauges.

The problem of the standardisation of screw limit gauges is very difficult one. A screw surface is a complex form, and to satisfy oneself that in all its dimensions it lies within certain limits involves much careful work. The question is fully discussed in the E.S.C. Report No. 38.

In the Whitworth thread standardised by the Committee there are seven elements, and error in any one of these may be sufficient to cause a gauge to reject work which ought to pass or *vice versa*. These elements are full (or major) diameter, core (or minor) diameter, effective (or pitch) diameter, pitch, angle, form at crest, and form at root. Of these, the most important and the most difficult to control are the pitch and the effective diameter.

In the Whitworth thread the attempt is made to obtain contact over the whole surface of the screw ; while possibly for some purposes this is desirable, it adds greatly to the difficulties of both construction and gauging, and there is much to be said for a system which allows definite clearances at crest and root. Four of the above seven elements—the first two and the last two—then become unimportant, and we are left to concentrate on the effective diameter, the pitch and the angle of the thread. If the screw bears along its slopes it is doing its work satisfactorily, and in most cases the fact that there is clearance at crest and root is immaterial.

The author next points out that errors in pitch and effective diameter are closely connected, and shows that one can compensate for an error, p, in pitch on a thread of which t inches are engaged by allowing a reduction of effective diameter of $2pt$ in the plug, or an increase of the same amount in the ring.

The Engineering Standards Committee, in their Report No. 38, stated that they have had two separate matters to decide upon :—

(1) To lay down tolerances on full, core and effective diameters to cover the case of fair and unavoidable imperfection of workmanship, and to provide minimum allowances in order that bolts and nuts may be assembled freely.

(2) To decide what errors in pitch could be permitted in ordinary practice, having regard to the allowances in effective diameter which they entail.

And as a result they recommended in Report No. 38 a series of

tolerances for the two threads considered—British standard Whitworth and British standard fine.

Turning now to the question of providing limit gauges for such threads, we are met with many difficulties.

For bolts, the three "go" gauges recommended by the Engineering Standards Committee may be, and usually are, replaced by a single "go" ring gauge, a ring screw of correct form and dimensions. Such a gauge is difficult to construct and verify with accuracy; hence Mr. Taylor suggested for pitch and effective diameter a three-point gauge which the author describes.

With this gauge a "go" and "not go" ring gauge is used for the full diameter, and "go" and "not go" snap gauge for the core diameter. With a complete ring gauge for the "go" gauge, "not go" gauges are required if the checking is to be complete for the full, core and effective diameters. In practice it is generally considered sufficient to use a "go" ring and a "not go" full diameter gauge, though this opens the door to the employment of thin threads. It should be remarked here that a "not go" screw ring is a useless and misleading gauge; it is difficult and costly to construct; it may tell you no doubt that the screw is wrong and ought to be rejected, but it affords no information as to what element in its form causes the rejection.

Up to the present no firm has undertaken the manufacture of the three-point pitch and effective diameter gauges, and they have not come into general use; they suffer also from the disadvantage that the wear is taken on the points, and even if these are properly hardened the life cannot be long.

It is easier to gauge a hole, for in this case the gauges are plugs. A complete plug gauge is required as a "go" gauge, and, to be strict, three "not go" gauges for the core, full and effective diameters. For the core the "not go" gauge is a simple plain plug of appropriate size. For the full and effective diameters we use two screw gauges, each having a single turn of the thread; the first has a very thin deep thread, cut away on the slopes and at the root so as to bear only on its crest, while the second is cut away at the crest and root, and bears on the slopes; the diameters are in each case of appropriate size and the screw is rejected if either gauge enters appreciably. If a "not go" core diameter gauge only is used, holes with thin threads, in which the effective diameter and probably the full diameters are too large, will be accepted.

We pass next to the tolerances on the gauges and the means of detecting these; the last is closely connected with the methods of production, and has recently been discussed in a memorandum, "Notes on Screw Gauges," issued in February, 1916, from the National Physical Laboratory. In the case of a plug gauge, if a satisfactory ring check is available, the first step will normally be to try it with this. If it fails to enter it is usually rejected, but further examination is made to see to what particular the failure is due. If it enters, examination, is still necessary to determine whether it is up to size in all its elements; it may have an excessive pitch error, which is compensated for by a large reduction in its effective diameter, and in this case it is useless as a gauge. Thus, in nearly all cases measurement is required.

For the full diameter a micrometer or some simple form of measuring machine is all that is needed. The principle involved in the measurement of the effective and core diameters is next dealt with, and the instrument employed at the National Physical Laboratory is described.

Turning now to the measurement of pitch, we notice first that pitch error may be of two kinds: (*a*) A progressive error increasing regularly as we go along the screw, and (*b*) superposed in many cases on this a periodic error depending frequently on some want of adjustment in the leading screw of the lathe on which the thread was cut.

The method of measuring the pitch in use at the Laboratory is as follows: The screw is mounted as before, but the feeler carried by the saddle takes the form of a small spherical ball at the end of a bent lever. The ball is held pressed into the threads of the screw by a light spring, and as the saddle is traversed along, the ball moves to and fro always remaining in contact with the screw. The ball is too large in diameter to reach the bottom of the thread. In its motion it slides down one flank of the thread until it is arrested by contact with the opposite flank, when it immediately begins to move up this flank; this change of motion is very sharply defined. By noting on the micrometer screw the positions of the slider at which these changes of motion take place, we clearly have a means of measuring the pitch of the screw. To effect this a mirror is attached to the arm carrying the small sphere, and rotates backwards and forwards as the arm moves. A spot of light reflected from the mirror on to a scale moves in one direction, then stops and moves back; after a time its motion is again reversed, and so on. The sharp reversals caused by the point of contact of the sphere passing from one flank of the screw to the opposite flank are clearly defined and by their means an accurate measure of the pitch is obtained.

To measure the angle and form of a thread a microscope is most conveniently used. The microscope is fitted with cross wires, and can rotate about its axis. Some means of measuring this rotation is required. Means also for bringing the part of the screw to be examined, and for focussing, are required, and care must be taken that the light which enters the microscope may come along the rake of the thread. The axis of the microscope is set at right angles to that of the screw.

To make a measurement of the angle, the microscope is first focussed on one of the centres which carry the screw; it is then moved aside, and the screw is put in position and traversed by means of the adjustments until in the field of view. This method of focussing ensures that an axial section of the screw is under examination. The microscope is then rotated about its axis until the cross-wire is along the flank of one of the threads, and a reading is taken; the tube is turned and the screw traversed until the cross-wire lies along the opposite flank and a reading is again taken; the difference between these gives the angle of the screw. By setting the cross-wire to run along the crests of the thread and taking a reading, the squareness of the threads to the axis can be verified, while the general shape of the thread is obvious to the eye. By attaching the part carrying the screw to two slides at right angles, one parallel to and the other at right angles to the axis of the screw, fitted with accurate micrometers, measurements of the diameters and pitch of a small screw may be made.

In many cases, however, observations on angle and form can be made most readily by a projection apparatus. The screw is suitably mounted and illuminated by the aid of a small arc lamp and condenser. Carefully arranged lenses throw a magnified image on a screen, and observations are made on this image. The lenses must be chosen to produce uniform magnification over the field, and there must be absence of distortion. At the Laboratory lenses to secure this have been obtained, and the method has proved rapid and of great value. A magnification of 50 has been selected: the screw carries an accurate drawing of a section of the screw 50 times actual size. It is easy to compare the image formed with this correct profile. The screen carries adjustments which serve to bring the image and the drawing readily into coincidence.

Another method of comparison is to project simultaneously the image of an accurate screw placed alongside the one under examination; the differences are readily apparent.

The checking of screwed ring gauges is more difficult. Direct measurement is only possible if they are of considerable diameter. Means have been devised, provided the ring is not too small, and, where the information is specially required, are employed for measuring the diameters by the aid of small spheres, fitting into the threads, and internal micrometers. In general, however, check gauges are resorted to, the Taylor system being employed whenever real accuracy is desired. This in itself does not give a measurement of the diameter, but it is generally possible by the use of a sufficient number of checks of slightly different sizes to form a close estimate of the limits within which it lies. A simple and rapid method of measuring internal diameters, specially of small screws, is much to be desired.

III. Form and Position Gauges.

These, which are often extremely difficult to make, to measure and to check, perhaps hardly come within the category of limit gauges. In the case of plate form gauges, the examination can sometimes be done readily by measurement, but check gauges are usually necessary, and the observation is made by bringing the two into contact on a plate of glass and holding them up to the light. The eye can readily detect a want of fit; to say exactly what is wrong is more difficult—*e.g.*, in the case of an elaborate band gauge for a shell. We have found the difficulty best met by the supply to the maker of an accurate check in addition to the drawing. More recently the projection employed for checking the form of a screw thread has been freely used and has given good results.

Position gauges, again, need checks for their verification, and the design and manufacture of these often presents difficulties. The check is clearly an accurate replica of the part which it is intended to gauge, made, however, in a form which lends itself to exact measurement so that its accuracy may be secured. The details of measurement will differ for each gauge, and no general account can be given.

Limit gauging is a wide field to discuss, and in this hasty survey the fringe has only been touched. The experience of the past year has shown its importance, and when once this was realised and the fact that accuracy was essential was grasped, British manufacturers have risen to the occasion and may be proud of the output of beautiful gauges now being passed into munition works.

THE AIR-GAP FIELD OF THE POLYPHASE INDUCTION MOTOR.

BY F. T. CHAPMAN, D.SC.

(*Continued from page 734.*)

SUMMARY OF CONTENTS.

IV.—THE EFFECTS OF MAGNETIC SATURATION.
Section 25.—The saturation curve. Fundamental and third harmonic of time-flux wave.
Sections 26 to 28.—Effect of saturation on multiple fields.
Section 29.—Effect of saturation on air-gap dispersion.
Section 30.—Calculation of no-load current.
Section 31.—The actual form of the current locus.

PART IV.—EFFECT OF SATURATION OF MAGNETIC CIRCUIT.

25. The paths of the lines of force constituting the fields we have been studying in Parts II. and III. include the air-gap and the teeth and cores of stator and rotor. The length of the path varies slightly from one part of the field to another, but the differences are small and are confined to the portions of the lines which lie in the cores, where the permeability is usually high. These differences will be neglected.

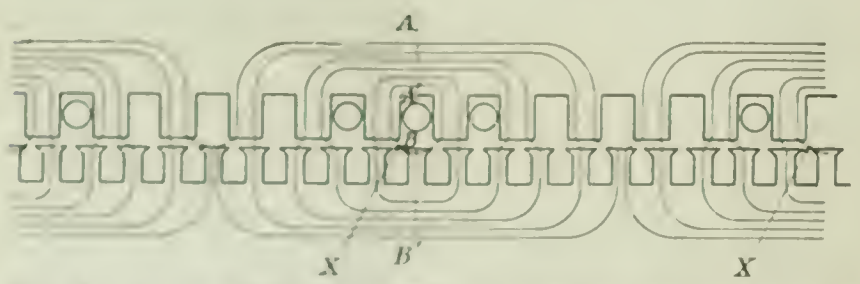


FIG. 10.—DIAGRAM SHOWING THE DIFFERENCES BETWEEN THE VARIOUS LINES OF FORCE COMPOSING THE FIELD, WITH SHORT LINES AT *XX*.

Some lines of force may take a considerably shorter path by crossing the head of a tooth, as shown at *X* in Fig. 10, and this is especially true of the fluxes constituting the higher multiple fields. No attempt has been made to allow for this in the following investigation, and the permeance between the planes

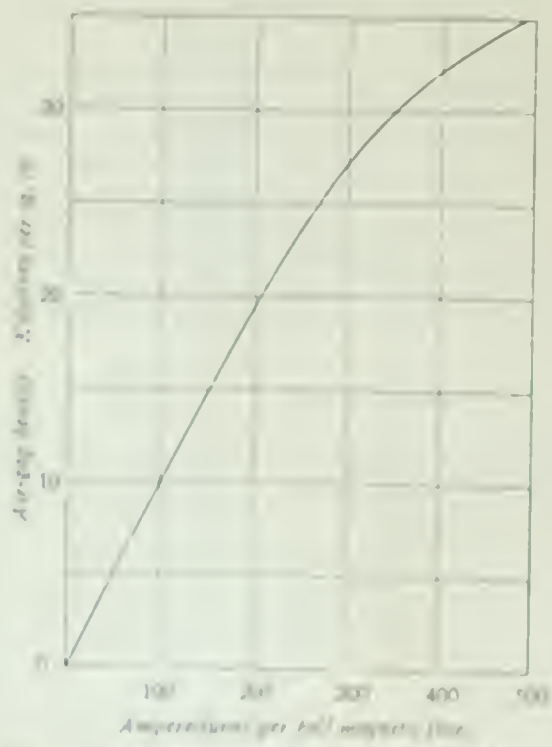


FIG. 11.—SATURATION CURVE OF TEST MOTOR.

AA' and *BB'* (Fig. 10) is taken to be the same function of the air-gap density for every line of force.

Fig. 11 shows the saturation curve of a small three-phase motor upon which experiments have been made, which will be described later. In this diagram the abscissæ represent the ampere-turns acting on a unit tube of magnetic flux between *AA'* and *BB'* in Fig. 10 (we shall refer to this portion of a tube of flux as a half line), while ordinates indicate the density in the air-gap at the point where this tube crosses it, the effect of slot openings being neglected.

If the ampere-turns acting on any path are a sine function of the time, the variation of the flux density is represented by a wave which is much flatter than a sine wave. Analysis of this wave shows that for practical purposes it may be supposed to contain a fundamental and a third harmonic only, all higher harmonics being negligible.* The time-flux waves obtained with various amplitudes of the M.M.F. in the motor

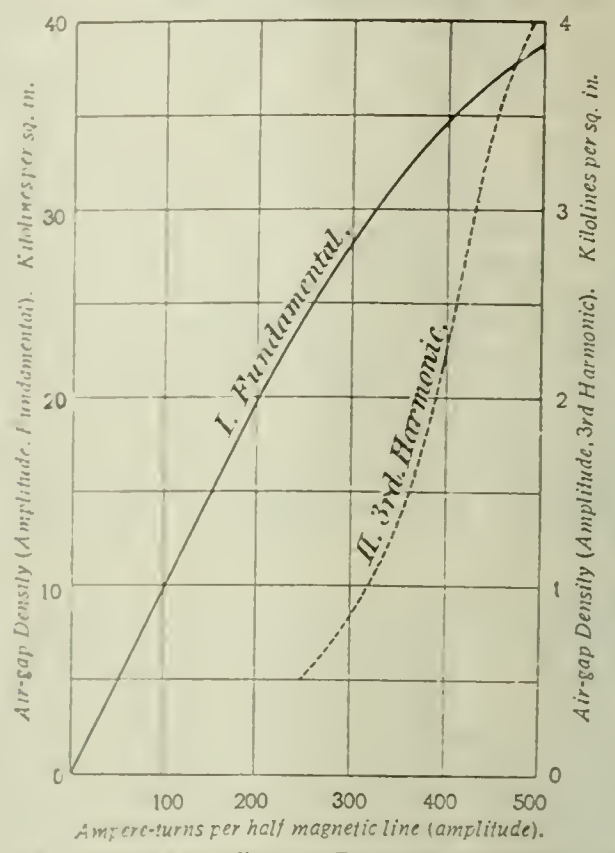


FIG. 12.—COMPONENT CURVES DERIVED FROM FIG. 11.

referred to above have been analysed, and the amplitudes of the fundamental and the third harmonic are shown, as a function of the amplitude of the M.M.F. wave, in Fig. 12. The forms of these curves may be compared with the experimental curves given by the author in a previous Paper on this subject, which were taken on the same motor.†

26. When the rotor circuits are open, or, if the rotor winding has a small number of phases, when the rotor is running at or near synchronism, we may assume that the resultant ampere-turns acting on the lines of force passing down the several stator teeth are given correctly by Görges' diagram.‡ In

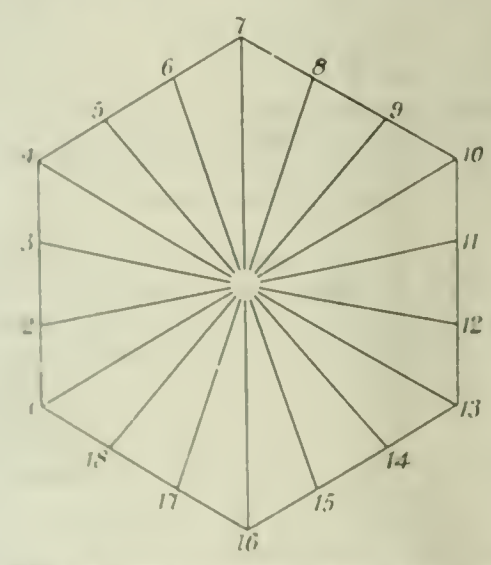


FIG. 13.—AMPERE-TURN DIAGRAM, NO LOAD. $m=3$, $P=3$.

Fig. 13 this diagram has been drawn for the motor to which reference has already been made. The particulars of this motor are:—

No. of poles = 4.	No. of stator phases = 3.
No. of stator slots = 36.	No. of conductors per slot = 18.
Connection of phases star.	Full span winding.

* Cp. S. P. Smith and W. H. Barling, THE ELECTRICIAN, Vol. LXXIV., p. 42, 1914. The space variation of M.M.F. and flux density is there considered, but the conclusions apply equally well to the time variation.

† THE ELECTRICIAN, Vol. LXXIV., p. 319, Fig. 2, December 11, 1914.

‡ "Elektrotechn. Zeitschr.," Vol. XXVIII., pp. 1–6, January 3, 1907.

Tooth No. 1 is between two phases, and the vector 01 represents the amplitude of the M.M.F. (measured in ampere-turns) applied to the flux traversing this tooth. Vectors 02, 03, &c., represent similarly the ampere-turns applied to the flux traversing teeth Nos. 2, 3, &c., respectively. The vector 12 represents the ampere-conductors in the slot between teeth Nos. 1 and 2. The diagram has been drawn to represent the conditions when the effective current per phase is 6·48 amperes. Vector 12 has a length equal to $\sqrt{2}\times 6{\cdot}48\times 18=165$ ampere-conductors, and this vector will be taken to represent $165 \sin 2\pi ft$. Vectors 23 and 34 have exactly the same length.

The angle 102 is less than $\frac{\pi}{9}$ by about 54′. If we represent by a_1, a_2, &c., the ampere-turns acting at any instant at teeth Nos. 1, 2, &c., respectively, we shall have

$$a_1=495 \sin\left(2\pi ft+\frac{\pi}{2}+\frac{\pi}{6}\right)=495 \cos\left(2\pi ft+\frac{\pi}{6}\right),$$

$$a_2=437 \sin\left(2\pi ft+\frac{\pi}{2}+\frac{\pi}{6}-19°6'\right)=437 \cos\left(2\pi ft+\frac{\pi}{6}-19°6'\right),$$

$$a_3=437 \sin\left(2\pi ft+\frac{\pi}{2}+\frac{\pi}{6}-40°54'\right)=437 \cos\left(2\pi ft+\frac{\pi}{6}-40°54'\right),$$

$$a_4=495 \sin\left(2\pi ft+\frac{\pi}{2}-\frac{\pi}{6}\right)=495 \cos\left(2\pi ft-\frac{\pi}{6}\right),$$

and so on.

From the curves of Fig. 12 we see that the corresponding air-gap densities will be

$$y_1=38{,}700 \cos\left(2\pi ft+\frac{\pi}{6}\right)+4{,}050 \cos\left(6\pi ft+\frac{\pi}{2}\right),$$

$$y_2=36{,}300 \cos\left(2\pi ft+\frac{\pi}{6}-19°6'\right)+3{,}150 \cos\left(6\pi ft+\frac{\pi}{2}-57°18'\right),$$

$$y_3=36{,}300 \cos\left(2\pi ft+\frac{\pi}{6}-40°54'\right)+3{,}150 \cos\left(6\pi ft+\frac{\pi}{2}-122°42'\right),$$

$$y_4=38{,}700 \cos\left(2\pi ft-\frac{\pi}{6}\right)+4{,}050 \cos\left(6\pi ft-\frac{\pi}{2}\right),$$

and so on.

The vector diagrams for the fundamental and third harmonic of the flux waves are drawn in Figs. 14 and 15 respectively.

27. We will now consider a general case and analyse the space flux waves due respectively to the fundamental and the third harmonic terms. The method to be employed is the same as that of sec. 14.

(*a*) *Fundamental Terms.*—In a P-phase machine with m slots per pole per phase, and a full span winding, we have the following as the fundamental terms of the flux wave for successive teeth.

$$y_1=F_1 \cos(2\pi ft+\pi/2P),$$
$$y_2=F_2 \cos(2\pi ft+\pi/2P-a_2),$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$y_m=F_m \cos(2\pi ft+\pi/2P-a_m),$$
$$y_{m+1}=F_1 \cos(2\pi ft-\pi/2P),$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$y_{2m}=F_m \cos(2\pi ft-\pi/2P-a_m),$$
$$y_{2m+1}=F_1 \cos(2\pi ft-3\pi/2P),$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$y_{3m}=F_m \cos(2\pi ft-3\pi/2P-a_m),$$

and so on.

The amplitudes F_1, F_2, &c., are determined from the ampere-turn diagram and the saturation and derived curves; a_2, a_m, &c., are obtained from the geometry of the ampere-turn diagram.

In symmetrical machines at no-load we have

$$a_2=\pi/P-a_m, \qquad a_3=\pi/P-a_{m-1}, \text{ &c.}$$
$$F_2=F_m, \qquad F_3=F_{m-1}, \text{ &c.}$$

As in previous sections, we take a space origin at the centre of a phase group in which the current is $I \sin 2\pi ft$. The amplitude of the sine component of the cth harmonic of the space flux wave, reckoned from this origin, is given by

$$S_c=\frac{2}{\pi}\left[\int_{-\frac{\pi}{2P}-\frac{\pi}{2q}}^{-\frac{\pi}{2P}+\frac{\pi}{2q}} F_1 \cos(2\pi ft+\pi/2P) \sin c\theta \, . \, d\theta + \int_{-\frac{\pi}{2P}+\frac{\pi}{2q}}^{-\frac{\pi}{2P}+\frac{3\pi}{2q}} F_2 \cos(2\pi ft+\pi/2P-a_2) \sin c\theta \, d\theta + \ldots \right.$$
$$\left. \ldots + \int_{-\frac{\pi}{2P}+\frac{2n-3}{2q}\pi}^{-\frac{\pi}{2P}+\frac{2n-1}{2q}\pi} F_n \cos(2\pi ft+\pi/2P-a_n) \sin c\theta \, . \, d\theta \, . + \ldots \text{ to } q \text{ terms} \right]$$

where $q=mP$=number of slots per pole as before.

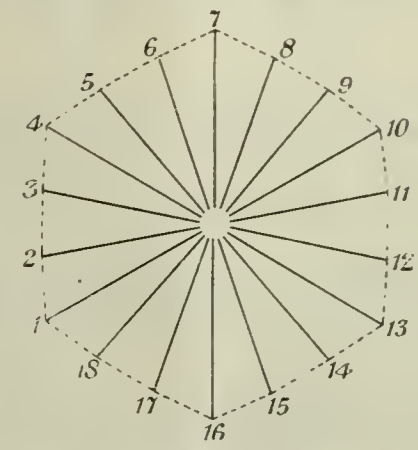


Fig. 14.—Tooth-flux (Fundamental), No Load. $m=3$, $P=3$.

The first term of this series is

$$\frac{2}{\pi}\frac{F_1}{c}\sin\frac{c\pi}{2q}\left\{\sin\left(2\pi ft-\frac{c-1}{2P}\pi\right)-\sin\left(2\pi ft+\frac{c+1}{2P}\pi\right)\right\}.$$

The $(m+1)$th term is

$$\frac{2}{\pi}\frac{F_1}{c}\sin\frac{c\pi}{2q}\left\{\sin\left(2\pi ft+\frac{c-1}{2P}\pi\right)-\sin\left(2\pi ft-\frac{c+1}{2P}\pi\right)\right\}.$$

The first $(m+1)$th, $(2m+1)$th, &c., terms make a series of P terms, the sum of which is

$$\frac{2}{\pi}\cdot\frac{F_1}{c}\cdot\sin\frac{c\pi}{2q}\left[\sin\left\{2\pi ft-\frac{c-1}{2P}\pi+\frac{(P-1)(c-1)\pi}{2P}\right\}\cdot\frac{\sin\frac{c-1}{2}\pi}{\sin\frac{c-1}{2P}\pi}\right.$$
$$\left.-\sin\left\{2\pi ft+\frac{c+1}{2P}\pi-\frac{(P-1)(c+1)\pi}{2P}\right\}\frac{\sin\frac{c+1}{2}\pi}{\sin\frac{c+1}{2P}\pi}\right]$$

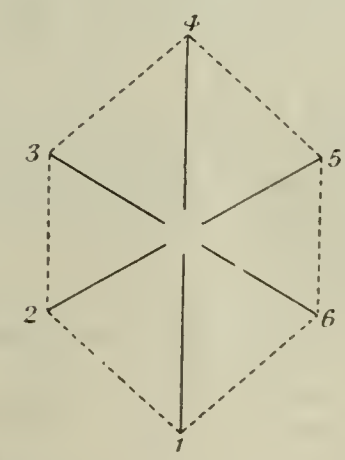


Fig. 15.—Tooth-flux (3rd Harmonic). $m=3$, $P=3$.

Now c is a whole number and odd, and if we confine ourselves to positive values at first we see that if $c=2Pd+1$, d being a positive integer, the last expression reduces to

$$\frac{2PF_1}{c\pi}\cdot\sin\frac{c\pi}{2q}\cdot\cos\frac{c-1}{2P}\pi\cdot\sin 2\pi ft,$$

whereas, if $c=2Pd-1$ its value is

$$-\frac{2PF_1}{c\pi}\cdot\sin\frac{c\pi}{2q}\cdot\cos\frac{c+1}{2P}\pi\cdot\sin 2\pi ft.$$

In the same way we find the sum of the series constituted by the 2nd, $(m+2)$th, $(2m+2)$th, &c.. terms to be

$$\frac{2PF_2}{c\pi}\,.\,\sin\frac{c\pi}{2q}\,.\,\cos\frac{c-1}{2P}\pi\,\sin\left(2\pi ft-a_2-\frac{c\pi}{q}\right),$$

or $$-\frac{2PF_2}{c\pi}\,.\,\sin\frac{c\pi}{2q}\,.\,\cos\frac{c+1}{2P}\pi\,\sin\left(2\pi ft-a_2-\frac{c\pi}{q}\right).$$

Altogether there are m series which can be summed this way, and the sum of them all is

$$S_c=\frac{2P}{c\pi}\sin\frac{c\pi}{2q}\left\{F_1\sin 2\pi ft-F_2\sin\left(2\pi ft-a_2+\frac{c\pi}{q}\right)+\ldots\right.$$
$$\left.\ldots+F_m\sin\left(2\pi ft-a_m\cdot\frac{m-1}{q}\,.\,c\pi\right)\right\}\cos\frac{c-1}{2P}\pi,$$

or,

$$S_c=-\frac{2P}{c\pi}\,.\,\sin\frac{c\pi}{2q}\left\{F_1\sin 2\pi ft+F_2\sin\left(2\pi ft-a_2-\frac{c\pi}{q}\right)+\ldots\right.$$
$$\left.\ldots+F_m\sin\left(2\pi ft-a_m-\frac{m-1}{q}\,.\,c\pi\right)\right\}\cos\frac{c+1}{2P}\pi,$$

according as $c=2Pd+1$, or $c=2Pd-1$.

In the same manner we find the amplitude of the cosine component to be

$$C_c=\frac{2P}{c\pi}\sin\frac{c\pi}{2q}\left\{F_1\cos 2\pi ft+F_2\cos\left(2\pi ft-a_2+\frac{c\pi}{q}\right)\right.$$
$$\left.+\ldots\right\}\cos\frac{c-1}{2P}\pi,$$

or

$$C_c=\frac{2P}{c\pi}\,.\,\sin\frac{c\pi}{2q}\left\{F_1\cos 2\pi ft+F_2\cos\left(2\pi ft-a_2-\frac{c\pi}{q}\right)\right.$$
$$\left.+\ldots\right\}\cos\frac{c+1}{2P}\pi.$$

If we write $\pi x/\tau$ for θ the density at any point distant x from the origin, due to any particular value of c, is

$$y_c=S_c\sin\frac{c\pi x}{\tau}+C_c\cos\frac{c\pi x}{\tau},$$

$$=\frac{2P}{c\pi}\sin\frac{c\pi}{2q}\left\{F_1\cos\left(2\pi ft-\frac{c\pi x}{\tau}\right)+F_2\cos\left(2\pi ft-a_2\right.\right.$$
$$\left.\left.-\frac{c\pi}{q}-\frac{c\pi x}{\tau}\right)+\ldots\right\}\cos\frac{c-1}{2P}\pi,$$

or,

$$y_c=\frac{2P}{c\pi}\sin\frac{c\pi}{2q}\left\{F_1\cos\left(2\pi ft+\frac{c\pi x}{\tau}\right)+F_2\cos\left(2\pi ft-a_2\right.\right.$$
$$\left.\left.-\frac{c\pi}{q}+\frac{c\pi x}{\tau}\right)+\ldots\right\}\cos\frac{c+1}{2P}\pi.$$

As in section 5 we may assign to c both positive and negative values corresponding to the equation $c=2Pd\pm 1$ in which d is either positive or negative, and include both the above cases in the single expression

$$y_c=\frac{2P}{c\pi}\sin\frac{c\pi}{2q}\cos\frac{c-1}{2P}\pi\left\{F_1\cos\left(2\pi ft-\frac{c\pi x}{\tau}\right)\right.$$
$$+F_2\cos\left(2\pi ft-a_2-\frac{c\pi}{q}-\frac{c\pi x}{\tau}\right)$$
$$\left.+F_m\cos\left(2\pi ft-a_m-\frac{(m-1)c\pi}{q}-\frac{c\pi x}{\tau}\right)\right\}+\ldots\quad(66)$$

This expression obviously reduces to the form

$$y_c=\frac{2P}{c\pi}\sin\frac{c\pi}{2q}\cos\frac{c-1}{2P}\pi\;F\cos\left(2\pi ft-\frac{c\pi x}{\tau}-a\right).\quad(67)$$

The reduction is generally effected most conveniently after the introduction of the appropriate numerical values.

At no load we may take advantage of the relations $F_2=F_m$ &c., given above, and obtain

$$y_{eP}=\frac{2P}{c\pi}\,.\,\sin\frac{c\pi}{2q}\,.\,\cos\frac{c-1}{2P}\pi\left\{F_1+2F_2\cos\left(a_2-\frac{c\pi}{q}\right)\right.$$
$$\left.+2F_3\cos\left(a_3-\frac{2c\pi}{q}\right)+\ldots\right\}\,.\,\cos\left(2\pi ft-\frac{c\pi x}{\tau}\right).\quad(68)$$

The last term in the expression in brackets $\{\ \}$ is

$$2F_{\frac{m+1}{2}}\cos\left(a_{\frac{m+1}{2}}-\frac{m-1}{2}\,.\,c\pi/q\right),\text{ if } m \text{ is odd,}$$

or $$F_{\frac{m+2}{2}}\cos\left(a_{\frac{m+2}{2}}-\frac{mc\pi}{2q}\right),\text{ if } m \text{ is even.}$$

These equations, like equation (6) of section 5, refer to a series of multiple fields, the velocities of which are given by

$$v_c=\frac{2f\tau}{c}.$$

(To be continued.)

FUEL ECONOMY.

REPORT BY THE BRITISH ASSOCIATION COMMITTEE.*

Introduction.

The national aspects of fuel economy may be considered from two somewhat different standpoints, namely, (1) in view of the economic situation created by the war, which will necessitate the general adoption of more scientific methods in the future development and utilisation of the nation's mineral reserves, and (2) in view of that remoter, but possibly not far distant future when our available coal supplies will be restricted by approaching exhaustion. In approaching its task the committee decided that it could best serve the national interest by concentrating its attention upon the more immediate aspect of the problem.

It can hardly be questioned that the chief material basis of the great industrial and commercial expansion of this country during the past century has been its abundant supplies of easily obtainable coal, which, until recent years, has given us a position of advantage over all other countries. It is also equally true that we can no longer claim any advantage in this respect over our two closest competitors.

There can be little doubt but that up to the present we have been wasteful and improvident in regard to our methods of getting and utilising coal, and that not only are great economies in both these directions attainable, but also that the question of the general adoption of more scientific methods in regard to these matters is one of vital importance, in view of the trying period of economic recuperation which will immediately succeed the war.

For some years before the war the average price of coal at the pit-head had been decidedly on the up-grade, owing chiefly to deeper workings, higher wages, and greater precautions for ensuring the safety of the miner. The result of the great coal strike of 1912, and the legislation which it provoked, was to accentuate this tendency. And if, as seems probable, prices continue to rise for some time after the war at an accelerated rate, as compared with the pre-war period, the question of the best utilisation of fuels will be of increasing importance to the nation.

If anything ought to arouse public opinion to the gravity of the situation, it is surely afforded by the statistics published in the Report upon the World's Coal Resources, issued by the International Geological Congress in the year 1913. According to this estimate, the geographical distribution of the world's total possible and probable reserves of coal of all kinds available within 6,000 ft. of the surface (amounting in all to 7,397,553 million metric tons) may be represented diagrammatically as in Figs. 1 and 2.

The fact that the available reserves of coal in Great Britain only amount to about one-fortieth, whilst those of the whole Empire do not amount to more than about one-fourth, of the world's estimated total, is one which ought to be brought home to everyone responsible for the

---

* The committee consists of Prof. W. A. Bone† (chairman), Mr. E. D. Simon† (secretary), the Rt. Hon. Lord Allerton,† Mr. Robert Armitage, Prof. J. O. Arnold, Mr. J. A. F. Aspinall, Mr. A. H. Barker, Prof. P. P. Bedson, Sir G. T. Beilby,† Sir Hugh Bell,† Mr. E. Bury, Dr. Charles Carpenter,† Dr. Dugald Clerk,† Prof. H. B. Dixon, Dr. J. T. Dunn,† Mr. S. Z. de Ferranti, Dr. William Galloway, Prof. W. W. Haldane Gee, Prof. Thos. Gray, Mr. T. Y. Greener,† Sir Robert Hadfield,† Dr. H. S. Hele-Shaw,† Mr. D. H. Holte, Mr. Greville Jones, Mr. W. W. Lackie, Mr. Michael Longridge, Dr. J. W. Mellor, Mr. C. H. Merz,† Mr. Robert Mond,† Mr. Bernard Moore, Hon. Sir Charles Parsons,† Sir Richard Redmayne,† Prof. Riggs, Prof. J. T. O'Shea, Mr. R. P. Sloan, Dr. J. E. Stead,† Dr. A. Strahan,† Mr. C. E. Stromeyer, Mr. Benjamin Talbot, Prof. R. Threlfall, Mr. G. Blake Walker, Dr. R. V. Wheeler, Mr. B. W. Wheeler, Mr. W. B. Woodhouse, Prof. W. P. Wynne, and Mr. H. James Yates.† Appointed for the investigation of fuel economy, the utilisation of coal and smoke prevention. † Denotes a member of the Executive Committee.

economic development of our national and imperial resources, especially in view of the fact that the United States, whose competition in the immediate future will probably be much more severely felt than ever before, possesses more than half the estimated world's coal, and that also in regard to the two prime considerations of quality and cost of production she probably compares favourably with Great Britain and the Empire.

Moreover, it may be pointed out that in the United States both the Government and the University of Illinois have, for some years past, conducted numerous important chemical investigations and large-scale trials upon the character of the principal American coal seams and their adaptation for various economic ends, and that, in consequence, American manufacturers have at their disposal much more complete and systematic information about their country's coal resources than

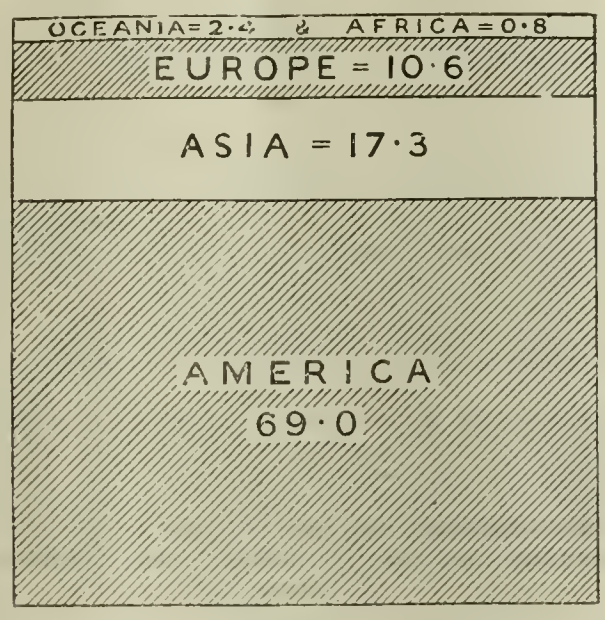


Fig. 1.—Percentages of World's Total Coal Reserves.

is at present possessed by their British competitors. Also, the United States Government, which is continually extending its policy of the conservation of its natural resources, has already taken legislative steps to prevent the premature exploitation of the coalfields of Alaska. Nor has Canada lagged behind her neighbour, as is proved by the recent exhaustive "Investigation of the Coals of Canada with reference to their Economic Qualities," conducted at the McGill University, Montreal, under the authority of the Dominion Government, and published in the years 1912 and 1913 by the Department of Mines in six imposing volumes. No such comprehensive investigations have ever been undertaken in this country, where they are much needed. The committee is of opinion that the example of the United States and Canada might be followed with advantage to the industrial community by the Government of Great Britain, and that representations should

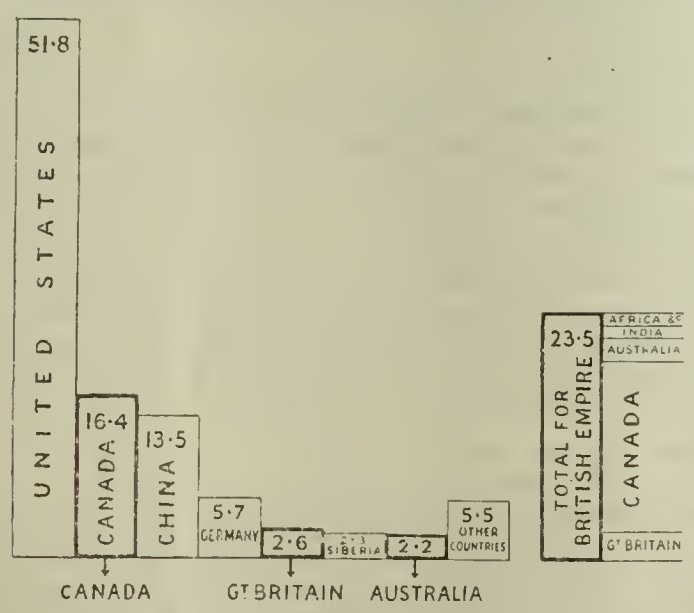


Fig. 2.—Percentages of World's Total Coal Reserves.

be made with the object of inducing the Government to provide adequate funds in aid of further researches and investigations upon the chemical character of the principal British coal seams, the best means for their future development in the national interest, and upon problems of fuel economy, including the utilisation of all the by-products obtainable from coal.

The rapid increase during recent years in the world's demands for coal is shown by the following approximate figures covering the 10 years' period immediately preceding the outbreak of war :—

Year.	Approximate total. Millions of tons.
1903	800
1908	1,000
1913	1,250

From these figures it would appear that, during the period in question, the world's demands have continuously increased at a compound interest rate of nearly 5 per cent. per annum. Another important fact is that these demands have been principally met by three countries, namely, the United States, Great Britain and Germany, which, between them, have hitherto annually raised 83 per cent. of the total anthracite and bituminous coals consumed in the world. This being so, it is of interest to compare the relative rates of increase in the coal productions of these three countries during recent years, which may best be deduced from a comparison of quinquennial averages over a period of 15 years, from 1900-1914 inclusive, as follows :—

[*British Outputs of Coal* 1870 *to* 1914.]

Coal Productions of the United States, Great Britain and Germany—Quinquennial Averages 1900 *to* 1914.

Period.	Millions of tons per annum.		
	United States.	Great Britain.	Germany.*
1900-04	288·2	226·8	112·5
1905-09	400·5	256·0	139·8
1910-14	519·2	269·9	168·3

From these figures it may be inferred that up to the outbreak of the war the coal output of the United States was increasing annually at a compound interest rate of about 6 per cent., that of Germany at a compound rate of about 4 per cent., whilst the British output was increasing at a compound rate of 2 per cent. only. During the period 1910-14 the United States produced nearly twice as much coal as Great Britain, and, assuming that these relative rates of increase are maintained after the war, it may be predicted that Germany's output of coal will overtake that of Great Britain about 20 years hence, when each country will be producing some 420,000,000 tons per annum.

The public cannot be too often reminded that not only is coal of prime importance as a fuel, but also that, when suitably handled by the chemist, it yields very valuable by-products, which are the raw materials of important industries. Thus from coal-tar, and other by-products of its distillation, are obtained the raw materials for the manufacture of both synthetic dyes and drugs and certain high explosives. Another important by-product obtainable is ammonia in the form of sulphate, which is chiefly used as a fertiliser in the production of foodstuffs. The use of artificial fertilisers, including ammonium sulphate, by agriculturists in Great Britain is still in its infancy, and the near future ought to see a large expansion in the home demands for nitrogenous fertilisers.

Among other products obtainable by the low-temperature distillation of coal are liquid hydrocarbons of the paraffin and naphthene series, and it is probable that large quantities of "motor spirit" could be manufactured in this country from coal. There is no doubt that we in this country have not been sufficiently alive to the importance of recovering such by-products from the raw coal raised in our mines, and that we have been very much behind Germany in this respect. Thus, for example, whilst in the coking industry modern by-product recovery plants had been universally installed years ago throughout Germany, we were, in 1913, still carbonising about 6½-million tons of coal annually for metallurgical coke in old-fashioned bee-hive ovens. Also, whereas our total production of ammonium sulphate from coal was in 1913 about 318,000 tons, Germany produced nearly half a million tons from a very much smaller output of coal.

The community needs to be reminded that, at least so far as this country is concerned, progress in fuel economy involves something more than increased thermal efficiency in respect of power production and of heating operations generally, important as these undoubtedly are. It also involves the whole question of the better utilisation of our coal, including the recovery of by-products and the consequent abolition of the smoke nuisance, which at present, directly and indirectly, costs the country many millions of pounds per annum.

There are two outstanding features in the history of the British coal trade to which the committee desires to draw attention. One is the remarkably steady increase in the total output of our mines, which, since 1870, has been maintained at an almost uniform compound interest rate of 2 per cent. per annum, as the following table of quinquennial averages over a period of 45 years—1870-1914—shows :—

Coal Production in Great Britain—Quinquennial Averages, 1870 *to* 1914—*Millions of Tons per Annum.*

Period.	Average output.	Calculated at 2 p.c. compound interest.	Proportion of total output exported.
1780-74	121·5	121·5	0·13
1875-79	133·6	131·4	0·146
1880-84	156·4	148·1	0·172
1885-89	165·2	163·5	0·200
1890-94	180·3	180·5	0·220
1895-99	202·0	199·3	0·237
1900-04	226·8	220·1	0·27
1905-09	256·0	243·0	0·31
1910-14	269·9	268·2	0·326

The second feature is the phenomenal growth of our export trade, which, during the past 60 years, has increased something like twenty-fold, both as regards the quantities and the values of coal exported.

* Excluding lignites and brown coals.

Moreover, its value relative to other values exported has, during the same period, increased fourfold, until at the outbreak of war it constituted about 10 per cent. of our total exported values. We were then actually transacting over 70 per cent. of the total sea-borne coal trade of the world. It must, however, be borne in mind that a considerable proportion of the exported coal supplies the needs of our mercantile marine.

Another circumstance which demands attention is the fact that the proportion of the coal raised annually in the United Kingdom which is exported has been doubled within the past 35 years, trebled within half a century, and is still increasing. Three factors have operated in producing this result. One is the proximity of the finest coalfields to our ports, another is the increased demands for coal from Europe and South America, while a third has been the phenomenal growth of our mercantile marine.

The foregoing figures for the total outputs of our mines by no means represent the real rate of depletion of our available coal reserves. A vast amount of usable coal is left behind in the mine because, under present individualistic conditions, it does not pay to bring it to the surface. A larger profit on the capital of a colliery company can often be earned by working the better classes of coal and leaving the less valuable grades underground. According to figures issued in the Report of the 1905 Royal Commission on Coal Supplies, this wastage amounted to nearly 25 per cent. of the total raised in the larger coalfields. The question of checking this wastage by finding out in what ways the less valuable grades can be turned to good account commercially is one of supreme national importance, and the Committee desires to draw special attention to it. Much of the coal now left behind in the mines ought to be converted into useful forms of energy and products for public purposes, and one of the most important aspects of the fuel economy problem in Great Britain is the devising and organising of means for making it possible to raise this hitherto wasted coal at an economic advantage.

So much for the general statistics of coal production. Coming now to the possible saving in the coal consumed annually in this country at the outbreak of the war (nearly 200,000,000 tons), it will be remembered that the 1905 Royal Commission on Coal Supplies found that the possible saving in our then annual coal consumption (157,000,000 tons) amounted to between 40- and 60-million tons. There are many competent judges who consider that, notwithstanding the improved apparatus which has been put into use in the best factories throughout the country during the last 10 years, the average result obtained for the country as a whole still lags behind the best obtainable to-day in as great a proportion as it did in 1905. It will be the business of this Committee (1) to estimate as nearly as may be the present possible margin of saving, and (2) to point out the particular directions in which it can be attained from a national point of view.

Organisation of the Committee's Work.

Having regard to the magnitude of its work, and the fact that the coal question is one upon which almost every branch of manufacturing and transport industry is dependent, the original committee of 13 members appointed by the Association in October, 1915, decided to exercise very freely its powers of co-option, so as to make a General Committee sufficiently large and representative of all the important interests involved.

For the more detailed and special study of particular aspects of the fuel question the enlarged General Committee resolved itself into the following five sub-committees, each of which subsequently elected its own chairman, and, subject to its reporting from time to time to the General Committee, proceeded to make such arrangements as seemed best for the prosecution of its work :—

(*a*) Chemical and statistical.
(*b*) Carbonisation.
(*c*) Metallurgical, ceramic and refractory materials.
(*d*) Power and steam raising.
(*e*) Domestic heating and smoke prevention.

The General Committee next appointed an Executive Committee, composed of the chairman and secretary of the General Committee, the chairmen of each sub-committee (ex officio) and 12 other members, which could meet frequently in London for the discussion of matters relative to the organisation and co-ordination of the work of the Committee as a whole, to deal with matters arising out of the proceedings of the sub-committees which might require immediate action or decision, and to receive and consider communications either from Government departments or technical associations concerning subjects under investigation by the committee.

The General Committee has met in London four times since its appointment in October, 1915, the various sub-committees have each met about four times since their formation in January, 1916, whilst the Executive Committee has met regularly on alternate Fridays since April 28th last. In all 30 meetings have been held during the year.

At the first meeting of the General Committee it was decided to organise a series of conferences of manufacturers and others interested in the fuel question in a number of the larger industrial centres, for the purpose of arousing interest in the work of the Committee, of inviting co-operation and suggestions from large users of fuel, and of educating public opinion in respect of the national importance of the question.

All but one of the following meetings were addressed by the chairman and one or more of the other members of the committee, and the discussions which invariably followed were productive of valuable suggestions or information regarding local conditions which demand special consideration. It may be also mentioned that the chairman lectured at the Royal Institution of Great Britain on Thursdays, January 20th, 27th, and February 3rd last, on "The Utilisation of the Energy of Coal."

The following six conferences have already been held :—

Date.	Place.	Under the auspices of
1915.		
November 19	Stoke-on-Trent	English Ceramic Society. North Staffs. Mining Institute.
1916.		
March 6	London	London Section of the Society of Chemical Industry.
March 13	Middlesbrough	Cleveland Institution of Engineers.
March 29	Nottingham	Nottingham Section of the Society of Chemical Industry.
April 5	Manchester	Manchester Section of the Society of Chemical Industry.
April 6	Sheffield	Sheffield Society of Engineers and Metallurgists.

In March last the committee was asked by the newly-formed Central Coal and Coke Supplies Committee of the Board of Trade to make suggestions as to economies in fuel consumption which could be made at the present time, and, as the result of further correspondence upon the matter, it was arranged that Sir Richard Redmayne should act as the representative of the Board of Trade Committee on this committee.

During the first year of its existence the attention of the committee has been fully occupied with questions of organisation and a preliminary survey of the ground which must be explored later on. Already several important lines of investigation needing the co-operation of manufacturers have been instituted and are well in hand. But the returns are in most cases not yet sufficiently complete to justify publication in the report, and, in view of the importance of the interests and issues involved, the committee feels that it would be premature to issue any detailed report on particular aspects of the fuel question until its inquiries have reached a more advanced stage than at present.

The committee recommends that it be re-appointed to continue its investigations, as outlined and foreshadowed in this report, and, in view of the considerable expense involved in carrying out such work, it feels justified in asking for a grant of £100.

APPENDICES.*

The Work of the Sub-committees.

The following memoranda concerning the work of each of the five sub-committees will sufficiently indicate the various matters which are at present chiefly under consideration, and the arrangements which have been made for their future investigations.

A.

Chemical and Statistical Sub-Committee.†—Dr. J. T. Dunn (Chairman), Prof. P. P. Bedson, Dr. W. Galloway, Prof. Thos. Gray, Mr. T. Y. Greener, Prof. L. T. O'Shea, Sir Richard Redmayne, Dr. A. Strahan and Dr. R. V. Wheeler.

The sub-committee is preparing a memorandum and a bibliography upon the question of the chemistry of coal, and is of the opinion that the time has now arrived for a re-investigation of the subject in order to clear up a number of outstanding points connected with the chemical constituents of coal, their mutual relations in the raw material, and their influence upon the character of the various products obtainable by its distillation or oxidation. As an important part of the work, the sub-committee hopes later on to organise systematic investigations upon the chemical character of the principal British coal seams.

The sub-committee is also compiling statistical information relative to the different purposes for which coal is used, and has entered into communication with the Board of Trade upon the question, but the collection and analysis of such statistics has been greatly impeded by the war.

Another important matter into which the sub-committee proposes to inquire is the amount of wastage due to coal which, for one reason or another, is at present left behind in the pits. Part of such wastage, for example, that due to the occurrence of faults in the coalfields, is unavoidable, but when all such allowances have been made, there undoubtedly remains a large wastage in working which might be and ought to be avoided. A memorandum is being prepared on the reduction of such wastage by the adoption of hydraulic stowage, a practice which, although in vogue on the Continent, has not yet been established in Great Britain.

B.

Carbonisation Sub-committee.—Mr. T. Y. Greener (Chairman), Prof. P. P. Bedson, Sir G. T. Beilby, Mr. E. Bury, Dr. Charles Carpenter, Dr. J. T. Dunn, Prof. Thos. Gray, Mr. D. H. Helps, Mr. C. H. Merz, Prof. L. T. O'Shea, Dr. J. E. Stead, Mr. G. Blake Walker and Dr. R. V. Wheeler.

The total amount of coal carbonised in this kingdom for the manufacture of metallurgical coke or for towns' gas in the year 1913 was probably about 35- to 40-million tons, or approximately one-fifth of the total home consumption of coal for all purposes.

* Slightly abbreviated.

† The chairman and secretary of the General Committee are *ex-officio* members of each sub-committee.

According to a recent Parliamentary return relating to all authorised gas undertakings in the United Kingdom, the total quantity of coal carbonised for towns' gas by 831 such undertakings in the year 1913 amounted to 16,971,724 tons, from which 195,826-million cubic feet of coal gas were produced, or, say, on the average, about 11,500 cubic ft. per ton of coal carbonised. There are a number of gasworks not included in this Parliamentary return, and it is computed that they carbonise about 1¼-million tons of coal per annum. Thus the total coal carbonised in gasworks throughout the kingdom in the year 1913 would be about 18,200,000 tons.

The amount of ammonium sulphate produced by gasworks in that time in the United Kingdom was officially given as 182,180 tons, which on the above basis would represent an average yield of about 22·4 lb. per ton of coal carbonised.

No such complete returns are available in relation to the manufacture of metallurgical coke, but the amount of coal carbonised for this purpose in 1913 probably did not fall much short of 20-million tons. Of this coal, the larger proportion was carbonised in by-product ovens, producing, besides coke, tar, benzol, &c., some 133,816 tons of ammonium sulphate. Assuming an average yield of 22·5 lb. of ammonium sulphate per ton of coal, it would appear that approximately 13·3-million tons were carbonised in by-product ovens, and probably about half that amount in beehive ovens.

With regard to the coking industry, the sub-committee has already undertaken steps to secure a complete return of the number of by-product recovery ovens installed and working througout the country, the character of each installation (whether waste heat or regenerative), its coking capacity, the description of the recovery plant connected with it (whether direct or indirect), the number of benzol recovery plants in operation, the quantities and yields of the by-products obtainable, and the purposes for which waste heat and surplus gas are being employed. It is also intended later on to consider the question of low-temperature carbonisation from the point of view of its possible economic results, but up to the present time so little authentic information is available that the committee would welcome the offer of proper facilities to enable them to investigate the matter.

C.

Metallurgical, Ceramic and Refractory Materials Sub-committee.—Dr. J. E. Stead (Chairman), Mr. Robert Armitage, M.P., Prof. J. O. Arnold, Sir Hugh Bell, Bart., Mr. E. Bury, Sir Robert Hadfield, Mr. Greville Jones, Dr. J. W. Mellor, Mr. Robert Mond, Mr. Bernard Moore, Mr. Benjamin Talbot, Mr. B. W. Winder and Mr. H. James Yates.

The amount of coal consumed in metallurgical, ceramic, refractory materials and cognate industries probably amounts to approximately 20 per cent. of the total home consumption. Of this, probably about three-fourths must be debited to the iron and steel industries.

The sub-committee has taken steps to ascertain from some of the larger manufacturers data which will assist it in determining the actual amount of fuel which is being used on the average in the manufacture of the various brands of pig iron, spiegeleisen, ferro-manganese, &c., throughout the kingdom. A memorandum is in preparation concerning the heat balance of a blast furnace of modern construction for the manufacture of Cleveland No. 3 and other pig irons, and a description will be given of the best methods now available for the utilisation of the surplus gases from such a furnace. Inquiries are also being made as to the results of the application of dry air to blast furnaces.

In like manner a series of questions relative to fuel consumptions in steelworks has been prepared for circulation among the larger steel plants in the kingdom, with a view to ascertaining both the present average consumption and the directions in which further economies may be looked for in the near future. In this connection the sub-committee will endeavour to draw up a statement as to the best lay-out and arrangement of a combined by-product coking, iron-smelting and steel-making plant from the point of view of utilising as completely as possible surplus gases and waste heat, and thus realising the maximum fuel economy in the heavy-steel industry.

Similar inquiries will be instituted in regard to present-day practice and results in relation to (1) iron foundries, (2) manufacture of wrought iron and (3) specialised steel industries.

D.

Power and Steam Raising Sub-committee.—Mr. C. H. Merz (Chairman), Lord Allerton, Mr. J. A. F. Aspinall, Dr. Dugald Clerk, Mr. S. Z. de Ferranti, Sir Robert Hadfield, Dr. H. S. Hele-Shaw, Mr. W. W. Lackie, Mr. Michael Longridge, Mr. Robert Mond, Hon. Sir Charles Parsons, Prof. Ripper, Mr. R. P. Sloan, Mr. C. E. Stromeyer, Prof. Threlfall, Mr. G. Blake Walker, and Mr. B. W. Woodhouse.

The special duty of this sub-committee is to investigate the economies in fuel which would result from the use of improved methods, and it has been decided to deal with the subject under the following heads: (1) To consider (*a*) the amount of fuel consumed, and (*b*) the corresponding power developed in the United Kingdom under the following heads: Factories, mines, railways, ships and steam raising for other purposes than power. (2) To consider the present position of central electrical power plants and gas undertakings as regards power supply. (3) To discuss the relative merits of the present methods for producing power by steam, gas, oil and petrol engines respectively. (4) To investigate the possible saving of fuel which might be effected (*a*) by improved plant, (*b*) by greater centralisation of power production, (*c*) by co-ordination with metallurgical and other manufacturing processes, (*d*) by some measure of public control, (*e*) by better supervision, and (*f*) by the use of inferior grades of fuel which are at present wasted.

The average figure of 5 lb. of coal per horse-power hour which was given in the Report of the Royal Commission on Coal Supplies in 1905 was, we believe, deduced from returns from a number of typical industrial concerns where information could be obtained, and it is probable that this estimate did not exaggerate the actual coal consumption per horse-power hour at that time. In view of the impossibility of obtaining accurate returns of fuel consumption per horse-power hour from the whole of the power users in this country, it has been decided to investigate the matter by asking for detailed returns from typical factories in various trades and in different districts throughout the country, selected by members of the sub-committee who have special knowledge of particular trades.

E.

Domestic Fuel Sub-committee.—Mr. E. D. Simon (Chairman), Mr. A. H. Barker, Prof. H. B. Dixon, Prof. W. W. Haldane Gee, Prof. W. P. Wynne, and Mr. H. James Yates.

The amount of coal actually consumed for domestic purposes in the United Kingdom probably does not fall far short of 36-million tons per annum—nearly one-fifth of the total consumption for all purposes in the kingdom. To this would have to be added the "coal equivalent" of the gas and electricity consumed for domestic purposes, if a correct estimate of the total domestic coal consumption is to be made. The Royal Commission of 1905 estimated that 50 per cent. of the coal consumed for domestic purposes might be saved by the installation of better appliances, so that there is clearly a vast field for economy.

The whole question of domestic uses of fuel bristles with difficulties and complications. In the first place, it is necessary to discriminate between fuel or energy consumed in the kitchen for cooking and other similar purposes, and that applied for the heating of ordinary living-rooms.

In the vast majority of the houses inhabited by the artisan population the kitchen fire or stove is the only place in the house where fuel is burnt; also in better-class houses it is only in the kitchen that fuel is burnt daily throughout the whole year. Hence it would appear that the kitchen is responsible for the greater part of our annual domestic fuel bill, and, therefore, the question of the relative efficiencies of kitchen ranges, gas and electric cookers, and hot-water supply apparatus assumes considerable importance.

Again, the selection or recommendation of particular means or apparatus for domestic heating cannot always be based simply upon the question of thermal efficiency, because it also involves considerations of a physiological and even a psychological character. Thus, for example, systems of central heating which have been recommended on grounds chiefly of thermal efficiency, and which are so universally used in America and on the Continent, are not usually acceptable to the average Englishman, who undoubtedly prefers to be warmed by the radiation from a bright fire.

This being so, the sub-committee feels that it will be wise to recognise at the outset that there is probably no single solution of the domestic heating problem which is likely to be universally adopted within any measurable period of time; and that, therefore, it should preferably concentrate its efforts upon questions of more immediate practical importance.

It will be generally agreed that any reform in domestic fuel consumption should aim at achieving one or more of the following objects, namely:—

1. Actual reduction in cost of domestic heating, either in the form of direct saving of fuel or labour, or both;
2. Mitigation or abolition of the domestic smoke nuisance; and
3. Better hygienic conditions in living apartments generally.

The sub-committee can perhaps best discharge its duties by considering how far the various systems now available for domestic heating fulfil such requirements, and how they may severally be installed and operated to the best advantage.

In order to do this the sub-committee has arranged for experiments to be carried out with the object of determining how to produce in a given room suitably warm and healthy conditions at a minimum cost and with a minimum production of smoke, and how such conditions may be defined for any particular room. Also, experimental work is being carried out upon the relative efficiencies of coal fires, gas fires, electric heaters and the like.

Inasmuch, however, as in this country the use of the open coal fire will probably continue for some time to come, and as there are undoubtedly great economies to be immediately realised by the wider adoption of improved fire-grates, the sub-committee will pay special attention to the question of improvements in the construction and installation of such grates, to which the attention of architects, builders and the public generally ought to be drawn.

Arising out of the present extensive use of solid fuel in domestic fires the sub-committee will also consider the important question of the prospects of substituting for raw coal some form of carbonised fuel (semi-coke or coke). There can be no doubt but that if such a substitution could be effected, without either increasing the domestic coal bill or involving some other disadvantage, not only would there be a great addition to the amount of valuable by-products annually obtained from coal consumed in the kingdom, but also the smoke nuisance in our large centres of population would be materially reduced.

Work on these lines is being carried out in the Department of Heating and Ventilating Engineering at the University College, London; at the Municipal School of Technology, Manchester; and at the Department of Chemical Technology at the Imperial College of Science and Technology, London.

THE LAWS OF VARIATION OF RESISTANCE WITH VOLTAGE AT A RECTIFYING CONTACT OF TWO SOLID CONDUCTORS, WITH APPLICATIONS TO THE ELECTRIC WAVE DETECTOR.*

BY D. OWEN, B.A., B.SC.

Various theories have been put forward to account for the rectifying action at a contact such, for example, as that between zincite and chalcopyrite, to which an alternating voltage is applied. It has long been recognised that certain minerals possess extraordinarily large thermo-electric powers, exceeding in some instances by 10 times or more that between bismuth and antimony. A natural explanation in terms of thermo-electric action thus lay to hand, which appeared all the more probable from the fact that these minerals also possess a large negative temperature coefficient of resistance.

A theory—since known as the electronic valve theory—has also been suggested, according to which we have in certain minerals a new phenomenon, namely, the easy passage of free electrons in one direction across the contact, but not in the contrary direction.

The present Paper deals with measurements of the resistance of the contact. The primary aim was to examine to what extent the resistance-characteristic expresses the nature of the physical actions occurring, and to obtain data leading to a discrimination between the hypotheses referred to.

The characteristic obtained with a zincite-chalcopyrite contact is shown in Fig. 1.

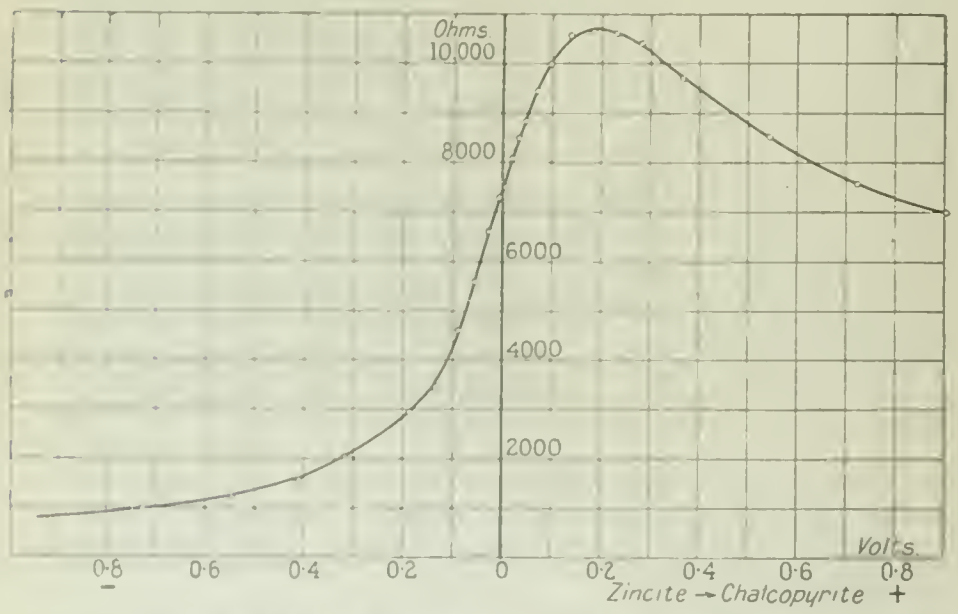


FIG. 1.—RESISTANCE CHARACTERISTIC OF A ZINCITE-CHALCOPYRITE CONTACT.

This type was followed by all the mineral combinations tried. The main points of interest are as follows: When a small voltage is applied the resistance rises, falling at the same rate when the voltage is reversed; a maximum occurs on the side of initial increase: at the higher voltages the characteristic is a falling one, the gradient diminishing on either side, positive or negative. Let

v = voltage applied across the contact.

R_0 = resistance when v is zero.

R_m = maximum value of resistance, occurring at voltage v_m.

Investigation of a great number of contacts has led to the following quantitative results:

1. At $v = 0$ the gradient of the resistance characteristic is proportional to the limiting resistance R_0, that is, $\left(\frac{1}{R}\frac{dR}{dv}\right)_0$ is a constant for a given pair of materials. This quantity, which is analogous to the temperature coefficient of resistance, may be termed the voltage coefficient of the contact;

2. v_m is independent of R_0;

3. The ratio R_m/R_0 is independent of R_0. When a series of characteristics are obtained from contacts of widely varying resistance or area of contact, and the ordinates of each reduced in the ratio $1 : R_m$, the resulting curves are found to coincide, yielding what may be called the *specific characteristic* of the given pair of substances (Figs. 2 and 4).

The above results are found to conform to an expression connecting R and v derived on the basis that the phenomena are thermo-electric.

A series of experiments was carried out on a number of contacts both elements of which were metallic, and for which the thermo-electric and other relevant constants are known. These confirm the same view.

The facts as to the sign of the rectified current will be shown on close examination to be not in opposition, as some writers have supposed, but in simple accordance with the thermo-electric explanation.

The experimental results above outlined form the basis of a calculation of the conditions of best sensibility in a wireless receiving circuit, with or without a polarising voltage. Similar considerations determine the sensitiveness to be expected in a combination of rectifying contact and direct-current galvanometer, as applied to the detection of small alternating voltages in bridge or other null methods of measurement.

Experimental Details.—The contacts tested were found to range in resistance from fractions of an ohm in the case of metallic combinations to millions of ohms in the case of zincite or corborundum contacts. The Wheatstone bridge was employed throughout. The applied voltage was varied from a millivolt or less up to 1 or 2 volts.

The mineral contacts tested were the following:—

Zincite-platinum.	Galena-platinum.
Zincite-chalcopyrite.	Chalcopyrite-platinum.
Carborundum-platinum.	Bornite-platinum.
Chalcopyrite-bornite.	

Ten different contact points were taken in succession between the same pair of mounted minerals, and sets of readings taken from which the resistance characteristics were plotted. The following Table summarises the results of the series for zincite-chalcopyrite:—

Table I.—*Series of Contacts Between Zincite and Chalcopyrite.*

No.	R_0	R_m	R_m/R_0	v_m	$(dR/dv)_0$	$\left(\frac{1}{R}\frac{dR}{dv}\right)_0$
1	6,480	10,100	1·50	0·17	27,700	6·70
2	7,360	10,800	1·47	0·18	32,800	4·40
3	20,340	30,600	1·47	0·17	113,800	5·07
[4	24,000	28,100	1·17	0·30	39,500	1·64]
5	57,200	83,000	1·45	0·15	296,000	5·17
6	77,200	104,200	1·35	0·12	405,000	5·24
7	80,800	132,000	1·63	0·16	591,000	7·32
8	123,000	202,500	1·62	0·14	925,000	7·40
9	251,500	445,000	1·77	0·18	$2·18 \times 10^6$	8·70
10	540,000	855,000	1·58	0·11	$4·1 \times 10^6$	7·6
			Mean = 1·54	Mean = 0·15		Mean = 6·40

With the exception of No. 4 (which was excluded in calculating mean values), it will be seen that the variations in the three quantities v_m, R_m/R_0 and $\left(\frac{1}{R}\frac{dR}{dv}\right)_0$ are insignificant compared with the range of resistance covered by the series. It seems safe to conclude that the essential action at the contact is expressed in the statement that $\left(\frac{1}{R}\frac{dR}{dv}\right)_0$, R_m/R_0, *and* v_m *are dependent only on the materials constituting the contact, and not on the area or resistance of the contact itself.*

A similar series of measurements was undertaken on contacts between platinum and galena. The specific resistance of the latter is much smaller than that of zincite, so that very small mechanical pressure at the contact must be used in order to secure even moderately high values of the resistance. Another series of results was obtained with carborundum. In each case the same general conclusions were realised.

Experiments on the combinations platinum-chalcopyrite and chalcopyrite-bornite show that the sensitiveness of these contacts is negligibly small compared with that of the preceding combinations. In the case of chalcopyrite-bornite three contacts were tested, the values of R_0 being respectively 1,952, 1,880 and 1,500 ohms. The corresponding voltage coefficients at $v = 0$ were 0·073, 0·05 and 0·00. A few contacts of platinum-zincite were also tested; they yielded values of $\left(\frac{1}{R}\frac{dR}{dv}\right)_0$, R_m/R_0, and v_m, practically agreeing with those of chalcopyrite-zincite.

We may conclude that chalcopyrite, bornite and platinum are almost interchangeable elements of a combination whose other member belongs to minerals of the class zincite or carborundum.

The characteristics shown in the Paper are drawn in accordance with the convention that the applied voltage is positive when producing current across a junction in the same direction as that caused by a slight rise of temperature at that junction.

The Thermo-electric Theory of the Phenomena.—The effects may be simply explained provided the applied voltage is restricted to a sufficiently small value. In the account that follows this limitation is assumed

* Abstract from the "Proceedings" of the Physical Society of London, June 15, 1916.

Consider in the first place the case of a contact having zero temperature coefficient of resistance. If the Joulean heat could be neglected a rise of temperature would occur on applying a voltage in one direction, and an equal fall with voltage reversed. Equal and opposite thermo-E.M.F.s will be generated, the direction being such as in each case to *oppose* the applied voltage. The apparent resistance of the contact will be greater than the true resistance, the excess being independent of the direction of the current. Its value will be constant, since for small voltages the back thermo-E.M.F. will be proportional to the applied voltage. Now let us correct this result by taking the Joulean heat into account. For one direction of current this will be added to the Peltier heat, thereby increasing the rise of temperature and the back E.M.F., and consequently the apparent resistance. For current in the opposite direction the Joulean heat will partially neutralise the Peltier cooling; and the fall of temperature, the back thermo-E.M.F. and the apparent resistance will all be reduced. The resultant effect will be to give a straight line law connecting apparent resistance and applied voltage, the line being now inclined to the axis of voltage.

Another elementary thermodynamic principle of importance is that when current across the junction causes Peltier *absorption* of heat, an external supply of heat must cause an E.M.F., and, therefore, a current, in the *same* direction across that junction. It follows that at a junction of materials possessing zero temperature-coefficients of resistance the apparent resistance *falls* when the current is of the same sign as that caused by heating the junction. Such a case is found in the combination manganin-constantant, observations on which are described below.

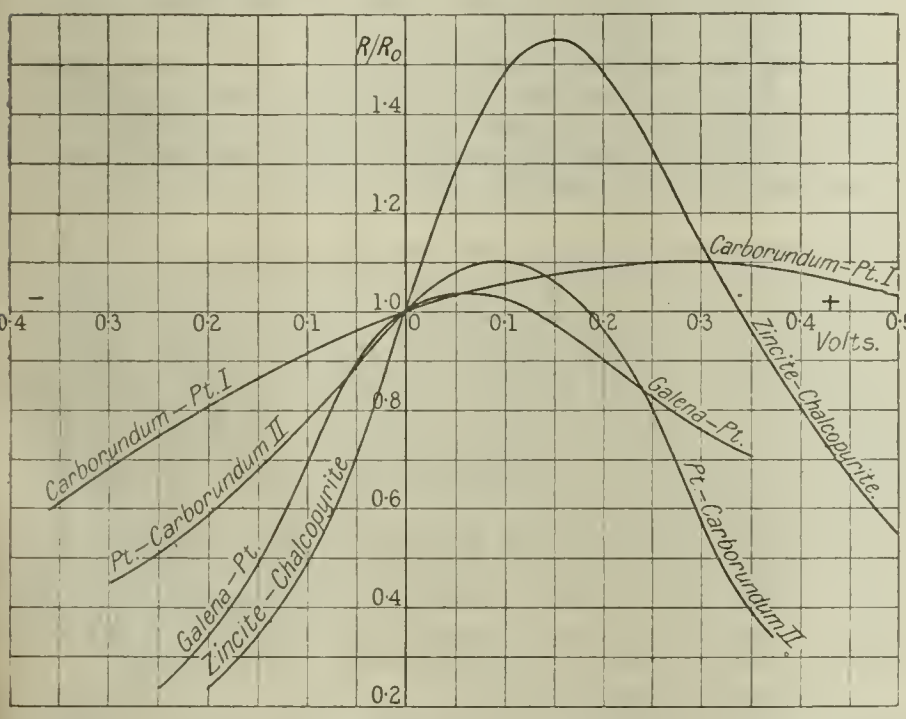


FIG. 2.—SPECIFIC RESISTANCE CHARACTERISTICS OF SOME MINERAL CONTACTS.

If the temperature coefficient is positive the effect will be to augment both the fall of resistance for one direction of current, and the rise for current in the reverse direction. The slope of the resistance characteristic in the immediate neighbourhood of zero voltage will be of the same sign as before, but increased in value.

When the temperature coefficient is negative, on the other hand, the slope of the characteristic at zero voltage is reduced, and changes sign when the coefficient is sufficiently large numerically, in which case we have a *rise* of apparent resistance when the current is in the same direction as that caused by applying heat to the junction. The large negative coefficients occurring in minerals like zincite and galena are amply sufficient to produce this rise. Thus is explained the apparent anomaly of a reduction in resistance, despite the fact of a back thermo-E.M.F.

In working out an exact treatment of the actions which are assumed to take place at a contact the author is indebted to the Papers of Dr. W. Eccles* on this subject. Nevertheless the conclusions of the present Paper will be found to differ from those of the Paper quoted in several material respects. Thus, whereas much importance is attached in the latter to the part played by the Thomson effect, in the present treatment the experimental results find their explanation in terms of the Peltier effect and the temperature coefficient resistance.

The equation of the resistance-characteristic is as follows:—

$$KR^2-R(KR_0'+a^2T_0)=v^2bR'_0-av(R+bT_0R_0'),$$

where a=thermo-electric power; b=temperature coefficient of resistance; K=heat dissipation constant; R=apparent resistance of contact; R'=true resistance; and T_0=absolute temperature.

Three main types of characteristic are derivable, which are represented diagrammatically in Fig. 3.

Type I. is the limiting case where $b=0$, when equation (7) simplifies to a straight line, denoting a resistance which falls for voltage applied in the positive direction. It is practically realised in the contact constantan-manganin.

Type II. includes all cases where b is positive, and thus covers all combinations of pure metals. With voltage in the positive direction the resistance at first falls, reaches a minimum, and afterwards rises.

Type III. represents cases for which b is negative and large. It includes all the mineral contacts possessing marked rectifying properties. The resistance *rises* at first with a positive voltage, reaches a maximum and then falls continuously.

Putting $v=0$, the characteristic equation reduces to

$$R_0=R_0'\left(1+\frac{a^2T_0}{KR_0}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The apparent resistance is greater than the true resistance by an amount proportional to the square of the thermo-electric power.

Differentiating (6), we have

$$\frac{dR}{dv}=\frac{2bR_0'v-a(R-bT_0R_0')}{2KR-KR_0'-a^2T_0-av}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

There are two important special cases. First, let $v=0$. Then

$$\left(\frac{1}{R}\frac{dR}{dv}\right)_0=\frac{-a(1+bT_0R_0'/R_0)}{KR_0}. \quad . \quad . \quad . \quad . \quad . \quad (10)$$

This expression represents the value of the voltage-coefficient of resistance of the contact.

Next consider the point at which dR/dv is equal to zero, that is, R a maximum or minimum. The applied voltage at which this occurs is given by

$$v_m=\frac{a(R_m/R_0'+bT_0)}{2b}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Substituting this expression for v in the general equation, we obtain a function of the form $f(R_m/R_0, KR_0)=0$, which means that provided KR_0 is independent of R_0, so also is R_m/R_0.

Returning to equation (11), and putting R_m/R_0' equal to a constant, we see that v_m necessarily becomes independent of R_0.

It follows, therefore, that on the thermo-electric theory of the effect the three quantities $\left(\frac{1}{R}\frac{dR}{dv}\right)_0$, v_m, and R_m/R_0 are independent of R_0, provided KR_0 is independent of R_0.

In seeking for a theoretical basis yielding the requirement that KR_0 should be a constant, or approximately a constant, for any given pair of materials, two views of the nature of the contact have been taken. From either of these the required condition can be deduced.

(*a*) We may assume that the contact resistance is given by the end-correction formula applied to, say, a uniform column of mercury in a capillary tube terminating within a considerable bulk of mercury.

(*b*) We may suppose that the resistance R_0 is located mainly—let us suppose entirely—in a thin film of molecular dimensions whose area is that over which the two elements of the contact intimately meet. In either case it may be shown that KR_0 is independent of the contact area, and proportional to the ratio of the thermal and electrical conductivities.

Experiments with Metallic Contacts.—The following were selected as test cases:—

Bismuth-Antimony.—a large, $b+$.
Iron-Nickel.—a fairly large, $b+$.
Constantan-Manganin.—a fairly large, $b=0$.
Copper-Manganin.—a very small, $b=0$.
Bismuth-Bismuth.—a zero, $b+$.

A series of contacts was examined in each of these cases, the results being to show (1) that the voltage-coefficient at zero voltage is independent of the resistance: (2) that the sign of the above coefficient is negative: (3) that a minimum occurs on the side of positive voltage.

We may conclude that the phenomena occurring at metallic contacts are thermo-electric in nature, and are essentially identical with those of mineral contacts.

The voltage coefficient is largest in the case of antimony-bismuth, though even here it has only one-fifth the value found at a galena-platinum contact, and about one twenty-fifth that of a zincite contact. The specific characteristics of the above two contacts are shown in Fig. 4, which is drawn to the same scale as Fig. 2.

Softening of the Contact due to Rise of Temperature.—All the resistance-characteristics of this class exhibit a droop on both the

* Eccles, "Proc." Phys. Soc., Lond., XXV., p. 273, 1913.

positive and the negative side when the voltage rises to a certain value dependent on the duration of the current. It occurs most readily in contacts containing bismuth as one element, the melting point of which is 269°C. The effect is evidently due to softening and plastic yielding at the contact, which results in rapid increase of area. There is little doubt that this effect is present to an important extent in the case of mineral contacts also, though not so obvious since it then occurs on a falling characteristic.

Constantan-Manganin.—This constitutes the case $b=0$. The characteristic equation reduces to $R=R_0'-\frac{a}{K}\cdot v$, which represents a straight line. This linear type of characteristic was found as expected.

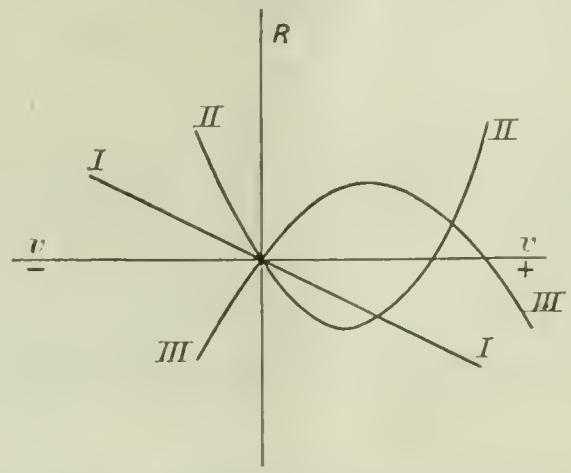


Fig. 3.—Three Theoretical Types of Resistance Characteristic.

Type I, $b=0$. Type II, b positive. Type III, b negative and large.

The Rise of Temperature at the Contact.—An expression is obtained for the rise of temperature t in terms of v, which for small values of v reduces to

$$t=-v\cdot\frac{aT_0}{KR_0}.$$

The temperature change is thus proportional to the applied voltage and to the thermo-electric power. In the case of constantan-manganin the equation becomes $t=-30{\cdot}5v$, which denotes a fall of temperature for current in the direction constantan to manganin across the contact, at the rate of 30·5 C. per volt. We may obtain an estimate in the case of mineral contacts by assuming values for (a) and (b). Thus, in the case of galena we may accept roughly $a=500\times10^{-6}$, $b=0{\cdot}01$, whence $t=-177v$, *i.e.*, a fall at the rate of 177 C. per volt for current crossing the contact from galena to platinum.

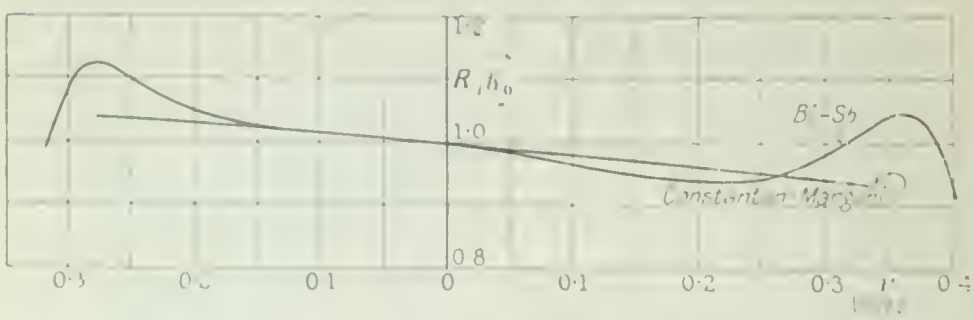


Fig. 4.—The Specific Resistance Characteristics of Two Metallic Contacts.

The Reception of Electric Waves by the Contact Rectifying Detector. Conditions of Highest Sensibility.—The law of constancy of the voltage coefficient can be applied to the receiving circuit in which a contact detector is employed in series with a magnetic telephone. It will be supposed in the first place that no polarising voltage is used. Let

$v=v_0\sin pt$ = applied voltage.
i = instantaneous current.
R = apparent resistance of contact.
R_t = resistance of telephone.

$$A=\left(\frac{1}{R}\frac{dR}{dv}\right)_0.$$

A simple treatment is adopted, the inductance of the telephone and leads being neglected and the resistance assumed to be independent of frequency. The conclusions thus reached may be corrected in the direction required by the practical conditions applying in any given case.

The current at any instant is given by

$$i=\frac{v_0\sin pt}{R+R_t}.$$

The mean or rectified current is

$$\frac{1}{T}\int idt=\frac{-AR_0v_0^2}{2(R_t+R_0)^2}.$$

Its value is proportional to the square of the R.M.S. value of the applied voltage, a result first empirically deduced by L. W. Austin.*

The pull on the telephone diaphragm is determined by the number of ampere-turns. The best resistances of contact and telephone are those which make the ampere-turns a maximum for a given applied voltage. For maximum sensibility of receiving circuit, therefore, $\frac{nAR_0}{2(R_t+R_0)^2}$, must be a maximum, where n denotes turns on telephone.

For high sensibility: (1) The contact should be of materials having as large a voltage-coefficient as possible; (2) the resistance of the contact should be low (the lowest value depending on the impedance in receiving antenna, &c.); (3) the resistance of the telephone should be about one-third that of the contact.

Use of a Polarising Voltage.—By applying the above considerations and paying due regard to the form of the resistance characteristic for any combination, the effect of a polarising voltage may be foreseen. It is evident that if the polarising voltage be such as to lead to the point of maximum resistance on the characteristic, then the rectifying power and the sensibility become zero.

Again, if the resistance of the contact is below that of the telephone, it is quite possible that a polarising voltage in either direction may be deleterious or at least ineffective.

It is when the resistance of the contact happens to be much larger than that of the telephone that the advantage of a polarising voltage will be decisively seen. Its sign must evidently be chosen in the direction of the initial fall in the characteristic, *e.g.*, for the perikon the polarising current must cross the contact from chalcopyrite to zincite.

An examination of the curves shows that with voltages increasing from zero in the direction just specified, the slope of the characteristic at first increases. As the polarising voltage is increased further the slope at the corresponding points of the characteristic falls off, and evidently a value of the polarising voltage will be reached at which a maximum effect occurs. This value will depend on the initial resistance of the contact; it is thus not possible to specify any definite figure for the optimum polarising voltage at a contact of given materials.

Theoretically it appears that, given the receiving telephone, the ideal contact is one to which is applied the small polarising voltage leading to the point of maximum slope on the characteristic: and of initial resistance such that under that polarising voltage the resistance falls to a value exactly equal to that of the telephone.

Use of Direct-Current Galvanometer in Series with a Rectifying Contact in Null Alternating-Current Bridge Methods.—This problem is amenable to the treatment applied in the last section. If the galvanometer be regarded as given, then for highest sensibility the resistance of the contact should be equal to that of the galvanometer, but if a given contact be taken then the best galvanometer to choose is one of resistance one third that of the contact at zero voltage.

It may be shown that the minimum voltage detectable cannot be reduced greatly below a millivolt. For currents within the range of useful frequency of the telephone and the vibration galvanometer the combination of contact and direct-current galvanometer thus falls much below those instruments in sensibility. This conclusion is in accordance with experimental results.

The following example of a test may be quoted. The agreement between the observed rectified current and that calculated by equation (23) is very satisfactory.

Contact of galena-platinum: $A=1{\cdot}20$.
$R_0=95$ ohms.
Galvanometer resistance $=250$ ohms.
Sensibility $=186$ scale divisions (1/40 in.) per microampere.
Applied voltage (R.M.S.) $=0{\cdot}05$ volt, at 85 ~.
Observed steady deflection $=383$ scale-divisions: whence rectified current $=2{\cdot}06\times10^{-6}$ amperes.
Rectified current calculated by (23)

$$\frac{1{\cdot}2\times95\times0{\cdot}05^2}{345^2}=2{\cdot}38\times10^{-6}\text{ amperes.}$$

Taking half a scale-division as the minimum observable deflection, the minimum alternating voltage detectable with the given galvanometer and contact $=\frac{0{\cdot}05}{\sqrt{766}}=1{\cdot}81\times10^{-3}$ volt.

* Austin, "Phys. Rev.," 1907.

CROWN MINES HOIST INSTALLATION.*

BY F. L. STONE.

Summary.—The author gives an interesting description of the physical characteristics of the Crown Mines on the Rand and shows why electrical equipment was not used at an earlier date. The last part of the article is devoted to a description of the large electrical equipments furnished in the last few years.

The Crown Mines are located in about the centre of the principal gold field in South Africa. The gold-bearing reef extends east and west, a few miles south of Johannesburg, and has a total length of approximately 50 miles. The reef outcrops almost continuously throughout the entire distance, and pitches south at angles varying from 30 deg. to nearly vertical.

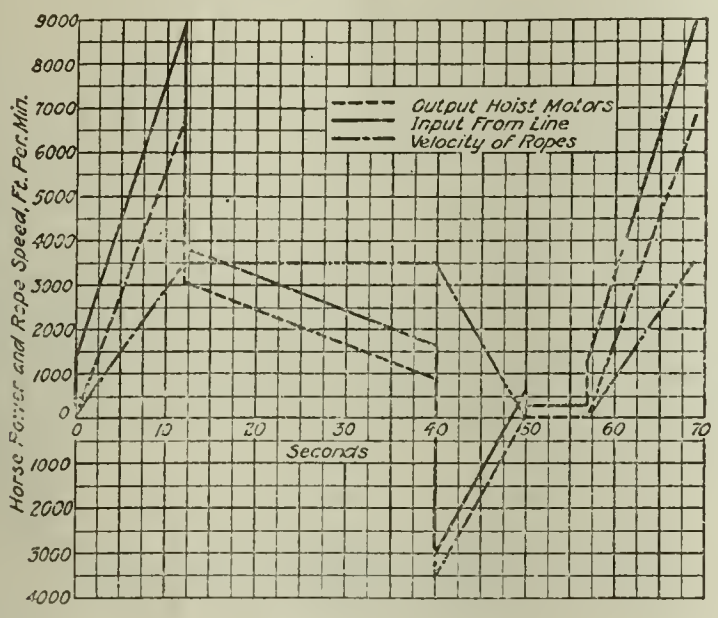


FIG. 1.—DUTY CYCLE WHEN WINDING FROM THE 2,260 FT. LEVEL.

No mining of any importance was carried on in this locality until about 30 years ago, when the value of the deposits became known. Up to this time, and for quite a number of years following, the principal mining was naturally carried on along the outcrop. Later, however, when the geology of the country was better understood, other properties were opened south of the outcrop, and vertical shafts sunk until they intersected the gold-bearing strata. Cross tunnels were driven at various points in the shaft both above and below the vein, until they intersected it, and thus the ore could be brought to the shaft from many levels.

The general indications seem to be that the main body or vein

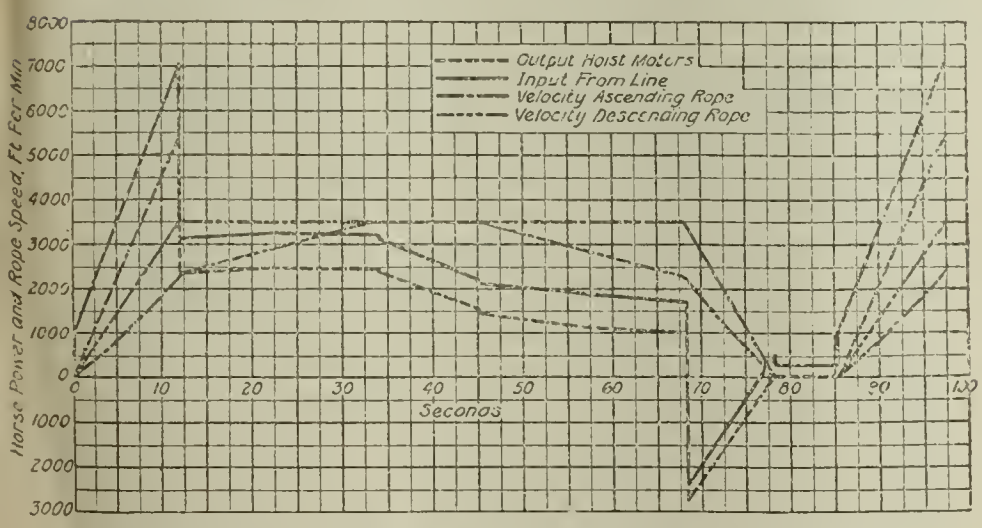


FIG. 2.—DUTY CYCLE WHEN WINDING FROM THE 3,540 FT. LEVEL.

somewhere reaches a basin, though this has never been proven. Very thin outcrops, however, have been found many miles further south. They are so lean, however, that mining has only been attempted in one or two places. On the other hand, a very good body of ore has been found well to the north of the original outcrop. It is very limited in its area, however, paralleling the main reef for a very short distance. Its existence has proved a constant source of argument among geologists for many years. As the wonderful possibilities of the Rand became appreciated, engineers of marked ability devoted their attention to the recovering of the ore. A system of mining was evolved which looked well into the future. It is very questionable if, even at this time, the real value of this tremendous body of gold-bearing ore was appreciated.

Originally all of the winding engines were steam driven. Later some comparatively small isolated electric plants were put down and the winders were electrified. This in some instances did not show the saving hoped for, due to the poor load factor of the small plants. It was not until the Victoria Falls Power Co. erected its plants (which now have a capacity of approximately 220,000 kw. all available for mining purposes), and ran its power lines the entire length of the Rand, that electrification was really well started. As soon as a constant source of power was assured the electrification of the mines was taken up most energetically.

In September, 1912, specifications were issued by the engineers of the Rand Mines (Ltd.) for a hoisting equipment for their own Crown Mines, South Rand shaft. The principal data submitted was as follows :—

Depth of shaft	3,540 ft.
Inclination of shaft to horizontal	90 deg.
Weight of ore per trip	16,000 lb.
Weight of skip	8,700 lb.
Size of rope	2 in.
Weight of rope per side	22,300 lb.
Type of drum	Double cylindro-conical
Diameter of rope centres at small end of drums	12 ft.
Diameter of rope centres at cylindrical end of drums	20 ft. 8 in.
Number of turns of rope on cone	25 turns
Number of turns of rope on cylinder, 1st layer	21 turns
Number of turns of rope on cylinder, 2nd layer	14 turns
Maximum rope speed, ft. per minute	3,500 ft.
Maximum revolutions per minute of drums	53·5 r.p.m.
WR^2 of revolving parts of hoist (less motors)	15,810,000 lb.-ft.
Time for acceleration	12 seconds
Time for retardation (assumed)	10 seconds
Rest period	7 seconds.

The equipment was to consist of two direct-connected motors for driving the hoist and motor-generator set, made up of an induction motor and two direct-current generators, all the direct-current machines being wound for 550 volts, both the motors and generators being operated in series. The motor speeds were to be controlled by varying the voltage of the generators, which were to be separately excited. Duty cycles were made up showing the operation of the hoist when lifting from the deepest level and also when lifting from intermediate levels. Fig. 1 shows the input from the line to the induction motor, the output of the hoist motors and the rope speed when hoisting from the 2,260 ft. level; while Fig. 2 shows the operation of the hoist when lifting from the 3,540 ft. level. It is interesting to note that while hoisting from the upper levels, as shown in Fig. 1, the rope never leaves the cylindrical portion of the drums; on the other hand, while lifting from deeper levels the conical effect of the drum is used. It was found that the heating of the apparatus when winding from the higher levels was considerably in excess of that developed when winding from the deeper levels. To meet the duty cycles the following apparatus was supplied by the General Electric Co., of Schenectady :—

Two 22-pole 2,000 H.P. 53·5 revs. per min. 550-volt shunt-wound motors.

One four-unit motor-generator set consisting of one 16-pole 5,000 H.P. 375 revs. per min. 2,000-volt induction motor; two 14-pole 1,650 kw. 375 revs. per min. 550-volt shunt-wound generators; and one 60 kw. compound-wound exciter, together with the necessary control apparatus.

On account of the size of the motors it was found that they would have to be built up on the scene of operation.

This equipment has been in operation for over a year, and no delays or troubles of any kind have been experienced. In fact, an order has been awarded for an almost exact duplicate equipment for the New Modderfontein mines.

* Abstract of an article in the "General Electric Review."

BOOKS RECEIVED.

[Copies of the undermentioned works can be had from THE ELECTRICIAN Offices, post free (unless otherwise stated), on receipt of published price, adding 3d. for books published under 2s. and 5 per cent. for books published net. Add 10 per cent. for abroad or for foreign books.]

"Electric Switch and Controlling Gear," by C. C. Garrard, Ph.D. (London: "The Electrician" Printing & Publishing Co.) Pp. xviii.+656. 15s. nett.

"Prineiples of Electrieal Engineering and their Applieation," by Gisbert Kapp. Vol. I. Principles. (London: Edward Arnold.) Pp. xii.+356. 15s. net.

"Alternating Currents in Theory and Praetiee," by W. H. N. James. (Cambridge: University Press.) Pp. vi.+353. 10s. 6d. net.

"Mechanical Drafting." By C. P. Howe, M.E. (London: Chapman & Hall.) Pp. x.+147. 7s. 6d. nett.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence. Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone: City **4698** & **4699.** *Tels.:* ELECTRICIAN NEWSPAPER LONDON.

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," Salisbury. court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in "THE ELECTRICIAN," or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential and a World-wide circulation.** *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d nett. Postage of all copies to Continent of Europe, 1s. 8d ; Canada and India, 2s. ; Australasia and South Africa, 3s. ; United States of America and other Countries, 2s. 6d.

The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preparation.*

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s 6d., post free 2s. 8d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation.*

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie, A.M.Inst.C.E. *New Edition in preparation.*

BRAKES FOR TRAMWAY CARS. By H. M. Sayers. Price 2s. 6d. nett

ELECTRICITY IN HORTICULTURE. By Prof. S. Lemstrom. Illustrated. 3s. 6d. nett.

RADIO-ACTIVITY: AN ELEMENTARY TREATISE FROM THE STANDPOINT OF THE DISINTEGRATION THEORY. By Fredk. Soddy, M.A. Price 4s. nett.

MOTIVE POWER AND GEARING FOR ELECTRICAL MACHINERY. By E. Tremlett Carter. Revised by G. Thomas-Davies, A.M.I.E.E., F.C.S. Price 5s. nett.

ELECTRIC LAMPS AND ELECTRIC LIGHTING. By Prof. J. A. Fleming. 4s. nett.

A POCKET BOOK OF ELECTRICAL ENGINEERING FORMULÆ. By W. Geipel and H. M. Kilgour. Price 7s. 6d. nett.

THE ALTERNATE-CURRENT TRANSFORMER IN THEORY AND PRACTICE. By Prof. J. A. Fleming, M.A., D.Sc., F.R.S. Vol. I., 12s. 6d. post free, abroad 13s. Vol. II., 12s. 6d. post free, abroad 13s.

THE ART OF ELECTROLYTIC SEPARATION OF METALS. By Dr. G. Gore. Price 10s. 6d.

ELECTRO-CHEMISTRY. By Dr. George Gore. Price 2s. nett.

THE RATING OF ELECTRIC LIGHTING, ELECTRIC TRAMWAY, AND SIMILAR UNDERTAKINGS. By W. G. Bond, M.I.E.E. Price 2s. 6d. nett.

CARBON MAKING FOR ALL ELECTRICAL PURPOSES By Franck Jehl Price 10s. 6d.

"THE ELECTRICIAN" HANDY WIRE TABLES FOR THE POCKET. By P. B. Down, Wh.Ex. · M.I.Mech.E. Price 2s. 6d. nett

THE STEAM-ENGINE INDICATOR AND INDICATOR DIAGRAMS. Edited by W. Worby Beaumont, M.I.C.E., M.I.M.E., &c. Price 5s. nett.

INTERNATIONAL TELEGRAPH CONVENTION AND SERVICE REGULATIONS. (LISBON REVISION, 1908.) Price 6s. nett. Also LONDON 1912 AMENDMENTS to same. Price 8d. nett.

INTERNATIONAL RADIO-TELEGRAPH CONVENTION AND SERVICE REGULATIONS (London Revision, 1912). Price 5s. nett, post free 5s. 6d.

ELECTRICITY METERS. THEIR CONSTRUCTION AND MANAGEMENT. By C. H. W. Gerhardi. Profusely Illustrated. Price 7s. nett. [Price 10s. 6d.

MAGNETIC INDUCTION IN IRON AND OTHER METALS. By Sir J. A. Ewing, F.R.S.,

Now Ready.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E

FIRST EDITION: Price **15s.** nett, post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

NOW READY.

Vol. LXXVI. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 17s. 6d. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVI., price 2s. ; post free, 2s. 4d.

FUEL ECONOMY.

The question of economising our supplies of coal is one that has been raised very frequently during the past few years, but those who have advocated such economy have met with but little support. It is generally realised that our national prosperity is largely bound up with our supplies of cheap coal: that if we were dependent upon imported coal our position would be very different commercially, and that in the case of war our naval position might be seriously threatened. In everyday commercial matters men look forward to the future so as to provide as far as possible against all contingencies, but in the case of fuel economy the contingency of the exhaustion of our supplies seems to be too far in the future for many people to take any particular interest in it, and, therefore, the retort has generally been.—Let future generations look after themselves. It is argued that there may be developments which will render coal less important in the future, and that we should concern ourselves only with the present. But what will later generations say if they find themselves against this difficulty, and that it has been thrust upon them largely by the folly and negligence of their forefathers? So far there is no indication that the importance of coal commercially and industrially will diminish, and, therefore, we of this generation have the responsibility and duty of considering what should be done for the safety of this country, not merely for the present generation, but for later generations also. If other competitive countries were in the same predicament it would not so much matter, but this is not the case with our competitors. In the report which has just been issued by the British Association, and which will be found on another page, it is shown that the available reserves of coal in Great Britain only amount to about one-fortieth of the world's estimated total, whereas the United States possesses more than one-half the estimated world's coal and Germany possesses more than one-twentieth.

The war has brought about many changes, and among these there may be noted a change of opinion on such matters as fuel economy and a realisation that such matters are important. When, however, it comes to the question of regulating the waste of coal we are faced with considerable difficulties. The uses to which fuel are put are numerous. Broadly speaking, it may be said that those uses which can be most easily controlled are (1) export trade, (2) power supply and (3) domestic uses. In regard to the first, it is a question whether the export of coal should not be prohibited except for our own use, such as providing for our mercantile marine. This is probably the direction in which the smallest economy can be made. It is otherwise in the case of power. In the Report of the Royal Commission on Coal Supplies in 1905 it was stated that the average consumption of coal per horse power hour in this country amounted to 5 lb. As an average, of course, this is a poor result, and the worst results are far higher. If merely 1lb. of coal per horse power hour could be saved throughout the country, the total saved would be enormous. That this is being brought about slowly by means of electric power there can be little doubt, but the best results in economy can only be secured by the generation of electrical power on a far larger scale than has hitherto been attempted. Moreover, there is the great question of the recovery of

by-products in the use of coal. That the valuable nitrogen, oils and other bodies in coal should be simply wasted, as they mostly are, is a great reflection upon our methods of utilising coal, and in this respect it seems that we are somewhat behind Germany.

Perhaps the most difficult class of consumer in which to secure the desired economy is the domestic consumer. In many respects, however, this part of the problem is likely to solve itself. Owing to domestic difficulties the use of electricity and gas will certainly increase; in due time the use of the ordinary kitchen range for burning coal is likely to disappear and the ordinary open coal fire in sitting rooms, although there is much to be said for it from the point of view of comfort, will become more and more rare. In all probability, therefore, this part of the question will require less drastic action than any other.

We quite admit that there are many difficulties in the whole problem. It is very easy to say what are the right means to adopt and what is the right course to follow, but the fact remains that what is everybody's business is nobody's business, and consequently in the past very little has been done. If anything serious is to be accomplished in the future suitable steps must be taken by the Government, and on this occasion the matter must not be allowed to rest.

ELECTRIC POWER DISTRIBUTION.*

BY CHARLES H. MERZ.

"It appears that . . . the coal should be converted . . . . into a form in which it is most generally applicable to all purposes without exception, and in which it is most easily applied to all our wants, and is at the same time in a form in which it is most difficult to waste or us improperly.

"We are therefore forced to the conclusion that the only complete and final solution of the question is to be obtained by the conversion of the whole of the coal which we use for heat and power into electricity, and the recovery of its by-products at a comparatively small number of great electricity producing stations. All our wants in the way of light, power, heat and chemical action would then be met by a supply of electricity distributed all over the country."

[Extract from Presidential Address of Mr. S. Z. de Ferranti to the Institution of Electrical Engineers in 1910.]

The fuel and other economies and the industrial advantages of dealing with electricity supply for the country as a whole in a comprehensive manner—although appreciated and acted upon by many of those who are in the electric supply business—are not generally realised to day by the industrial community or by the State.

The compact nature of our industrial districts and their proximity to each other as compared with those of other countries, such as the United States and Germany, makes it economically possible and advantageous to deal with all the power requirements of the community in each industrial area from inter-connected electrical power distribution systems tapping all sources of power, however scattered, and delivering electrical energy wherever required.

Power undertakings (electric power companies) have been started in most of the industrial areas of the country, and if these were developed throughout the country to the same extent as the system which has been for some time in operation on the North-east coast, it is estimated that the resultant economies in coal consumption would, in the near future, amount to 25,000,000 tons per annum, and eventually to 50,000,000 or 60,000,000 tons per annum. The immense importance of this to the country is realised even if one only considers the revenue from the sale of this quantity of coal if it were exported.

Another way to look at it is, that if the present industrial power requirements of the country were supplied as cheaply as they could be from such a comprehensive system, there could be such an expansion of industry that present-day power requirements might in no great time be more than doubled. Yet there would be no necessity for increased coal consumption, for the simple reason that under such conditions we could use our coal at least twice as efficiently.

The economical generation of electricity implies the use of the largest possible prime movers and the running of such machines at as steady a load as possible, since only under these conditions is the highest possible coal economy attainable.

While on the North-east coast and also in some other districts the generation and supply of electrical power is being developed on correct lines, it is still broadly true to say that, as regards the country as a whole, the requirements of each municipal area are dealt with separately, with the result that the average size of generating machine employed is certainly not more than a tenth—and probably not more than a twentieth—of what it ought to be. Under such conditions economical coal consumption is impossible. The result is cumulative, because, on account of the small size of generating machine employed in public stations and the consequent low economy, manufacturers, railway companies and other large power users in many districts are still compelled to run power plants of their own, and the use by many manufacturers of their own plant further reduces the average size of power generating machines, taking the country as a whole.

The only way in which public supply stations can secure the business of supplying all the manufactories in their neighbourhood is to have generating machines much larger than the largest individual manufacturer could find use for.

If instead of each municipal area being dealt with independently, there were one uniform inter-connected electrical power distribution system throughout each industrial area, as we now have practically throughout the north-east coast district, just as there is one railway system throughout the country with a uniform gauge, it is clear that, on account of the magnitude of the resultant load, it would be possible to secure the following results:—

1. The largest and most economical generating machines could be installed.

2. These could be located where large sites are available and land is cheap; where coal and water facilities are good; and in the best position having in view the probable eventual power requirements of the whole community, including factories, railways and domestic users.

If, on the other hand, each municipal area is dealt with independently, it is clear that in many cases the sites on which the power generating plant is installed must necessarily be cramped, being in the middle of large towns or congested districts, and that the best coal and water facilities will not be available.

As regards reliability of supply—an essential condition—concentration of generating capacity in large units in conjunction with a main electrical power distribution system is not a source of danger but the reverse, because by means of such an inter-connected distribution system, one set of generating plant can act as spare to another, whereas, according to the present method of dealing with electricity supply by means of isolated networks, each supplied in general from one generating station, there is no duplication of generating stations or alternative ways of feeding a given area whatever.

Thus, if the community is to benefit by the electric supply industry being given the maximum chance of development, and if the erection of the most economical generating machines in the best possible positions for economical production is to be secured, and insisted upon, as it must be, by some central authority, the first thing to aim at is the establishment in each industrial district of a common interconnected electrical power distribution system.

As has already been indicated, such an ideal may be achieved in this country, on account of its compact nature, to an extent which is not possible in other countries. What is required is co-operation and joint working between the different company and municipal electric supply undertakings, and this, except in certain cases, has not been possible in the past, due largely to Parliamentary and municipal opposition. If such a complete and unified system of mains could be established in each industrial area, the erection in the best situations of generating plant of the highest economy would naturally follow. That this has not been done in the past is not the fault of the electric power companies, and I am glad to see that many municipal undertakers are now as convinced as the power companies that this joint working is essential.

Another advantage which would follow the erection of plants on roomy and efficient sites, rather than on crowded and inefficient sites, is that this would materially facilitate the extraction of the by-products which can be obtained from the coal before it is consumed in the boiler furnace, wherever it is commercially possible to do so. This process will require large sites. Such by-products may be of as great a value to the community as the residue of fuel, for they include:—

1. Sulphate of ammonia and other products of value as manure and as raw material for manufacturers.

2. Benzol and other important hydro-carbons, of value in the dye industry, for example.

3. Oils, including motor spirit.

It has been calculated that the requirements of the country in the way of manures, crude oils, oils for marine propulsion and motor spirit for road traction can all be largely supplied as a by-product

*Paper read before Section G of the British Association at Newcastle.

of our own normal coal consumption, if only proper encouragement is given to the establishment of really economical electrical power distribution systems throughout the country, but it would be out of the question to carry out such schemes in large towns.

An urgent matter for settlement is the standardisation and unification as rapidly as possible of the frequency and voltage adopted for distribution purposes in neighbouring localities. Electrically, this, as I have said, is as important as having all the railways of uniform gauge. It is not proposed that uniformity of frequency and voltage should be established throughout the whole country, as this would entail the scrapping of a very large amount of valuable plant, but there would be no difficulty (and considering the issues at stake, comparatively little expense) in standardising a single frequency for each of the industrial areas of the country as follows :—

Midlands	25 cycles.
West of Scotland	25 ,,
North-east coast	40 ,,
Lancashire	50 ,,
Yorkshire area	50 ,,

As regards the voltage this will require careful consideration ; on the north-east coast we have standardised 20,000 volts, and in some of the other areas 10,000 volts has been adopted, but it is a question whether this is not too low for main trunk lines.

The question is, who is to pay for this unification ? It is not, in general, the fault of the existing undertakings that they have adopted different voltages and frequencies to those in vogue in the surrounding industrial district—though in some cases it must be admitted that it has been their desire to remain isolated, whatever the interests of the country in general and their own consumers in particular. The chief fault lies at the door of the nation itself, the Board of Trade having in the past even encouraged, in some cases, the establishment of different systems in adjacent areas.

The Board of Trade already has a right to say what system (electrical) shall be adopted as regards all new undertakings or existing undertakings developing newly acquired areas. The Local Government Board, in the case of municipal undertakings only, as loan authority, has control over expenditure on extensions of plant and mains by municipal electrical undertakings. As regards municipal undertakings which propose to adopt and/or extend electrical systems (plant or mains) of a type which would be inconsistent with development on uniform lines throughout the area in which they are situated, the Local Government Board could attach a condition to the loan to prevent this. The privately-owned concerns are not, of course, subject to Local Government Board control, but the powers of the Board of Trade as regards the sanction of systems to be adopted would probably be sufficient, and in any case the large power companies, who are the most important of the private concerns, operating as they do over large areas, are already fully alive to the necessity for standardisation and unification.

What is important is that a main inter-connected electrical power distribution system should be established in each industrial area as soon as possible. Just as trade between different parts of the country would be impossible or practically impossible without railways, so trade in power—that is, the supply of power where most required, from the source where it can be most economically generated—is impossible without a trunk main. The electrical "roads" of the country must be standardised and made just as the railroads have been. To-day if a colliery owner has small and poor coal in his colliery which it does not pay him to bring up because it cannot stand the cost of transport, he cannot contemplate turning it into electricity at the pit mouth—extracting the by-products in doing so—because, except in certain areas where a trunk main system exists, there is no market for the electricity, there being no means of distributing or transmitting it. Each individual colliery owner cannot establish his own electrical distribution system to neighbouring towns or manufactures any more than each manufacturer can provide his own railway system for distributing his goods. If a man has waste heat—or could, by improving his manufacturing or chemical process, combine it with the generation of power—there is no one to take his power, because the "roads" are not there to carry it ; and in most districts the large towns, where the concentrated loads already exist, are not electrically connected with adjacent industrial and colliery areas.

In the above remarks I have considered the matter chiefly from the point of view of saving fuel ; it is worthy of note, however, that inter-connected electrical power distribution systems are essential if the capital charges and labour costs, which are very important items in the production of electricity, are to be kept to a minimum. This arises from the fact that it is only by supplying all the needs of the community from one system that the maximum use can be made of the plant. As a great many individuals in a given community do the same thing at the same time, what we must take advantage of is that the individual does not and cannot do half-a-dozen things at once. The economy of the combination of all requirements, power, traction, heating and lighting is fundamental.

To show how far we are from this ideal let us take the case of London :—

LONDON ELECTRICITY SUPPLY.
Present position.

	Central area.	Greater London
Number of Authorities	39	70
Number of generating stations*	41	70
Average size of stations	7,646 kw.	5,285 kw.
Average size of units	787 kw.	632 kw.
Number of types or systems of generation	31	49
Number of frequencies	8	10
Number of voltages { Generation	20	32
Number of voltages { Distribution	21	24
Number of methods of charging and prices	Over 50	Over 70

A man lives, say, in Hampstead, he cooks his breakfast if he can buy electricity sufficiently cheaply, by electricity supplied from one station ; he travels to his office by electric train supplied by electricity from another station ; his office in the City is supplied by electricity from a third station ; probably he gets his lunch at a restaurant supplied by electricity for light, &c., from a fourth station ; if he has to go out of the office and visit other people in the afternoon he travels probably by a tram supplied by a fifth station ; he may eat his dinner at night in a West-end restaurant supplied from a sixth station, go to a theatre supplied from a seventh station, and so on. So that an inhabitant of London may quite well require throughout the day anything between five and ten sets of plant to supply his needs. In other words, the capital costs of supplying him are increased five or six fold.

This is a result altogether apart from the fact that, due to the enormous number of systems and stations in London, the plant used is of ridiculously small size, and therefore the efficiency as regards coal consumption is very low—in fact the average efficiency of conversion from coal to electricity in London to-day is only a third of what it would be under any modern scheme.

What applies to London applies equally to other industrial districts if we substitute the factory for the office.

It may be well, in conclusion, to summarise the advantages and economics resulting from electrical development on correct lines :—

1. A large saving in coal as a result of the erection of plants of the most economical size, according to the load, in the best positions.
2. The utilisation of waste heat.
3. The utilisation of coals which are too friable for transport.
4. The utilisation of coals now left in the pits because their value will not stand the cost of transport, and of other combustible materials not at present used as fuel for the same or other reasons.
5. The development of new carbonisation and distillation processes.
6. The more general use of electrical energy for all purposes, *e.g.* industrial power, rail traction, metallurgical, electrochemical and furnace work, and the development of industries which it has hitherto not been possible to carry on in this country.
7. Increased industrial output as a result of a greater use of power in consequence of its lower cost.
8. A general improvement in the efficiency of prime movers by British manufacturers, which cannot but have a marked effect on all power generating machinery (including that for marine purposes) and on our foreign trade. The British manufacturer can only compete with those of other countries if the things he has to sell are as good or better. In the case of the largest prime movers there are at present only two purposes for which they are used on a large scale, namely, for marine purposes and for driving electric generating plant. It is a fact that, in recent years especially, the larger prime movers have invariably been developed for land purposes first, the marine engines following, *e.g.*, the Parsons turbine and the large internal combustion engine. One reason for this is that the experimental work involved in developing new types and larger sizes of prime movers is more easily and more economically carried out ashore. Hence it is clear that the development of electric supply on right lines affords the best field for progress in design and economy.

What is fundamentally and immediately necessary is the establishment of a national electrical trunk mains distribution system.

Proceeding on these lines we shall not be merely copying America or Germany—we shall be doing something that is right for England because it is England, and because England is radically different from other countries as regards the technical development and "lay-out" necessary to secure cheap power. We have delayed making a start on right lines 15 years longer than is necessary—let us delay no longer.

* In addition there are nine traction stations within the Greater London area, eight of which are within the Central area.

FUEL ECONOMY ON THE NORTH-EAST COAST AS A RESULT OF ELECTRIC POWER SUPPLY *

BY R. P. SLOAN.

Electric power supply, though of comparatively recent development, has already had a marked effect upon the industries of the North-East coast. For example :—

1. A great saving of coal and reduction of smoke has resulted. There is now, apart from the power companies, practically speaking no coal burned on the Tyne for power purposes, except by the railways and chemical factories and some collieries. The Tyne shipyards and engineering works may be said to have adopted electricity to the exclusion of all other forms of motive power.

2. The application of electricity to all new uses has been facilitated :—

(*a*) Many collieries depend entirely upon electricity supplied from the Newcastle and Durham electric power companies' combined system for all their power requirements.

(*b*) As a result of the adoption of electric traction, the suburban railway traffic facilities of Newcastle are more ample than those of any other town of similar size.

(*c*) Electricity has been applied to freight haulage on the Newport–Shildon line (and this is the first real example of heavy freight haulage by electric locomotives in this country).

(*d*) Electricity has been applied with particular success to drive rolling mills and colliery winders, and for other purposes requiring the concentration of a large amount of power on one shaft.

3. New industries have been established in the district purely because of the cheap power available.

4. Extensive utilisation has been made of the waste heat and gases existing in the area for the production of electrical energy. In this regard the district occupies a unique position owing to the extent to which its power requirements have been met by electricity produced as a by-product of two of its largest industries—the making of pig iron and the making of coke.

5. Several small, and therefore uneconomical, generating stations (municipal and company) have been shut down, and the electrical distribution systems which they supplied have been connected up to the power supply companies' system.

The problem of power supply in any district is so completely governed by local conditions that it may be permitted at the outset to summarise the nature and extent of the staple industries of the north-east coast. The table below does this in convenient form.

It will be seen that in coal, iron and shipbuilding the north-east coast figures represent respectively and approximately one-fifth, one-third and one-half of the nation's output.

It was early realised that the more completely the electrical wants of the whole community could be met the more cheaply could a supply of electricity be given and the more stable would the electric supply industry become. Our engineers, therefore, proceeded to design the system so as to be capable of producing current at a minimum of cost and of providing a satisfactory supply for all purposes—power, traction, lighting and electrochemical and similar processes. The map shows the area served by the power companies.

The extent of this area (1,400 sq. miles) necessitated the generation of electricity at a pressure and in a form facilitating transmission over long distances, while the nature of the market to be catered for made it essential that the current should be produced as cheaply as possible. This, in turn, involved the use of extensive sites with ample coal and water facilities for the main coal-fired power stations, which were erected to deal with such portions of the load as could not be supplied with electrical energy generated by waste heat. From the two main stations situated on the River Tyne the transmission and distribution networks extend into and through the city of Newcastle-on-Tyne, northwards to Blyth and beyond, and eastwards along the River Tyne, through Wallsend to North Shields. On the south bank of the Tyne the system extends southwards through the county of Durham from the coast to Consett and Bishop Auckland on the west, and then joins up with the system of the Cleveland & Durham Electric Power Co., whose area covers the South Durham and Yorkshire districts, including the Cleveland mining district, Stockton-on-Tees, Middlesbrough, &c. The distance between the northern and southern extremities of the transmission system is 70 miles, and it is now possible to obtain electricity on the same system as regards frequency and voltage throughout practically the whole of the area shown on the map. The main transmission and distribution system is a three-phase system with a frequency of 40 cycles per second, and the working pressure is 20,000 volts.

The capacity of plant installed represents about one-ninth of the total plant installed in public supply stations in the United Kingdom, but as the north-east coast power companies are working at a more constant load—*i.e.*, a better "load factor"—the electricity actually generated is about one-fifth. The total horse-power at present being supplied is 343,000 H.P.

Though the extension of the power supply system has been rapid, its development and the growth of its profit-earning capacity were considerably delayed by the work which had to be done from time to time, and the sacrifices that had to be made, to secure uniformity of system. Unfortunately, with each amalgamation or extension of area considerable alterations had to be effected in the system of the new undertaking concerned. For example, the system of the Newcastle-upon-Tyne Electric Supply Co.—the pioneer company—the first instalment of which was laid down in 1899, is a three-phase 40-cycle system. That of the Durham Collieries Electric Power Co., the operation of which the Newcastle-upon-Tyne Electric Supply Co. took over in 1907, was a 50-cycle three-phase system, while the Tees area of the Cleveland & Durham Electric Power Co., where supply was begun in January, 1906, was originally designed for 25 cycles. The same company's Consett and Bishop Auckland stations were designed, one to give three-phase 25-cycle current, the other two-phase 50-cycle current. It will be appreciated that these alterations (involving in some cases the complete re-design of system) have necessarily delayed development, but it was considered best to secure uniformity, even at some sacrifice of time and money. All those other systems were sanctioned and commenced some time after the original Newcastle system was laid down.

The work of making the systems uniform has been completed, and, in addition, several small, and therefore uneconomical, generating stations have been shut down. Throughout the area shown on the map there are now only three public supply stations not conforming to the standard system and frequency—viz., those of the Sunderland, South Shields and Darlington Corporations.

The local conditions governing power supply in the district are :—

1. The low price of coal, which would enable the manufacturers to produce power themselves at relatively low rates.

2. The fact that the manufacturers' works are mostly of considerable size, *i.e.*, their individual electrical requirements are large. (A factor invariably of vital importance in the production of cheap current, whether by a public company or a municipality or by a private manufacturer, is the capital expenditure per useful horse-power of plant. This decreases as the size of plant grows, while the running efficiency at the same time increases.)

3. The existence of large quantities of potential energy in the form of waste heat and combustible gas.

The first and second conditions have been met by the power companies in erecting their main generating stations : (*a*) by taking full advantage of the best coal and water facilities available ; (*b*) by installing plant of a capacity much in excess of that which any individual manufacturer, however large, could adopt ; (*c*) by catering for all classes of consumers, thereby securing a diversity of load, with a resulting constancy of output, and so utilising the plant installed to the best possible advantage. These factors, combined with the employment of a highly skilled technical staff and attention to numberless relatively minor details, have resulted in securing an efficiency of production much greater than that practicable to any manufacturer producing power merely as an auxiliary to his main business. This is, after all, an age of specialisation, and the production of electricity from coal at a minimum of cost presents opportunities for the highest technical skill and for unremitting vigilance.

Power supply in this district began on the north bank of the Tyne. It is natural, therefore, that its highest development was reached there earlier than in other parts of the district. By 1908 it could be said that there was not a single firm of shipbuilders or engineers on the north bank of the Tyne which did not take 95 per cent. of its power from the company. To-day the proportion is probably higher

North-East Coast Industries.

——	Population at census 1911.	Coal mined, 1913.	Coke made, 1913.	Ironstone mined, 1913.	Pig iron made, 1913.	Merchant shipping built, 1913.
N.-E. coast industrial area...	2,300,000	Tons. 56,352,218	Tons. 7,500,000	Tons. 6,010,836	Tons. 3,869,214	Net tnage. 625,289
United Kingdom	45,211,888	287,430,473	20,529,732	15,997,328	10,260,315	1,231,921
Ratio— N.-E. coast / United Kingdom	5·1%	19·6%	36·5%	37·5%	37·7%	51·0%

* Paper read before Section G of the British Association at Newcastle.

still. Even taking the whole area, it may be now said that, as regards the engineering trades as distinct from collieries and iron and steel works, from 75 to 80 per cent. of the power is supplied from the power companies' system.

The credit of electrifying the Newcastle suburban railways is, of course, due to the enterprise of the North-Eastern Railway Co.; but the fact that they were the first important English railway to electrify a portion of their system, and that they purchased the necessary electricity from the power company, shows that the availability of cheap power is an advantage not only to manufacturers, but to the public generally in facilitating the introduction of electric traction. Since the electrification of the Newcastle system the train service has been more then doubled, and the scheduled speed improved by 20 per cent. A comparison with other cities at home and abroad shows that no other town of similar population has so extensive an electrified railway system or so frequent a suburban service, and this has, of course, resulted in a large increase of travel.

The Newcastle and coast suburban railways were electrified more than 10 years ago. More recently the North-Eastern Railway Co. have applied electricity to a freight line, and have electrified some 50 miles of track on their Shildon–Newport route, which carries the heavy mineral traffic between the coalfields of south-west Durham and the blast furnaces and ironworks of the Middlesbrough district.

Few people realise that goods traffic forms the greater portion of the total business of the railways in this country, and is therefore of greater importance than the passenger traffic.

The electric locomotives, designed by Mr. Vincent Raven, the railway company's chief mechanical engineer, and built under his supervision at the railway company's works at Darlington, are each capable of hauling a load of 1,400 tons at a normal speed of 25 miles per hour on the level, and of starting a train of the same weight on a 1 in 300 gradient.

No special generating station has been built, the whole of the current required being supplied by the power companies, whose existing mains are tapped at two points where they touch the railway.

The supply of electricity to coal mines—though the important colliery areas were not touched until some five years after power supply started on the Tyne—has now reached a high stage of development. It is estimated that, apart from the smaller colliery supplies, pits having an output of over 20,000,000 tons of coal per annum now depend upon the power companies for their power supply. The uses to which electricity is put include pumping, hauling, ventilating, winding, &c., and, as elsewhere, the simplicity and general advantage of the electric motor over all other forms of engine has made itself apparent. It is estimated, in the case of collieries, that at least 75 per cent. of the coal previously used for power purposes has been saved as a result of burning it at the economical generating stations of the power companies instead of each pit generating its own power; this is equivalent to a saving of at least 1,000,000 tons of coal per annum, apart altogether from the saving of coal resulting from the utilisation of waste heat, discussed below, and the saving of coal used for producing power for shipbuilding and engineering works and for the railways.

One of the most interesting features of the problem that had to be dealt with, and which it is not too much to say is also of considerable national importance, was the utilisation of the waste heat in the district. The counties of Northumberland and Durham and the North Riding of Yorkshire produce some 7,500,000 tons of coke per annum. The bulk of this used to be made in the old-fashioned beehive ovens, but during the last decade the retort type of oven has made rapid progress on account of its increased coke yield and the value of the by-products recoverable.

The waste heat from these ovens and from the blast furnaces and the exhaust steam from blowing engines in the Cleveland district form a considerable source of power.

The problem of the utilisation of this waste heat has been solved by the establishment of local generating stations where such surplus power is available. These plants feed into the main power companies' system, and the stations work in parallel with the five main generating stations of the power companies. These local generating stations, or "waste heat" stations, as they are commonly called, are run so that they each supply the maximum amount of energy possible—depending on the supply of waste heat or steam available—all regulating being done by the main power stations.

The power company need instal no spare plant in any of the waste heat stations connected to its system, being able to meet any variation of load by means of its coal fired stations, which also act as stand-by against any breakdown. Moreover, the power company, having a market for current many times greater than the output of any individual waste heat station, is able to run such stations continuously at their maximum output capacity, so utilising completely all the current that can be produced therein; whereas it is impossible to conceive the power requirements of an individual coke-oven and colliery installation coinciding even approximately over 24 hours with the amount of gas or waste heat available.

The first waste heat station was erected in 1905 by the Priestman Power Co., a subsidiary company formed jointly by the Priestman Collieries (Ltd.) and the Newcastle-on-Tyne Electric Supply Co. (Ltd.) at Blaydon, in conjunction with new coke ovens then being erected by the Priestman Collieries (Ltd.), who were the first to see the advantages of co-operating with the power company.

There are now 11 waste heat stations in operation in the north-east coast area, and, in practical illustration of the economy of coal effected thereby, I show a typical day's working of two electrical generating stations run by waste heat. It will be seen that the waste heat available is sufficient for the generation of an amount of power very considerably in excess of that required by the colliery owners. As a matter of fact, during the year 1915 these two stations alone turned out 40,000,000 units, of which only 10,000,000, or 25 per cent., were required for the working of the collieries, the remaining 30,000,000 units being delivered into the mains of the power supply company.

The total coal saving due to utilisation of waste heat in the north-east coast now amounts to some 150,000 tons per annum.

This brief account of what has already been done on the north-east coast will show the great economy which has been effected.

There can de no doubt that a proper appreciation of the enormous economies which may be effected by the avoidance of inefficient and wasteful separate power installations, and by the pooling, not only of all power requirements of all kinds, but also of all power-producing plants, into one interconnected power supply system in each industrial district, will be one of the most important factors in that general development of the country's industries which we are all hoping to see.

TRADE AFTER THE WAR.

A meeting was held at the Mansion House, London, on Wednesday, under the presidency of the Lord Mayor (Sir Charles Wakefield), to discuss trade policy after the war, with special reference to the engineering industry.

The meeting had the support of the British Electrical and Allied Manufacturers' Association, the British Engineers' Association, the British Empire Producers' Organisation, the engineering and electrical sections of the London Chamber of Commerce, and many prominent engineers and scientists. Mr. T. C. Elder (of the B.E.A.M.A.) was organising secretary.

The meeting was attended by the Presidents of the Institutions of Civil, Mechanical and Electrical Engineers, representatives of the Ministry of Munitions and Board of Trade, and other engineering and electrical associations, chambers of commerce, universities, municipal authorities, electric power and traction undertakings, railway and shipping companies, &c.

The Lord Mayor of London (chairman) moved: "That this meeting expresses its appreciation of the great national service rendered by the munition workers of the country, whose patriotic support of our fighting forces on land and sea is hastening the achievement of final victory, and expresses the hope that permanent remunerative employment will be secured in the vigorous economic development of the engineering industry after the war"; and, in introducing the resolution, said during the past two years there had been much useful discussion on the subject under review, but it had not been followed promptly by practical methods of reform. To find any simple formula for the re-organisation of British trade was no easy feat, but they were all agreed that the nation and the Empire must jealously guard the security and the progress of engineering. If the engineering works had done nothing more than the building of our Navy they would be entitled to the admiration and gratitude of all in this war on the side of righteousness and freedom. The Germans overlooked the undeveloped destructive powers of our engineering industry, and before the war we scarcely appreciated what a treasure we possessed. To-day it was recognised that British engineering was more than a trade; it was the main bulwark of European liberty. While the war was still raging we were justified in taking thought how we could keep this magnificent industry working in the future. It was the basis of every industry. By the intelligent combination of man power, money power and horse power we should hold what we had won. It was a national and imperial duty and responsibility. It was to be hoped that Englishmen would see that the way to prosperity was to use our horse-power with horse sense, and it should be possible to arrange now general terms of an industrial truce for, say, five years, which would ensure that British engineering would take the leading part in the most astonishing era of mechanical progress in the history of the world.

Mr. Ald. and Sheriff G. A. Touche, M.P., in seconding the resolution, said the heroism of our soldiers in the trenches found its parallel in the devoted work of the men and women who were toiling in our factories and workshops. The nation had been tried and produced pure gold. There had been some dross—we had heard of strikes and diminution of output when shells and munitions of war meant the lives of British soldiers—but against those few misguided men we could point to two

million workers who had sought no other freedom than freedom to serve the State. We must decide now what had to be done after the war, when those who had been fighting abroad or working in the munition factories would be coming back to civilian employment. We ought to be in a position to give them work at good wages; we had such factories as we never had before, and it was the business of statesmanship to see that they were employed. He saw no reason why we should not manufacture the greater part of the 56 million pounds' worth of goods which we bought from Germany in the year before the war or why the Empire should not produce the 11 million pounds' worth of sugar which we bought from Germany in the same year. He would seek to establish barbed wire entanglements which no German dumper could ever crawl through. Before the war German bankers fostered and financed German trade in British dominions and in other countries, and London bankers financed the German bankers. We had supported our competitors in that way long enough. After the war our banking facilities should be used to extend British trade and to obtain orders for British goods. Production was the real strength of a nation. The engineering industry had saved the situation during the war, and it should save the situation after the war.

Mr. G. H. Roberts, M.P. (Lord Commissioner of the Treasury), in supporting the resolution, said he was glad that the munition workers were being thanked. If the nation was to remain great, and if its integrity was to be preserved, we must preserve the harmony and co-operation which had characterised all classes throughout this war. There had been little strife, and the working classes were not second to any other class in patriotic impulse. We recognised to-day that the differences that previously divided us were all too insignificant to warrant the depth of our divisions, and we had stood together to demonstrate our patriotism and love of our country. Unless in the ensuing years of peace we could establish a reasonable period of industrial harmony the British Empire would rest on a very shaky foundation. We had to make up for the colossal expenditure on the war, estimated at some £3,000,000,000. Neutral nations had been profiting at our expense, and they would be better equipped than ourselves after the war to pursue competition. We should be in a less favourable position after the war than we were in prior to the war, with this exception—the war had awakened us in a way nothing else would have done. The output of engineering work during the war had proved that heretofore there must have been deficiencies in the ranks of capital and labour. He was a labour advocate. He did not say they were wholly blameless, but their opportunity had been less. The upper class could not disregard the failings of their own order when they approached the labouring class to assist in the task of recuperation. It was necessary to create a friendly understanding between the two great industrial classes, and the atmosphere was more favourable now than at any time. He declared that the whole future of our nation and Empire abided in this understanding being created early. The working classes had grievances. His relatives were agricultural labourers; 11s. to 14s. a week was the environment into which he was born. Could they be expected to remain always in those depressed circumstances? They, like the upper classes, were instinct with feeling and vibrant with desire and ambition. It was in our power to base human society on more elevating principles, and such a favourable chance as the present was not likely to recur. When it was recognised that the workers required time for rest and leisure, and when a living wage was assured to them, he would say to them "You are fairly treated, and you are expected to render of your very best." The workers recognised that, in order that the nation might recover from the wastage of war, they would have to redouble their efforts, and they were prepared to do it. In the past, owing to imperfect organisation, when we had speeded up and increased the output, gluts and unemployment ensued. This apprehension of the workers that increased output would result in unemployment had to be faced, but economic production and increased output increased the selling power of the nation, and unless this were accomplished the nation must decline. We must enter into co-operation to perfect the organisation of national industry so as to prevent these cyclical and seasonal fluctuations which had disorganised industry in the past. Let us get together at once and arrange the conditions which are to prevail after the war, and a solid contribution will have been made to the future security and stability of the State.

The resolution was then put and carried unanimously.

The Lord Mayor of Manchester moved "That the indispensable military service rendered by the engineering industry, and its fundamental importance in the future as the basis of defensive power and of prosperous economic development, entitle it to special recognition in any reform of a national and Imperial commercial policy, and to the patriotic support of all public and private users of plant and machinery throughout the Empire." He added that Manchester was now turning out incredible quantities of machinery, and even before the war it was the greatest of the machinery markets. Its prosperity was built up on the production of the best machinery that could be designed. Manchester was prompt to take efficient action in the matter of patriotic buying, and the Corporation had adopted a standing order that no contract should be entered into with any person of German or Austrian nationality or with a firm or company whose capital was held to the extent of one-third or upwards by persons of German or Austrian nationality. The Town Clerk transmitted copies of this standing order to each county borough in England, and it had been adopted largely throughout the country. He advised engineering firms not to quote abnormally high prices, as that would arouse the indignation of the purchaser and lead to an alteration of the policy his and other Corporations had adopted. The balance of engineering trade in 1913 was £7,000,000 in favour of Germany, and one of our problems was to retain that balance in this country. He advocated the adoption of the metric system of weights and measures as being intelligible to people abroad with whom we trade and simpler and quicker than our antiquated methods.

Mr. C. Sandbach Parker (Chairman, British Empire Producers' Organisation), in seconding, emphasised the value of the Empire's overseas markets. There was an enormous field for machinery of various kinds, especially electrical. To increase the trade and capacity of the overseas markets, it was necessary to increase their purchasing power. Production was the backbone of the purchasing power of the Empire. Something must be done to accelerate the development of these great dominions. In regard to foreign trade, the Empire must be treated as a whole and the arrangements be as between the Empire and foreign countries, not as between individual units of the Empire and foreign countries.

Sir Oliver Lodge, F.R.S., said that what we had to recognise more than before was the importance of the union and inter-action between science and every branch of engineering. He used the term engineering in its widest sense, not merely mechanical, civil, electrical, but also chemical, military, agricultural—every kind of applied science might be summed up in that great term. He also used the term science in its widest sense. The two must harmonise and co-operate. The nation had discovered it could stand more taxation than it thought it could, and he believed it would continue to stand more than before, but on good and worthy and profitable objects. We had been too poverty-stricken in many important directions. One was the development of scientific discovery and invention, and the trial of all manner of things which ought to be tried. Discoveries were waiting to be made, and young men were ready to work hard at making them; but they must have the means, not too economically, bestowed upon them. A little lavishness here and there was really wise; that was how many important organisations had succeeded. The Government had discovered the use of scientific advisory committees, which were doing good work. Many of the things happening on sea and land owed some of their success to those advisory committees, which ought to continue and be put on a proper basis. They should consist of young men to a large extent, men likely to have their eyes open to novelties, with open minds and plenty of energy. There was no reason why a salary should not be attached to the office, and he suggested that the men might be elected by, say, the Royal Society. Every discovery was likely to open a new branch of industry. There ought to be capital waiting for development, so that anything these advisory committees thought ought to be tried should be tried on an extensive scale. In thinking of engineering, they should not think too narrowly; for instance, while the Panama Canal was an engineering problem it was also a biological problem. There should be a Chemical Committee, a Biological Committee, an Agricultural Committee, &c. Machines might be made as fast as they liked, but the populace could not live on them. All the food came out of the soil, and if we did not grow the things ourselves we should have to buy them.

The resolution was carried unanimously.

Mr. W. Wilfrid Stokes (Chairman, British Engineers' Association) then moved:—

"That this meeting expresses its general approval of the proposals of the Paris Economic Conference, and recommends that their practical application for the benefit of British industry should be furthered by the immediate appointment of a Ministry of Industry."

Our industries were the backbone of the prosperity of the nation, and should be adequately encouraged and helped. Our troubles in the past were mostly due to our national failing of individualism. The British Engineers' Association was making a great effort to mobilise the engineering industry. The common wants of all industries should be in the hands of an association of associations, and the Federation of British Industries had been started with this object in view. Finally, there was the effort which could best be excited by the community as a whole through its Government departments and officials. It was difficult to understand the reluctance of our present statesmen to plan such important work under a special minister and organisation, instead of leaving it tucked away in a corner of the Board of Trade. The Ministry which they were pressing for would not be open to the objection that it would only be adding another badly-run department under the control of red tape civil servants, as a council formed of representatives of each important industry would take a leading part in it. Its members would be elected at stated periods by their industries, and would thus be free from the taint of party politics. The time had come when we should strike out on new lines such as would give our industries a fair chance of success in the inevitable struggle after the declaration of peace.

Mr. T. C. Elder seconded the resolution, in the absence of Mr. H. B. Rowell (President of the N.E. Coast Institution of Engineers and Shipbuilders), whose name was on the agenda, but who was prevented attending the meeting owing to a bereavement

Mr. George Terrell, M.P. (British Electrical and Allied Manufacturers' Association), proposed a vote of thanks to the Lord Mayor. He emphasised that we could do nothing if, when the war was over, the factories had to be put on half-time owing to lack of orders.

Mr. C. P. Sparks (President of the Institution of Electrical Engineers), in seconding, said their special thanks were due to the Lord Mayor for calling them together. It was the first time in his experience of the association of the engineering industry with the City of London. The Institution of Electrical Engineers had considered the matter which was before the meeting, and concluded that the first thing necessary was to protect home trade if they were going to secure the overseas trade hereafter.

The proceedings then terminated.

LEGAL INTELLIGENCE.

Valuation Appeal.

At the County Valuation Appeal Court at Oban last week, Mrs. G. H. B. Hill, of Kilbowie, asked that the sum of £15 entered as the valuation of the electric light installation at Kilbowie be deleted from the roll.

Mr. J. W. E. Steedman, for appellant, explained that this entry had appeared in the roll some years ago when the late Mr. Hill introduced an electric light installation into Kilbowie. That installation was simply put into one of the existing offices of the house. It was only this year that the matter was brought to the notice of Mrs. Hill's agents in Edinburgh, and as the agents were of opinion that the entry was not a proper one, the present appeal was made. Mr. Steedman argued against the assessment, in view of the fact that the machinery in connection with the installation of the electric light having been introduced after the building was erected, could be removed without the necessity of taking down any part of the building. Accordingly, it was not assessable, the machinery not being fixed to any lands or heritages. In the assessment of a dwelling house the dwelling house and its appurtenances must be taken as a *unum quid*—they must be taken together, and not separately.

The Assessor agreed with the last mentioned statement, but in this case the entry was put in as a separate item to show that there had been an addition of the electric light to the subjects, and that, so to speak, the rent had been enhanced to the amount stated. He suggested that the Bench might delete the entry and add the £15 to the rental.

The Chairman said the appellants had objected to the entry of £15 as it stood, and that was the only point the Court had to consider. The appeal was sustained.

EDUCATIONAL.

Armstrong College (University of Durham), Newcastle-on-Tyne.—The next session commences on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

Royal Technical College, Glasgow.—The session 1916-17 begins on Sept. 26.

The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, &c. There are also full courses of instruction in the schools of navigation and wireless telegraphy, and both day and evening classes are held. The diploma courses extend over three or four sessions, and the average fee is £12. 12s. per session. The college is affiliated to the University of Glasgow, and the degrees of the university in engineering and applied chemistry are open to its students. Prospectuses from the Director.

The calendar for the session 1916-17 has been issued and contains full particulars of the courses of instruction fees, classes (day and evening), examinations, &c. The head of the electrical engineering department is Prof. Magnus Maclean, M.A., D.Sc., and the laboratories are well equipped for practical work. The calendar is published at 1s. (post free 1s. 4d.)

Northampton Polytechnic, London.—In the day engineering college full day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. The entrance examination takes place on Sept. 26th and 27th. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

Manchester School of Technology.—Full courses, leading to the Manchester University degree in the faculty of technology, are provided in mechanical, electrical and sanitary engineering (including municipal engineering), the chemical and textile industries, mining, architecture, &c. During the session 1916-1917, first year courses will be specially adapted to the requirements of students who may wish to take commissions in H.M. Forces.

The prospectus of the University courses in the 1916-17 session has been issued and gives full particulars of the instruction, fees, conditions of admission to classes, &c. The school of technology affords a systematic training in all branches of engineering, the chemical and textile industries, &c. There are part time day courses for engineers' and other apprentices, and there are also part time evening courses, the latter course extending over five years. There are well equipped laboratories for practical and research work.

King's College (University of London). The new term begins on Wednesday, Oct. 4th. The Faculty of Engineering have arranged courses of study extending over three or four years in civil, mechanical and electrical engineering for the engineering degrees of the University of London and for the diploma and certificate of the College.

The four years' course provides, in addition to the academic training, opportunities for practical training in works. Additions to the engineering department include a large drawing office and lecture rooms for the mechanical and civil engineering departments and a lecture theatre and rooms for research, including wireless telgraphy, for the electrical engineering department. There are well appointed laboratories for teaching and research work. Full information may be obtained from the Dean or the Secretary, King's College, London, W.C.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by Messrs. Mewburn, Ellis & Pryor, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1914 Specification.

7,336 Maitre & Martin. Electromagnetic means for vibrating piano strings and the like.

voltage to supply working apparatus which should operate at a constant voltage.

23,075 Soc. Anon. des Etablissements L. Bleriot. Regulating means for electrical installations. (26 11 13.)

Comprises regulating means adapted to cause the supply circuit which is of varying consisting of a motor generator which itself is insensible to the actions which it is to regulate, combined with a very sensitive regulator comprising electromagnets, the whole operating under the influence of the voltage of the working circuit, so that the voltage of the said circuit remains constant or does not vary beyond certain predetermined limits whatever may be the voltage of the supply circuit or the current intensity in the two circuits.

1915 Specifications.

10,667 Morse & Indo-European Telegraph Co. Electric alarm of calling devices used in receiving apparatus, and more particularly in wireless receiving apparatus.

Consists in causing the liquid of a jet which is deflected in a known manner under the control of a received electric current, such as the jet of an Orling relay, to accumulate in a receptacle for a predetermined period of time corresponding to the duration of the calling signal and to close an alarm circuit when the upper level of the liquid accumulated in the receptacle reaches a predetermined point.

11,600 Relay Automatic Telephone Co., Ward, Bryant & Inman. Telephone systems. (Cognate application, 1,869/16.)

11,655 Relay Automatic Telephone Co. & Aitken. Telephone systems.

11,690 Helm Hansen. Electric regulator or governor.

A fixed magnet core is provided excited by the tension or the current to be regulated, which core is provided with a pivoted armature taking a position corresponding to the degree of excitation and carrying a change-over switch sliding on two contact bars, one of which is divided by an insulating part into two parts, both of which are connected with a corresponding circuit in the electric clutch.

11,935 Neuland. Dynamo-electric machines.

11,974 Rhodes & Fifth. Driving and controlling dynamo-electric generators. (Cognate application, 13,469/15.)

11,981 Reed-Letheridge. Electrical flasher.

12,000 Marks. (Motor Ignition & Devices Co.) Electric supply systems for use with internal combustion motors.

12,103 Frampton & Callender's Cable & Construction Co. Electric distribution systems.

12,314 Palmer, Denham & Ferranti Limited. Electrical instruments of the moving-coil type.

Comprises an electric measuring instrument of the moving-coil type having one or more cylindrical gaps, preferably of relatively long axial dimensions, each external polar extension enclosing said gap or gaps being joined to its pole limb by a neck of small angular extent and co-acting with one or more moving coils having active and inactive parts of small angular extent compared with their inner active parts.

12,361 B.T.-H. Co. (G.E. Co., U.S.) Systems of electric ship propulsion.

12,868 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems.

13,815 Van Deventer. Ignition apparatus for internal-combustion engines. (1/10/14.)

14,311 Benitez. System for the generation of electric currents. (Addition to 17,811/14.)

14,436 Balma-Riva. Coupling for mechanically and electrically connecting wood, metal or stone and the like.

15,304 Turner. Controllers for electrically-driven vehicles.

16,151 Marconi's Wireless Telegraph Co. & Bangay. Wireless telegraphy.

Comprises a wireless telegraph transmitter which has an aerial of variable [illegible] and in which the inductance of the primary circuit consists of a variometer and is for the purpose of coupling with the aerial circuit.

16,695 Raillie & Ancelin. Electric arc lamps.

17,008 Bowden & Hart. Electric starters for internal combustion engines.

17,901 Jones & Jones. Earth current detectors and cut-outs for electric [illegible].

APPLICATIONS FOR PATENTS

Note.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

August 18, 1916.

11,707 Cu[illegible] Sup[illegible] pneumatic telegraphic apparatus.

11,713 Birmingham Electrical Accessories Mfg. Co. & Carrett. Electric lamp [illegible].

11,736 Kin[illegible] & [illegible] & Theodor. Pocket or portable electric lamp.

11,740 La[illegible] & Gas Supply Assn. Prepayment electricity meters. (18/9/15 Switzerland.)

11,743 Ha[illegible] for internal combustion engines.

11,[illegible] Co[illegible] America. Electric motor cycles [illegible]. (3/4/15 U.S.)

August 19, 1916.

11,[illegible] [illegible] America. Electric motor cycles. (3/11/15 U.S.)

11,[illegible] L[illegible] & L[illegible] & Simms Mfg. Co. Sparking plugs for internal combustion engines.

11,[illegible] Electric Transformer Co. Electric transformers.

11,[illegible] Variable frequency of alternating electric currents.

11,[illegible] Gramophone Co. Producing electric oscillations.

11,[illegible] West & Wes[illegible] Co. Electric lighting masts.

11,[illegible] [illegible] Electric lamps.

August 21, 1916.

11,[illegible] Ac[illegible] [illegible] locks &c.

August 22, 1916.

11,[illegible] Brass [illegible]

11,[illegible] Sir [illegible] Ashmore. Preparation and preservation of radioactive substances.

11,[illegible] Gen[illegible] Co. Protective devices for cables and electric conductors.

11,[illegible] Mc[illegible] & Morris. Magnetos.

11,[illegible] Telephone & Electric Co. Lacquering machines.

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	921	Crompton Half-Watt Lanterns. Illustrated	185
Imports and Exports of Electrical Manufactures	922	Lamp Calls v. Cab Whistles	186
Business Notices	922	Scientific Lighting for Railways. Illustrated	186
Bankruptcies, Liquidations, &c.	922	The "Esco" Buzzer. Illustrated	188
Electricity Supply	922		
Lighting and Power Notes	924	Miscellaneous Notes	926
Traction Notes	924	Tenders Invited	927
Telegraph and Telephone Notes	924	Tenders Received & Accepted	927
Empire Notes	924	Municipal Accounts	928
Foreign Notes	925	Companies' Meetings and Reports	929
The Round Table	181	New Companies, &c.	929
Sandycroft Liquid Starting Switches. Illustrated	182	City Notes	929
Ediswan "H_2O" Cells. Illus.	184	Electrical Companies' Share List	930

COMMERCIAL TOPICS.

Inventions Useful for Military Purposes.

Additional regulations have been made under the Defence of the Realm Acts and among these are the following :—

It shall be lawful for the Admiralty or Army Council or Minister of Munitions, with a view to the more efficient or increased production of war material, to require any person to communicate to a person nominated for that purpose by the Admiralty, Army Council, or Minister of Munitions, all such particulars as may be in his possession of any invention, or process or method of manufacture, or of any article manufactured or proposed to be manufactured, and to furnish drawings, models, or plans thereof, and to explain and demonstrate the same to such person, in all or any of its uses and workings ; and if any person fails or neglects to comply with any such requirement he shall be guilty of an offence against these regulations ; and if the requirement is addressed to a company, every director, manager, or officer of the company who fails or neglects to comply with such requirement shall also be guilty of an offence against these regulations.

No communication of an invention made in consequence of any requirement under this regulation, or the use thereof by any person authorised under this regulation to use it, shall prejudice any right of the inventor or owner thereof subsequently to apply for or obtain a patent for the invention.

There are provisions relating to the preservation of documents, plans, models, &c.

* * * *

Our Trade with New Zealand.

The New Zealand Trade Commissioner (Mr R. W. Dalton) states that, judging from his correspondence, a number of British firms have decided to establish agencies in New Zealand after the war, but are contented to wait for peace before taking any active steps.

It is said that New Zealand firms are of opinion that the preliminary negotiations should be commenced without delay. In New Zealand firms are even more anxious than formerly to deal in British goods and to hold British in preference to foreign agencies. At the same time, they must naturally take into consideration their means of livelihood after the war. The position is that, while British firms are postponing the appointment of agents, and even postponing negotiations to that end, American and Japanese firms are seeking to appoint agents in various directions. It should not be forgotten by United Kingdom manufacturers that, while the war has quickened British interest in trade, it has also had the effect of offering an opportunity to foreign manufacturers to obtain trade—not only that which was formerly in German hands, but also the trade which United Kingdom manufacturers are precluded from attending to at present. The New Zealand market has direct connection with two progressive manufacturing countries (United States of America and Japan), and the manufacturers of these countries have been making considerable efforts to establish connections which they hope will prove to be permanent. The point of view of the agent with whom a British firm will not negotiate now is that, if he waits until the war is over and the negotiations then carried on should not prove satisfactory, he may probably lose other opportunities during the war. Most New Zealand firms realise, often from experience, the difficulty and often impossibility of obtaining goods from the United Kingdom at present. What they naturally want to obtain is some security that their position after the war will be satisfactory and that they will not suffer by having refused other offers.

Key Industries and After-war Trade.

The Associated Chambers of Commerce have sent out inquiries to the various chambers as to essential national industries and the steps to be taken to recover home and foreign trade, &c. The questions were as follows:—

(*a*) What industries are essential to the future safety of the nation and what steps should be taken to maintain or establish them ?

(*b*) What steps should be taken to recover home and foreign trade lost during the war, and to secure new markets ?

(*c*) To what extent, and by what means, the resources of the Empire should and can be developed ?

(*d*) To what extent, and by what means the sources of supply within the Empire can be prevented from falling under foreign control ?

The replies of the Council of the Hull Chamber of Commerce were as under :—

(*a*) The Council is of opinion that such a system of fiscal policy should be adopted as would prevent unfair competition arising from dumping and subsidies.

(*b*) By really effective consular assistance and that such consuls should have a commercial knowledge and training.

(*c*) By internal preference as against foreign countries. Greater banking facilities should be provided for the development of trade at home and abroad by a liberal extension of credit.

(*d*) By registration of names of private companies' partners. By home control of real property and mining rights. By limited companies having at least 75 per cent. of British shareholders.

In addition to the foregoing recommendations, the Council consider the establishment of a Ministry of Commerce to be of paramount importance.

* * * *

The British Consular Service.

Many of the chambers of commerce are now taking a keen interest in the personnel of our Consular Service. For instance, the Hull Chamber has just passed the following resolution on this important subject :—

That all consuls should be of British nationality ; that consuls should be men of commercial experience, or have attached to the consulate commercial agents ; that adequate remuneration should be paid in order to secure an efficient consular service.

In our opinion the above resolution does not go far enough. All consuls-general and consuls should certainly be of British nationality, and wherever possible vice-consuls and consular agents also. A certain percentage of the consular officials should be technically trained men ; there should be a much closer connection between our diplomatic and consular representatives than hitherto : and consular reports should be readily available to British manufacturers and traders and to their representative trade organs at a trifling cost. Other conditions may be necessary in order to have an ideal consular service, but the foregoing requirements are essential if we are to have anything like useful commercial and technical representation in foreign countries.

* * * *

A Birmingham House of Commerce.

The Birmingham Chamber of Commerce (Winchester House, Victoria-square, Birmingham) is appealing for donations towards a development scheme, which is estimated to cost £50,000.

The main feature of the scheme is the establishment of a "House of Commerce" for Birmingham and the surrounding district. During the past 10 years the membership of the Chamber has grown from less than 800 to more than 2,300, and the demands made by all classes of business men upon its services have increased proportionately. It is thought that the time has come when it should be housed in a building of its own, devoted entirely to the work of organising, developing and protecting the commercial resources of the "metropolis of the Midlands." Contracts have been entered into for the acquisition of a large "island" block of buildings in the heart of the city, which will not only accommodate the staff of the Chamber, but afford room for meetings and conferences, a commercial reference library, and an exhibition of samples, including foreign goods which compete with British manufactures in the markets of the world. A sum of at least £25,000 is required to enable the Chamber to enter into occupation on the 29th inst., and about £22,000 has been raised by private effort.

* * * *

Indian Industrial Commission.

A preliminary Note on the scope of the inquiry by the Indian Industrial Commission into the proposed development of the manufacturing and other industries of the Empire has been issued It states that the Commission is asked to suggest lines of action to encourage the investment of capital now lying idle ; to build up an

artisan population; to carry on scientific and technical researches required to test known raw materials and to design and improve processes of manufacture to distribute information obtained from other countries; and to develop machinery for financing industrial undertakings and for marketing products. The Commission will tour the provinces to collect evidence and make personal inspection of industrial enterprises. The Note also contains information regarding the suggested establishment of Imperial Departments, Provincial Industrial Departments, the granting of Government aid to industries, &c.

* * * *

Anglo-Portuguese Commercial Relations.

The Anglo-Portuguese Commercial Treaty Act, 1916, received the Royal Assent on Aug. 23 and comes into operation one month after that date.

In consequence of the passing of this Act, the Treaty of Commerce and Navigation between Great Britain and Portugal, signed on Aug. 12, 1914, will come into force on the 23rd inst. The treaty provides that national treatment shall be accorded to the citizens of each of the contracting parties in the territories and ports of the other. Any privilege, favour or immunity which either contracting party has granted or may hereafter grant to the subjects or citizens or ships of any other State shall be extended immediately to the subjects or citizens or ships of the other contracting party. Articles, the produce and manufacture of one of the contracting parties imported into the territories of the other, shall not be subject to higher duties or charges than those levied on the like articles exported to any other foreign country. The trade of the United Kingdom with Portugal will benefit by the application to certain classes of articles in respect of which special rates of duty have been conceded by Portugal in respect of such articles in commercial arrangements with Russia, the Netherlands and France. These "conventional" rates have been extended also to similar goods from other countries enjoying most favoured nation treatment in Portugal, including the U.S.A., Italy and Spain. Articles imported by commercial travellers as samples will be admitted duty free into the respective countries of the contracting parties. Equal rights to those of its own subjects are to be given by each of the contracting parties to subjects of the other in its territories with regard to patents. Amongst the articles which will benefit by the application of the conventional duties instead of the general tariff rates are mineral oils, cast and rolled steel, unwrought iron, instruments and tools and automobiles.

* * * *

Prohibited Exports.

Additions have been made to the list of goods that can be exported to Holland, Sweden and Norway.

In future no export licences or other facilities will be given for the importation of nickel into Holland, of petroleum and stearine pitch into Sweden, or of clover seeds into Norway. Holders of unexhausted licences should at once communicate with the War Trade Department, stating the reasons for which they desire to receive such special authorisation.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From Sept. 9, 1916, *to* Sept. 15, 1916.

IMPORTS.

FOLKESTONE.—*France:* Elec. carbons, 6 pkgs.; glow lamps, 10 pkgs.; unenumerated 10 cases.

HULL.—*Dunkirk:* Unenumerated, 21 cases.

LIVERPOOL.—*U.S.A.:* Electrodes, 31 p.c.s.; insulated copper wire, 51 cases; unenumerated, £317—5 pkgs. *Spain:* Elec. carbons, 200 cases.

LONDON.—*U.S.A.:* Carbon candles, £155; wire and cable, £585; telephone material £26; carbon electrodes, 14 crts., 70 p.c.s., unenumerated, £4,511—910 pkgs. *Holland:* Elec. lamps, 508 pkgs.; elec. glow lamps, £6,270; unenumerated, £158. *Japan:* Unenumerated, £4,375—240 pkgs. *Switzerland.* Telephone material, £102; unenumerated, £218. *Sweden:* Unenumerated, £213. *Canada:* Unenumerated, £94.

SOUTHAMPTON.—*France:* Unenumerated, 24 crt.

EXPORTS.

TO AUSTRALASIA.—*Auckland:* Wire and cable, £104; telegraph material, £10; unenumerated, £228. *Melbourne:* Wire and cable, £3,020, unenumerated, £738. *Sydney:* Elec. machinery, £200; telegraph material, £240; wire and cable, £3,464, elec. lamps, 5,000 n.o.; unenumerated, £1,101. *Wellington.* Elec. lamps, 9,100 n.o.; wire and cable, £115; elec. machinery, £3,946, unenumerated, £1,019. *Lyttelton.* Wire and cable, £1,049. *Dunedin:* Wire and cable, £264, unenumerated, £73. *Adelaide:* Wire and cable, £482; railway elec. lighting material, £1,096, unenumerated, £167. *Christchurch:* Wire and cable, £44, unenumerated, £353. *Perth:* Unenumerated, £32. *Fremantle:* Wire and cable, £186, unenumerated, £145. *Brisbane:* Wire and cable, £2,317, unenumerated, £431, elec. machinery, £73. *Newcastle:* Wire and cable, £428.

AFRICA.—*Durban:* Elec. machinery, £1,084, wire and cable, £13.2, unenumerated, £1,138. *Cape Town:* Elec. machinery, £113, wire and cable, £2.2, telegraph material, £39, unenumerated, £363. *Port Elizabeth.* Wire cable, £364, unenumerated, £194. *East London:* Elec. machinery, £10, wire and cable, £108, unenumerated, £197. *Beira:* Unenumerated, £40.

EGYPT.—*Alexandria:* Wire and cable, £17, unenumerated, £19. *Port Sudan:* Unenumerated, £684. *Suez:* Telegraph material, £170. *Port Said.* Wire cable, £223, unenumerated, £14. *Aden:* Telegraph material, £129.

MALTA.—Telegraph wire and cable, £11,000; unenumerated, £129.

INDIA, CEYLON, INDO-CHINA AND STRAITS SETTLEMENTS.—*Penang:* Wire and cable £3,400; elec. machinery, £1,152; unenumerated, £1,[illegible]. *Calcutta.* Wire and cable, £1,920; unenumerated, £2,989. *Madras.* Wire and cable, £40[illegible]; unenumerated, £[illegible]. *Colombo:* Elec. machinery, £164, telegraph material, £66, unenumerated, £484. *Port Swettenham:* Elec. machinery, £338; unenumerated, £183. *Penang:* Unenumerated, £46. *Bankok.* Elec. machinery, £21, unenumerated £370. *Singapore.* Elec. machinery, £74; wire and cable, £84; unenumerated, £1,738. *Karachi.* Unenumerated £77. *Sourabaya:* Elec. machinery, £901. *Rangoon.* Wire and cable, £258, unenumerated, £12. *Semarang:* Elec. lamps, £30, unenumerated, £17. *Kobe.* Unenumerated, £32. *Padang:* Unenumerated, £50.

CHINA.—*Shanghai:* Elec. machinery, £235; elec. lamps, 12,100 n.o.; unenumerated £663. *Tientsin:* Elec. lamps, 700 n.o.; unenumerated, £44. *Hongkong:* Wire and cable, £185; unenumerated, £601.

U.S.A.—*New York:* Unenumerated, £161.

SOUTH AND CENTRAL AMERICA.—*Buenos Ayres:* Wire and cable, £476; unenumerated, £1,767. *Punta Arenas:* Wire and cable, £254. *Monte Video:* Unenumerated, £373 *Rio de Janeiro:* Unenumerated, £74. *Valparaiso:* Elec. machinery, £841. *Laurenco Marques:* Unenumerated, £20.

JAVA.—*Batavia:* Elec. machinery, £33; unenumerated, £48. *Samarang:* Elec. machinery, £38; wire and cable, £25.

JAPAN.—*Kobe:* Unenumerated, £20. *Yokohama:* Unenumerated, £80.

HOLLAND.—*Amsterdam:* Unenumerated, £196. *Rotterdam:* Wire and cable, £97.

RUSSIA.—*Petrograd:* Wire and cable, £126; unenumerated, £410.

FRANCE.—*Dieppe:* Elec. machinery, £119; unenumerated, £582. *Paris:* Elec. machinery, £376; unenumerated, £893. *Bordeaux:* Wire and cable, £95; elec. machinery, £20; unenumerated, £285.

PORTUGAL.—*Lagos:* Elec. machinery, £15.

FOREIGN GOODS (duty paid and free).

Sydney: Unenumerated, £34. *Durban:* Elec. lamps, 2,400 n.c. *Calcutta:* Unenumerated, £33. *Paris:* Unenumerated, £891. *Bordeaux:* Elec. machinery, £305; elec. cable, £133; unenumerated, £684. *Bankok:* Elec. meters, £340. *Boulogne:* Unenumerated, £48. *Dieppe:* Unenumerated, £158. *East London:* Unenumerated, £237. *Helsingfors:* Unenumerated, £718. *Hongkong:* Unenumerated, £700. *Malta:* Unenumerated, £80. *Petrograd:* Unenumerated, £278. *Shanghai:* Elec. lamps, 16,600 n.o.

IN TRANSIT.

Melbourne: Elec. lamps, £599. *Wellington:* Elec. lamps, £240. *Shanghai:* Glow lamps, £240. *Bluff:* Elec. lamps, £105.

NOTE.—**The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."**

BUSINESS NOTICES.

Sale by Tender.—Messrs. Wheatley Kirk, Price & Co. have been instructed by the Controller, Mr. J. E. Percival, F.C.A., to sell by public tender the stock of cable and electrical accessories upon the warehouse premises of Turner & Burger, 149, Farringdon-road, London, E.C. On view Sept. 25 to Sept. 30 inclusive. Catalogue (gratis) from Messrs. Wheatley Kirk, Price & Co., 16, Watling-street, E.C., to whom tenders by noon Wednesday, Oct. 4. *See advertisement.*

Plant for Sale.—Messrs. Marshalls, Gainsborough, have a 2½ H.P. Wilson Hartnell electric motor and an E.C.C. compound-wound dynamo for sale.

Patent Development.—The proprietor of patent No. 24,751/1912, for "Improvements in and relating to the synchronous running of electric motors," desires to enter into arrangements for the purpose of exploiting same in this country. Applications to Messrs. Haseltine, Lake & Co., Patent Agents, 28, Southampton-buildings, Chancery-lane, London, W.C.

Britannia Lamp.—Messrs. Dick, Kerr & Co. (Ltd.) inform us that in future the sale of the Britannia lamp in the United Kingdom will be entirely in the hands of a subsidiary company known as the Britannia Lamp & Accessories Co. (Ltd.), which will incorporate the existing business of Watlington & Co. (Ltd.), who have hitherto been the distributors in London and South of England. The Britannia lamp will still be made by Messrs. Dick, Kerr & Co. at their Preston works. Any communications in respect to lamps for use in the United Kingdom should be addressed to the Britannia Lamp & Accessories Co. (Ltd.), Britannia House, 48, Milton-street, London, E.C.

BANKRUPTCIES, LIQUIDATIONS, &c.

Claims against Jas. Brockie, mechanical engineer, 41, London-road, Forest Hill, London, S.E., are to be sent to the Hon. W. J. H. Boyle, 132, York-road, London, S.E., preparatory to the payment of a dividend.

The Derby Electrical Co. (Ltd.) is being wound up voluntarily, and Mr. J. Perry Jones has been appointed liquidator. A meeting of creditors will be held at the registered office, Woods-lane, Derby, to-day (Sept. 22), at 5.30 p.m.

ELECTRICITY SUPPLY.

EXTENSIONS.

Bradford.—The city electrical engineer (Mr. T. Roles) has been instructed to prepare a further statement on the proposed extensions of plant at the Valley road electricity works, to enable the Special Committee to approach the Government department interested in regard to a loan.

Wakefield.—The Corporation have decided to apply for sanction to a loan of £3,200 for additional plant at the electricity works.

GENERAL.

Callington.—At a public meeting last week it was decided by a practically unanimous vote to proceed with the proposed scheme of electricity supply for the district.

Dewsbury.—At the last meeting of the Council Mr. J. E. Kilburn gave particulars of a new agreement entered into with the Yorkshire Electric Power Co. for the supply of current in Ravensthorpe.

The price to be paid was £4 per kilovolt-ampere per annum and 0·65d. per unit. In addition, for every penny per ton over 10s. in the price of coal, the Corporation would have to pay 1d. for each 400 units, and as the present price of coal was 14s. per ton the charge per unit had already increased to about ¾d. Last year the Corporation lost £25 on the supply to Ravensthorpe, and this year the estimated loss was £65, so there would have to be a revision of the charges to consumers.

Gas Fuel for Electricity Works.—The British Coalite Co. (Lt.) have placed before the Brighton Lighting Committee proposals for supplying gas to be used as fuel for boilers at the Corporation's electricity works on mutually advantageous terms. The committee states that some expenditure upon pipes, adaptation of boilers, &c., would be involved, but it is estimated that half the present cost of fuel would be saved.

Glasgow.—The Municipal Employés Association in Glasgow have applied for an advance of 4s. per week for their members employed in the Corporation electricity department. The claim, which affects labourers and semi-skilled workers, has been remitted to a special sub-committee.

Increased Charges for Electricity Supply.—As from Sept. 30, *Hove* Corporation is increasing its flat rate for lighting by 2½d. per unit and the maximum demand rates of 7d. and 4d. by 10 per cent.

Swindon Council's charge for current for lighting is to be increased from the same date from 4½d. to 5d. per unit. *Ayr* Council is increasing its rates for current for heating, power, private lighting and tramways to 25 per cent. over pre-war rates and for public lighting to 60 per cent. over pre-war rates for public lighting (an increase in the present case of 25 per cent.). *Elland* Council has agreed to an increase to 5d. for lighting and an increase of 7½ per cent. (making a total of 20 per cent.) for power as from Oct. 1. At *Denny* prices are raised ½d., making the rates 5d. for lighting and 3¼d. for power as from the beginning of the present quarter.

Newport (Mon.).—The Electricity Committee's recommendation that the borough electrical engineer, Mr. A. Nichols Moore, M.I.E.E., should be allowed to act in an advisory capacity to the board of management of a certain shell factory, and also to be responsible for the supervision of the electrical equipment of the factory (which recommendation had been previously referred back to the committee) was unanimously re-affirmed by the committee, and was adopted by the Council at its last meeting without discussion.

Linking-up or Bulk Supply.—The St. Pancras (London) Electricity and Public Lighting Committee report the receipt of a communication from the Board of Trade calling attention to the advantages of connecting up with power stations supplying tramways and railways.

The hon. secretary of the Conference of Metropolitan Boroughs had also asked what action St. Pancras proposed to take in the matter, and the Lighting Committee of Islington Council had suggested negotiations between themselves and St. Pancras.

Mr. Sydney W. Baynes (borough electrical engineer), reporting on the subject, says none of the adjoining installations generates power at the voltage or periodicity suited to the Council's needs, therefore transforming plant would be essential. The L.C.C. had informed him that they would have no power to spare during the coming winter, the Underground Railways Co. stated that they had no powers under their Act to give supplies to other undertakings, and that they had arranged with most of the companies not to apply for such powers. He estimated the cost to St. Pancras of linking-up St. Pancras with Islington or Hampstead and with the Central Electric Supply Co. or Marylebone (assuming the connected systems shared the cost of the mains) at £25,450 (including transformers), and the cost of mains to link up with the North Metropolitan Co. would be about £18,000—a prohibitive figure. Linking-up (Mr. Baynes says) is an illusion, as its advocates know, but it is a means to the end they have in view—viz., supply in bulk. There is not an installation more reliable than that of St. Pancras, and a stand-by secured by linking-up is of less utility than formerly, and not worth the capital outlay. Sooner or later, if they connected to a company, they would be forced by circumstances to take a supply in bulk. The companies he had been in touch with were not keen on a linking-up scheme, unless they were at the business end of the main. On the other hand, the borough authorities were more inclined (if a scheme of linking-up be commercially practicable) to regard the chargeable costs as purely reciprocatory, the balance in the exchange of current in each year being returned to them, or paid for at an agreed nominal rate. The following figures were quoted for a supply in bulk measured at the switchboard at the Central Electric Co.'s power station, the Council bearing all transmission and transformation losses :—

For maximum demand of 500 kw. during next winter, £3 per kilowatt, or £1,500 per annum, and 0·33d. per unit, with coal at 20s. This adjusted to 27s. (present price of best steam nuts) would make the cost of 876,000 units at 20 per cent. load factor, after allowing for transmission and transformation losses, 0·926d. per unit. St. Marylebone figures were the same as dealt with by the committee in December, 1913. Correcting their price for coal at present prices, and allowing for transmission and transformation losses, at a 20 per cent. load factor their price would be 1·19d. per unit. The St. Pancras Council's new plant (correcting coal to present prices) and including repayment of capital and interest, produced current at 0·5462d. The cost of production at the Council's present power house would be increased were they to purchase current; all extra current that was generated went to proportionately reduce wages and other standing charges. With reference to the Board of Trade letter as to saving coal by a scheme of linking-up, bearing in mind the phenomenally low steam consumption obtainable with the new Ljungstrom turbine in operation, and having regard to the extra capital expenditure on linking-up it would be difficult, he concludes, to show a commercial economy, including a saving in coal consumption, were the Council linked-up to neighbouring power stations which did not possess machinery of so high a standard of efficiency.

The committee are of opinion that at present the advantages that might be derived by the Council through linking-up with the other electricity undertakings would not be commensurate with the cost which would have to be incurred, and recommend that, for the present, no action be taken in the matter.

Sheffield.—There was an interesting discussion upon the finances of the electric supply department at the Council meeting last week.

Ald. Hobson moved the rejection of a minute of the Electric Supply Committee, which submitted to the Council "That the auditor should supply any observation to this Committee he has to make upon the affairs of the department at the same time as he submits them to the Finance Committee." He pointed out that the proposal was contrary to the financial regulations of the Council, which provided that the accountant auditor "shall be responsible only to the Finance Committee and the City Council for a continuous audit after payment of all the accounts of the Corporation, and for the disclosure of any irregularities, &c." He thought the committee could perfectly well rely upon what had been the practice up to now. The claim that the auditor should report direct to the Electric Supply Committee was contrary to the regulations, and might lead to a lessening of the auditor's independence.

Ald. Styring, in opposing the amendment, said he thought the Council would, as it always had done, stand firm to the proposition that the trading departments were responsible to the Council alone, and not to the Finance Committee. The accountant auditor was responsible for a continuous audit of the accounts, after payment. He must see that they were properly paid, and that there were proper vouchers for them, and if he could find any irregularities with reference to them he must report to the Finance Committee. There was not the slightest idea, either in the electricity or any other trading department, of concealing anything from the accountant auditor or the Council. What they said was that if that official had any questions with reference to the accounts, he should send his report to them, so that they might have an opportunity of giving their explanations to the Finance Committee before the matter came to the Council.

Col. Hughes supported the amendment, and urged that according to the regulation the auditor was responsible to the Finance Committee and the Council only for the disclosure of irregularities. They did not want to interfere with anybody in any particular way, but the Corporation did want to know whether everything was going well with everybody. For years past there had been an intense desire on the part of the L.G. Board to have a public audit of Corporation accounts, and over and over again, when the Corporation had been in contact with public officials, in getting loans or consents, they had prided themselves upon the fact that they had an audit of their own which was absolutely independent.

Several other members took part in the discussion, and the amendment was carried by 23 votes to 22.

Councillor Graves alluded to the observations of the Electric Supply Committee contained in the minutes, assuring the Council that the financial condition of the undertaking was absolutely sound and satisfactory, and that the accounts were in order. He said that as far as the public confidence in the sense of trading with the department was concerned, there was not the slightest doubt that the financial condition of the undertaking was sound and satisfactory, for behind the undertaking were the great resources of the city. The committee observed that the accounts were in order, and he had not the slightest doubt they were. But if it was intended that these words meant more than that he did not agree with them. He thought the depreciation allowed was inadequate.

Ald. Styring said it was just 17 years since they took over the undertaking under great difficulties. They had gone through a period of stress and strain up to the present time, and he ventured to think they were now getting into smoother water.

Councillor Evans expressed surprise at the pessimistic tone of Councillor Graves, and maintained that the department was in a strong financial position.

The Electric Supply Committee, in its report, expressed the opinion that such charges as were made at the previous meeting of the Council disturbed public confidence in the electricity undertaking, and put the Committee at a disadvantage at the Council meeting, owing to their not having seen the report of the accountant auditor. The Council were indebted to the staff and workpeople for the faithful performance of their duties under abnormal conditions. The Committee submitted a table drawn up by the City Treasurer and Mr. Terrey showing how the electricity department compares with other trading departments of the Corporation. The electricity department, which had been an undertaking 2½ years less than the tramway department, had spent £1,058,987 on capital works, and had placed £43,201 to sinking fund, compared with £918,057 and £47,655 respectively in the case of the tramway undertaking. Assuming the continuance of sinking fund payments on the

same basis as last year, the electric supply undertaking and the tramway undertakings would become the property of the Corporation, without debt, in 17·42 and 14·56 years respectively.

Swansea.—The Electric Lighting Committee has decided to hire out electrical apparatus, the cost of same to be charged to revenue.

The engineer, Mr. J. W. Burr, has been instructed to report upon the question of borrowing money for the purchase of plant to secure greater efficiency in the production of electrical energy at the power station.

The committee has deferred consideration of the proposal to reduce the charges for current for power.

Wigan.—At the meeting of the Council last week it was reported by the chairman of the Electric Light Committee (Ald. Grimshaw) that the boilers were not expected to be erected in the specified time. In view of that fact, and as they were likely to be laid up by the L.G. Board for, perhaps, two years (and possibly three years), he did not know that there was any real limit to the time when the extension scheme, which had been recommended by the expert, could be properly undertaken. Under the conditions a sub-committee had been appointed to enter into negotiations with an outside company for the purpose of obtaining a bulk supply, but the negotiations were not yet complete.

Councillor Farr hoped that by the next meeting the chairman would be able to make a definite statement on the question of the electricity supply, so that consumers and public would know how they stood.

Ald. Grimshaw said he thought a special meeting of the Council would be called straight away and the whole situation explained.

LIGHTING & POWER NOTES.

Dromore.—At the last meeting the Urban Council accepted an agreement with the Dromore Electric Lighting Co. for lighting the town for three years.

The agreement provided for the lighting and maintenance of 81 lamps, not less than 56 c.p. nor more than 200 c.p., including seven all-night lamps and the lighting of the town clock, at an annual cost of £134.

Electricity in Collieries.—At the Elliot Collieries, New Tredegar, owned by the Powell Duffryn Co., a new 3,000-volt turbo-electric generator has been erected.

The cost of the new plant was over £30,000. Preparations are being made for the transmission of power from the Elliot Pits to Deri, where sinking developments are proceeding.

Keynsham.—The Parish Council has decided not to have any public lighting while the war lasts, and not to call a rate for lighting purposes.

The Keynsham Electric Light & Power Co. has suggested that the Council should pay the company £8. 6s. 8d. per month while the public lighting is discontinued, as the company is losing £100 per annum while the plant provided for street lighting is idle, but the Council declined, on the ground that it is entitled to charge the expense upon the rates.

Luton.—The Sanitary Committee recommend the Corporation to authorise the House Sub-committee to adopt electric lighting in the blocks not already lighted electrically at the Spittlesea Hospital, and to have electric radiators installed if considered desirable.

TRACTION NOTES.

C.O.D. System on Tramways.—At a recent meeting of Oldham Corporation Councillor Dixon objected to the collection by the tramways department of money for goods carried by them.

It was explained that the intention was not to collect money for the goods, but only for carriage, although the manager, Mr. Priestley, admitted that the notice issued by the department (which would be altered) conveyed the impression that money for goods would be collected, and in isolated cases it had been done.

Glasgow.—The Tramways department has decided to improve the lighting of the cars. In view of the fact that the electric light can be switched off at a moment's notice it is recognised that a considerable modification may be made of the drastic restrictions which have been in operation since the Lighting Order came into force in the spring.

Southend-on-Sea.—The Council has decided to purchase an oxy-acetylene welding plant for the tramways department, at a cost of £48.

TELEGRAPH AND TELEPHONE NOTES.

Australian Government Wireless Apparatus Factory.—The Minister for the Navy of the Australian Commonwealth, Mr. J. A. Jensen, recently stated that he had accepted the offer made to his department for the sale of the land, buildings, machinery and stock at Randwick (Sydney) of the Shaw wireless works. The purpose for which the works were to be used was the manufacture of wireless apparatus, for the equipment of all land stations, and the installation of plants necessary for ships. Experts have declared the plant and machinery of the Shaw Company to be up-to-date and in good order. The Australian "Mining Standard" states that it had been rumoured that the price (£57,000) included £11,000 for the patent rights obtained by Father Shaw some years ago; but as the validity of these rights is being challenged this amount may be modified.

Radiotelegraph Notes.—The French Marine Commission is appointing nine commissioners, who, with the delegates of the French Navy, will control the installation of wireless telegraphy and armaments on mercantile ships and the rules for the navigation of such ships.

It is stated that a harbour is being constructed and a wireless telegraph station is being built in connection with the State coal mining operations which have been commenced in the newly-discovered mines on Bjoernoeen (Bear Island), between Spitzbergen and the northern point of Norway.

Telephony in Argentina.—The Argentine Government has authorised Messrs. Sotorra & Co. to transfer to Senor Lucio Oliva the telephone service hitherto conducted by them in Laboulaye (Province of Cordoba), and also the services linked up with the adjacent townships and those connecting Laboulaye with Rufino (Santa Fé) and General Lavalle (Cordoba).

The National Government has also authorised the Compania Union Telefonica to open its new exchange at Dionisia (F.C.S.) to public service.

EMPIRE NOTES.

Australasia.—The Victorian Committee of the Advisory Council of Science and Industry recently sent a circular letter to the Chambers of Manufactures, Mines and Commerce containing the following questions:

(1) Whether there is any industry in Victoria which has encountered technical difficulties or disabilities which affect its development and progress. (2) Whether any particular firm or any person has encountered and failed to overcome such difficulties and disabilities. (3) Whether there are any industries which could be advantageously established in Victoria—either (*a*) primary—such as the production of raw material or utilisation of products not yet turned to account; (*b*) secondary—such as the utilisation of by-products from existing industries.

The Australian "Mining Standard" says Kilmore (Victoria) Shire Council has purchased the plant and business of the Kilmore Electric Supply Co. for £2,000.

Perth (W. Australia) City Council recently decided to take steps to secure the transfer of the metropolitan tramway system from the Government to the municipality. The tramway was originally laid by Perth Electric Tramways (Ltd.), the City Council retaining reversionary rights which would accrue in 1929. Various suburban municipalities also had agreements with the company, terminating at different dates. The Government, in 1912, passed an Act authorising the purchase of the tramways for £175,000 and the Premier promised the City Council that there would be increased accommodation, reduced fares, a better service, &c. Perth councillors are now asking in what way the assurances of better service, &c., have been fulfilled, and as nationalisation has failed on all those points which were declared to be in the people's favour, the endeavour to obtain the return of municipal rights is believed to have some prospect of success.

Traffic returns of the Prahran & Malvern (Victoria) Tramways Trust show that during the 16 weeks ended June 28 the revenue was £16,216 (13·79d. per car-mile), operating expenses being 9·525d. The poles and 600 tons of rails ordered for the construction of the Burke road and Whitehorse road extensions were in a vessel which had been sunk at St. John's, New Brunswick, in March. The material has been recovered in a much rusted condition. Sufficient rails and poles to construct the Whitehorse road line are at hand and a contract for the construction of the permanent way has been let. The line will be ready next month.

The Melbourne Electric Supply Co. has informed Geelong City Council that it proposes, after the war, to extend the electric tramway system from Geelong West terminus to North Geelong, and the South Geelong terminus to Belmont, and to duplicate another line.

Some dissatisfaction is being expressed in Hobart at the extent to which the Government has mortgaged its prospective supplies of elec-

trical current to large mining and metallurgical companies, which it is believed will prevent for some time the supply of current for other industries which it had been hoped would grow up The Government is to supply a large quantity of energy to the originating company for producing metallic zinc direct from the ore; an agreement has been made to supply the Amalgamated Zinc (De Bavay's), Ltd., with 30,000 H.P., and conditionally a further 20,000 H.P.; and a provisional agreement has been made to supply the Mt. Lyell company with a further 50,000 H.P. for operating its scheme for smelting the Rosebery Mt. Read ores. The ultimate result will probably be a considerable enlargement of the Government's plant.

The Council of the Bendigo School of Mines state in their annual report that, in spite of war conditions, the school continues to progress. The enrolment of students is up to the standard of previous years. The electrical engineering department has been equipped with several specially designed machines and an up-to-date experimental switchboard. A storage battery and several instruments are still required to be secured.

It is stated that Mr. Justice Powers has awarded increases in the salaries of telegraphists in the Commonwealth service.

Canadian Water Power.—The High Commissioner for Canada has received information that the water-power capable of development in Ontario is 4,929,000 H.P., while only 702,000 H.P. is being developed at present. Of this 574,000 H.P. is used to generate electrical energy, 69,000 H.P. is used in pulp and paper manufacturing, and 59,000 H.P. is used mainly in the form of hydraulic power.

India.—"Indian Engineering" says a hydro-electric scheme to supply Coimbatore with electric power and water is being investigated and its success is reported to be almost assured. The power station will be located at Podanur.

A separate scheme for lighting Ootacamund from the Sandinullah River is also being investigated and prepared by Mr. H. P. Gibbs.

The question of introducing some form of electrically-propelled vehicle for use in Simla is once more engaging the attention of the Municipality, and the electrical engineer has been instructed to submit specifications for an electrical jinrickshaw, based on suggestions made in a note by Capt. Batty in the report of the Simla Improvement Committee.

New South Wales Mines.—The annual report of the Department of Mines for 1915 contains the folowing:—

The Electrolytic Refining & Smelting Co. of Australia (Ltd.), at their Port Kembla works, produced gold valued at £560,225, silver £59,800, and copper £1,745,700; total £2,365,725 (an increase of £738,339, compared with 1914). The greater part of the 20,733 tons of copper was produced from imported blister copper.

The Sulphide Corp. (Ltd.) added a 300 kw. set to its Central Mine generating plant during the year.

The Chief Inspector also states in his report that though some attempts have been made to introduce electric safety lamps for workmen's use underground, up to the present these attempts have not been attended with success, owing to trouble with batteries and to the difficulty in keeping in order the mechanical parts of the lamps. Some few years ago a number were introduced into the Metropolitan Colliery, on the South Coast, but their use has been discontinued. In the northern and southern districts a few of these lamps are used by officials at various collieries; but that there are no electric lamps for general use for underground workers, although 60 electric safety lamps of the Wolf type were used during the past year at South Bulli Colliery, and the management are making arrangements to extend their use underground. Although there have been some improvements made in the ordinary safety lamp, with oil as the illuminant, little has been done by the managers in this State to introduce these improved types.

Inspector J. T. Tennant (Northern district) states in his report that electricity is extensively used for signalling, shot-firing, pumping, hauling, lighting, ventilation, and in one case for winding. At one colliery (Pelaw Main) there is only one steam haulage, and this is being dispensed with, when the whole work of this large mine will be done electrically. No accidents due to electric working were reported during the year.

Inspector J. P. Hindmarsh (Southern district) states that only one accident due to electricity was reported. This occurred to an elevator attendant at North Bulli Colliery, on Oct. 18. The attendant was in the act of starting up the motor driving the skip elevator at the New Tunnel, when, through putting the handle of the rheostat over too quickly, an arc occurred and burnt the back of his right hand slightly.

Inspector Hutton reports that in the Northern district electricity is used for lighting and power purposes at Aberdare, Aberdare Extended, Aberdare Central, Aberdare South, Abermain No. 1, Abermain No. 2, Bell Bird, Dudley, Hebburn, Hetton, Neath, N.C.M. Co.'s A Pit and South Greta Collieries. No accident due to current has been reported during the year, although electricity is extensively used in mining operations above and below ground at most of the large collieries.

Mr. Wm. Corin, consulting electrical engineer, reports that electrical inspector J. F. Dent has carried out the whole of the mine inspections. An abstract from Mr. Dent's report shows that the number of mines on the list at the beginning of year was 53, and at end of the year 55. At the examination for mine electricians held on July 20 at the Sydney Technical College, he (Mr. Dent) acted with Messrs. A. E. O. Sellers and A. E. Warburton as examiners, 20 candidates presented themselves, of whom eight were successful. This makes a total of 93 certificated mine electricians who have been awarded the department's certificate. Mr. Corin says a draft revision of the electrical special rules has been in course of preparation, Mr. Dent having given him considerable assistance in this matter. The draft will shortly be forwarded to the Minister of Mines. In connection with the proposal for the establishment of a State coal mine at Lithgow, correspondence has passed with the Public Works Department as regards the provision of a State power station at Lithgow, adjacent to the coal mine, for the purpose of providing power for all industrial uses in Lithgow and neighbourhood and in the Blue Mountain district, and for pumping for a comprehensive scheme for the water supply of the Blue Mountain towns.

Mr. J. F. Dent, electrical inspector of coal mines, gives a list of 54 mines using electrical appliances and states that the total number of inspections made was 121, against 118 in 1914. In carrying out these inspections Mr. Dent has travelled 11,972 miles, exclusive of distances underground. The papers for the electric motor drivers' examinations were prepared by Mr. Dent, who conducted the practical examinations in Sydney on May 18 and Nov. 26, and at Newcastle on Dec. 11. In all there were 51 candidates, of whom 44 passed. Mr. Dent says the use of electricity in and about the mines continues to increase, not only by the installation of new plants, but by existing installations increasing the size of their respective outputs. The chief causes of the increases are the use of additional subsidiary haulage gears and pumps. Only one electrical accident is known to have occurred during the year, a coal-cutter machine driver receiving a shock from the switch handle of a gate-end box when switching on, the earthing arrangements having been carelessly effected. In general, the conditions of the electrical equipments about the mines are good, and very little trouble is experienced in the majority of cases in keeping the installations in conformity with the rules.

FOREIGN NOTES.

Argentina.—The "Review of the River Plate" says an electric power house is being erected at Puerto Deseado (territory of Santa Cruz). The plant has been supplied by a United States firm.

The National Government has approved projects for electrical installations in the Hospital Comun Regional del Centro, Bell Ville, and at the Resistancia Hospital, Buenos Ayres, at an estimated cost of about £10,000 and about £1,160 respectively.

An expenditure of $62,150 m/n. upon an electrical installation for the military station of "Campo de Mayo" has been authorised by the Government.

Brazil.—In a report on the trade of the Porto Alegre district, H.M. Consul (Dr. Dillon) states that no statistics of imports are published, but the following facts are shown by approximate figures which have been compiled:—

The U.S.A. furnished 50 per cent. of the tinplates, formerly a British monopoly. The greater part of the importation of chemicals was from the United Kingdom, France being second. In constructional ironwork the United Kingdom came third, and in machinery first, the United States being second in machinery with 10 per cent. of the total supply. The vernacular is Portuguese, but German is nearly as much spoken. Catalogues in English and with the British system of weights and measures are worthless for the Porto Alegre market. Before the war German houses sent their catalogues in German, because 20 per cent. of the population is German, and practically all the local firms understand German, but not English.

Notes received by the Board of Trade state, with regard to imports at the port of Natal (State of Rio Grande do Norte), that Germany has up to now supplied all the electrical material required. The electric cars are also of German make. There seems, however, a prospect of American material being supplied in future, as there have been two travellers in American electrical supplies in Natal recently. The existing rolling stock appears to be in bad condition, and there can be no doubt that new material will be required shortly if the cars are to continue running.

Chili.—A Valparaiso correspondent of "La Prensa" states that a conflict has arisen between the lighting company and the Intendency. Owing to non-payment by the latter of a debt of 25,000 pesos, the company decided to cut off the electric light in the office of the Intendency and in the house of the Intendent. That official prevented this being done by calling in the police. The same company notified the Municipality that it would cut off the public lighting if the municipal debt to them of about 1½ million pesos was not paid by an early date.

Costa Rica.—A company, with an authorised capital of six million dollars, has been granted a concession by the Costa Rican Government to cultivate certain lands north of Limon for growing bananas, cocoa, &c., and the company has been further authorised to import free of duty railway rolling stock, motor boats, telegraph and telephone instruments, wire, engines, boilers, &c., for its own use.

Norway.—The Railway Committee of the Storthing has approved the proposal to convert the Drammen railway to electric traction at an esitmated cost of 21,369,500 kr.

Porto Rico (West Indies).—It is stated that a demand for electric fans might be readily created on this island.

Portuguese Patents.—A Decree (No. 2,452) has been issued to the effect that, so long as the war lasts, particulars of applications for patents of invention will not be published in the official "Boletim da Propriedade Industrial" if it is considered that the publication of such particulars might be detrimental to the national interests or to those of the Allied nations. The right of priority in respect of such inventions will be determined by the dates of presentation of the applications. Patents will not be granted until after the termination of the war, and after the particulars withheld have been published and the legal period for lodging statements of opposition has expired.

Russia.—An Imperial Decree has been issued authorising the town of Ekaterinodar to conclude a bond loan of 4,055,000 roubles for various works, including the following: Construction of various municipal buildings, 856,000 roubles; purchase and erection of a Diesel dynamo engine at electrical works, 84,000 roubles; plant for hydro-electric power station, 82,000 roubles; and other town works, 105,000 roubles. The conditions contain the usual clause requiring that in contracts and orders for materials, plant, &c., preference should be given to Russian works, articles and materials, exceptions being granted in each instance by special authorisation only of the Ministers of the Interior and Commerce.

The British Consul at Mariupol says there will be a rush to obtain supplies as soon as peace is declared. Amongst the most important classes of goods that will be required are machinery and electrical goods of all kinds.

The British Vice-Consul at Berdiansk says when direct communication with the Odessa district is re-established the demands for British goods will be very large. A good market will exist for tools, chemicals, engineers' supplies and electrical goods.

A Petrograd correspondent of the "Financier" estimates the water power of the Russian Empire at 11,000,000 h.p., of which 1,700,000 h.p. is in European Russia. The largest hydro-electric works (on the Murgah Imperial Estate, in the Caucasus) are only of 1,500 h.p.

A "Yorkshire Post" correspondent says the formation of a Russo-British Chamber of Commerce for the United Kingdom has been officially recognised by the Russian Government, but it will be well to note that we are not alone in seeking to supplant German traders in Russia, and there is urgent need for action to be taken. The "Commercant," a leading commercial journal in Russia, reports an interview with Mr. Fozenden Meserve, manager of the National City Bank of New York, which is about to open a branch in Russia. Mr. Meserve explains that the chief aim of the bank will be to give financial assistance for the development of Russo-American business relations. He says the methods which have built up the industries of America are better suited to the development of Russian industries than those of any other country, and in the near future it is proposed to open in Russia the American International Corpn., which will interest itself especially in the building of railways and exploiting water forces. He goes on to say that a commercial agent of the United States, Mr. W. T. Huntingdon, has left Petrograd for a business trip through Russia. Mr. Huntingdon is one of the most eminent representatives of the American Ministry of Trade, and has spent three years in Western Europe studying the conditions of European industry. The Russo-American Chamber of Commerce is discussing the question of organising in Moscow an exhibition of American and Russian goods. The "Commercant" also says action is being taken by the French with a view to promoting their commercial interests in Russia. An exhibit of French goods is to be opened at the Novgorod Fair, and afterwards to be transferred to Moscow. A representative of the Russo-French Chamber of Commerce will be present at the Fair, and one of his duties will be to induce Russian manufacturers to take part in the exhibition at Lyons in 1917. Efforts are being made to improve commercial relations between France and America after the war, and that a special mission founded by American exporters is about to visit France this month, which may afterwards go to Russia. The International American Corpn., with a capital of $50,000,000, will finance business undertakings in France and Russia.

Nothing is said in these articles in the "Commercant" of British goods, or of any movement for the purpose of furthering British commercial interests in Russia.

U.S.A. Hydro-Electric Works.—The Utah Power & Light Co. has commenced the construction of a fourth hydro-electric station on the Bear River at Cove, Idaho.

The new plant will have a capacity of 12,000 h.p., and with its completion the company will have utilised 865 ft. of the 1,710 ft. of fall in Bear River between Bear Lake and Great Salt Lake. The new plant is expected to be in operation in May, 1917. The first hydro electric plant of the company on Bear River is at Grace (60 miles from Bear Lake), and delivers 44,000 h.p.; the second plant is being erected at Cove; the third is the Oneida station of 27,000 h.p. capacity, recently completed; and the fourth plant is at Whelon, and has a capacity of 12,300 h.p.

Venezuela.—The British Vice-Consul at Caracas reports that the total railway mileage of Venezuela is 539 miles, including the 5 miles of the Macuto and Coast Line railway, which is really an electric tramway.

The "Gaceta Oficial" (Caracas) of July 13 contains a notice by the Ministerio de Fomento that Messrs. Sardi Bros., of Torondoy (State of Merida) has been granted a concession to construct two telephone lines of about 11 miles in length in the district.

MISCELLANEOUS NOTES.

Directory of British Manufacturers for Russian Trade.—The second edition of this directory is in preparation by the Russo-British Trade Exchange (Ltd.), 16, Regent-street, London, S.W., which also notifies that it has established a Russian reading room, where daily and trade papers can be consulted, and where technical information obtained of Russian requirements.

Directory of Merchants and Manufacturers of India, 1915.—We have received a copy of this book, which is published at R.3 (4s., plus postage) by Messrs. Laxmichand Dassabhai & Bros., Rajpot, Kathiawar, India.

In the classified list of merchants and manufacturers in India there are extensive lists of cotton-ginning factories, cotton mills, cotton-pressing factories, coal mines, tramways and railways, which should prove useful to British machinery merchants and exporters, manufacturers of electrical and other machinery. There are numerous other classified trade headings in the Indian Division, and there is also a foreign section, containing a classified list of cotton mills in China and Japan, besides selected machinery, chemical, &c., manufacturers in other countries. In the remaining portion of the book there is much and varied information regarding currencies, weights and measures, the Indian import tariff, the Indian and other rulers, the physical and other characteristics of the Indian provinces, &c.

Electricians' Demands at Liverpool.—The dispute between the Liverpool Masters Builders' Association and the Liverpool branch of the Electrical Trade Union arising out of a demand on the part of the men for increased wages, reduced hours and various minor concessions, has been referred to the Rev. H. Dunnico, secretary of the National Peace Society, as arbitrator, and it has been agreed that his decision shall be final.

Hebburn.—At the meeting of the Council last week a report was received from Prof. W. M. Thornton on the recent fatality due to electric shock received from a lamp standard.

The report stated that the leakage had occurred for some days prior to the accident. The type of lamp head and switch was acknowledged by the electric supply company to be imperfect, and he advised that a complete change-over of the lamp heads should be made before the bad weather set in. He also recommended that an inspection once a quarter should be made, and said that it was inconceivable that the present state of affairs should continue without an attempt being made to remove all source of danger.

The chairman (Rev. G. K. Wilkinson) said it was lamentable that a great company should be so indifferent in regard to danger, not only on the high road, where there was heavy traffic, but over the whole district generally. It was known all around that there had been minor cases of "burning," but the Council would be astonished to hear that the company pleaded ignorance in every case. He urged a systematic inspection of the switch boxes, and that an immediate effort should be made to adjust all faulty wires and parts, and that there should be a complete change over of the present method. He regretted that the company had refused to show sufficient sympathy with the deceased's family and pay for the burial expenses, and he understood that the Guardians would have to defray the expenses.

After discussion it was decided to refer the matter to the Board of Trade and to bear the expenses connected with burying the deceased.

Lights on Ships.—An Admiralty Order dated Sept. 8, has been issued under the Defence of the Realm Regulations, prohibiting the use of electrically lit lanterns as anchor lights, and ordering all anchor lanterns to be fitted with overhead screens, while their normal brilliancy is to be reduced by 50 per cent. Specimen screens can be viewed at the Board of Trade Surveyors' Offices at Leith, North Shields, Hull, London, Plymouth, Cardiff, Liverpool, Glasgow and Dublin. The employment of electric lanterns as bow and masthead steaming lights is prohibited in estuaries, harbours, anchorages and channels where navigation in the dark hours is permitted, and no lights, either aloft, on deck, or below, except those required by the regulations for the prevention of collisions, and such as may be permitted to be visible from outboard are permissible. This applies to vessels of every description other than H.M. ships and the vessels mentioned in the succeeding paragraph in the waters of the United Kingdom, except within three miles of the Irish Coast.

Vessels carrying volatile oil or spirits in bulk are, notwithstanding

these orders, to exhibit in lieu of oil lamps electrically lit lanterns, not exceeding in brilliancy 50 per cent. of the brilliancy of the normal oil lamps.

Maximum Prices of Pig Iron.—The Minister of Munitions has fixed the following maximum prices per ton for Derbyshire and Nottinghamshire pig iron :—

No. 4 forge, £4. 10s. ; No. 3 foundry, £4. 12s. 6d. ; No. 2 foundry, £4. 14s. 6d. ; No. 1 foundry, £4. 16s. 6d. ; basic, £4. 17s. 6d. The advance is to take effect as from July 19, 1916, until Sept. 30, 1916.

Munitions Court Case.—At the North Staffordshire Munitions Court on Monday a tramcar conductor, employed by the Potteries Electric Traction Co., applied for a leaving certificate in order to return to his former occupation as a potter's printer. The applicant said he had been employed by the company for 13 years prior to last April, when he left to take a situation at his former trade. Owing to the hot weather, however, the change did not suit his health, and he returned to his occupation of tram conductor. When he left his pay was 6d. an hour, but on his return he was put on the beginners' rate of 5d. an hour.

The representative of the company contended that tramway facilities were necessary for the manufacture of munitions, and that their conductors came within the Act.

The chairman (Mr. J. B. Simmons), in granting the certificate, said when a previous application was made the company produced a certificate from the Ministry of Munitions, which was granted apparently on the assumption that light, heat and power were being produced, which were of importance to munitions. That certificate appeared to have been withdrawn, and the certificate upon which the company relied depended on the supply of tramway facilities. On the point of law he should be pleased to give the company leave to appeal to the Central Munitions Court.

TENDERS INVITED.

Telephone and Telegraph Material, Instruments, &c.

Tenders are invited up to Dec. 22 for the supply to the Australian Commonwealth Postmaster-General's Dept., State of Western Australia, at the Telegraph Office, Eucla, of 340 Accumulators, with associated apparatus, as per schedule No. 492. Specification, &c., from the Commonwealth Offices. London. *See also an advertisement.*

Tenders are invited for the supply to the Postmaster-General's Dept., State of South Australia, of Telephone Material in accordance with schedule No. 428, and tenders are invited (up to Oct. 4) for the supply to the Postmaster-General's Dept., State of Western Australia, of Telephone and Telegraph Instruments in accordance with schedule No. 501. Tenders are also invited (up to Nov. 15) for the supply and erection at the telephone exchanges of Glenelg and Brighton, State of South Australia, of Automatic Switchboards and all associated apparatus (as per schedule No. 426). Tender forms, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, Perth (W.A.), wants tenders by 3 p.m. Oct. 4 for the supply and delivery of various Telegraph and Telephone Measuring Instruments and Parts for the Australian Commonwealth Postmaster-General's Dept. Specification, &c., from the Deputy Postmaster-General, Perth, W.A.

Tenders are invited by the Deputy Postmaster-General, Adelaide, for the supply and delivery of Telephones, Telephone Material, Instruments and Parts. (Schedule Nos. 429 to 437). Specifications, &c., and sealed patterns may be inspected at the Office of the High Commissioner in London for the Commonwealth, 72, Victoria-street, S.W. Tenders by 2 p.m. Sept. 27.

The "Departamento de Fomento de la Mancomunidad de Cataluna," Barcelona, require tenders by noon Sept. 25 for the installation of a Telephone System connecting the towns of Balaguer, Artesa, Pons and Calaf, at a cost of £2,850.

The Departments de Fomento de la Mancomunidad de Cataluna, Barcelona, also require tenders by noon Oct. 3 for the installation of a Telephone System connecting the towns of Gandesa, Falset and Reus, at an estimated cost of £3,100.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. Oct. 17 for supply of (1) Sleeves and Tapes (schedule 1,355) and (2) 3,100 Stay Rods with bow tighteners (schedule 1,359) for Australian Commonwealth Postmater-General's Dept. Specifications from the Deputy Postmaster-General, Melbourne.

The Public Service Stores Tender Board, Wellington (N.Z.) require tenders by 4 p.m. Oct. 11 for supply of 1,000 Magneto Extension Bells and 4,000,000 Lead Seals. Particulars from the Controller of Stores, Post and Telegraph Dept., Wellington, the Storekeeper Post and Telegraph Dept., Christchurch, or the Telegraph Engineers, Auckland and Dunedin.

Coal Transporter Plant.

Tenders are invited for the supply, delivery and erection in Melbourne, of a Coal Transporter Plant of the travelling tower type and electrically operated. Tender form with specification can be obtained from the agents for the Melbourne City Council, Messrs. McIlwraith, McEacharn & Co. Ppty. (Ltd.), Billiter-square-buildings, London, E.C. Tenders by noon Dec. 11.

Tramway Material.

Johannesburg (Transvaal) Municipality require tenders by noon Nov. 6 for supply of 18 Grooved 12 ft. Points and 24 Grooved 9 ft. Points and six Ordinary Crossings (contract No. 171). Specifications, &c., from the Municipal Offices (Room 53), Johannesburg.

Carbons.

The Victorian Government Railways Dept. requires tenders by 11 a.m. on Nov. 1 for the supply of 50,000 Yellow Flame Arc Carbons. (Contract No. 30,405.) Specification, &c., from the Victorian Railway Commissioners, Spencer-street, Melbourne.

Tramway Track Work, Material, &c.

The Madrid "Gaceta" of Aug. 4 notifies that tenders will be opened on Oct. 7 for the Construction and Working of an Electric Tramway in Barcelona, an extension to Sans of the lines of the Cia Nacional de Tranvias de Barcelona, which holds an option on the proposed concession. Minimum rolling stock required will be Two Motor Tramcars and Two Trailers.

Tenders will be opened on Oct. 11 for Construction and Working an Electric Tramway in Madrid, from the Calle de Alcala to the Calle de Diego de Leon. Minimum rolling stock Four Cars.

In both cases construction work must be commenced within three months and completed within 10 months and a year respectively from dates of concession. An option on the concession is held by the Sociedad Tranvia del Este, Madrid.

Cooling Tower.

Gisborne (N.Z.) Council require tenders by noon Oct. 2 for the supply and erection of a Cooling Tower at the municipal electric power station. Specification from the borough offices, or from Mr. E. J. Fenn, consulting engineer, Auckland (N.Z.).

Electric Time-releasing Mechanisms.

The Victorian Railway Commissioners, Spencer-street, Melbourne, invite tenders (by 11 a.m. Oct. 18) for the supply and delivery of Electric Time-releasing Mechanisms (100 with two normal and two reverse contacts, and 50 with four normal and four reverse contacts) for automatic signalling. Specifications from the Commissioners, Spencer-street, Melbourne.

Electric Fittings, &c.

Manchester Guardians require tenders by noon Sept. 25 for six months' supply of Electric Lamps. Forms of tender from the Clerk, All Saints, Manchester.

South Dublin Guardians require tenders by noon Sept. 27 for six months' supply of Electric Fittings. Forms of tender from the Master of the Workhouse.

TENDERS RECEIVED AND ACCEPTED.

Mansfield.—The Council has decided, on the recommendation of the Health Sub-committee, to purchase from the General Vehicles Co. a 2-ton electric wagon, at £1,970.

St. Asaph. The Board of Guardians has accepted the offer of the Premier Accumulator Co. for accumulators for the electricity department of the workhouse, at £229. (Six tenders were received.) A proposal to purchase an electrically-driven sawmill for the workhouse is under consideration.

Luton. The Electricity and Tramways Committee recommends the Council to accept the tender of Herbert Morris (Ltd.) for the supply and erection of ash handling plant, consisting of an electric overhead telpher and runway and two tipping skips, at £1,888. (Three tenders were received.)

Buenos Ayres. The Argentine Ministry of War has approved the adjudication to Senor Max Hellmuth of the contract for the supply of a motor and electrical generator for the power house of Campo de Mayo, at $52,150 m/n. (about £550).

Commonwealth Contracts.—The following tenders have been accepted by the Australian Government Departments:—

Postmaster-General's Dept., Melbourne. Moreland Metal Co., 1 ton 21 lb. scrap copper £72 per ton, 55 tons 10 cwt. scrap copper wire £77. 15s. per ton, 17 tons scrap copper £77. 1s. 6d. per ton, 104 tons scrap cable £17. 10s. per ton; J. McIlwraith & Co. Pty., 523 disc lightning arresters 2½d. each, 100 brass arresters 4½d. each, 24 ditto 9d. each, 13¾ lb. binding screws 6½d. lb., 31 lb. copper connecting strips 7d. lb.; Lawrence & Hanson Elec. Co., 22,000 non-encrusting zincs 4½d. each, 16,500 ditto 6¾d. each for N.S.W., 18,000 non-encrusting zincs 4½d. each, 6,150 ditto 6¾d. each, 180 detectors £3. 8s. each for Victoria, 1,500 non-encrusting zincs 6¾d. each for Queensland, 1,900 non-encrusting zincs 4½d. each, 100 ditto 6¾d. each, 75 detectors £3. 8s. each for S. Australia.

Postmaster-General's Dept., Sydney.—Automatic Telephones (Australia), 200 c.b. automatic telephones, £3. 7s. 6d. each.

Postmaster-General's Dept., Perth (W.A.).—J. E. Stone & Co., 14 tons scrap copper wire for Perth £84. 12s. 6d. per ton, 11 tons 10 cwt. for Fremantle £84. 13s. 9d. per ton.

Postmaster-General's Dept., Brisbane.—British General Electric Co., 1,000 cords, 1s. 6d. each; Standard Waygood Hercules (Ltd.), 10 Edison Lelande cells 9s. 11d. each, 30 ditto 17s. 7d. each, 5 porcelain jars 2s. 9d. each, 500 oxide plates 2s. 4d. each, 100 pairs zincs 1s. 11d. per pair, 100 pairs ditto 3s. 8d. per pair; Brisbane Electrical Co., 5,000 corks for Meidinger cells, 1½d. each.

Postmaster-General's Dept., Hobart.—Western Electric Co., 320 retardation coils 4s. 3d. each, 5 ditto 8s. each, 10 ditto 15s. each, 45 repeating coils 32s. 6d. each, 5 jacks 1s. 9d. each, 5,500 ditto £1. 3s. 6d. per strip of 20, 320 ditto 16s. 6d. each per strip of 10, 2 ring back keys 7s. 6d. each, 5 party line ringing keys 7s. 6d. each, 35 order wire keys (strips of 5) 3s. 3d. each, 36 single listening keys 12s. 6d. each, 5 microphones 16s. each, 125 plugs 1s. 7½d. each 320 relays 10s. 3d. each, 320 ditto 5s. 11d. each, 68 ditto 7s. 11d. each, 3 ditto 10s. 6d. each, 10 ditto 8s. 3d. each, 45 ditto 8s. each, 320 lamp sockets (in strips of 10) 2s. 6d. each, 90 sockets for supervisory lamps 6½d. each, 12 sockets for pilot lamps 1s. 11d. each, 16 terminal strips 4s. 9d. each, 16 ditto 5s. 6d. each, 16 ditto 6s. 6d. each, 400 protectors 200 per strip £28 per strip, 800 fuses £17. 10s. per strip, 2 fanning wool strips £1 per strip, 45 mica resistances 1s. 1d. each.

Victorian Railway Commissioners.—G. Weymouth Pty., switchboards for signal generators £150 each; Warburton Franki (Ltd.), lamps, socket reflector holders and reflectors, for electric lighting of Jolimont Car Shop, at rates; R. W. Cameron & Co., electric train stops and spare parts, during five years, at rates, electric signals and spare parts, during five years, electric interlocking machine, at rates; British General Electric Co., static transformers, £87. 10s. each; Cambridge Scientific Instrument Co., thermo-electric pyrometers, with accessories, £62. 13s. 6d. per set; W. Adams & Co., 1,000-ampere-hour storage battery, £267. 6s.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Ayr.—The accounts of the electricity department for the year ended May 15 show total capital expenditure £123,852 (increase £11,205), of which £13,020 has been repaid.

Revenue was £16,251 (compared with £15,359 in previous year), and expenditure £16,181 (£14,111), leaving gross profit £6,432 (£7,199). Interest required £2,861 (£2,586) and sinking fund £3,495 (£3,364), leaving £73, which has been transferred to reserve. Units generated were 1,969,031 (1,931,968) and sold 1,510,715 (1,578,774). Total maximum demand was 936 kw. (900 kw.).

Capital expenditure on the tramways amounts to £102,422 (increase £976), of which £25,087 has been repaid. Income was £19,285 (£17,984), and gross profit £7,456 (£7,004). Interest required £2,716 (£2,725), sinking fund, &c., £2,383 (£2,310) and depreciation £2,547 (£2,494), the net result being a deficit of £16 (£351). Revenue per car-mile was 10·11d., and working expenses, including power, were 6·20d. Passengers carried were 1,352,113, car miles run 457,503, and units used 179,027 = 1·01 per car mile.

Bristol.—The accounts of the electricity department for the year ended March 31 show total capital expenditure £901,601 (increase £9,225), of which £516,923 is outstanding.

Revenue was £132,928 (compared with £116,626 in previous year), and working and general expenses were £75,291 (£53,574), leaving gross profit £57,636 (£63,051). Interest and stock dividends required £20,105 (£20,215), and debt redemption £30,431 (£29,419), and net profit was £7,911 (£13,591). £2,876 was provided for capital expenditure out of profits, and £2,391 provided for allowances to employés who are in H.M. Forces. Units generated were 26,080,648 and sold 21,665,968 (increase 3,463,812). Total maximum demand was 10,988 k.v.a. Consumers are 5,608 (a net increase of 338), and total connections are equivalent to 859,921·30 watt lamps (compared with 796,301).

Mr. H. Faraday Proctor (engineer and manager) says in his report it was found necessary during the year to raise the price charged for electricity for all purposes. The Price of Coal (Limitation) Act had not afforded the protection to consumers of coal that was anticipated, and it cannot be expected that the current year will show a net profit on the present rates of charge for energy. Owing to the rapid increase in demand for electricity, it was necessary to apply to the L.G. Board for sanction to raise money for further generating plant. It was proposed to lay down a 6,000 kw. set. The Board declined to sanction this, but authorised the purchase of a 3,000 kw. set. Both the Feeder road and Temple Backs generating stations have been running loaded to their full safe capacity, and the connection of any 800 kw. consumer has had to be postponed. The length of mains laid has been increased by 5·00 miles to a total of 382·77 miles. The aggregate horse-power of motors and heating apparatus connected is 21,661 (against 19,542 last year). Load factor was 26·5 (24·5) per cent. Total costs per unit sold were 0·798d. (0·668d.), and redemption and interest required 0·328d. (0·381d.) and 0·223d. (0·271d.) respectively.

Maidstone.—The accounts of the electricity department for the year ended March 31 show gross capital expenditure £104,243 (increase £9,137), of which £61,605 is outstanding.

Revenue was £19,771 (compared with £19,893), and total costs were £13,532 (compared with £11,992), leaving gross profit £6,238 (£7,900). Interest required £2,200 (£2,210), and repayment of principal £4,294 (£4,136), leaving a net deficit of £255 (£1,553). Total costs were 1·075d. (0·837d.) per unit sold, or 1·643d. (1·369d.) with capital charges. Units generated were 3,448,350 (3,595,584) and sold 2,753,788 (2,887,857). Maximum load was 1,142 kw. (1,321 kw.) and load-factor 27·56 (25) per cent.

Mr. E. E. Hoadley (engineer and manager) says in his report coal cost £2,019 more and street lighting produced £1,082 less than in the previous year. The power load was over 57 per cent. of the total output, and is ever increasing, and the heating and cooking business, though throttled for want of hiring powers, is now established on a firm basis, and its success is assured.

Portsmouth.—The Corporation tramway accounts for the year ended March 31 show gross capital expenditure £733,180 (increase £2,573), of which £311,994 is repaid or in sinking fund.

Revenue was £127,546 (against £123,991 in previous year) and working expenses were £59,360 (£56,888). Grants to dependents of employés serving with H.M. Forces required £2,777, interest £21,671, sinking fund £18,055, and income tax £4,713, and the total remaining available for disposal (including interest on credit balance £750, and amount brought forward from last account £9,568) was £31,345. After appropriating sums for purchase of property, wagons, &c., the contribution in aid of rates was £13,000, to renewals £6,060 and reserve and insurance £3,000. Average total revenue was 14·101d. per car-mile and working expenses, including power, were 6·556d. (against 5·599d). Passengers carried were 29,338,918, car miles run, 2,170,778 (decrease 267,843) and units used 3,009,880 = 1·238 per car mile.

The electric lighting accounts show gross capital expenditure £373,324 (increase £7,138), of which £248,109 is outstanding. Revenue was £50,605 (compared with £51,607 in previous year), working expenses and special charges amounted to £35,820 (£29,247), leaving gross profit £14,784 (£22,360). Instalments of principal, interest and income tax required £22,072 (£22,360), and to make up this amount £7,288 has been transferred from reserve. Units generated were 4,601,860 and sold 3,603,860. Total maximum supply demanded was 2,490 kw.

Reigate.—The accounts of the electricity department for the year ended March 31 show gross capital expenditure £57,399 (increase £193), of which £33,047 is outstanding.

Revenue was £8,086 (compared with £7,953 in previous year) and working and general expenses were £4,145 (£3,827), leaving gross profit £3,891 (£4,125). Capital charges were £3,858, leaving £33 net profit.

Yarmouth.—At the meeting of the Council last week the Tramways Committee reported that the month's takings (£2,205) were £117 less than those of the corresponding month last year.

Councillor MIDDLETON moved that the fares be reduced to 1d., as more people would use the trams if fares were reduced.

Councillor TUNBRIDGE said the tramways would not pay unless higher fares were charged. In no other town could people get a 2½ mile ride for 1d. The committee had to pay more for current, and therefore had to charge more.

The chairman (Councillor SALMON) said expenses had gone up in all directions. There were good long runs for 1d. Moreover, a discount had been given by the sale of 12 tickets for 10d., which nearly gave a 1d. fare over the whole distance. He hoped the public would agree to the present fares.

The motion was then withdrawn.

COMPANIES' MEETINGS AND REPORTS.

CHADBURN'S (SHIP) TELEGRAPH CO. (LTD.)—The directors' report for the year ending March 31, 1916, shows balance at credit of the profit and loss account £24,794. 8s., from which is deducted managing directors' remuneration, directors' expenses, depreciation on properties, plant, &c., £14,970. 15s. 9d., leaving £9,823. 12s. 3d., or, with the balance brought forward from last year, £1,101. 3s. 9d., £10,924. 16s. From this amount £5,400 must be deducted, representing two half-yearly dividends at the rate of £6 per cent. per annum on the preference shares, and an interim dividend at the rate of £6 per cent. per annum on the ordinary shares absorbed £5,400, leaving £5,524. 16s. Out of this sum a further dividend on the ordinary shares at the rate of £10 per cent. per annum, less tax, has been paid, for the half-year ended March 31, making a dividend of £8 per cent. per annum for the 12 months, and £2,524. 16s. is carried forward.

CLYDE VALLEY ELECTRICAL FOWER STORAGE CO.—The profits for the past half-year, including £12,612 brought forward, amount to £52,934. After transferring £17,500 to depreciation, &c., and transferring £3,835 to special reserve, it is proposed to pay a dividend of 1¼ per cent., tax free, on the ordinary shares, and carry forward £15,456.

ELECTRIC SUPPLY CO. OF VICTORIA (LTD.)—The report for the year ended March 31 states that the equivalent of 166,253 33-watt lamps was connected, against 150,132 in 1915, and the tramway department carried 4,877,325 passengers, against 5,177,368. The year's revenue was £86,080 (against £86,800), and expenditure was £55,378 (against £56,990), leaving £30,702 gross profit (against £29,810). As in the preceding year, the progress of the company has been adversely affected by the prevailing war conditions. The directors, therefore, consider that the returns for the past year may be looked upon as satisfactory. The balance to credit of profit and loss account is £28,944, and with £1,999. 15s. 10d. brought forward the total is £30,944. 3s. 5d. Deducting debenture interest (£7,742) and amount transferred to debenture stock redemption account (£6,547), the balance is £16,655, which the directors propose dealing with as follows: To pay on account of arrears of preference dividend £10,222. 10s., and to carry forward £6,432. 18s. 5d.

HAMPDEN CLONCURRY COPPER MINES CO. (LTD.)—The report for half year ended Feb. 29 last states that the whole of the company's output of copper is now refined at the works of the Electrolytic Refining & Smelting Co., of Australia, at Port Kembla. Early in the year the company disposed of its production of electrolytic copper to the British Munitions Department till the end of 1916. The refinery is not yet able to refine electrolytically the whole of the output, and the excess is fire-refined. The necessity for the extension of the works of the Electrolytic Refining & Smelting Co. to accommodate output, furnished an opportunity for the company to participate in the undertaking by acquiring 4,000 shares. In association with the Mount Morgan Gold Mining Co., the Electrolytic Refining & Smelting Co. of Australia, and the British Insulated & Helsby Cables (Ltd.), the company is participating in the Metals Manufactures (Ltd.), which has been formed to manufacture all classes of copper wire, copper tubes, sheets, &c. The works will be situate adjoining the electrolytic works at Port Kembla.

MARCONI WIRELESS TELEGRAPH CO. OF CANADA (LTD.)—The report of this company for the year ended Jan. 31 last states that the business continues to show substantial expansion. The most gratifying feature during the year has been the steady development of the company's Transatlantic traffic. The work being done by the Glace Bay station in maintaining direct communication between Canada and Europe shows a satisfactory increase. The value of Marconi wireless during isolation of any country owing to interruption of cable communication has been demonstrated on two occasions during the past year, when the business community of Canada was to a large extent dependent on the Marconi service between Glace Bay and Ireland. The company's plant in Montreal has been kept fully occupied in supplying the demand for additional installations on board ships and commercial stations, as well as in meeting increased Government requirements. Wireless stations on board ship are now being viewed with favour even on vessels exempt from compulsory equipment. Some 2,300 mercantile vessels have been fitted with wireless stations by the various Marconi companies. The company has established divisional offices and stores in the more important centres of St. John's, Newfoundland, Toronto and Vancouver. A school of instruction for operators has been established in Montreal. The adverse effect caused to the company's normal traffic to and from ships owing to the censorship has continued in evidence. The basis of remuneration from the Government for the use of a number of the company's coast stations taken over by the Department of Naval Service since the commencement of hostilities and for other services rendered is still under consideration, and an equitable settlement is awaited in the near future.

NEW COMPANIES, MORTGAGES & CHARGES.

NEW COMPANIES.

W. COX (MANSFIELD) (LTD.) (144,844).—Reg. Sept. 13, capital £500 in £1 shares, to carry on the business of gas, electric light, hot water and sanitary engineers, bellhangers, &c. First directors W. Cox and C. C. Knight (both permanent). Secretary: F. H. Spreckley.

C. S. HOOK & CO. (LTD.) (144,815.)—Reg. Sept. 9, capital £4,000 in £1 shares (2,000 "A" and 2,000 "B"), to carry on the business of engineers, manufacturers and suppliers of and dealers in power transmission, factory or works equipment, including shafting and pulleys of all kinds, hangars, plummer blocks, beltings, packings, pipes, &c. Private company.

LATIN AMERICA CHAMBER OF COMMERCE IN GREAT BRITAIN (144,797) Reg. Sept. 7, as a company not formed for profit and limited by guarantee, with not more than 1,000 members, each liable for one guinea in event of winding up, to promote and extend the trade and financial relations between the U. K. and the South and Central American and Mexican Republics; to promote the industries and the exploitation of the natural resources of the said Republics. The word "Limited" is omitted from title by licence of Board of Trade. The management is vested in a Council, the first members of which are H. Le Marchant, P. J. Machin, A. B. Legina, J. H. R. Kemmal, R. Shenton, J. A. Hill and A. R. Davies. Secretary: W. M. Ellis. Reg. office: 1, Gresham-buildings, Guildhall, E.C.

NOTABLE ELECTRIC CO. (LTD.) (144,824).—Reg. Sept. 11, capital £100 in £1 shares, to take over business carried on at 30, Margaret-street, Oxford Circus, W., as the Notable Electric Co., and to carry on business of manufacturers of and dealers in drawn wire, metallic filament and other lamps of all kinds, &c. Private company.

ORMANDY & SCOTT (LTD.) (144,833).—Reg. Sept. 12, capital £4,000 in £1 shares, to take over business of motor garage, and proprietors, hirers, repairers, &c., of and dealers in motor 'buses, cars, cycles, taxi-cabs and motor vehicles, contractors, mechanical, marine, electrical and general engineers, &c., carried on by Ward & Scott (Ltd.), at Carlisle-street, Barrow-in-Furness. Private company. First directors are S. Scott and R. O. Cooke. Reg. office: Carlisle-street, Barrow-in-Furness.

W. R. THORNTON & SON (LTD.) (144,787.)—Reg. Sept. 6, capital £5,000 in £1 shares, to take over the business of engineers' furnishers and electrical engineers and contractors for and dealers in mechanical and electrical apparatus and appliances carried on by the executors of W. R. Thornton as W. R. Thornton & Son. Private company. First directors are W. R. Thornton (permanent man. director, subject to holding 50 shares) and A. Haynes.

MORTGAGES AND CHARGES.

YORKSHIRE CABLE CO. (LTD.)—Charge on moneys due from War Office under contracts for supply of electric cables, dated Sept. 1, 1916, to secure all moneys due or to become due from Lloyds Bank (Ltd.), Lombard-street, E.C., and Bradford, not exceeding £4,000.

CITY NOTES.

MEMORANDA (Sept. 20).—**Bank rate 6 per cent. (since July 13, 1916).** Consols 59¾. Consols Pay Day, Oct. 4. **Stocks and Shares Ticket Days,** Sept. 28 and Oct. 12. **Pay Days,** Sept. 29 and Oct. 13. **Price of silver,** 32⅝.

BISHOP STORTFORD, HARLOW & EPPING GAS & ELECTRICITY CO. At the recent meeting the chairman (Mr. E. L. Burton) said that they had completed their electricity plant, which was now quite ready for working. It was a matter of regret that circumstances over which they had no control had hitherto prevented the company affording a supply to consumers in Bishop Stortford.

BRITISH ALUMINIUM CO. (LTD.)—Dividends at the rate of 8 per cent. per annum (less tax) on the ordinary shares and at the rate of 6 per cent. per annum (less tax) on the preference shares for the six months ended June 30 are to be paid on Oct. 1.

BRITISH INSULATED & HELSBY CABLES (LTD.)—The directors have declared an interim dividend of 5 per cent. for the half-year ended June 30, less tax.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units sold to consumers during the four weeks ended July 28, 1916, amounted to 2,020,562, compared with 1,972,641 during the corresponding four weeks of 1915.

COMPANIES TO BE STRUCK OFF THE REGISTER.—The following companies will be struck off the Register of Joint Stock Companies unless cause to the contrary be shown before Dec. 12: Commercial & General Engineering Development Co., International Power & Light Trust, Research Laboratory, Rochdale Electroplating Co.

The following will be struck off the Register unless cause to the contrary is shown before Dec. 15: Auto-Electrics, Auto-Flash Sign Co.,

Cable Construction Synd., Grindell-Matthews Radiophone Synd., Llanidloes Electric Lighting Co., Scientific Researches Co., Turbiro Engine & Pump Co., Wireless Telephones.

DICK, KERR & CO. (LTD.)—A dividend of 6 per cent. per annum on the preference shares has been declared.

DIRECT SPANISH TELEGRAPH CO. (LTD.)—The board have decided to pay, in addition to the dividend at the rate of 10 per cent. per annum on the preference shares, an interim dividend at the rate of 4 per cent. per annum (tax free) on the ordinary shares, both for the half-year ended June 30, 1916, and payable on Oct. 2.

EASTERN TELEGRAPH CO. (LTD.)—A dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending Sept. 30, and the second quarterly interim dividend of 1½ per cent. on the ordinary stock (tax free), will be payable on Oct. 16. The transfer books of the ordinary stock will be closed from Oct. 6 to 14 inclusive.

FOLKESTONE ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend at the rate of 6 per cent. per annum (3s. per share), less tax, on the ordinary shares for the past half-year.

LANCASHIRE DYNAMO & MOTOR CO. (LTD.)—An interim dividend on the ordinary shares of 5 per cent., tax free has been declared (against 3 per cent. for the corresponding period of last year).

LIVERPOOL DISTRICT LIGHTING CO. (LTD.)—An interim dividend at rate of 4 per cent. has been declared for the half-year ended June 30.

SIR W. G. ARMSTRONG, WHITWORTH & CO. (LTD.)—An interim dividend has been declared for the half-year ended June 30 at the rate of 10 per cent. on the ordinary shares, 4 per cent. per annum on the first preference shares and 5 per cent. per annum on the second preference shares.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date Sept. 19, the following as the present basis prices of—

New Metals.	per lb.
Solid Drawn Brass Tubes	15½d.
Solid Drawn Copper Tubes	18½d.
Brazed Copper Tubes	18½d.
Brazed Brass Tubes	17½d.
Brass Wire	15½d.
Copper Wire	18d.
Rolled Brass	14½d.
Brass Sheets	15½d.

	Per ton.
Spelter	£56 0 0

	Per ton
English Lead	£30 10 0
Antimony	Nominal.
Old Metals.	Per ton.
Clean Copper Scrap	£104 10 0
Clean Brass Scrap	64 0 0
Braziery Copper Scrap	88 0 0
Old Lead	26 0 0
Old Zinc	39 0 0
Hollow Pewter	125 0 0
Black Pewter	95 0 0
Gun Metal	83 0 0

Mr. A. Joseph, Earl-street, Long-road, Southwark, London, S.E., quotes under date Sept. 19, the following approximate prices of Scrap Metals:—

	Per ton.
Aluminium Cuttings	£110 0 0
Clean Mixed Brass	64 0 0
Clean Copper	102 0 0
Braziery Copper	88 0 0
Gun Metal	85 0 0

	Per ton.
Old Lead	£3 15. under English lead price
Old Zinc	38 0 0
Hollow Pewter	130 0 0
Shaped Black Pewter	90 0 0

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80; Commercial Tinman's Solder, £97. Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

We give below the latest prices at which actual transactions took place on or before Tuesday, Sept. 19.

Shrs.	Last Dividend	Name.	Price, Tues., Sept. 19	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	8⅛	7 4 4	Mar., Sept.
10	4½%	Do. 4½% Cum. Pref.	8⅞	5 11 8	Feb. Aug.
10	6%	Do. 6% Cum. 2nd Pref.	9½	6 3 1	Feb, Aug.
5	10%	Brompton & Kensington Ord.	6¾	7 6 9	Mar, Sept
5	7%	Do. 7% Pref.	7	5 0 2	Mar, Aug
St.	4%	Central Elec. Supp. G. Deb. St.	80	5 0 0	..
St.	4%	Charing Cross West End & City Deb.	80	5 0 0	Jan, July
5	2/3	Do. 4½ Pref.	3½	6 10 11	..
5	5%	Do. Ord.	3½	7 2 10	Aug, Feb
5	4½%	Do. City Pref.	3¼	6 18 6	Jun, Dec
5	4%	Chelsea Elec. Supp. Co. Ord.	3½	6 8 7	Mar, Sept
St.	4½%	Do. do. Deb.	85	5 5 11	Jan, July
10	8%	City of London Elec. Lt. Ord.	12¼	6 6 6	Feb, Aug
10	6 0	Do. 6% Pref.	10⅞	5 13 7	Mar, July
St.	5%	Do. 5% Deb. St.	97½	4 17 6	Jun, Dec
St.	4½%	Do. 4½ Debs.	80	5 2 6	Jun, Dec
10	7%	County of London Ord.	10½	6 9 6	Mar, Sept
10	6%	Do. 6% Pref.	10¾	5 15 8	Feb., Aug.
St.	4½%	Do. 1st Deb.	86½	5 4 0	Jan, July
St.	4½%	Do. 2nd Deb.	84	5 7 2	May, Nov
St.	4½%	Edmundson's Elec. Supp. 4½% Debs.	73½	6 2 5	July
5	7%	Kensington & Knightsbridge Ord.	5⅞	6 11 9	Feb, Aug
St	4%	Do. Deb. St	7½	5 1 0	Jan, July
5	6%	London Elec. Supply 6% Pref.	4½	6 13 4	..
St	4%	Do. 4% Mort. Deb.	80	4 14 1	Jan, July
5	3%	Metropolitan E. Supp. Ord.	2¾	5 9 1	Mar, Aug
St	4½%	Do. 1st Mort. Deb.	80	5 11 6	Jan, July
St.	5%	Midland Elec. Corp. 1st Mort. Deb. St	99	5 1 0	Jan, July
..	6%	Newcastle & Dist. E.L. 6% 2nd Debs.	99½	6 0 6	Mar, Sept
St	5%	Newcastle-on-Tyne E.S. 5% 2d Mt. Db. St	92	5 8 8	Mar, Sept
1	6%	North Metropolitan E.P. Supp. 6% Pref.	9¾	6 3 10	Apl, Oct
4	5%	South London E.S. Ord.	2¼	7 2 3	Mar, Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price Tues., Sept. 19	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
5	8%	St. James' & Pall Mall Ord.	6⅜	6 5 6	Feb, Aug
5	7%	Do. do. Pref.	5⅞	5 19 2	Feb, Aug
St.	3½%	Do. do. Debs	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	72½	6 4 7	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations	1⅜	6 14 8	Mar, Aug
5	7%	Westminster E.S. Corp. Ord.	6⅝	5 10 11	Mar, Sept
5	4½%	Do. 4½ Cum. Pref.	4⅛	5 4 1	Jan, July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	86	5 16 3	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	80½	7 9 6	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	72	5 11 1	..
St.	4%	Do. do. Assented Def. Ord.	72	5 11 1	..
St.	4½%	Do. 4½% Pref.	82½	5 9 1	Jan, July
St.	4%	Do. 4% Deb. St.	76	5 5 3	Jan, July
St.	4%	City & S. London Deb.	74⅜	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70½	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2⅜	5 14 3	Jan, July
St.	4%	Do. 4% Pref.	66	6 1 4	Mar, Sept
St.	4%	Do. 4% Debs.	75⅜	4 19 3	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	24¼	4 0 7	Feb, Aug
St.	3½%	Do. 3½% Pref.	62⅝	5 11 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	59½	5 17 8	Feb, Aug
St.	3½%	Do. 3½% A Debs.	67½	5 3 8	Jan, July
St.	3½%	Do. 3½% Debs.	68⅞	5 1 8	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18	..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 4	May, Nov
St.	4½%	Do. 4½ First Pref.	73	6 3 3	Feb, Aug
St.	6%	Do. 6% Perp. Debs.	109	5 10 1	Jan, July
St.	4%	Do. 4% Debs.	73	5 9 7	Jan, July
St	4%	Do. 4% Debs. (1903-5)	75	5 6 8	Jan, July
St.	4%	Do. 4% Guar. Stock	70⅛	5 14 2	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	3 3/32	4 17 0	Apl, Oct
1	6%	Do. 6% Pref.	1½	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1⅛	5 6 8	Mar
100	5%	Do. Prior Lien Debs.	93½	5 6 11	Jan, July
1	6%	Do. 6% Pref.	⅞	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12⅜	6 17 3	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5⅛	5 15 8	Jan. July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	⅞	6 8 0	Mar, Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2 3/32	5 3 7	April
100	6%	Do. 6% Prior Lien Debs.	102½	5 17 1	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	67½	5 18 1	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12⅜	8 1 7	Jan, July
5	5%	Do. 5% Pref.	4½	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	86	5 4 8	June, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	3/32	7 13 7	Sept.
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	½	..	Feb. Aug
St.	4%	Do. 4% Deb.	61½	6 10 7	Jun. Dec
1	7½%	Elec. Construction Ord.	3/32	8 5 6	May
1	7%	Do. 7% Cum. Pref.	1 3/32	6 15 9	Jan. July
St.	4%	Do. 4% Debs.	68	5 17 8	Jan. July
10	10%	General Electric Ord.	14½	6 17 11	July
10	6%	Do. 6% Pref.	9 3/32	6 0 5	June, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	16⅛	5 18 1	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4	5 12 6	..
St.	4½%	Do. 4½% Db.	88½	5 1 8	Jun, Dec
10	10%	India Rubber, G.P. &c., Ord.	12⅛	8 5 10	Feb, Aug
10	5%	Do. Pref.	7¼	6 7 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39½	6 0 9	Mar, July
100	4%	Do. 4% Debs.	95⅛	4 4 1	Jan. July
1	7½%	Vickers Ord.	1⅞	4 0 0	May, Aug
1	6d.	Do. 5% Pref.	3/32	5 10 4	May. Aug
St.	4%	Do. 1st Debs.	81¼	4 18 3	June. Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 8	June, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	41½	9 18 10	..
St.	4%	Do. 1st Mt. Deb. St.	56½	7 1 0	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	101½	5 18 2	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23⅛	7 0 2	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	70½	5 13 6	Ja. Ap. Jly.O
10	5%	Cuba Submarine Ord.	8 3/32	6 0 9	May, Nov
10	10%	Do. 10% Pref.	15½	6 11 2	..
5	5/0	Direct Spanish 10% Pref.	7¼	6 13 4	..
10	4%	Direct United States	6½	6 0 9	Ja.Ap.Jly.O
St.	8%	Eastern Tel. Co. Ord.	145	5 10 4	Ja.My.Jly.O
St.	3½%	Do. 3½% Pref.	66½	5 5 10	Ja.My.Jly.O
St.	4%	Do. 4% Deb.	79½	5 0 8	May, Nov
St.	4%	Eastern Extension Tel. Co., 4% Debs.	78	5 2 7	Feb, Aug
10	8%	Do. Ord.	14½	5 9 5	Ja,Ap,Jly,O
10	22%	Gt. Northern Tel. Co. With Coup. 11	42½	5 4 2	Ja. My. Jly
25	13%	Indo-European	49½	6 12 0	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3⅜	3 2 9	April
1	7%	Do. 7% Pref.	2 3/32	2 14 0	July
10	1%	West India & Panama Ord.	1 1/32	9 0 3	May, Nov
10	6%	Do. 1st Pref.	8	7 10 0	May, Nov
10	8%	Western Telegh. Co.	15⅛	5 6 3	Mr. Jly.O.Dec
St.	4%	Do. 4% Deb. St.	77	5 3 11	June, Dec
..	4½%	Western Union 50-yr. Bds.	99½	4 10 10	May, Nov
		Telephones.			
1	7½	Monte Video Teleph. Ord.	9 3/32	7 13 7	Nov
1	10%	Oriental Telephone Ord.	2 3/32	4 15 6	Apl, Oct
St.	4%	Do. Db St.	79	5 1 3	Jan, July
St.	4½%	Telegh. Co. of Egypt Db. St.	83	5 8 5	Jan, July
5	8%	United River Plate Ord.	6½	5 17 5	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4½	5 4 7	Jan, July
St.	4½%	Do. Deb Stk.	85½	5 5 3	Jan. July
		Financial and Investment.			
10	6%	Globe Telegh. & Trust	12½	4 13 8	Sp,Dc,Mr,Jn
10	6%	Do. 6% Pf.	10½	5 12 11	Sp,Dc,Mr,Jn
100	5%	Mackay Companies' Common	85½	5 17 6	Ja.Apl.Jly,O
..	4%	Do. $100 Pref.	70	5 14 3	Ja.Apl.Jly,O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl, Oct
		Colonial and Foreign Electric Supply, &c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4½	6 1 6	Mar, Sept
St.	5%	Do. 5% Debs.	94½	5 5 10	Jun, Dec
10	6/0	Bombay E.S. & T. 6% Pref.	10½	5 15 8	..
St.	4½%	Do. 4½% Debs.	83	5 8 5	Jan. July
5	9%	Calcutta E.S. Corp. Ord.	6½	6 18 5	May, Nov.
5	5%	Do. 5% Pref.	4⅛	5 12 8	Mar. Sept.

† Ex dividend or interest.

THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED, First Series (Weekly), 1861; Second Series (Weekly), 1878.

JOINT EDITORS: W. R. COOPER *and* H. H. BROUGHTON.

No. 2,002. [Vol. LXXVII. No. 26.] FRIDAY, SEPTEMBER 29, 1916. PRICE SIXPENCE (by post, 7d.).

Abroad 9d., or 20 cents, or 1fr., or 90pf.

CONTENTS OF THE CURRENT NUMBER.

NOTES..... 931
Arrangements for the Week.. 933
The Mathematical Design of Transformers. By Prof. David Robertson, D.Sc. Illus. 934
The Air-Gap Field of the Polyphase Induction Motor. By F. T. Chapman, D.Sc. Illustrated.—*Continued*.... 936
Municipal Tramways Association. Fifteenth Annual Conference 939
Some Notes on Passenger Transportation in Large Cities. By J. M. McElroy. Illustrated 939
Utilisation of Tramways for Goods Traffic. By G. W. Holford and W. Clough.. 943
Inductance of Conductors at Close Spacings. By F. B. Silsbee. Illustrated..... 945
The Tungsten Arc Under Pressure. By G. P. Luckey 947
Electric Power Plants of the Montana Power Co. 947
THE UNION OF CAPITAL AND LABOUR..... 948
A New Method of Braking Cranes. By E. Luft. Illus. 949
CORRESPONDENCE..... 950
The 2000th Issue (A. E. Kennelly).
The Evolution of the Electric Lamp (F. W. Willcox).
The I.E.E. and the City and Guilds of London Institute (A. P. Lundberg & Sons).
Vacuum Detectors (Samuel Cohen).
A One-Ton Electric Lorry at Manchester. Illustrated.. 952
Higher Harmonics of Induction Motors Due to Winding Distribution. By A. H. Mittag. Illustrated..... 953
An Imperial Trade Bank 954
Educational 955
LEGAL INTELLIGENCE 955
The "Electrician" Commercial and Industrial Section .. 957–964

NOTES.

Enlightened Finance.

IN some respects it is a little unfortunate that one must judge a business undertaking by its balance sheet. This applies with particular force to tramways. Owing to defective legislation, to bad engineering and to the foisting of ill-considered schemes on the public, the latter rightly feel that they are hardly used when they fail to secure a return on the money which they have invested. Notwithstanding the unsatisfactory financial position of many of the tramway and railway undertakings, it is due in large measure to these that life in our large cities and towns is possible. For this reason the question as to how far a tramway or railway company is entitled to receive assistance from the local authority is an important one. The matter was referred to by Mr. J. M. McELROY, at the Conference of the Municipal Tramways Association, in his Paper on "Some Notes on Passenger Transportation is Large Cities," of which we give an abstract elsewhere. It appears that in New York the total outlay on the underground and elevated lines, when the extensions are fully completed, will be £137,000,000. This capital is being provided equally by the city authorities and operating companies. The latter are to get out of the revenue all their operating expenses and 6 per cent. upon their investments, and out of the balance the city is to get the interest on its investment plus 1 per cent. for sinking fund, and if there is any profit after these payments have been made it is to be divided equally between the city and the companies. In Mr. McELROY'S opinion it is doubtful whether there will be the available net revenue to meet the interest and sinking fund payments of the city, and the possibility of any ultimate profits to the city is remote But the city authorities are determined to provide adequate travelling facilities, and they have made up their minds to do it properly, even if it entails a charge upon the rates.

Goods Traffic on Tramways.

THE second Paper at the Conference of the Municipal Tramways Association was read by Messrs. G. W. HOLFORD and W. CLOUGH, and dealt with the Utilisation of Tramways for Goods Traffic. Owing to the unsatisfactory position of many tramways at the present day their utilisation for goods traffic is a subject of some importance. It is desirable to increase the revenue-earning capacity of such undertakings if possible. In some cases, as mentioned by the authors of the Paper, it has been possible to arrange definite contracts for the carrying of material from one point to another, and for this purpose it has generally been necessary to put down special sidings for handling the material at the two extreme points. It is not at all improbable that a satisfactory and remunerative contract may be made under these conditions. When, however, we come to ordinary traffic in parcels, it is altogether a different matter. Here it is improbable that the public will be satisfied to hand in a parcel at a definite depot and to fetch it from some other depot. It is quite possible that a considerable amount of traffic might be carried on by means of receiving depots if that were the only impediment, but it is the delivery of parcels that presents the greatest difficulty. If a tramway undertaking decided to provide for the delivery of parcels the undertaking would then be saddled with a considerable department for this sole purpose, and it is questionable whether a suitably popular tariff would prove truly remunerative. The difficulty in dealing with a subject of this kind is that a tramway is not primarily concerned with such business, and may be open to competitors with professionals in such matters, they themselves being merely amateurs.

An Imperial Trade Bank.

THE Report to the Board of Trade by the Committee appointed to investigate the question of Financial Facilities for Trade has been issued very promptly, and marks an important step in public opinion. It is well known that the industrial banks in Germany have done much to promote German trade, and although everyone may not agree that the ultimate result for Germany was all that was desirable, it must nevertheless be admitted that the industrial bank filled a gap which is very noticeable in this country. In the Report to which we have referred a strong recommendation is made that an Imperial Trade Bank should be established with a capital of £10,000,000 in order to assist British firms on sound financial lines. There are a great many transactions which are desirable and which are financially free from serious risk, but which nevertheless

are outside the scope of operations of the usual joint-stock bank, and we think rightly so. Let our banking, which has a very high reputation in the financial world, remain as it is; but this is no reason why there should not be an industrial bank with Government assistance, an institution which would deal with such financial propositions as our present banks cannot handle. For this reason we welcome the recommendation of the Committee that an Imperial Trade Bank should be established without delay.

The Institution and the City and Guilds.

In our Correspondence columns we publish a letter from Messrs. Lundberg & Sons dealing with the Institution of Electrical Engineers and the City and Guilds of London Institute. With most of the letter we are in hearty agreement. We have long felt that both the Institution of Electrical Engineers and the City and Guilds of London Institute, while doing work of inestimable value, do so without the assistance of the big drum. In consequence the man in the street knows little of the activities of either body. It is to be regretted that on account of the war the prizes and medals given by the various City Livery Companies are not definitely offered this year. What is wanted by electrical engineering students is a competition similar to the "Whitworth" in mechanical engineering. Although we hear little of the Whitworth scholarships and exhibitions in these days, it used to be the aim of every ambitious student in mechanical engineering to secure the medal, and the abolition of the examinations in science by the technical schools, at the suggestion of the Board of Education, made it impossible for the rank and file of engineering students to enter the competition. It would be a fitting tribute to the memory of one of our great electrical engineers if the Institution would found such a competition on very broad lines for electrical students. Although we do not propose to discuss details in this note, we suggest that certain of the City and Guilds examinations could be included. We would make it a qualifying condition that every candidate should be connected with the Institution. Many students, and many who are no longer students, have yet to learn that not only is it their duty to belong to the Institution but also their privilege so to do.

Air Raids and Electric Tramways.

During the last air raid on London we were surprised to notice that the railway and tramway traffic proceeded as usual, the view apparently having been taken by the authorities that the cessation of traffic was an unnecessary precaution. We do not think this view is altogether justified. Undoubtedly the presence of trains and trams may be rendered more or less unnoticeable by obscuring lights and drawing down blinds, but in the case of electric trains and electric trams in motion there is always a certain amount of arcing. The flashes from electric trams are noticeable for miles on a dark night, and would certainly be extremely evident to any aircraft. We think this probably accounts for the routes followed by the Zeppelins during the last raid on London, and we would, therefore, suggest that the military authorities consider once more the advisability of stopping the traffic on tramways during such raids.

Congratulations from the "Electrical World."—We have received the following cablegram from the "Electrical World" congratulating us upon our 2000th issue: "Our Editors have read your September 15th issue with interest and appreciation, and congratulate you on passing your 2000th milestone."

North London Railway.—Next month is to see the inauguration of electric train services on the North London Railway and its connections, constituting a through route from Broad street to Richmond and to Kew Bridge via Hampstead Heath and Willesden. This is only the first instalment of a more comprehensive scheme undertaken by the L. & N.W. Railway, which includes the electrification of the lines from Euston and Chalk Farm to Watford, and will make the City and the West End equally accessible to that district.

Provisional Orders.—It is announced that the Board of Trade, realising the altered conditions since the issue of their notice on August 28, 1915, will be prepared to entertain applications for provisional orders in the ensuing session when it can be shown that the establishment of works under the schemes proposed will be proceeded with as soon as practicable after the termination of the war.

Research on Dye-Stuffs.—Details are now available regarding the arrangement under which the University of Leeds will co-operate with British Dyes (Ltd.) in research on dye-stuffs. A new staff has been appointed under the direction of Mr. A. G. Perkin (son of Sir W. Perkin). Mr. G. H. Frank, M.Sc., and Dr. Oesch, an eminent Swiss expert, are both retained on the staff, and with them will be associated Mr. P. E. King, Lieut. A. E. Woodhead, M.Sc., Prof. E. R. Watson, D.Sc., of Dacca College, and, as outside lecturers, Mr. H. P. Hird and Mr. C. F. Cross, both specialists engaged in allied industries.

The subjects for research include the investigation of anilines, new processes, the constitution of colour, and the industrial applications of cellulose. An experimental dye-house is also being installed.

Self-Luminous Paints.—Self-luminous paints consist of a mixture of an alkali sulphide (zinc sulphide is commonly used) with a small amount of radio-active material which excites the sulphide, producing a continuous glow. According to a contribution by W. S. Andrews in the "General Electric Review," the initial brightness depends on the proportion of radium: a higher percentage of this element increases the luminosity but shortens the life of the paint by a corresponding amount. The United States Government specifies that paint used by the Army and Navy should maintain its luminosity undiminished for two years. Meso-thorium, a by-product of incandescent mantle manufacture, is sometimes mixed with the radium element on account of its comparative cheapness, but opinion differs as to the comparative value of paints so treated and those containing radium only.

Institute of Metals—Autumn Meeting.—Among recent Papers presented at the autumn meeting of the Institute of Metals on September 20th may be noted "The Development of the Spelter Industry," by Ernest A. Smith: "The Annealing of Arsenical Brass Containing 61 and 62·5 per cent. of Copper," by C. H. Mathewson and E. M. Thalheimer (Yale University, U.S.A.); "Cadmium in Spelter," by W. R. Ingalls (U.S.A.): "The Allotropy of Silver," by W. D. Helderman (Utrecht University). In view of the measures now being taken to promote the production of zinc within the British Empire, Mr. E. A. Smith's Paper, which traces the history of the spelter industry in the years preceding the war, is of special interest. For many years Germany was the chief zinc producer, but in recent years America has made great strides. Efforts are now being made to increase the smelting capacity of this country and Australia, in which large stores of zinc are available. Germany has still certain sources of supply in Silesia and Hungary, and she has also interests in China which may be considerably developed in the future.

Influence of Hours of Work on Output.—Memorandum No. 12 issued by the Committee of the Ministry of Munitions on the health of munition workers, contains a report by Dr. H. M. Vernon on the relation between output and hours of work. Experiments covering a considerable period fully justify the recommendation previously made by the Committee that the hours of work should not exceed 65–67 hours for men and 60 hours for women; in many cases even a smaller number of hours per week would give the best results. Some striking examples of the effect of continued fatigue in diminishing output are recorded. Thus, in the case of some youths of 14–17 years, working on steel base plugs, a rise of 16 per cent. in hourly output took place after the Christmas holidays, and subsequently when the hours of labour were reduced from 70·3 to 57·0 an increase of 12 per cent. was obtained. Thus, in spite

of the diminution in the number of hours worked, an increase in total output of about 19 per cent. was reached. These and other results show that it is possible to be engaged for longer hours and yet do less work.

Complex Quantities in Alternating-Current Theory.—In an interesting Paper read before the American Institute of Electrical Engineers, Mr. N. S. Diamant describes a new polar form for representing complex quantities and its application to the calculation of alternating-current phenomena. It is based on the use of the operator j^n, where n, contrary to ordinary usage, may be any positive or negative number :—

Just as j or j^1 indicates rotation through 90×1 deg., and j^3 indicates rotation through 90×3 deg., so $j^{\frac{1}{2}}$ is interpreted as rotation through $90\times\frac{1}{2}=45$ deg. In general Aj^{χ} $(\chi>O)$ may be interpreted as rotation of the number A through $90\times\chi$ deg. or $\pi\chi/2$ radians in the positive or counterclock wise direction ; similarly $Aj^{-\chi}$ $(\chi>O)$ represents a vector which has been turned through $\pi\chi/2$ radians in the negative direction. Thus the exponent of j may be any number, and it indicates the phase relation of the quantity under consideration. For instance, an E.M.F. of E volts and 60 deg. out of phase with the current will be represented according to the above, as $Ej^{\frac{2}{3}}$, where $\chi=(60/90)=\frac{2}{3}$; and the current as $Ij^{o}=I$, since j to the zero power is unity, just as for any other algebraic quantity. Hence E.M.F., which in the rectangular form of notation was written $a+jb$ or $E(\cos\chi+j\sin\chi)$ in the usual polar form or $Ee^{j\chi}$ in the exponential form, becomes $Ej^{\chi/\pi}$ in the Diamant notation. If the angle χ is given in degrees instead of fractions of π the notation becomes $Ej^{\chi/90}$. The Diamant notation has various advantages. Multiplication and division of vectors are, of course, very simple. The Paper also gives the rules for addition and subtraction for calculating the power, for determining the logarithm of Aj^{n}, and for differentiation. A number of problems are solved in the Paper, using the four different methods of notation side by side for the sake of comparison as to their relative convenience.

OBITUARY.

Sir Geo. Franklin.—We regret to record the death of Sir George Franklin, which occurred suddenly at Llandudno on Saturday.

Sir George Franklin, who was among the new knights when the New Year honours were announced last January, was 63 years of age, and was head of the firms of Franklin, Wild & Co., of London, and Franklin, Greening & Co., Sheffield. He was pro-Chancellor of Sheffield University and a former Lord Mayor of Sheffield. He was chairman of the United River Plate Telephone, China & Japan Telephone, Oriental Telephone & Electric Companies, the Telephone Co. of Egypt, and the Telephone Development Co., president of the Société anonyme Ottomane des telephones de Constantinople, and a director of the British Thomson-Houston and Lanarkshire Tramways Companies. As chairman and managing director of the National Telephone Co. he carried through the negotiations for the transfer of the company's undertaking to the Post Office.

Killed in Action.—The following deaths in action or from wounds are reported :—

Flight-Lieut. Wm. H. S. Garnett (R.F.C.), who has been killed while making a flight in this country, was the son of Dr. Wm. Garrett, who was until recently educational adviser to London County Council. Lieut. Garnett took a first class in the Mechanical Science Tripos, and wrote a book on the turbine engine.

Lieut. J. C. Noakes (R.E.), who has been killed in action, was born in 1886, served an apprenticeship with Messrs. Hans Renold (Ltd.), and later occupied an important position with the company. He also received his technical education partly at the Manchester School of Technology, and was an Associate Member of the Institution of Civil Engineers.

The death in action is also announced of Capt. C. M. Hughman, youngest brother of Capt. R. W. Hughman, of the "Electrical Times."

From the County of London Electric Supply Co. we have received the following list of members of their staff who have lost their lives on active service : Second-Lieut. D. A. Lardner (9th Bedford), L.-Corp. G. Tebby (9th Queen's) (died of wounds received on Aug. 16), Rifleman A. B. Watkins (L.R.B.), Corp. Amos Rose (5th Royal Berks), Private W. Amey (Middlesex Regt.) and Private E. Alexander (E. Surrey). All were in the engineer's department, except Lieut. Lardner, who was in the secretarial department.

We are also informed that the following Simplex Conduits (Ltd.) men have died in the service of their country : E. A. Mousley (R.A.M.C., who has died of wounds), P. F. Fowkes (R.E., who died in training at home), A. Betts (Worcester Regt.), H. Bodfish (Warwickshire Regt.), J. Ireland (Warwickshire Regt.), C. Parker (Warwickshire Regt.), S. Robbins (Worcester Regt.), D. H. Swarsbrick (Warwickshire Regt.), W. A. Lock (R.F.A.), and B. Liddiard (Warwickshire Regt.).

PERSONAL.

Mr. J. S. D. Moffet, tramways manager at West Ham, who was recently appointed tramways manager at Belfast, was entertained to dinner on the 15th inst. by the Metropolitan Association of Electric Tramway Managers.

At the annual general meeting of the Municipal Tramways Association on Friday last, Mr. Henry Mozley, general manager of Burnley Corporation tramways, was elected President for the ensuing year.

Mr. Henry Fowler, chief mechanical engineer to the Midland Railway Co., has been appointed superintendent to take sole charge of the Royal Aircraft Factory at Farnborough.

Capt. Harold Gray, R.F.A. (borough electrical engineer of Accrington), was married on Saturday last to Miss Lillian Boyle, of Accrington.

The marriage of Mr. Chas. W. Erskine (Tyne Elec. Engineers R.E.), formerly an assistant in the Sheffield Corporation electric supply department, to Miss A. W. Rhind took place on the 20th inst.

We regret to hear that Mr. Harold Dickinson, city electrical engineer of Liverpool, has had to undergo an operation, which will necessitate his absence from duty for some time.

Royal Engineers (T.F.).—The following appointments have been made :—

London Electrical Engineers : Sergt. H. P. Waterhouse, Sec. Corpl. W. S. Browne, Q.M.S. K. W. Adcock (Singapore R.E. Vol.), and Sec.-Lieutenant P. Lunn (Manchester Regt.) to be Second Lieutenants (on probation).

Tyne Electrical Engineers : Sergt. R. O. Porter (from Devon, Fortress, R.E.) and H. Joseph to be Second Lieutenants (on probation.)

War Casualties.—In addition to the casualties to Simplex Conduits men recorded under "Obituary," we regret to hear that the following members of the company's staff have been wounded : N. Bill (Warwickshire Regt.), G. Baird (Scottish Horse), J. Cain (Warwickshire Regt.), J. Quinney (R.F.A.), F. Raison (Lancs. Fusiliers), M. Gough (R.G.A.), Aldrich (Warwickshire Regt.), W. Howell (Middlesex Regt.), R. Wooland (Warwickshire Regt.), A. Birtley (Warwickshire Regt.) and C. Boulton (Wilts Regt.).

In addition to the members of the staff of the County of London Electric Supply Co.'s staff whose deaths are recorded in our obituary column, the following members have been wounded : Private G. F. Ayling (Duke of Cornwall's Light Infantry), formerly in the company's secretarial department, is wounded and a prisoner in Germany, and Rifleman W. E. Dossett (L.R.B.), who was in the engineer's department.

APPOINTMENTS VACANT AND FILLED.

Wigan Corporation invite applications for the position of borough electrical engineer and manager. Salary £400 per annum. Applications to the town clerk, Mr. Wm. Hy. Tyrer, Municipal Offices, King-street West, Wigan, by Oct. 19. *See also an advertisement.*

A company transacting electrical insurance requires a qualified electrical engineer to inspect, test and report upon electrical units. *See an advertisement.*

A man is wanted to take charge of electrical equipment. *See advertisement.*

West Ham Corporation received 31 applications for the position of tramways manager in succession to Mr. Moffet, who has been appointed to a similar position at Belfast.

Seven candidates were selected for interview, and this number was reduced to two—viz., Mr. W. Clough, of Bury, and L. Slattery, of the L.C.C. tramways department. Ultimately Mr. Slattery was appointed to the vacant position at a commencing salary of £600 per annum.

ARRANGEMENTS FOR THE WEEK.

1st LONDON ENGINEER VOLUNTEERS.

Office Commanding, Lieut.-Col. C. B. Clay, V.D.

Orders for the week:

Officer for the Week.—Platoon Commander Hughes Hallett.

Next for Duty.—Platoon Commander J. O. Cheadle.

Monday, Oct. 2.—Technical for Platoon No. 9 at Regency-street ; squad and platoon drill, Platoon No. 10 ; signalling class ; recruits' drill, 6.25 to 8.

Tuesday, Oct. 3.—School of arms, 6 to 7 ; lecture 7.15, "The Development of the Soldierly Spirit," the Adjutant ; range practice.

Wednesday, Oct. 4.—Instruction class, 5.45 ; platoon drill, Platoon No. 3 ; range practice.

Thursday, Oct. 5.—Platoon drill, Platoons Nos. 5 and 6 ; range practice.

Friday, Oct. 6.—Technical for platoon No. 10, Regency-street ; squad and platoon drill, No. 9 ; signalling class ; recruits' drill, 6.25 to 8.25.

Saturday, Oct. 7.—N.C.O.'s class, under Company Commander W. D. Bentley, 2.30.

Sunday, Oct. 8.—Entrenching at Otford. Parade Victoria (S.E. & C. Railway Booking Office), 8.45 a.m. Uniform, haversacks, water bottles. Midday rations to be carried. Railway vouchers will be provided.

Musketry.—For all companies, see notice at headquarters.

Note.—Unless otherwise indicated, all drills, &c., will take place at headquarters. Members who have not yet obtained their cards of membership should apply to the Adjutant on Tuesdays or Thursdays.

THE MATHEMATICAL DESIGN OF TRANSFORMERS.*

BY PROF. DAVID ROBERTSON, D.SC.

1. Introduction.

The method of getting the leading dimensions of a transformer here described was first given by the author in Bohle and Robertson's "Treatise on Transformers" (London, 1911). Recent discussions and criticisms have led to the present re-statement of the method, with such slight modifications as have been found desirable.

2. Data Required.

The data generally specified for a transformer in addition to its output are: Temperature rise; efficiency, or iron and copper losses; voltage-drop; and exciting current. These are not, however, independent of one another. In particular, temperature rise and efficiency are very closely related, the standard commercial efficiencies being the lowest ones at which the temperature rise can be kept within the specified limits with the given output, type of transformer and method of cooling.

With given dimensions, the relation between the losses and the load is perfectly definite, but the heating depends very much on the method of cooling, on the size and shape of the tank, and on the skill of the designer in arranging the ducting. The voltage-drop at unity power factor is practically determined by the copper loss, while the exciting current largely depends upon whether the iron loss is a high one or a low one for the other ratings. Owing to the variation of the permeability of the iron, no useful algebraic relations can be obtained between the exciting current and the dimensions.

Although it is quite easy to obtain a relation between the temperature rise and the "fundamental length," owing to the uncertainty of the thermal constants it is best to take the losses as the basis of the design. If these are normal for the output, type and materials, the others will also be normal.

For the purposes of this theory, the transformer is supposed to consist of copper and iron spaces, each of which entirely fills the opening through the other. The boundary between them is drawn apparently arbitrarily, but it is in reality fixed by the assumptions made when estimating the mean length of one turn, and it is conveniently taken as the circle or rectangle circumscribing the iron core. We must suppose that the space-factors, as given by the ratio of the net section of the metal to the cross-sections of these spaces, can be estimated beforehand with sufficient accuracy. If in the final design the clearances do not come out quite right, it will usually be sufficient to adjust the window to suit. It is only when the change of proportions thereby introduced is considerable that a fresh estimate and design need be made.

In addition, we must know the properties of the materials employed, and, if the cheapest arrangement is required, also their relative cost, including labour.

3. Assumptions.

Since it is impossible to take complete account of all the variables in a general theory, certain assumptions are necessary to bring the problem within the compass of our mathematical knowledge. Those made in this theory are:—

1. The flux density is uniform throughout the iron.
2. The current density is uniform throughout the copper.
3. The cost of active material may be divided into two parts, of which one is proportional to the amount of iron and the other to the amount of copper.
4. The copper loss is proportional to the square of the current density.
5. The iron loss is proportional to the square of the flux density.

The last three assumptions do not arise until we seek to obtain the best proportions for given conditions, such as minimum cost, or until we compare different types with one another. They scarcely affect the problem of designing to given proportions.

None of these assumptions is strictly accurate. The first would require the corners of the cores to be rounded off, which is not usually done, as the cost of doing so would exceed the value of the scrap metal removed. It also excludes the well-known possibility of reducing the cost by diminishing the section of the wound cores while increasing that of the unwound yokes, but in any case the extent to which this could be practically applied is limited by excessive exciting current and local heating.

The second assumption is open to the criticism that the minimum loss with a given volume of copper is not obtained in every case with equal current densities in the primary and secondary coils owing to differences in their mean perimeters.

With a given copper space, the minimum copper loss is obtained when the current density is so graded that it diminishes outwards in such a way as to make the resistance E.M.F. the same for every turn. It is scarcely practicable to change the size of conductor from layer to layer, but with concentric coils we can give the outer coil more, and the inner coil less, than its fair share of the total section of copper.

With rectangular coils of standard proportions the outermost turn will be about 65 per cent. longer than the innermost. Compared with uniform current density throughout, the copper losses will be about 1½ per cent. less if the outer coil gets 56 per cent. and the inner coil 44 per cent. of the total section of copper. The result is thus the same as if the resistivity had been reduced 1½ per cent., making the loss-length about ¾ per cent. and the weights about 2¼ per cent. less. The effect on the most favourable proportions is quite negligible, but it is such as to make long thin coils appear a trifle better than they really are. This matter is fully dealt with in an appendix to the original paper.

The third assumption is probably as nearly accurate as any generalisation regarding cost can be. When making comparisons between different types it should be remembered that it neglects differences between the labour of winding equal amounts of copper in round or rectangular coils, in short thick coils or in long thin ones, with thin wire or with copper bar, of preparing stampings of different shapes, and of assembling different types. It also leaves out differences in the proportional cost of material cut to waste.

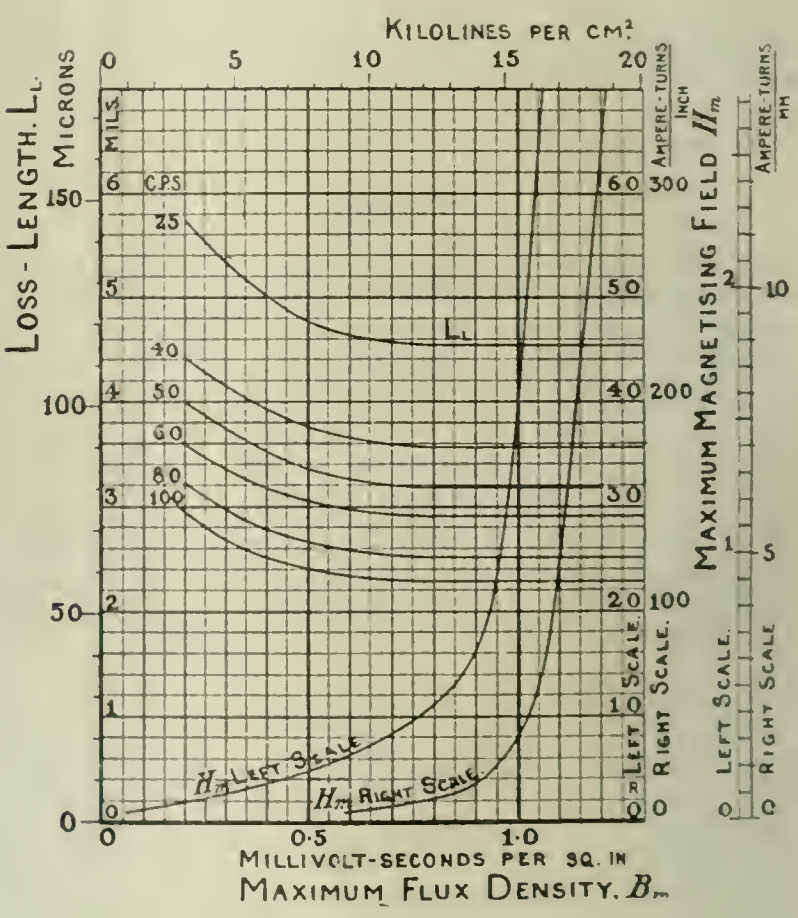


FIG. 1.

The fourth assumption calls for no special comment, but the fifth is the weakest of them all. So far as the eddy-current component is concerned it is accurate enough, but it is not quite true for the hysteresis component. However, except at flux densities below 10,000 lines per square centimetre, its variation from the truth is of no importance, as may be seen from the loss-length curves of Fig. 1.* It drops less than 2 per cent. when the flux density is raised from 10 to 20 kilolines per square centimetre, but rises about 13 per cent. when it is reduced to 5 kilolines per square centimetre.

4. Symbols.

In the mathematical work the following symbols are employed:—

ΣIE — Aggregate loading of all the windings.
P_i, P_c — Iron and copper losses.
f — Frequency of supply.
f — Form-factor of the E.M.F. wave.
E_1, E_2 — Primary and secondary E.M.F.s.
— Primary and secondary P.D.s.
I_1, I_2 — Primary and secondary currents.
I' — R.M.S. current density (supposed uniform).

* Abstract of a paper published in the "Journal" of the Institution of Electrical Engineers, Vol. LIV., pp. 142-161.

* The effects of the departure of the facts from our assumption are discussed in an article by W. E. Burnand on "The Cost and Efficiency of Transformers" in THE ELECTRICIAN, Vol. LXXV., p. 10, 1915.

B_m=Maximum flux density (supposed uniform).
ρ_C=Copper-loss coefficient (resistivity).
$=P_C \div (I'')^2 V_C$.
K_1=Iron-loss coefficient$=P_1 \div B_m{}^2\ V_1$.
L_O=Fundamental length$=(S_{IS}\, S_{CS} \div L_I L_C)^{\frac{1}{2}}$.
L_L=Loss-length$=(K_1 \rho_C^{\frac{1}{2}}) \div 4ff$.
L_I, L_C=Equivalent mean lengths of iron and copper such that $L_I S_I = V_I$, and $L_C S_C = V_C$.
L_{IS}=Depth of iron space perpendicular to laminations with rectangular coils.
L_{CS}=Distance between yokes.
$\mathbf{1}_{IS}$=Width of iron space.
$\mathbf{1}_{CS}$=Conventional winding depth round each wound limb =width of opening through iron, or half of it according to type.
S_{IS}, S_{CS}=Cross-sections of iron and copper spaces.
S_I=Net cross-section of iron$=\sigma_I S_{IS}$.
S_C=Net cross-section of copper$=\sigma_S S_{CS}$.
S_{W1}, S_{W2}=Cross-section of primary and secondary wire.
V_O=Fundamental volume$=L^3{}_O$.
V_I, V_C=Net volumes of iron and copper.
M_I, M_C=Mass of iron and copper.
σ_I,σ_C=Gross space-factors of the iron and copper spaces.
$x=L_{CS}/\mathbf{1}_{IS}$.
$y=\mathbf{1}_{CS}/\mathbf{1}_{IS}$.
$z=L_{IS}/\mathbf{1}_{IS}$.
a, b, c, d, e=Numerical coefficients, the meaning of which appears in the text.
N_1, N_2=Number of turns in primary and secondary windings.
£=Cost of active material, including labour.
£$_O$=Fundamental cost$=\mathbf{c}_I \sigma_I V_O$=cost of fundamental volume filled with iron having same space-factor as iron space.
$\mathbf{c}_I$, $\mathbf{c}_C$=Cost per unit volume of iron and copper.
$\mathbf{m}$=Specific cost ratio$=\dfrac{\mathbf{c}_C \sigma_C}{\mathbf{c}_I \sigma_I}$
$=\dfrac{\text{cost of copper space}}{\text{cost of same gross volume of iron space.}}$

5. Dimensions and Efficiency.

The activity of the material is not changed if we suppose the copper fused into a single turn surrounding the magnetic circuit. We thus see that the aggregate volt-amperage of all the windings is

$$\Sigma IE=(4ff B S_I)\times(I'' S_C) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$=4ff\left(\frac{P_I}{K_I V_I}\right)^{\frac{1}{2}} S_I \left(\frac{P_C}{\rho_C V_C}\right)^{\frac{1}{2}} S_C$$

since $P_I=K_I B^2 V_I$ and $P_C=\rho_C (I'')^2 V_C \quad . \quad . \quad . \quad . \quad . \quad (2)$

$$=4ff \frac{\sqrt{(P_I P_C)}}{\sqrt{(K_I \rho_C)}} \left(\frac{S_I S_C}{L_I L_C}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$=\sqrt{(P_I P_C)}\sqrt{(\sigma_I \sigma_C)}\left(\frac{S_I}{\sigma_I}\cdot\frac{S_C}{\sigma_C}\div L_I L_C\right)^{\frac{1}{2}} \div \left[\frac{\sqrt{(K_I \rho_C)}}{4ff}\right] \quad . \quad (4)$$

$$=\sqrt{(P_I P_C)}\sqrt{(\sigma_I \sigma_C)}\left[\left(\frac{S_{IS} S_{CS}}{L_I L_C}\right)^{\frac{1}{2}}\right] \div \left[\frac{\sqrt{(K_I \rho_C)}}{4ff}\right] \quad . \quad . \quad . \quad . \quad (5)$$

The two expressions within square brackets are each of the nature of a length. The first depends on the dimensions of the transformer and is conveniently called the "fundamental length," while the other is a quantity depending on the loss-coefficients of the materials and may, therefore, be termed the "loss-length." The ratio between them is fixed by the output, losses and space-factors. The loss-length would be constant for a given frequency and materials if our fifth assumption were exactly true. From Fig. 1, which gives values for 20 mils Stalloy calculated from the makers' curves and taking the resistivity of copper at 0·90 microhm-inch (the steady current value at about 100°C., which leaves a margin at lower temperatures for the skin effect with alternating current), it will be seen that it actually is very constant except at low flux densities. For this material we may take the loss-length as follows :—

Frequency—Cycles per sec.	25	40	50	60	80	100
Loss-length—Mils.....	4·7	3·7	3·3	3·0	2·6	2·4
Microns (10^{-3} mm.)	120	94	84	76	66	60

These values are correct for a flux density of 0·55 m.v.s. per square inch (8,500 lines per square centimetre). Should the flux density come out lower than this, the iron losses will be somewhat greater than those assumed ; whereas if the flux density be higher they will be slightly less. We should, therefore, take rather larger values of the loss-length if a low flux density is expected owing to the iron losses being small.

With graded concentric coils the loss-length should be taken 0·7 per cent. lower than the standard, and the resistivity in the winding equations (29)-(31) as 1·37 per cent. less than that assumed in calculating the loss-length. Putting

$$L_O=\left(\frac{S_{IS} S_{CS}}{L_I L_C}\right)^{\frac{1}{2}}=\left(\frac{S_I S_C}{\sigma_I \sigma_C L_I L_C}\right)^{\frac{1}{2}}, \text{ the fundamental length} \quad . \quad . \quad . \quad (6)$$

and $$L_L=\frac{\sqrt{(K_I \rho_C)}}{4ff}, \text{ the loss-length} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

we get $$\Sigma IE=\sqrt{(P_I P_C)}\sqrt{(\sigma_I \sigma_C)}\,.\,L_O/L_L \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

or $$L_O=\frac{\Sigma IE}{\sqrt{(P_I P_C)}\sqrt{(\sigma_I \sigma_C)}} L_L \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Thus, the fundamental length can be at once determined from the known data. Each of the leading dimensions is obtained by multiplying it by the proper factor, conveniently termed the "dimension coefficient," which depends on the type of transformer and on the proportions, being fixed when these are fixed, and so can be calculated once for all.

6. Dimension Coefficients.

If we write a, b, c, d, e for certain numbers easily obtained for any given type from a diagram,* we can express all the dimensions in terms of one, say, the width of the iron space, and the proportions which the others bear to that one. We are then able to get the values of the dimension coefficients and other functions required to carry the theory further. Thus :—

Rectangular Coils.	*Circular Coils.*
$L_I=aL_{CS}+b\mathbf{1}_{CS}+c\mathbf{1}_{IS}=(ax+by+c)\mathbf{1}_{IS}$	$L_I=aL_{CS}+b\mathbf{1}_{CS}+c\mathbf{1}_{IS}=(ax+by+c)\mathbf{1}_{IS}$ . . . . . (10)
$L_C=e\mathbf{1}_{CS}+2\mathbf{1}_{IS}+2L_{IS}=(ey+2+2z)\mathbf{1}_{IS}$	$L_C=\pi(\mathbf{1}_{CS}+\mathbf{1}_{IS})=\pi(y+1)\mathbf{1}_{IS}$ . . . . . (11)
$S_{IS}=\mathbf{1}_{IS} L_{IS}=z\mathbf{1}^2{}_{IS}$	$S_{IS}=\frac{1}{4}\pi\mathbf{1}^2{}_{IS}$ . . . . . (12)
$S_{CS}=dL_{CS}\mathbf{1}_{CS}=dxy\mathbf{1}^2{}_{IS}$	$S_{CS}=dL_{CS}\mathbf{1}_{CS}=dxy\mathbf{1}^2{}_{IS}$ . . . . . (13)
$L_O=\sqrt{\left(\frac{S_{IS} S_{CS}}{L_I L_C}\right)}=\left[\frac{dxyz}{(ey+2+2z)(ax+by+c)}\right]^{\frac{1}{2}}\mathbf{1}_{IS}$	$L_O=\left[\frac{dxy}{4(y+1)(ax+by+c)}\right]^{\frac{1}{2}}\mathbf{1}_{IS}$ . . . . . (14)
$\therefore \frac{\mathbf{1}_{IS}}{L_O}=\left[\frac{(ey+2+2z)(ax+by+c)}{dxyz}\right]^{\frac{1}{2}}$	$\therefore \frac{\mathbf{1}_{IS}}{L_O}=\left[\frac{4(y+1)(ax+by+c)}{dxy}\right]^{\frac{1}{2}}$ . . . . . (15)
$\frac{L_{CS}}{L_O}=x\frac{\mathbf{1}_{IS}}{L_O}$	$\frac{L_{CS}}{L_O}=x\frac{\mathbf{1}_{IS}}{L_O}$ . . . . . (16)
$\frac{\mathbf{1}_{CS}}{L_O}=y\frac{\mathbf{1}_{IS}}{L_O}$	$\frac{\mathbf{1}_{CS}}{L_O}=y\frac{\mathbf{1}_{IS}}{L_O}$ . . . . . (17)
$\frac{L_{IS}}{L_O}=z\frac{\mathbf{1}_{IS}}{L_O}$	. . . . . (18)

* The values are given in Table I., Appendix 4 of the original Paper ; d is the number of wound limbs and e takes account of the corners of rectangular coils when estimating the mean length of one turn of copper. For the latter, the round number 3 has been chosen in preference to π, to allow for the closer bedding at the corners. It would be still less if the iron were chamfered.

7. Cost Equations.

For a given value of the fundamental length—that is for a given value of the efficiency with a given ratio of iron to copper loss—we have

$$\pounds = c_1\sigma_1 V_{1S} - c_C\sigma_C V_{CS} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

$$= c_1\sigma_1 V_C \Big/ \frac{V_{1S}}{L^3_C}\left(1 - \frac{c_C\sigma_C}{c_1\sigma_1}\cdot\frac{V_{CS}}{V_{1S}}\right) \quad . \quad . \quad (20)$$

$$\therefore \frac{\pounds}{c_1\sigma_1 V_C} = \frac{L_1 S_{1S}}{[S_{1S}S_{CS}(L_1L_C)]}\left(1 + m\frac{L_C S_{CS}}{L_1 S_{1S}}\right) \quad . \quad . \quad (21)$$

$$\therefore \frac{\pounds}{\pounds_C} = \frac{L_1 L^2_C}{S^2_{1S}S_{CS}}\left(1 + m\frac{L_C S_{CS}}{L_1 S_{1S}}\right) \quad . \quad . \quad . \quad . \quad . \quad (22)$$

The fundamental cost, $\pounds_C$, is fixed when the fundamental length, the cost of the iron, and its space-factor are known; it does not depend on the type of transformer nor on its proportions. The expression on the right-hand side of the equation, conveniently termed the "cost function," is a mere number which does not depend on the actual size, efficiency, actual specific costs, or actual space-factors; but it varies with the type, proportions and relative costs and relative space-factors. We have thus separated the cost into these two factors, which are affected by different variables, and need only consider one factor at a time when studying the effects of these variables. The cost function thus forms a convenient starting-point for comparing different types and different proportions.

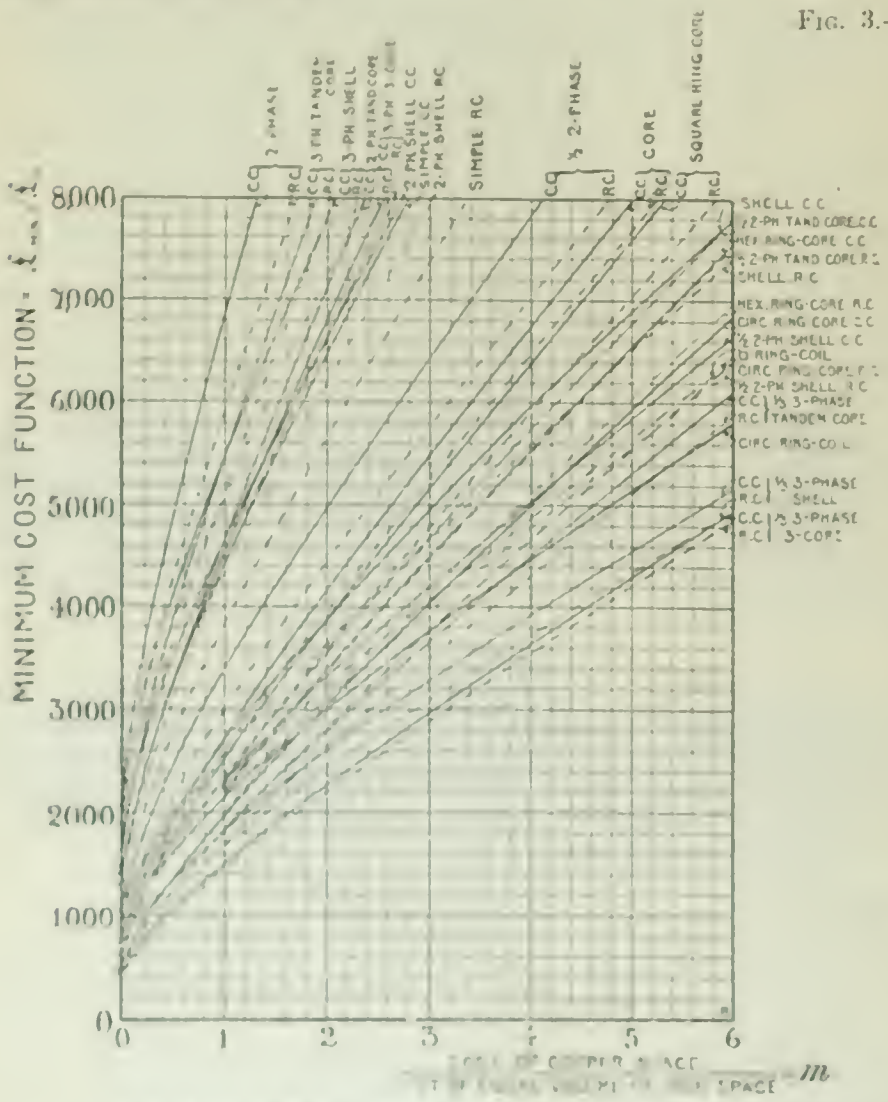


Fig. 2.—Minimum Values of the Cost Function.

(The full lines refer to transformers with circular coils and the dotted ones to those with rectangular coils.)

By inserting values in terms of the constants a, b, c, d, e for any type, and the proportions x, y, z, and equating to zero the partial differential coefficients with respect to x, y and z, we can obtain the cheapest proportions and the corresponding dimension coefficients. This was done in the 1911 Paper for 30 different types, namely, ring-core types with cores in the forms of a circle, dodecagon, octagon, hexagon, pentagon and square; simple, shell and core types of single-phase transformers, three-limb, tandem shell and tandem core types of two phase and three phase transformers; each with circular coils and with rectangular coils. The mathematical analysis is far too long to repeat in the present Paper, but to illustrate the method it has been given in an appendix for the ring-core (Berry)

types which were not included before. The ring types are simpler to deal with than the others because there is one variable less.

Fig. 2 shows how the minimum cost function varies with the specific cost ratio for all these types. Fig. 3 repeats the curves for

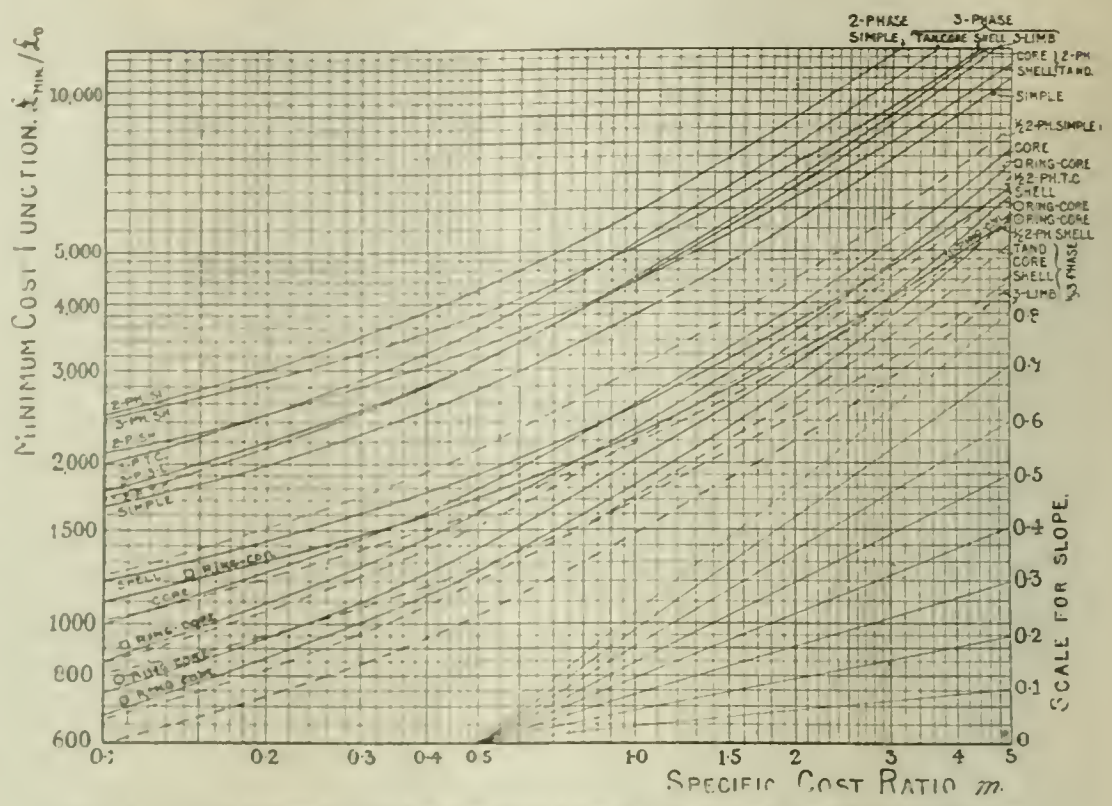


Fig. 3.—Logarithmic Curves of Minimum Values of Cost Functions of Transformers of Rectangular Coils.

rectangular-coil types on logarithmic paper. The ratio between the cost functions for any two types can be very easily obtained from the latter diagram by setting up the vertical distance between the corresponding curves from the 1,000 mark on the ordinate scale.

(To be concluded.)

THE AIR-GAP FIELD OF THE POLYPHASE INDUCTION MOTOR.

BY F. T. CHAPMAN, D.SC.

(*Continued from page* 906.)

SUMMARY OF CONTENTS.

IV.—The Effects of Magnetic Saturation.
- Section 25.—The saturation curve. Fundamental and third harmonic of time-flux wave.
- Sections 26 to 28.—Effect of saturation on multiple fields.
- Section 29.—Effect of saturation on air-gap dispersion.
- Section 30.—Calculation of no-load current
- Section 31.—The actual form of the current locus.

(*b*) *Triple Frequency Terms.*—The triple frequency components of the flux density opposite successive teeth are respectively—

$$y_1' = F_1' \cos(6\pi ft + 3\pi/2P),$$
$$y_2' = F_2' \cos(6\pi ft + 3\pi/2P - 3a_2),$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
$$y_m' = F_m' \cos(6\pi ft + 3\pi/2P - 3a_m),$$
$$y_{m+1}' = F_1' \cos(6\pi ft - 3\pi/2P),$$

and so on.

Combining these as in case (*a*) we find the possible multiple fields to be given by

$$c = 2Pd + 3, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (69)$$

and the density at any point due to any field is

$$y' = \frac{2P}{c\pi}\sin\frac{c\pi}{2p}\cdot\cos\frac{c-3}{2P}\pi\left\{F_1'\cos\left(6\pi ft - \frac{c\pi x}{\tau}\right)\right.$$
$$\left. + F_2'\cos\left(6\pi ft - 3a_2 + \frac{c\pi}{q} - \frac{c\pi x}{\tau}\right) + \ldots\right\}, \quad (70)$$

which reduces to the form

$$y' = \frac{2P}{c\pi}\sin\frac{c\pi}{2p}\cdot\cos\frac{c-3}{2P}\pi\cdot F'\cdot\cos\left(6\pi ft - \frac{c\pi x}{\tau} - a\right). \quad (71)$$

The speed of any field is given by $v_c' = 6f\tau/c \quad . \quad . \quad . \quad . \quad (72)$

28. The multiple fields due to the triple frequency terms produce effects which are quite different from those due to the fundamental terms. They do not induce E.M.F.s of fundamental frequency in the stator windings, and cannot, therefore, be regarded as leakage in the same sense as the other multiple fields we have so far considered. They tend to increase the density in certain parts of the magnetic circuit, but otherwise exert no influence on the operating qualities of the motor. Squirrel-cage rotor windings damp out almost all of them.

If $P=3$, the following values of c are possible :—

$$c=\begin{cases} 3, & 9, & 15, & \&c. \\ -3, & -9, & -15, & \&c. \end{cases}$$

The condition $c=3$ characterises a field of $3p$ poles having a speed of $2f\tau$—*i.e.*, the same speed as the first field due to the fundamental terms.

The condition $c=-3$ characterises a field of $3p$ poles running backwards at the same speed. The amplitude of this field is small compared with the previous one, and it is largely damped by a squirrel-cage winding. The field for which $c=3$ is practically unaffected by a squirrel-cage winding, except when the slip is large.

The effect of the field for which $c=3$ on a delta-connected stator winding has already been pointed out by the author* ; triple frequency damping currents are produced which reduce the value of this field, and thus purify the resultant. The delta connection has a slight advantage over the star connection on this account. The effect is exactly analogous to that occurring in delta-connected banks of transformers ; but in the case of induction motors the elimination of the triple field is not so complete.

If $P=2$ the series for c is

$$c=\begin{cases} 3, & 7, & 11, & \&c. \\ -1, & -5, & -9, & \&c. \end{cases}$$

The field for which $c=3$ rotates at the same speed as the first flux due to the fundamental terms, and induces triple frequency damping currents in the stator circuits. In other words, the magnetising current will contain a triple frequency component which will reduce the value of this field. The other fields are of no importance.

29. We will now examine the effect of saturation on the value of λ'_1. This is best done by means of a concrete case, and we shall take for this purpose the four-pole motor, of which data were given in Sec. 26.

The amplitude of any harmonic is obtained from equation (68), the expression in brackets { } has only two terms, since $m=3$, and the following are the numerical quantities required : $P=3$, $q=9$, $F_1=38{,}700$, $F_2=36{,}300$ and $a_2=19°\ 6'$. The possible values of c are 1, −5, 7, −11, 13, &c.

Table VII.

C.	II.	III.	C.	II.	III.
1	36,900	36,900	13	+382	+646
−5	−996	−1,677	−17	−2,170	−2,170
7	−359	−974	19	+1,937	+1,975
−11	+229	+620			

Table VII. gives the amplitudes of some of the more important multiple fields in column II., and column III. contains for comparison the amplitudes that the harmonics would have if the permeance were constant at the value which gives for the first field the same amplitude as in column II. :—

It will be seen that, except where c approximates to $\pm 2q$, a very considerable reduction in the amplitudes of the multiple fields is effected by the saturation of the magnetic circuit. The conditions assumed for this example represent a degree of saturation which is slightly higher than is usual in practice. In spite of the considerable reduction in the amplitudes of the individual harmonics of lower orders the reduction of λ_1' is by no means great, as the following calculations show.

When we know the amplitudes and phase-angles of the fluxes in the several teeth the maximum number of linkages in one phase can be determined, the fundamental field and the linkages it produces can also be obtained. The ratio of the linkages in the first case to those in the second is $1-\lambda_1'$. On the assumption of constant permeance the expression $\pi^2 Q/4pK^2_{m_1 1}$ has already been obtained for this function, and in the case of the motor under consideration its value is 1·014.

The results of such calculations on this machine are given in Table VIII. The figures refer to no-load conditions and neglect rotor reaction. Table IX. refers to the same machine supposed re-designed as a two-phase motor with eight slots per pole. The figures in the columns I., II. and III. will be referred to later :—

Table VIII.

Max. amp. conductors per slot.	F_1.	F_2.	Amplitude of first field. I.	II.	III.	$1+\lambda_1'$.	$\frac{\pi^2 Q}{4pK_{m_1 1}}$
165	38,700	36,300	36,900	37,200	36,950	1·012	1·014
150	37,000	34,500	35,120	35,200	35,100	1·012	1·014
133	34,600	31,700	32,480	32,500	32,480	1·013	1·014

Table IX.

Max. amp. conductors per slot.	F_1.	F_2.	F_3.	Amplitude of first field. I.	II.	III.	$1+\lambda'_1$.	$\frac{\pi^2 Q}{4pK_{m_1 1}}$
177·0	39,000	34,300	31,700	34,530	34,850	35,000	1·026	1·033
162·0	37,500	32,400	29,800	32,750	33,200	33,200	1·028	1·033
148·5	35,600	30,200	27,700	30,650	31,050	31,000	1·029	1·033
134·5	33,500	28,000	25,800	28,600	29,000	28,800	1·029	1·033

The examination of the fluxes under load conditions is not so satisfactory as the foregoing, for, although it is possible to calculate approximately the total flux in any tooth, the distribution of this flux in the air-gap is not readily obtained, and, as formula (66) cannot be applied, the amplitude of the first field in the air-gap cannot be determined with the necessary accuracy.

The author has attempted to solve the problem as follows :—

The motor of the previous section was again considered, its circle coefficient being estimated as in Parts II. and III., taking $\lambda_1'=0{\cdot}014$, $\lambda_2'=0{\cdot}006$, $\lambda_1=0{\cdot}095$ and $\lambda_2=0{\cdot}04$, $\sigma=0{\cdot}162$. The circle diagram was drawn on the assumption that the magnetising current was 6·48 amperes, corresponding to 165 maximum ampere-conductors per slot. Points on this circle were taken corresponding with stator currents of 12 and 24 amperes (virtual) respectively. For these two conditions the amplitudes and relative positions of the first stator and rotor M.M.F. waves were determined, and the ampere-turns acting on each stator tooth due to the stator currents alone were calculated. For each tooth the stator M.M.F. was combined with the mean value of the rotor M.M.F. over the same tooth, and the resultant M.M.F. acting on each tooth thereby obtained. The amplitude of the fundamental flux wave for the several teeth was then read from curve I., Fig. 12. The total flux per tooth and its phase relative to the stator current being thus known, the total number of linkages per stator phase and their component in phase with the current were calculated.

The amplitude of the first field was obtained from the amplitude of the resultant M.M.F. wave by means of curve I., Fig. 12, and its phase angle relative to the stator current was taken to be the same as that of the M.M.F. wave. The linkages due to this field, and their component in phase with the current were deduced. The difference between the in-phase components in the two cases was taken as the leakage.

This method of calculation can make no pretence to accuracy, since it involves differences between functions of the densities read from a curve at points close together. The results appear to indicate that saturation of the magnetic circuit may reduce considerably the value of λ_1', the value obtained in both cases was $\lambda_1'=0{\cdot}0086$.

The author is of opinion that this figure is too low, but the calculation suggests that λ' diminishes as the load increases. It must be remembered also that the reductions due respectively to saturation and to the reaction of a squirrel-cage

* *Loc. cit.*

winding are not strictly additive. The final columns of tables at the end of this Paper give the values of λ_1' which are recommended in these cases.

The method of calculation given above is only strictly applicable to machines having two or three-phase rotors, where the reaction of the rotor currents on the stator multiple fields is negligible. It is interesting to notice that in this case the resultant field is by no means the uniform rotating field we generally imagine. For instance, when the stator current is 12 amperes in the above example the mean flux densities opposite teeth Nos. 1, 2 and 3 are respectively 38,800 sin $(2\pi ft+72^\circ\ 32')$. 34,700 sin $(2\pi ft+43\ 18')$ and 36,300 sin $(2\pi ft+20^\circ\ 52')$. If the field were moving uniformly the successive phase differences would be 20 each. At 24 amperes the differences are still more striking, the figures being $-38,550$ sin $(2\pi ft+72^\circ\ 13')$, 31,750 sin $(2\pi ft+28^\circ\ 17')$, 34,800 sin $(2\pi ft+5^\circ\ 57')$ and in tooth No. 4 $-38,550$ sin $(2\pi ft+12^\circ\ 13')$. The flux in tooth No. 4 is thus in advance of the flux in the tooth which is next behind it, from the point of view of the direction of rotation of the first field.

30. Having seen the influence which saturation of the magnetic circuit exerts on the value of σ we must next investigate the calculation of the no-load current.

In the case of slip-ring motors the effects of the rotor multiple fields may be neglected when calculating the flux density at any point, since they merely introduce high-frequency terms of small amplitude in the expression for the M.M.F., and the individual and total fields may be calculated as in Secs. 26-29. In the case of squirrel-cage machines, the rotor multiple fields do not affect the fields considered below, and they are taken fully into account by employing the appropriate value of λ_1'. The first field and the triple field which is introduced by the form of the saturation curve are by far the most important at no-load. The determination of these fields has already been dealt with in Secs. 27 and 28. Alternatively, the amplitude of the first field may be obtained by reading from curve L, Fig. 12, the density corresponding to the amplitude of the first M.M.F. wave. The figures in the columns headed II. in Tables VIII. and IX. have been obtained in this way, and it will be seen that they agree closely with those in column I. obtained by the more exact method.

Neither of these methods is suitable for practical work, since both require a complete saturation curve, and another curve derived from it by a laborious process, but a satisfactory method is obtained by taking advantage of the fact that the triple field has zero value at the 60° and 120° points on the main flux wave.* The procedure is as follows: The amplitude of the first M.M.F. wave and the value of the ampere-turns at the 60° point are calculated. The density corresponding to the latter is found from the saturation curve and when divided by cos 60° gives the amplitude of the first flux wave. The figures given in columns III. in Tables VIII. and IX. were calculated by this method. Their agreement with those of column I. is sufficiently close to fully justify the use of this method.

In practice the process is usually inverted, being directed to the determination of the M.M.F. when the flux density is known, and it takes the following course:

Let V_1 be the effective value of the applied E.M.F. per phase, A_0 the effective no-load (magnetising) current, then

$$V_1=A_0X_1=A_0(1+\lambda_1)X_1'$$

Now $X'_1=2\pi f_1Q_1\dfrac{T_1^2\mathrm{P}l\tau}{p}\times10^{-8}$ (equation 40),

but $1+\lambda'_1=\dfrac{\pi^2Q_1}{4P_1K^2_{m1}}$ (equation 61),

and therefore $Q_1=(1+\lambda'_1)\cdot\dfrac{4P_1K^2_{m1}}{\pi^2}$.

Hence $V_1=A_0X_1$

$$=A_0(1+\lambda_1)(1+\lambda'_1)\frac{8f_1P_1T_1^2\mathrm{P}l\tau}{p\pi}K^2_{m1}\times10^{-8}. \quad . \quad (73)$$

If we compare this expression with equation (44) or equation (9) we see that

$$V'_1=A_0\frac{8f_1P_1T_1^2\mathrm{P}l\tau}{p\pi}\cdot K^2_{m1}\times10^{-8} \quad . \quad . \quad (74)$$

represents the E.M.F. induced in the stator winding (per phase) by the first field due to the current A_0.

Let Φ_1 represent the flux per pole due to this field, then we may write, according to a well-known formula,

$$V'_1=4{\cdot}44K_{m1}T_1f_1\Phi_1\times10^{-8}. \quad . \quad . \quad . \quad (75)$$

and since $V_1=(1+\lambda_1)(1+\lambda'_1)V'_1$ we find

$$\Phi_1=\frac{V_1\times10^8}{4{\cdot}44(1+\lambda_1)(1+\lambda'_1)K_{m1}f_1T_1}. \quad . \quad . \quad (76)$$

The density at a point 60° from the zero point is

$$B_{\frac{\pi}{3}}=\frac{\Phi_1}{l\tau}\times\frac{\pi}{2}\times\cos60^\circ$$

$$=\frac{0{\cdot}306V_1\times10^8}{(1+\lambda_1)(1+\lambda'_1)K_{m1}f_1T_1l\tau}. \quad . \quad . \quad (77)$$

Let the ampere-turns required to produce this density in the air-gap be determined, say $\bar{A}_{\frac{\pi}{3}}$ (a complete saturation curve is not required), the amplitude of the first M.M.F. wave will then be $\bar{A}_{\pi/3}\div\cos60^\circ$. But by equation (6) the amplitude of this wave is

$$\frac{2I_1P_1T_1}{p\pi}K_{m1}=\frac{2\sqrt{2}A_0P_1T_1}{p\pi}\cdot K_{m1},$$

whence $$A_0=\frac{0{\cdot}408\,\bar{A}_{\pi/3}p\pi}{P_1T_1K_{m1}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (78)$$

The values of A_0 and σ being thus known, the circle diagram can be constructed.

31. The circle diagram was developed in Part III. on the assumption that P was constant under all conditions of load and slip, when the applied E.M.F. is constant. This would only be true if the magnitude of the air-gap fluxes and the degree of saturation of the iron were constant. The resistance of the stator winding, and the slot and end-leakage cause the gap fluxes to diminish and tend to make P increase to an appreciable extent as the load increases. On the other hand, the large differences which exist between the fluxes in adjacent teeth in slip-ring motors (and to a less extent in squirrel-cage motors) produce an opposite tendency and reduce the value of λ'_1. Hence the size and position of the circle will really vary with every change in the stator current; it is not possible to say definitely that the scale of the diagram increases or that it decreases as the load increases, in fact, it increases over some parts of the range and decreases over others. It should be pointed out that although λ'_1 and λ'_2 are practically independent of P, λ_1 and λ_2 are inversely proportional to it, and as they are usually much greater than λ'_1 and λ'_2, the effect on σ of a change in P largely counteracts the effect of the change on A_0.

Saturation of the teeth has an important influence on slot leakage, especially at high currents and low power-factors. A complete discussion of this question is beyond the scope of this Paper, but it may be pointed out that the result is to increase the diameter of the circle for these conditions, and to cause the points corresponding to large values of the slip to lie outside that circle which is appropriate to the conditions at no load, and over the working range. The actual shape of the locus as a whole is more nearly an ellipse than a circle, although the circle is more accurate over the working range.

In determining the diagram experimentally it is usual to employ the no-load and "standstill" points, the latter being obtained at a reduced voltage with approximately full load current in the stator winding, and with the rotor turning slowly. Although the circle deduced from these readings may be considerably in error under real standstill conditions, the conflicting factors seem to cancel each other to such an extent that it is sufficiently accurate for practical work over the normal range of the motor.

(*To be concluded.*)

* Smith and Barling, *loc. cit.*; Author, *loc. cit.*

MUNICIPAL TRAMWAYS ASSOCIATION.

FIFTEENTH ANNUAL CONFERENCE.

The annual conference of this Association took place on Thursday and Friday, September 21st and 22nd, at the Surveyors' Institution, London.

The PRESIDENT (Mr. Peter Fisher, Dundee) expressed his pleasure at the large attendance of members and visitors, and announced with regret that Mr. A. L. C. Fell, who had been ill for some time, had had a relapse, and had been ordered away for six months.

The meeting passed a resolution of sympathy with Mr. Fell and expressed the hope of a rapid recovery to normal health.

The HON. SECRETARY (Mr. C. J. Spencer) announced invitations to the members to inspect the London General Omnibus Co.'s training school, the Bexley Council's Woods-Gilbert rail grinder and planing machine, the L.C.C. generating station and its trailer car system.

The PRESIDENT then read his Presidential Address, of which the following is a full abstract :—

The great European War is still being waged with as great if not greater intensity as when we last met in conference, and in consequence of its overshadowing influence our conference meets here to-day instead of, according to the usual procedure, in Dundee. As the annual report of the Executive Council states, a large proportion of the work of that body during the past year has been in relation to problems arising out of the war, *i.e.*, supply of tramway tickets tramway tyre supplies, retention of tramway employés, Munitions, of War (Amendment) Act, 1916, classification of tramway material, women as tramcar conductors, Lights (Vehicles) Orders, 1915, British trade after the war, and disabled soldiers and sailors. In connection with the Munitions of War (Amendment) Act, 1916, the Council, with outside assistance, got the term "munitions work" extended to cover "tramway facilities." Forty-four municipal tramway undertakings are certified under the Act, and many others are authorised to issue Class "B" Priority Certificates to facilitate the delivery of supplies for maintenance. Tramways are to-day playing a very important part in the national crisis in carrying workpeople from their homes to the factories and vice versa. It is, therefore, gratifying that the Government have realised the great importance of tramway undertakings and have given them such facilities as enables them to keep going. The Lights (Vehicles) Order, 1915, was, in its original form, such that tramway authorities, to comply with it, would have been put to the necessity of making considerable expenditure, and that at a time when the staffs in their workshops are depleted. There is also the difficulty of obtaining materials. The past year has not been fruitful in developments and extensions so far as tramways and other passenger-carrying facilities are concerned. The most outstanding features of the year are the re-adjustment of tramway fares and stages, the employment of females and the introduction of volunteer labour for driving, the latter having been introduced in Birmingham, Newcastle and Bradford, where 320 auxiliaries are employed with satisfactory results. During the year proposals for increasing fares, shortening stages, or abandoning ½d. fares have been considered by various tramway authorities, and in several cases changes have been made whereby the average fare has been materially increased, and in all these cases additional revenue has been the result. Strange as it may seem, some authorities have actually been considering the decreasing of fares. It is remarkable that, in the main, tramway fares have not increased very seriously. Tramway travelling is about the only commodity that has not been generally increased. Having regard to the increased working costs consequent on higher wages and bonuses, war allowances and the increased cost of tramway supplies, it is not surprising that the question of increasing revenue should demand the attention of those operating many tramway systems Present conditions provide ample justification for suggesting that the existing low fares should be adjusted so that the increased costs should be fully met. While the accounts of most municipal tramway undertakings look fairly satisfactory, it must be admitted that much necessary expenditure is only suspended till the end of the war. There are now 8,609 females employed on tramways: 8,433 as conductors and 176 as drivers, and they have earned the approbation of the tramway authorities and tramway patrons.

The number of municipal tramway employés who have joined His Majesty's Forces is 20,905, the percentage of total number of employés being 38, while 1,893 men have left municipal tramway undertakings to join munition factories, the percentage being 3½. The amount paid to dependents of employés serving with His Majesty's Forces is £854,649. The amount collected on cars for various national and other objects is £43,800, and the amount contributed by municipal tramway employés to various relief funds is £36,070. Tramways are also doing much to assist the national cause which cannot be expressed in figures. Munition workers and others engaged in important national work is a case in point. The war certainly will not only be an interruption of what formerly existed. What will be the precise nature of the problems which, when they emerge, must be boldly faced, no one can forecast. One thing certain is that victory in the field will not put an end to the strenuous life in industrial enterprise.

Competition will be as keen as in bygone days, and although we, as tramway operators, are neither manufacturers nor merchants, I have no hesitation in predicting that we will be able to do much to assist British brains and ingenuity. When peace returns, pressing problems will present themselves to us in their true perspective, and these will probably involve adjustments such as we scarcely dreamt of in pre-war days. Simultaneously with the cessation of hostilities various problems relating to our employés will present themselves. For example, the question of war wages and bonuses, and the position to be taken up regarding our men who may be in receipt of pensions but still able to perform certain duties. I have no doubt that municipalities will sympathetically consider the above questions and it is to be hoped that friendly conferences between all interested will from time to time take place, and, with a spirit of reasonableness of "give and take," will act as lubricants to all those negotiations which will undoubtedly have to be faced. The services which can be rendered to the country by using the tramways to their fullest extent in this connection can only be appreciated when the subject is considered on lines such as were outlined by the late Mr. Bellamy in his presidential address at the Conference in Liverpool in 1904.

Transit, such as tramways can offer for goods, should have our fullest consideration. On the face of it, it appears reasonable to say that if a tramway is of value for picking up passengers from railway stations and other points, and depositing them at their destinations, it should be equally true in the case of goods. In fact, one might suggest that in the tramway undertakings in the country the railway companies have a suitable instrument for detail distribution which could be used to mutual advantage and to great public convenience. In the days to come transit will undoubtedly play an important part. The writers of a book on the "Coming Trade War" contend that cheap and efficient production is attained by the influences of five sciences, one of which is "transportation." Upon our ability to assist will depend to a considerable extent the success of the nation in the economic fight of the future. Relaxation of restrictions and regulations may be necessary to enable tramways to play the important part that they are destined to do, but there should be no difficulty in this respect. It seems a little doubtful whether the Government have yet realised the very great assistance which tramways throughout the country can render, even at the present time, as a transit instrument for goods as well as passengers. Railways are crowded with traffic of all kinds, and considerable complaint is heard all over the country regarding the delays that are taking place. It is therefore, a little surprising that the Government have not seriously considered the usefulness of the tramway undertakings for the carriage of munitions and general merchandise. I feel that I cannot close without making reference to those of our men who have fallen in the conflict. We offer our condolences to their relatives and friends who have been bereaved and who have also been denied the sacred privilege of paying their last respects to their loved ones. I would also like to take the opportunity of recording my appreciation of the honour conferred upon me in appointing me as President of this important Association and to express my gratitude to the Executive Council and to our hon. secretary for their many kindnesses and whole-hearted support throughout my year of office.

After a vote of thanks to the President had been passed. Mr. J. M. MCELROY read the following Paper :—

SOME NOTES ON PASSENGER TRANSPORTATION IN LARGE CITIES.*

BY J. M. MCELROY.

Systematic studies of the passenger transportation requirements of the large cities in this country—studies directed towards making proper provision for meeting the constantly increasing traffic demands which follow the cities' development—have not in the past

* Abstract of a Paper read before the Municipal Tramways Association.

been undertaken with that thoroughness which has been characteristic of many cities abroad, particularly in America.

As cities grow, due to the gradual increase in population, and as the riding habits of the people develop, it becomes more and more difficult to make the channels of passenger transport equal to the ever-growing demands. In every city the main factors affecting this problem are much the same. There is a constant migration of the population from the inner to the outer zones, and this is greatly accelerated by every extension and improvement in the means of transit. Smaller towns and districts on the outskirts are drawn into closer touch with the cities, and a greater community of interests is being established over a gradually widening area. Every extension of the means of transit into the outer zones adds to the difficulties of handling the traffic in the central zone, and in time the congestion becomes so acute that the city authorities realise that they are face to face with the inevitable traffic problem.

It is well known that the passenger traffic in cities grows at a much greater rate than the increase in the population. Some years ago it was found that on the average the number of passengers carried increases in the same ratio as the square of the population. This rule does not appear to be true as regards British cities. In some of our cities the number of passengers carried is increasing at a much greater rate than the square of the population.

In considering the traffic statistics of various cities it may be very misleading to draw general inferences unless the local circumstances

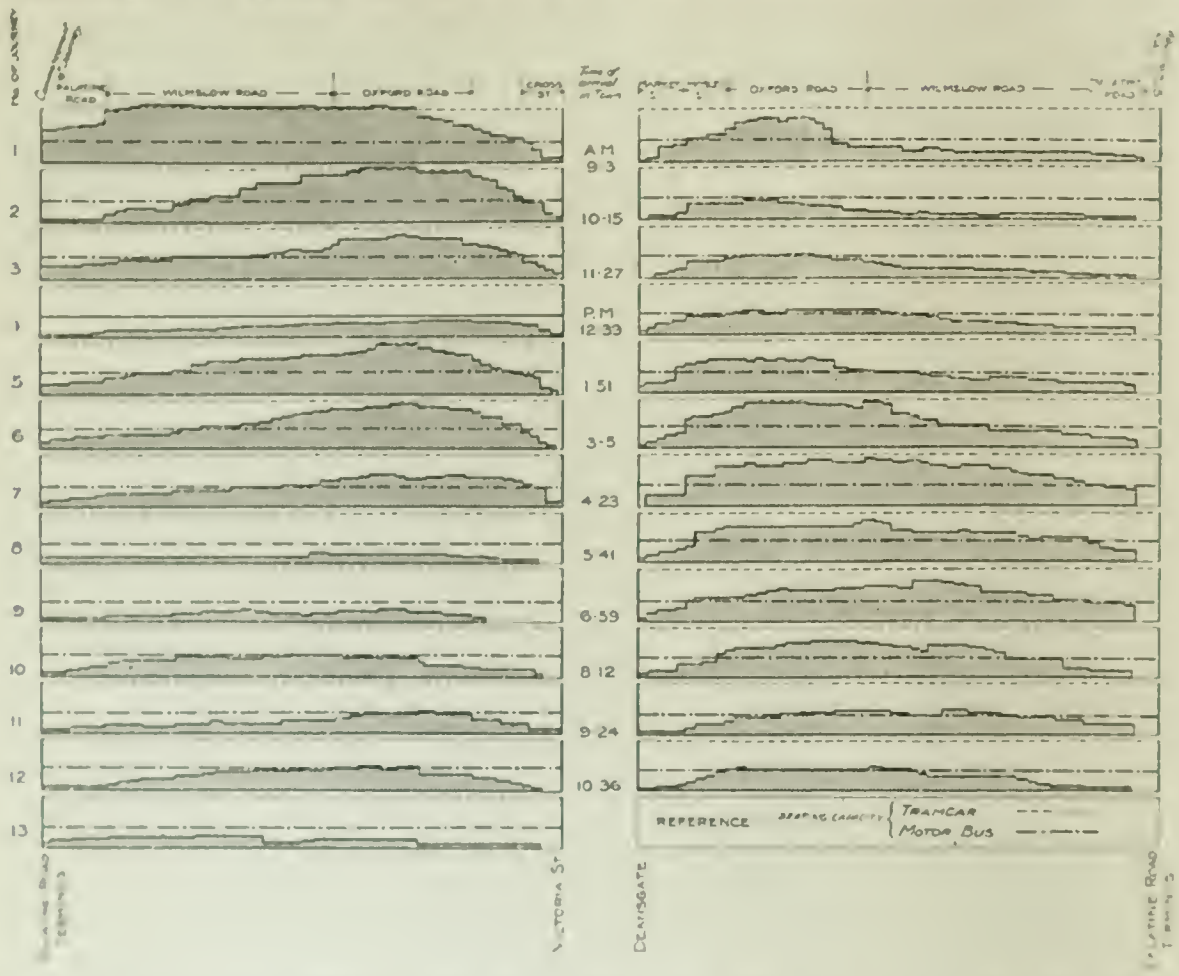


Fig. 1.—Diagram showing Loading of a Typical Car during a full day's continuous running on Palatine-road Route, Manchester.

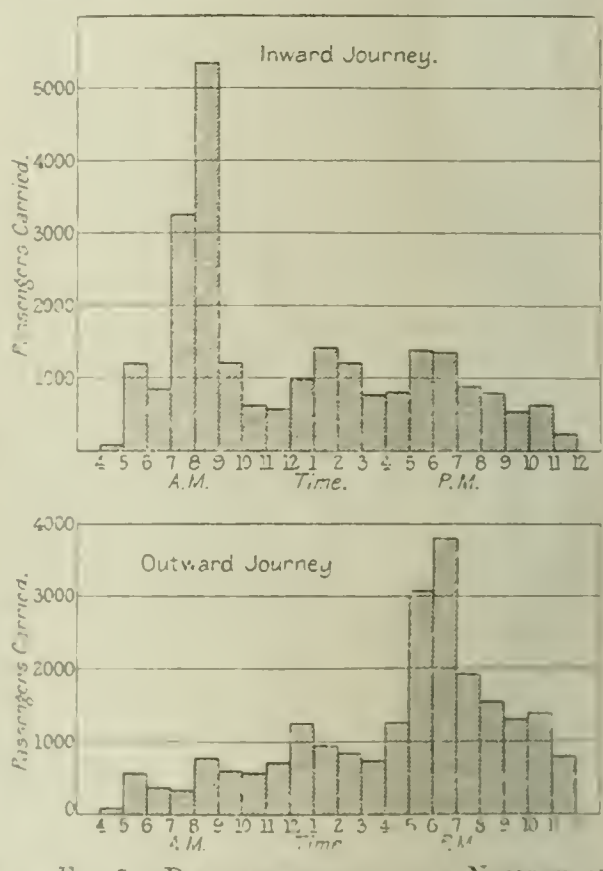


Fig. 5.—Diagram showing the Number of Passengers carried each hour of a Typical Day. Rochdale-road Route, Manchester.

in each case are fully recognised and clearly kept in mind. Many factors tend to accelerate the normal growth in a particular city, and unless we are acquainted with these we may be drawing wrong conclusions from the data. Quite apart from the question of the increased facilities and the introduction of general improvements in the means of transit—which are always followed by a rapid rise in the number of passengers carried—the factor as to the fares charged, and the changes made therein from time to time, has a most important bearing on the subject. We have, therefore, in the case of each city, not only to look at the total transit facilities provided, and gauge their excellence or otherwise, but we have to look at the fares charged, and see the effect of these. We should ascertain the extent to which long distance and short distance passengers are respectively catered for. In short, comparative statements as to the number of passengers carried tend to be misleading, because they do not indicate the average distance travelled by each passenger.

The ultimate volume of passenger traffic which can be dealt with by facilities which use the street surface is limited by the capacity of the arterial routes near the central parts of the city. When the traffic on these routes approaches the saturation point then additional arteries must be opened out or other transit facilities provided.

The new facilities which may be provided are:—

1. Railways—(*a*) in shallow subways; (*b*) in deep level "tubes"; (*c*) on elevated structures.

2. Shallow subways in the congested areas into which the surface cars can be run.

Many cities have not waited until the saturation point of the surface facilities has been reached before underground or overhead railways have been constructed. Because the demand for the railways has arisen through the constant desire for quicker movement. In other words, *time saving* has been the main factor which has led to the construction of many city railways, and the patronage they receive from the public depends largely upon the time-saving capabilities of the lines.

Experience shows that the provision of shallow subways into which surface cars can be run so as to relieve the traffic congestion in the central parts of cities cannot be justified owing to the great cost of construction and the comparatively small amount of traffic which can be passed through them.

Underground lines of any description can only be justified by a dense traffic demanding the operation of high speed trains run at very close intervals.

In planning new transit facilities a wide outlook is all-important. Any schemes carried out on narrow or confined lines, or which do not form part of the transportation requirements of the city viewed as a whole, ultimately result in serious losses to the community from every point of view.

Underground lines should be so laid out that they can be worked in conjunction with the surface lines by providing suitable transfer points from surface to underground and *vice versa*. The surface lines should gather the local traffic and feed the underground lines, which, in order that they may pay their way, must be provided with an immense volume of traffic.

It is not at all likely, having regard to the general experience, that private enterprise will be willing in future to shoulder the great outlay involved in the provision of underground facilities.

In London—where all the capital for the underground railways has been found by private enterprise—it is pointed out by Sir Albert Stanley that in 1913 the amount available for dividends on the ordinary capital was only sufficient to pay just over 2 per cent.—not a very encouraging result for a city which has the largest population in the world.

In studying the problem which we are now faced with in Manchester—where several of our arterial routes approaching the centre of the city have practically reached the saturation point—I came to the conclusion, after careful consideration, that the proper course for the Corporation to pursue to meet the constantly growing requirements was—before attempting to provide underground facilities, the cost of which is so enormous—to improve and make more efficient the existing surface lines by opening out parallel routes, by forming new streets and widening others at considerable cost, and also by adopting tramway terminals near the heart of the city, the latter being necessary on account of the narrowness and bad lay-out of the central streets.

The necessity of utilising the streets to the fullest advantage for

meeting the demands for passenger transportation involves the consideration from time to time of the question as to the most suitable means of surface transit, having regard to the traffic requirements.

Much has been written about the relative merits of tramcars and motor 'buses, unfortunately, not without bias on the part of the advocates of each class of vehicle.

An abstract discussion as to the relative merits of tramcars and motor 'buses, without reference to the particular purpose for which they are intended to be used, is likely to be very misleading. Each type of vehicle has its peculiar advantages, and in the future each will be utilised for handling that class of traffic for which it is best suited. The tramcar, on account of its greater seating capacity and its ability to cope with traffic of a widely fluctuating character, will be utilised where heavy peak loads have to be catered for. On the other hand, where the volume of traffic is not great, or where there is a steady traffic flow throughout the day, motor 'buses will probably prove to be the more suitable vehicles. In some instances it may be found to be advantageous to run the two types of vehicle along the same routes.

The aim should be to use the highways as channels for passenger transport to the best possible advantage, and the most efficient means of doing this can only be decided upon in any particular case by a study of the traffic characteristics.

Attempts have been made to show the relative efficiency of the two types of vehicles—tramcars and motor 'buses—by comparing the *average* loading. It has been pointed out that " the average load of a tramcar with 74 seats is 10½ passengers, and of the motor 'bus with 34 seats is eight passengers, and, therefore, the relative efficiency of the motor 'bus is almost twice as great as that of the tramcar."

This is a distortion of the meaning of the word " efficiency." In practice we have not to deal with hypothetical averages, but with actual traffic conditions—conditions often varying greatly at different times of the day. The relative efficiency of the two types of vehicle cannot otherwise be gauged than by their ability to cope with the volume and flow of traffic in particular cases.

Fig. 1 shows the loading of a typical tramcar during a full day's continuous rnning on the Palatine-road route, Manchester. The car has a seating capacity for 75 passengers. The intermittent nature of the loading, and the effectiveness of the tramcar in handling it, are clearly indicated. The diagram also shows by a red line the seating capacity of a motor 'bus. The tramcars on this route have the upper saloons covered, and therefore the whole of the seating accommodation is available in all conditions of weather. In bad weather the outer seats of motor 'buses are nearly always empty, hence their effective seating capacity under these conditions may be said to be reduced by about one-half. The *average* number of passengers carried per car-mile on the tramcar shown on the diagram was 14. The fallacy of using this figure as a measure of the car's efficiency is too obvious to need comment.

Figs. 2 and 3 (kindly prepared for the author by Mr. A. L. C. Fell) show what the tramcars and motor 'buses are doing respectively to meet the traffic demands on a typical route in London. From Fig. 2 it will be seen that the number of tramcars passing in one direction at the hours of peak load is 82. At the slack hours nearly half the cars are withdrawn. On the other hand, the motor 'buses make no attempt to deal with the peak between 7 and 8 a.m., but obviously cater for a steady all-day traffic. Fig. 3 shows the relative seating capacity of the tramcars and motor 'buses referred to in Fig. 2, and illustrates the effectiveness of the former.

The trams are dealing with the peak loads and the 'buses are catering for the steady pick-up traffic throughout the day.

Fig. 4 (taken by permission of Sir Albert Stanley from his Paper on London Traffic) shows the fluctuating character of the loading on the London electric railways and on one route of the London General Omnibus Co. Here is an illustration of the ability of the railways to handle heavy peak loads and the lack of capacity in the case of the motor 'buses.

Sir Albert Stanley in his Paper points out that—

The motor 'bus, when operating in conjunction with other means of transit, has not a peak load. One reason is the absence of workmen's return fare, which cuts it off from a fair share in the traffic before eight o'clock in the morning. Another reason is the smallness of the units required to be filled with traffic, which allows of a closer adjustment to demands. A third reason is the special feature of motor 'bus traffic casually picked up all day long, so long as there is traffic in the street. The motor 'buses are always reasonably full throughout the day. *At the time of peak load they are quite full.*

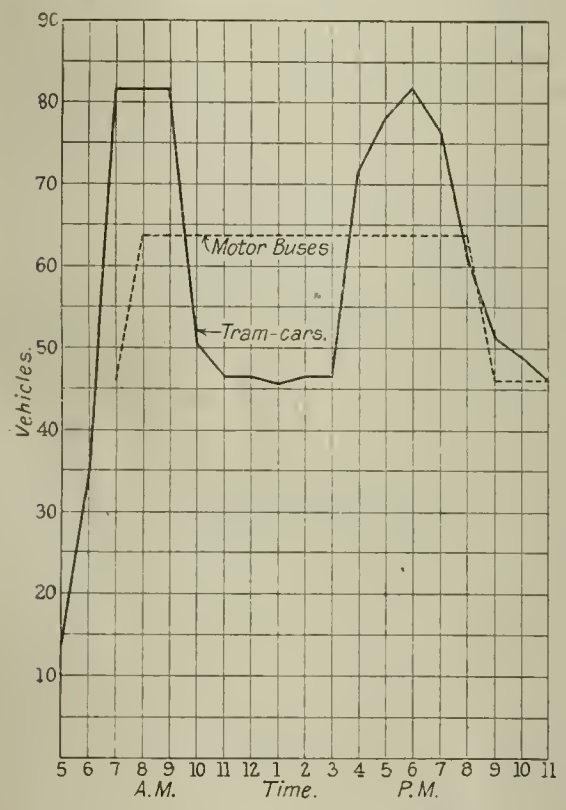


Fig. 2.—Diagram showing number of Tramcars and Motor 'Buses passing in one direction along Walworth-road, London, July, 1914.

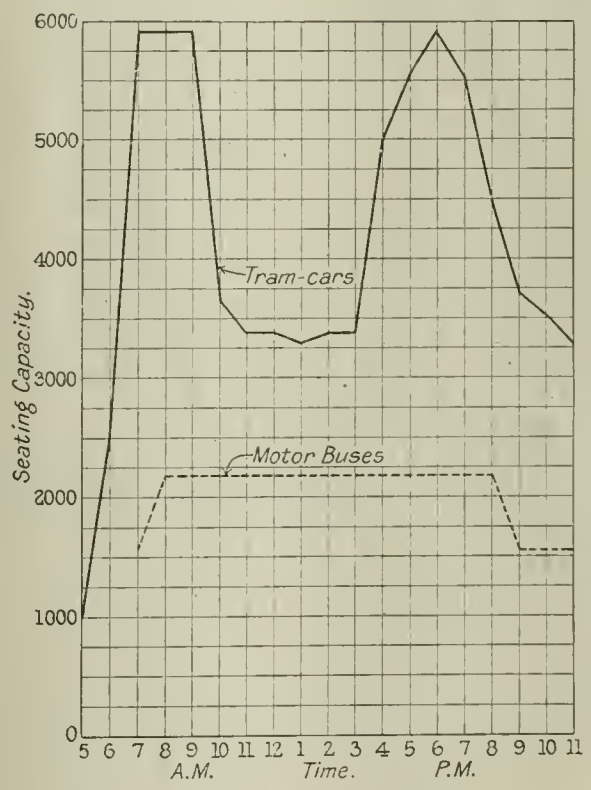


Fig. 3.—Diagram showing Seating Capacity on Tramcars and Motor 'Buses passing in one direction along Walworth-road, London, July, 1914.

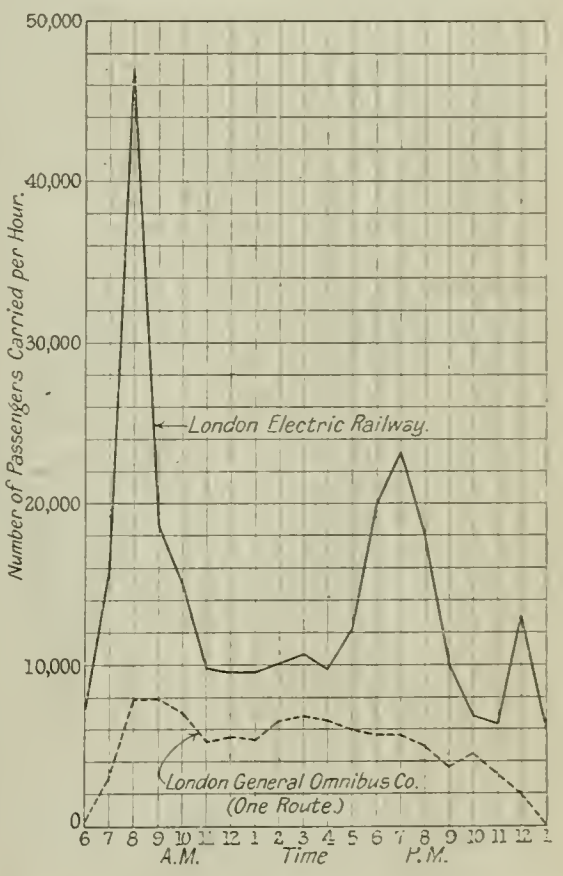


Fig. 4.—Hourly Number of Passengers carried on the London Electric Railways, and one route of the London General Omnibus Company.

The opening sentence and the last sentence of this quotation put the facts very frankly: At the rush hours the motor 'buses are quite full, but the other transit facilities are looking after the peak loads.

Fig. 5 shows the number of passengers carried each hour of a typical day on the Rochdale-road route, Manchester. The heavy peak loads are carried mainly by large tramcars with a seating capacity of about 75, which are taken out of service immediately the rush hour is past. The difficulties that would be encountered if we had to handle these loads by means of small traffic units are obvious.

The making of proper provision for handling the rush-hour traffic will always be the difficult part of the passenger transportation problem. It involves, and will continue increasingly to involve, a large expenditure of capital and comparatively high operating costs. It is on account of this that competition by separate companies for the steady all-day traffic by means of vehicles which can be run on the public streets at a relatively small capital cost, and which escape many of the obligations placed upon those who cater for the peak loads, is unfair and should not be permitted.

The right to operate public service vehicles, acquired by merely obtaining an annual license, is archaic, and new legislation dealing with this matter is urgently needed. Concessions to use the public streets, if granted, should carry with them obligations in the public interest, with corresponding security and protection for the operators

It is becoming more and more clearly recognised, by all those who are qualified to judge, that the public interests are best served by making the facilities for city passenger transportation a monopoly —a monopoly subject to the control of the city authorities, who should possess full powers either to provide and operate the facilities themselves, or, if they think fit, to grant franchises to private companies to do so, subject to control and regulation in the public interest. The world's experience has shown that every city should have a permanent authority directing the initiation and carrying out of all schemes for new transit facilities, in order that there may be continuity of policy, and that the future needs of the city and the surrounding districts over a wide area may be properly looked after.

DISCUSSION.

Mr. Geo. Gordon (deputy-chairman of London County Council) said, in opening the discussion, years ago he visited large cities on the Continent to collect information on traffic facilities there. He found many things in which we did not show to advantage in the cities he visited. Berlin was first in the number of journeys per head of population, the number being 280 in 1913. In London the number was 211. London was seventh in point of numeration of the travelling habit of the citizens of great cities. Manchester in that year had 201 journeys per head. The difference between this country and the Continent was attributable to the fact that in few cities had we such a great tramway development as was characteristic of the great cities on the Continent. In Milan the journeys per head of population by tramway alone were 267, in Berlin 190 and in London 113. In Milan there were 20 miles of tramway for every 100,000 of population: in London there were 4 miles. The result was that the travelling habit was not so greatly developed here as it was on the Continent. The number of journeys was not in proportion to the population. In 12 cities in this country he could find no relation, whether calculated on the number direct, or the square, or any other factor of the population. Mr. Bion J. Arnold had found that in America there was no direct connection between the number of journeys and the population. At Chicago there were increasing traffic facilities, but a decreased number of journeys, due to adverse trade conditions. With regard to the traffic problem in the centres of our great cities, it had been suggested that the congestion might be relieved to some extent by the construction of underground or overhead railways or shallow subways. He did not believe in any such means. On the Continent and in America that idea was confirmed. To relieve such congestion in the Rue de Rivoli, Paris, the Metropolitan Underground Railway was constructed, and motor 'buses were substituted for horse 'buses; but there was no diminution in the number of pedestrians. The Metropolitan line was doubled, and there were more passengers in the centre of the street than ever. The same experience was confirmed in Oxford-street, London, and in Budapest, where a shallow electric railway was constructed in 1913, but had not succeeded in banishing the horse 'buses. He hoped the centres of the towns would become more crowded, as that was an indication of prosperity. He agreed with Mr. McElroy that we should devote ourselves more to the better construction of the laws which apply to the regulation of all vehicles in the streets. We were not usefully occupying more than a third of the available roadway. The tramway occupied less street space per passenger carried than the omnibus. It had been said that tramways were becoming a hindrance to transit because of their inflexibility, while the flexibility of the 'buses enabled them to use every portion of the street space. This was a fallacy. Traffic should not run all over the road, but should flow in straight lines, with uniform intervals between. Such abominations as standing vehicles, loading or leaving goods, in streets that had been widened at enormous cost should be abolished. In Berlin traffic regulation was much better than in any town in this country. Large new premises must have a private wharf for loading and unloading. Tramways had to bear a large share of the peak load, and omnibuses did not, but tramway men had reason to be thankful that they did not have the diversity factor of the railway traffic. The Great Eastern Railway brought in 16 times as many passengers in the hour of most traffic as it did in the hour of least traffic, a diversity of 16 to one, while the tramways had a diversity of eight to one. That showed that it would be impossible to carry the Great Eastern traffic by means of tramcars. Railways and motor buses were as essential as tramcars in the solution of the traffic problem. The limiting factor in perfecting organisation was capacity of internal area, as Mr. McElroy said. If the L.C.C. tramcars had to carry the Great Eastern Railway traffic between Poplar and Aldgate, the streets could not accommodate the traffic. For very heavy peak load there was no system so efficient as a railway. Where the peak load was eight to one, the tramcar was most efficient, and where traffic was intermittent, varying from day to day, the motor omnibus was most efficient. Dealing with high peak loads meant enormous expense, which was shown by the dividends of the London tube railways, only 2 per cent., although they had the richest traffic area in London. Mr. Blain's company had shown the direction in which development was to be made. The motor buses were paying the dividends of the tube railways. The tube railways, with their high capital cost and low cost of operation, were combined with the omnibus company, which had low capital cost and a large number of passengers. What was wanted was to extend that combination to the tramways, so that there would be a unified control of the instruments of transit, utilising each to the best advantage and in the way they should be employed. He thought the authority controlling all forms of transit in a large city should be a public authority, whose object should be not catering for dividend, but serving the best interests of the community.

Councillor H. Barrow (chairman of Birmingham Tramways Committee) remarked that Mr. Baker, in reading a Paper some years ago on town planning and tramways, said they were hoping in Birmingham to get wide roads made, with tramways on separate tracks. They had not got them yet, but Liverpool had some such tracks. At Birmingham they had two schemes of town planning agreed to by Parliament. In two cases roads of 100 ft. in width were to be laid down with separate tracks for tramways, and they were also preparing three other schemes of town planning, with roads of 120 ft. in width for tramways. There was no need to spend any money on it at present: all that was necessary was to see that the space was left for future purposes. It was not too late to have town planning now. Miles of streets to many suburbs would in a few years be full of houses, and there would be a great deal of building as soon as the war was over. They had had great difficulty in dealing with the traffic in the centre of Birmingham, and it had been suggested that they should construct subways, but the figures given to-day seemed to point to the fact that that was not going to be a solution of the difficulty.

Ald. Fred Smith (Liverpool) said that he looked at the German system in 1897. He admired some portions of it, but it was clear that by the development at Liverpool they would improve on it considerably. The working of the German system of the one-deck car seemed to him at the time to be a most admirable system, but when they tried it at Liverpool they found the one-deck car with a trailer was not suitable for their work. They could shift a greater number of passengers by double-deck car than was possible either by the American or German systems. He thought the future of the development of tramways would involve the laying of parallel or broader roads. With regard to tramways and town planning departments working together, he thought they would find that the city engineer would dip into the tramways pocket for some portion of the wide roads the town planning department wanted, although he did not see much objection to that; the great thing was to move the travelling public quickly and safely. There should be one authority for traffic only, which should have powers to deal with the antiquated carter who pulled carefully across the front of tramcars.

Councillor H. W. Wale (Coventry) said the population of Coventry had increased by 50 per cent. in a decade. When they tried to become the permanent authority for traffic in that neighbourhood they were looked upon as aggressors, and attempts were made to "scotch" every scheme they put forward. Unless there was a single authority with Parliamentary powers for traffic in a district the railway companies and motor omnibus companies coming into the area would feel their interests affected, and would oppose any new scheme, and they would not be able to get anything of permanent benefit to the population.

Mr. J. B. Hamilton (Leeds) said that he thought there had not been many speakers because Mr. McElroy had practically finished the job, and whatever he had not said had been ably said by Mr. Gordon. No doubt there must be a central body for traffic, but how it was to be constituted might be a matter which would be different in different towns, according to the conditions there presented. There must be a town planning committee and co-ordination with the body that dealt with city improvements. They had a Town Planning and a City Improvements Committee at Leeds, and they were approaching the period of saturation with regard to traffic in the centre. Mr. McElroy had girded at their want of foresight in this country, but he (Mr. Hamilton) did not think that was quite justified. Ten years ago no tramway man could have anticipated the increase of traffic which had resulted from their efforts. In many provincial towns, as well as in London, there was sufficient street room if properly utilised; but with the lowering of fares and the spread and increase of population an enormous development of traffic had resulted. A comparison of the number of passengers carried 10 years ago with last year would show that there was some excuse for what Mr. McElroy had described as want of foresight on the part of municipalities. At the same time, he thought the cities should wake up, and that there must be co-ordination between the traffic authorities and the body controlling improvements of streets and the provision of large arterial entrances and exits to cities. Undoubtedly the public authority should control all means of public transport in the city. He was engaged with a colleague upon a report on tramway facilities for a municipality, and he would bear in mind what Ald. Smith had said about the town planners dipping into the tramways pocket. The best plan was to form a joint committee of all authorities interested in street traffic, so that whatever scheme came forward the tramway undertaking would bear its proper share of the cost and have its interest preserved in the laying-out of streets.

Mr. J. M. McElroy, in reply to the discussion, said he was pleased to have had the assistance of so able a man as Mr. Gordon. Many tramway managers might say "our city is a long way from wanting the facilities foreshadowed in the Paper." They should not be too sure of that. The number of journeys per head of population was growing enormously, and in some cities, much sooner than they thought, the arterial roads would have reached "saturation" point. In many towns it was the custom in making up accounts to give large sums for the relief of rates: but the arterial roads were being gradually filled up, and in a few years time new arteries would be required, and it was necessary to put sufficient by in prosperous times for making adequate provision for those times which were ahead. Instead of giving large sums for the relief of rates, a large depreciation fund should be provided for developments when the new arteries were required. He thought every city should be the permanent authority directing the travelling facilities over a wide area, and it should be done under some Parliamentary sanction.

A vote of thanks to Mr. McElroy was then passed.

Mr. G. W. Hotford (Salford) then read an abstract of the following Paper written by himself and Mr. W. Clough (of Bury).

UTILISATION OF TRAMWAYS FOR GOODS TRAFFIC.

BY G. W. HOLFORD AND W. CLOUGH.

After referring to previous Papers on this subject, the authors consider more particularly the network of tramways in Lancashire. This continuous network of tramways covers a street mileage of 403 route miles. In a similar manner are the large industrial areas of Yorkshire linked together by tramway lines.

If the transport of merchandise over certain areas could be dealt with under one board or organisation there is no doubt that many of the grievances that at present exist would be removed and many facilities and benefits would follow ; but whether such a system could be introduced is a matter for the consideration of the whole of the interested parties in the several areas.

There have been several instances in this country where the use of tramways has not been solely confined to passenger traffic, and in order that there may be no misconception of the extent to which this has been done it is perhaps advisable that a brief description should be given of each case. Taken in alphabetical order they are as follows :—

Burnley.—In September, 1912, the Corporation of Burnley commenced to run a goods wagon for the conveyance of heavy parcels—*i.e.*, parcels between 56 lb. and 5 cwt. The charges were based on 3d. per cwt. per package, with a minimum charge of 3d. The goods were placed in an open wagon of the railway type, and if necessary covered with a sheet. This wagon was placed *in front* of a service car and propelled along the tramways. The wagon was run at specified times, and was allowed to stand at the terminus for 10 minutes, and the sender or receiver of the goods had to meet the wagon on its arrival. The financial results were not satisfactory, and the daily running of the wagon has been abandoned ; but it is now run on receipt of an order and a guaranteed load which will produce not less than 4s.

Glasgow.—By the Vale of Clyde Tramways Act, 1871, the Glasgow Corporation have to allow the use of the tramways for the conveyance of goods and mineral traffic, with wagons and other vehicles in ordinary use on railways, upon payment to the Corporation of tolls, not exceeding six-tenths of a penny per ton-mile, on the weight of traffic so conveyed, exclusive of the weight of the vehicle, empty vehicles passing free of toll ; provided always that the Corporation shall be entitled to charge for traffic conveyed for 3 miles, or any shorter distance, any sum not exceeding 2d. per ton.

Huddersfield.—Since September, 1904, the Corporation of Huddersfield has been utilising the tramways for the conveyance of coal from a railway siding to three different mills, two of which are a distance of 3 miles away and the other 5 miles. The difference in level between the railway siding and the street is such as to allow the railway wagons to run over and discharge the coal into shoots, which empty into carts or tramway vehicles. This makes it possible to deal with coal delivered at the sidings from any colliery. The railway siding is 340 yds. from the main line of tramways, and the Corporation incurred the expense of £1,243 for the requisite tramway connection. At the other end each mill owner constructed his own tramway connection. Two self-propelled wagons were built, but only one of these is in daily use. The wagons are similar to railway wagons, but are mounted on an ordinary tramway truck, and have a platform at each end and a trolley standard mounted on a framework in the centre. During the year ending March 31, 1916, 12,121 tons of coal were conveyed.

Leeds.—During the summer of 1910 the Corporation completed negotiations with certain contractors for the sand required in connection with the new filter beds of the waterworks department at Headingley. The quantity required was approximately 30,000 tons, and the distance about 3½ miles from the Sovereign-street depot of the tramways department, which has a wharf on the river and canal bank. To enable the work to be carried out, suitable wagons with hoppers and a 2-ton electric crane were purchased and installed. The revenue from this amounted to £1,908. After providing for all necessary charges, including full track maintenance, a very satisfactory net profit resulted to the undertaking. Since then there have been other developments in the conveying of materials, notably for the Leeds Fireclay Co.

There have also been other instances where the use of tramways cannot be said to have been confined exclusively to passenger traffic. A number of tramway systems convey their own permanent way materials on the tramways, and there are several systems on which important parcel departments have been instituted and special vans provided. In this connection we may mention the case of the Manchester tramways undertaking and Sutton & Co. The judgment which was obtained in this case has a most important bearing, as it permitted the Corporation to act as carriers so long as the articles were merely carried along the tramways.

Having endeavoured as far as possible to submit the past history of the subject, we will now consider whether there are any legal, physical or financial difficulties which prevent the utilisation of our tramways for the conveyance of goods.

The authors then consider whether tramway authorities have sufficient powers. They are permitted to convey goods, they may run two or more attached vehicles if the Board of Trade consents, but there is no power to construct lines into premises not owned by the Corporations.

The Tramways Act of 1870 foreshadowed the probable use of tramway lines for other than passenger traffic, yet for 46 years, with the very few exceptions to which we have referred, the use of tramways in this country has been confined to passenger traffic and the conveyance of parcels.

We would next draw attention to a clause which is now usually found in the Tramways Acts obtained by municipalities (Salford Corporation Act of 1899 and Bury Corporation Act of 1901), which reads : "The tramways shall be constructed on a gauge of 4 ft. 8½ in., *but carriages or trucks adapted for use upon railways shall not be run thereon.*" This clause, although it may not have been framed with the object of superseding section 25 of the Tramways Act of 1870, has the effect of preventing the use on tramways of a vehicle which is also adapted for use upon railways.

On referring to the Standing Orders relating to Bills deposited in Parliament it will be found that provision is still made for the running of tramways of "carriages or trucks adapted for use upon railways" (clause 13). But in the utilisation of tramways for the conveyance of goods, however great an advantage it might be to use the same vehicle both on railway lines and on tramway lines, we must at the outset accept the following facts : (*a*) *That railway wagons cannot be run along tramways as at present constructed*, because their overhang is too great as against the 11 in. in the case of a tramcar. The wheels, which are 5 in. wide and have a flange of 1 in., are not suitable for grooved rails. (*b*) *That tramway wagons cannot be used on railway lines*, because the wheels are not wide enough to pass over the gap of 4 in. in railway crossings ; the wheel flanges are too small to safely negotiate the curves even at the slow speed attained in goods yards or sidings.

In dealing with the general subject of the transport of goods, we have confined our attention principally to the following classes, as being those which might afford fields for operation by tramway undertakings—namely, the collection and delivery of goods : (1) Between towns separated some distance apart—*i.e.*, Liverpool and Manchester; (2) between towns fairly adjacent to each other; (3) between dock or railway yards and the mills, manufactories, &c., in the immediate locality.

We have first to consider what are usually the methods in vogue for dealing with this traffic, and taking the above in numerical order we find :—

Between Towns Separated some Distance Apart.—This work is carried out by the combined use of horse, petrol or steam vehicles and railway lines and wagons. How does the position of the tramway undertakings compare in this case ? The goods have to be collected from a point and conveyed to a railway siding or depot (they could be just as easily collected and conveyed to a tramway depot), they are then transported by rail to another depot or siding in the town of delivery (they could be just as easily conveyed from the tramway depot over the tramway lines to the tramway depot in the town of delivery), they are then conveyed by horse, petrol or steam vehicle to the mill, works, &c., where they are required (this work could be just as easily undertaken by the tramway authority).

What, then, are the advantages possessed by either party ? The railway companies are enabled to transport large train loads at one time, which the tramway undertakings could not do. Nor could the tramway undertaking from a financial point of view deal with loads of a small character, as the revenue to be derived would not cover the working expenses. But with loads of a moderate character the cost of transport between towns would certainly be cheaper as compared with the present railway charges.

Taking, for instance, the cost of providing and running on the rails a self-propelled tramway vehicle carrying 10 tons at 10d. per mile (again remembering that not only must there be a sufficient load but also a sufficient distance, for clearly we could not undertake to carry 10 tons 1 mile for 10d., anymore than we could undertake to carry 1 ton 10 miles for 10d.), and assuming a distance of 25 miles, and making no allowance for a return load, the tramway charge would be 41s. 8d., or a carriage rate of 4s. 2d. per ton, whereas the railway rate (an actual case having been taken) was 13s. 2d. per ton

This leaves a large margin out of which to provide any warehousing or loading facilities at tramway depots.

It must, however, be expected that as soon as it became a question of competition as to which *could* do the work the cheapest the advantage would be decidedly with the railway company, and whilst it may be in the interests of the trading community that the railway companies should be called upon to face competition, this alone is not sufficient to warrant municipalities entering into such competition.

The tramway undertakings might be able to still further reduce the handling of these goods by the laying down of sidings (where convenient) from the tramway lines direct to the mills, warehouses, works, &c.

But even under the most favourable circumstances—*i.e.*, where the mill or warehouse is on the line of route and there is sufficient space to build a tramway curve and line to the point of loading and unloading—there must be the requisite points and crossings, and although the extent of traffic in exceptional cases might warrant the expense of these, no tramway manager wishes to increase the number of points and crossings on a line used for passenger traffic. There, however, may be localities in our manufacturing districts where there is a cluster of mills and warehouses, and where it might be of advantage to construct a branch line for the conveyance of goods. To obtain access to the large warehouses of our cities (usually situated in very narrow streets) by means of tramway sidings is entirely out of the question.

If the transport of goods over the tramway lines between towns of the character referred to developed to any large extent, then it might be found desirable to construct central goods depots (in lieu of the use of tramway depots) at points or positions found to be most suitable.

There is also one other phase to be considered in referring to this class of business, and which is dealt with later in the Paper, and that is the introduction of a vehicle that could utilise to some extent the benefit of the tramway system and at the same time dispense with much of the expense consequent upon the several processes of handling now in vogue.

Between Towns fairly Adjacent to Each Other.—It is apparent that in large industrial areas there must be a considerable interchange of goods traffic of a varying character between towns lying adjacent to each other. This work is at the present time partly carried out by the utilisation of the railways (as mentioned in the previous classification), but mostly by the employment of horse, petrol or steam vehicles. Can tramway undertakings compete successfully for this traffic? We are forced to the conclusion that this can only be done by the use of a vehicle which could avail itself in part of the benefit of the tramways and yet be on equal terms in the handling of the goods, and which we will refer to after the next classification. Where the goods are conveyed partly over the railway, as in class 1, then the handling by the tramway undertakings would be on equal terms with that of the railway, with a possible reduction, as in the previous case; but the length of tramway to be utilised *would be of a shorter character*, and the cheapness of transportation less in proportion. When the goods are conveyed by vehicles (horse, petrol or steam) the handling charges are reduced to a minimum, and the financial benefit would be entirely in favour of this method, except probably in the case of horse vehicle transportation, but even then the cost of handling forms such a serious item in the consideration of the subject that it would be unsafe to say that the tramway method would be the cheaper.

Between Dock and Railway Yards and the Mills and Warehouses.—The work referred to in this classification may be said to-day to be entirely carried out without the utilisation of railway lines, but solely by horse, petrol or steam vehicles, with one handling for loading and another for unloading. Can the tramway undertakings compete successfully in this case? Except in isolated cases where conditions are particularly favourable (such as the Huddersfield, Leeds and Glasgow instances) we are of opinion that they could not. With the introduction, however, of a suitable vehicle we believe to a very large extent they could. Therefore, in considering all these classes of work, we arrive at the same conclusion—*i.e.*, the necessity for a vehicle which can make use to a great extent of our tramways and at the same time reduce the handling of the goods to a minimum. A vehicle of this description (which by the kindness of the designer we have had the pleasure of inspecting) has been introduced as an experiment by Mr. C. J. Spencer, the general manager of the Bradford Corporation tramways.

It may shortly be described as a "railless trolley battery vehicle." In appearance it is similar to a petrol-driven wagon with the addition of a trolley and boom.*

* This was described in THE ELECTRICIAN, Vol LXXVII., p. 225.—EDS. *E.*

Mr. Spencer has very kindly supplied some details as to the usage of the vehicle to date as follows:—

"The experimental vehicle for this purpose was constructed and actually put into use on May 15, 1916, and has been running up to June 17th.

"During that period 741 miles have been run and 247 tons of material have been carried varying distances, and according to market rates it has earned £73. 14s. Various kinds of merchandise have been handled, including wool, stone, vitrol, sand and other material.

"In this period 85½ hours have been spent in the depot, where the vehicle has been undergoing various experimental alterations and repairs to chassis. Had these alterations and repairs not been necessary (and they would not have been had not the vehicle been an experimental one) the vehicle would have been available for a further 85½ hours, and under those circumstances the total earnings would have been £17 more, making a total of £90. 14s.

"In order to arrive at the cost of earning this money it would be obviously unreliable to take the actual expenditure on this experimental vehicle. There would, first of all, be great difficulty in arriving at the correct capital value of the vehicle in question. The chassis and equipment which are being used have been taken almost literally off the scrap heap, and therefore one might be tempted to give a very low capital value to the apparatus.

"It is, therefore, necessary to assume what would be the price under normal conditions of special vehicles for the work. I estimate that a vehicle, including accumulators, would cost from £800 to £900."

After a careful comparison of working costs of this type of vehicle as against petrol-driven vehicles, Mr. Spencer is of opinion that the advantage is much in favour of the electric battery type, and he states:—

"Summed up, it seems that this vehicle would cost in round figures £10 per week, working six days per week and running 240 miles, against £12. 5s. for a petrol vehicle doing the same work. The figures, so far as the actual revenue from the experiment is concerned, must be examined in the light of the fact that we have been able to select very advantageous traffic and obtain in some cases a return load. *If this vehicle is used in its proper sphere—viz., doing a large percentage of its work on the tramway track—and using power from the tramway trolley wire, its operating costs will be from 20 to 25 per cent. less than a petrol vehicle doing the same work in the same time.* Generally the experiment has been exceedingly successful, and gives promise of good results in the future."

Whether such a vehicle would be sanctioned for general use by the Board of Trade under the existing powers granted to Corporations for the working of tramways is somewhat doubtful, but it is more than probable that little difficulty would be experienced in the obtaining by such authorities of additional powers to run these vehicles where it was shown that their introduction would benefit industry in many directions.

DISCUSSION.

Mr. C. J. SPENCER (Bradford) said, as a result of the war, new ideas had been and would be carefully scrutinised, and the effect would be felt in the transit world. They, as tramway operators, should consider how they might best help in the great transit problems of the future. If they could handle passenger traffic to the public advantage they should also be able to handle goods traffic; but unless tramways handled traffic more economically than it was handled at present it was useless to put forward any scheme, and unless the income was equal to the expenditure it would be useless to consider the matter further. Taking a rough and ready estimate, and assuming that a tramway system had 100 cars, and that each car carried an average load weighing 10 tons and ran 100 miles per day, 1,000 tons would be carried 100 miles per day, or 100,000 ton-miles. If the total cost of operation be 10d. per car-mile, the gross cost would be 1d. per ton-mile. Suppose that instead of carrying passengers they were carrying goods, and the dead load carried was only 50 per cent. of the total possible load, the net cost would be 2d. per ton-mile. It might be urged that there were some fallacies in this rough and ready method of calculation—not every vehicle would be full all the time, and the average speed might not be so good as that of vehicles carrying passengers, and there would be dead time, when the vehicle was loading and unloading. Also the dead load had to be put on the vehicle, whereas the live load put itself there; but the vehicles need not be quite so expensive as passenger vehicles, and the cost of ticket collections and checking, &c., would be considerably modified. There was, he thought, a *prima facie* case for examination. A big percentage of the capital expenditure on the tramway had, in the event of goods being carried over the same lines as passengers, to be divided by a much higher car-mileage. To quote from their friends the electrical engineers, the addition of goods traffic would improve the load factor materially. Any figure in the neighbourhood of 2d. to 6d. per ton-mile for transit was a figure worth considering. A question to be considered was whether tramway vehicles could handle traffic at less cost than petrol or steam vehicles. He had had a considerable experience with petrol vehicles,

and had had long consultations with transport experts with experience of modern steam and petrol vehicles, and he had come to the conclusion that there was not much to choose between the efficiency of petrol and steam under normal conditions. Electric power was considerably cheaper than petrol power; and repairs, lubrication and driving were cheaper with electric vehicles, and it was likely to continue to be so. It must be remembered that the petrol vehicle needed a road on which to run, and at present it did not provide and maintain the road ; but the tramway authority had to provide and maintain its road, and the cost of that provision and maintenance was automatically charged against income on anything carried over it. They had also to consider whether the carrying of goods on tramways would help in any way to minimise the street congestion. The question was whether it was better to allow transport to remain in the hands of scattered individuals who were disorganised, and who were not using in a broad sense the best vehicles for the work, and who could not be properly controlled by the street authority, or to put it in the hands of a public or semi-public body working under Parliamentary sanction, and more amenable to the public interest than unorganised and largely irresponsible individuals. Had it not been proved in the past that the placing of passenger traffic under the control and management of properly organised bodies had resulted in great public advantage ? And was it not reasonable to expect that the placing of goods transport under similar control and management would result in similar advantage ? It had been pointed out to him by men concerned with the industrial welfare of the country that the future of the country depended largely upon the efficiency of its transport, and particularly local transport, whether they used vehicles with flanged wheels or rubber tyres, and whether they were run by electricity or petrol, the issue was scarcely affected. If tramway authorities were charged with the duty of handling goods traffic they would, if they were allowed, use the most efficient vehicle for the purpose.

Mr. Henry Mozley (Burnley) said, in regard to the carriage of goods on tramways, he did not think the authors had considered the conditions sufficiently. There must be a considerable volume of goods traffic in the area covered by a 10-mile radius from a big centre, and the railway company did not care to be bothered with that short-journey traffic. The statutory charges must be considered. In the early eighties he found that the companies' powers assumed train loads and the tramway authority could not have handled the traffic and made a profit, because the statutory charges assumed train loads. Happily now Parliament had sanctioned such statutory charges as would enable single wagon loads or two or three wagons to be used. The charges were now 3d. per ton per mile for coal and coke, &c., with a minimum of 3 miles ; iron ore, &c., 4d. ; sugar, grain, corn, &c., 5d. ; cotton, wools, &c., 6d. ; carriages, 1s. ; small packages, 7 lb. 3d., 14 lb. 5d., 28 lb., 7d., 56 lb. 9d. ; above that weight and under 500 lb., any charge the Corporation thought fit. If one had statutory charges similar to those it might be possible to handle the traffic with advantage to themselves and the commercial community if a suitable vehicle could be obtained. Night traffic would be intolerable and was unnecessary. The goods traffic could be worked in the daytime amidst the passenger traffic. The authors had dealt with the Manchester side, where all the systems had the 4 ft. 8½ in. gauge. In the north-east division of Lancashire they had the 4 ft. gauge, and the network would in time have physical connections down to Darwen and the Rossendale Valley, and the question of gauge would then be more important. Also, in considering interchange of traffic, it should be remembered that there might be a big variety in the statutory charges of the various authorities. The ancient carriers were going daily over the roads in a radius of 10 miles from the centre of Burnley with loads of 1 ton and upwards, and it was that class of traffic he was catering for in his experiment with a goods wagon. He believed they could handle that traffic by the use of a road and rail truck. The vehicle must go to the manufacturer's warehouse or the shops and must deliver the goods to the consignee, otherwise the traffic would never be secured. The problem was a very aged one, but he thought it could be solved if the tramway managers had sufficient encouragement. He believed the Bradford system was likely to be a very successful method of dealing with traffic, because it had been going on for years in the shape of petrol and steam. It was not a tramway except for obtaining power. But the municipalities had no powers to deal with heavy motor traffic, and would have to go to Parliament for powers. The Paper stated that Mr. Hamilton (Leeds) was carrying minerals at 1s. 2·22d. per ton for 3½ miles=4d. per mile. How could he make a profit on that ? What rates was he going to charge for carrying fireclay ? What were his statutory charges ? The authors said tramway undertakers had no power to put sidings down to anybody's works. He thought that was wrong. At Huddersfield they had put a siding into a colliery at a cost of £1,000. He hoped the whole question would be dealt with thoroughly by the best men in the business, but he did not think they had a suitable vehicle yet.

Mr. J. B. Hamilton (Leeds) said the question of goods traffic on tramways presented itself to his mind from two points of view, that of the public interest and that of the saving of congestion arising from the carrying of goods and minerals on other vehicles than tramcars. The coal now carried on the Leeds tramways (about 400 or 500 tons a week) was formerly conveyed in steam tractors with two trailers, and their passage was a serious danger and annoyance. Its conveyance on a wagon which was much less obtrusive, which followed a regular and orderly line, and which made no particular noise, was a great advantage to the city. There was no doubt in his mind that, given suitable conditions, they could convey such goods at prices and costs which no steam or petrol tractor could face. The fact that they were able to get a contract given them by a company proved that. The price was considerably less than they were paying under keen competition before, and the prices were remunerative to the department. He was sorry to hear Mr. Spencer talking of 2d. per mile, notwithstanding Mr. Mozley's reference to 3d. and 4d. as practically the statutory figure for goods of that class. That was the figure in Leeds (3d. per mile), but it was a purely relative term, and depended on many other conditions. They carried the goods 5 miles across the city at 3d. per mile, avoiding as far as possible the busy centres. The company did the loading and had paid for all the terminal connections. Under these conditions the department was just making a little profit.

Mr. R. H. Wilkinson (Huddersfield) said the Paper (on p. 19) referred to a cost of 10d. per ton per mile. It did not seem to have ever been considered what the cost would be if a vehicle carried 20 tons, or if it had a trailer attached conveying 20 tons with the same driver and conductor. The cost would be much reduced. The railway had many trailers. A few years ago he had to consider the question of goods haulage, and under the scheme he drew up he proposed to get a railway truck complete and put it on a bogie to fit the tramway lines and driven by motors. This would avoid handling the goods at railway sidings and reduce the cost of conveyance. He intended laying a track specially for the job, the vehicle being too wide for the tram lines, and he was confident that he could have carried the goods and provided the track at 3d. per ton per mile. His attention was called to the fact that a similar scheme had been in operation in Germany for some years, and he went and saw it. He also saw a railway which ran several miles out into the country, and the rate charged on that was 6d. per (10 ton) truck-mile. He was convinced that goods could be carried at a remarkably cheap rate, and the more there was to be carried the cheaper it could be done.

Mr. J. M. McElroy (Manchester) said when one began to touch goods traffic on tramways the terminals difficulty arose. The goods had either to be carried to the tramways by a separate vehicle or sidings must run into the warehouses. If they had to be carried to the tramways and delivered from the tramways the terminal charges did away with all the advantages of the cheap transit on the rails, unless there was a long run—say 25 miles. Even with 25 miles, unless one had sidings there would be difficulty in competing with the railways. Even in carrying their own permanent way materials there were many loads where they had to run off the tramways, and they did so by tramway part of the way and then transferred to another vehicle. They used the petrol vehicle for that class of work. Since Mr. Bellamy brought forward that question at the conference in 1904 the petrol transit had revolutionised road transit. The introduction of the petrol, steam and electric vehicles had so revolutionised the matter that one should hesitate before saying the tramways could be used for the carriage of goods except where sidings could be got into and out of the warehouses. Mr. Spencer's vehicle was a good one, but did not touch the Paper in one sense. The authors were talking about the advantages of running on rails, but Mr. Spencer spoke of getting advantages by taking energy from the overhead trolley line, which was not a tramway question at all.

Mr. W. Clough (Bury), in reply to the discussion, said it was rather too bad of Mr. Mozley. He was on the Committee, and compelled the authors to deal with the subject, and then he put on to them the task of finding a solution of the problem that had baffled him. He admitted that there were goods to be carried in a 10-mile radius at Burnley, but he could not carry them at 3d. per ton per mile. (Mr. Mozley : That was in 1879. The charges are different now.) Mr. Mozley said it was intolerable and unnecessary to carry the goods at night. The authors agreed that it could be done in the daytime without interfering with the passenger traffic. They agreed that to use Mr. Spencer's vehicle Parliamentary powers would have to be obtained. The authors had come to the conclusion that if they could get towns in Lancashire with sufficient distance between and sufficient loads, the tramway would be in as good a position as a railway to take up the conveyance of the goods. They could deliver them as the railways did. The better use of Mr. Spencer's vehicle would be to deliver the goods from the tramway depots.

A vote of thanks to Mr. Hoiford and Mr. Clough concluded the meeting.

INDUCTANCE OF CONDUCTORS AT CLOSE SPACINGS.*

BY F. B. SILSBEE.

Summary.—The author deals with the determination of inductance of copper tubing, and shows the effect of spacing and frequency under conditions approximating cable construction.

In view of the frequent use of conductors at close spacing in cables, it is important to determine the conditions under which copper conductors at moderate frequencies operate most satisfactorily. In the calculation of the inductance and capacity of transmission lines, the formulæ usually applied are :—

$$L = 4 \log \frac{d}{a} + L_i, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and

$$C = \frac{1}{4 \log \frac{d'}{a}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where L is loop inductance per centimetre length ; C is capacity between wires per centimetre length ; d is spacing of wires centre to

* From the "Electrical World."

centre ; a is radius of wire and L_i is so-called " internal inductance " of the wire.

These formulæ are undoubtedly correct, and can be very simply deduced for the case where d/a is large. However, when d/a is small formula (2) is very much in error, as has been shown by Kennelly * and others. The exact expression is :—

$$C = \frac{1}{4\cosh^{-1}\frac{d}{2a}} \quad \ldots\ldots\ldots\ldots \quad (3)$$

Equation (3) is correct for all spacings while (2) is merely an approximation which becomes more exact as d/a increases. The physical difference between the two cases is, that a direct derivation of equation (2) requires the assumption that the electrostatic charges on the wires are uniformly distributed around their circumference. Equation (3) takes account of the fact that when the wires are near together the mutual attraction of the charges causes the surface density of charge to be greater on the adjacent sides of the wires.

In the case of inductance the phenomenon is complicated by the fact that not only do the induced E.M.F.s tend to make the currents crowd together, in a manner analogous to the electrostatic case, but also the resistance of the conducting material tends to maintain a uniform distribution of current over the cross-section of the wire. If the former effect is overwhelming, as is the case with perfect conductors or very high frequencies, the formula

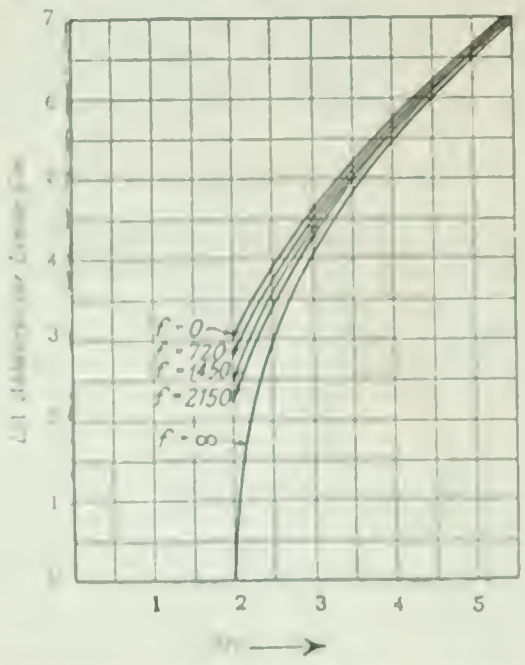
$$L = 4\cosh^{-1}\frac{d}{2a}, \quad \ldots\ldots\ldots\ldots \quad (4)$$

which is analogous to (3), is correct. On the other hand, if the resistance effect predominates, as at low frequencies and with materials of high resistivity, then formula (1) is correct for all spacings.

Table I.—*Effect of Spacing on Inductance of Parallel Copper Tubes Results at 60 ∼.*

Test No.	d/a	Observed—L/l absolute-henrys / centimetres	Corr. L/l absolute-henrys / centimetres	$4\log\frac{d}{a}+L_i$.
1- 2	50·00	15·96	15·86	15·86
24-25	49·76	15·97	15·87	15·84
20-21	20·10	12·20	12·18	12·21
22-23	20·08	12·25	12·23	12·21
7- 8	10·04	9·43	9·42	9·43
5- 6	5·03	6·79	6·78	6·67
11-12	$3·02_0$	$4·61_1$	$4·61_1$	$4·63_6$
9-10	$3·00_4$	$4·62_5$	$4·62_5$	$4·61_2$
3- 4	$2·02_0$	$3·14_1$	$3·14_1$	$3·02_4$
16-17	$2·04_8$	$3·08_3$	$3·08_3$	$3·08_0$
18-19	$2·03_6$	$3·07_6$	$3·07_6$	$3·05_6$

In order to determine experimentally which condition was more nearly satisfied by copper conductors at moderate frequencies specimens of commercial copper tubing 1·27 cm. external diameter and 0·10 cm. thick were used in the experiments. The tubular shape was selected because the correction term L_i was thereby made quite small ($0·053\cdot10^{-9}$ henrys per linear centimetre in this case). The tubes were 180 cm. long and the spacing could be varied from 50 radii down nearly to 2. Potential leads were attached to each tube at points 60 cm. and 120 cm. from the closed end of the circuit, and the inductance of the four-terminal conductor formed by each pair of potential leads and the main circuit was measured. The difference in the values thus obtained was taken as the inductance of the 60 cm. of circuit between the two pairs of potential leads. Corrections were applied to take account of (1) the mutual inductance between the connecting bar at the end of the circuit, and the potential leads, and (2) the fact that the conductor did not extend to infinity but terminated at the connecting link. These corrections in no case exceeded 1 per cent. and were usually entirely negligible. They were computed on the assumption that the conductors were replaced by their central filaments.*



Effect of Spacing and Frequency on Inductance of Copper Tubes.

The measurement of inductance was made by a substitution method in which the circuit under investigation X was compared with a standard 0·001 ohm resistance S of known inductance. The procedure was to determine the phase angle of a current transformer by one of the usual null methods using S as the standard resistance in the primary circuit. Then X was inserted in place of S and the phase angle again determined. The apparent change in phase angle of the transformer is due to the difference in the phase angles of S and X ; and from this difference and the known inductance of S, the inductance of X is easily calculated.

Table II.—*Effect of Spacing on Inductance of Parallel Copper Tubes Different Frequencies.*

Test No.	d/a	Freq. cycles / sec.	L_1 absolute-henrys.	L_2 absolute-henrys.	L/l abshen's. / cm.	$4\log_e\frac{d}{a}+L_i$	Diff. per cent.
29-30	2·048	716	358·3	185·1	2·873	3·080	7·2
53-54	2·048	1,460	319·5	163·1	2·594	...	...
33-34	...	1,560	321·5	170·6	2·553	3·080	20·0
35-36	2·048	1,500	322·1	167·4	2·565	3·080	17·9
51-52	...	2,140	294·0	150·7	2·375	.....	...
31-32	2·048	2,148	296·9	154·5	2·363	3·080	25·0
26-27	49·760	750	2,135·0	1,171·0	15·89	15·84	0·3
41-42	3·000	710	558·2	285·8	4·518	4·608	2·0
39-40	3·000	1,438	542·8	277·2	4·405	4·608	4·6
37-38	3·000	2,140	533·6	275·7	4·277	4·608	7·5
43-44	5·004	730	814·5	413·6	6·65	6·652	0·1
45-46	...	1,430	808·0	409·8	6·60	6·652	0·8
47-48	...	2,190	808·3	411·6	6.58	6·652	1·2

Table II. gives the observed inductance per centimetre of circuit for the spacings given in Column II., after the corrections mentioned above have been applied. Column V. gives the values computed from equation (1). The agreement is well within the experimental error, and indicates that up to this frequency the current remained uniformly distributed over the cross-section of the tube.

Further measurements at the three closest spacings were made at higher frequencies up to 2,100 cycles. The results are given in Table II., and are indicated by + marks on the spot. It was found that these values can be represented by the empirical formula,

$$L = 4\left\{\log\frac{d}{2a}\left[1+\sqrt{1-F\left(\frac{2a}{d}\right)^2}\right]+G\right\}, \quad \ldots \quad (5)$$

Table III.—*Observed Constants of Equation (5).*

Frequency, cycles, sec.	F.	G, absolute-henrys cm.
(0)	(0)	(0·053)
60	0·00	0·053
720	0·18	0·053
1,450	0·42	0·053
2,150	0·58	0·053
(∞)	(1·00)	(0)

where F and G are functions of frequency, but not of d/a. G, which represents the internal inductance, was practically constant over the range of frequency used. The values of F are given in Table III. Equation (5) goes over into the two theoretical formulas (1) and (3) if at $f = o$, $F = O$ and $G = L_i/4$, and at $f = \infty$ $F = 1$ and $G = O$.

These results bring out very clearly the ideas suggested in a recent Paper by Kennelly, Laws, and Pierce,† namely, F is a measure of what these authors call the " proximity effect," and is very pronounced at 2,000 cycles, while the decrease of G is a measure of the " skin effect " in the narrower sense and is negligible up to this frequency.

It is to be hoped that these measurements may be extended to a greater variety of sizes and thicknesses of tubes, and to solid wires.

* " Proc." Am. Phil. Soc., p. 142, 1909.

* " Bull " Bureau of Standards, Vol. VIII., p. 151, *et seq.*

† " Proc." A.I.E.E., August, 1915, p. 1750.

THE TUNGSTEN ARC UNDER PRESSURE.*

BY G. P. LUCKEY.

The following experiment was undertaken at the Nela Research Laboratory primarily for the purpose of determining whether the temperature of melting tungsten showed a marked change under pressure. For this purpose a tungsten arc was used, and the melting point of tungsten in an atmosphere of nitrogen was determined for pressures up to 35 atmospheres. The red black-body temperatures of the melting tungsten for $\lambda=0{\cdot}661\mu$ were measured by means of a Holborn-Kurlbaum pyrometer of the type in general use in this laboratory. The values used for the absorption coefficient of tungsten in computing the true temperature were obtained by extrapolating from values obtained by Worthing for temperatures up to 3,200°K.

The results of the melting-point determinations are given in Table I. The melting-point apparently decreases as the pressure is increased, but it is open to doubt whether this observed change is due to an actual decrease in the temperature of the tungsten, or whether the apparent diminution in brightness might not be due to an increased absorption of the gases above the surface of the tungsten. Above 12 atmospheres rather large uncertainties in the determination of the melting-point were introduced by the distortion of the image due to the refraction of the heated gases in the neighbourhood of the arc.

The value of the melting-point found for atmospheric pressure agrees closely with that found by Worthing in the tungsten arc, 3,630°K., while it is about 80 deg. higher than the value determined by Langmuir, 3,540°K. This discrepancy is due to the different value of the emissivity of tungsten taken in the two cases. The value used by Langmuir was 0·425 at $0{\cdot}667\mu$, and that found from the extrapolation of the values obtained by Worthing was 0·393 at $0{\cdot}661\mu$. The red black-body temperatures obtained give good agreement in all cases. The value found by Langmuir was 3,124°K. for $0{\cdot}667\mu$, while that found by Worthing was 3,140°K for $0{\cdot}666\mu$.

At the point where the main arc discharge centres on the electrodes of the arc, a temperature much higher than that of the surrounding melted tungsten was noticed. The temperature of this area varied with the pressure, the current through the arc, and the area over which the discharge took place. Measurements of the highest attainable red black-body temperature for $0{\cdot}661\ \mu$ were made of this area at different pressures, and the values found are given in Table II. If it be assumed that the relationship found by Worthing between the absorption coefficient and the temperature of tungsten holds up to the temperatures here attained, then the values of the true temperature would be given in the last column of Table II. There is a question as to what this temperature represents. It is doubtful whether it can be assumed to be the boiling-point of tungsten. It is more probable that it represents some temperature lying between the melting and boiling points.

In connection with the temperature determinations, measurements were also made of the electrical characteristics of the tungsten arc in nitrogen under pressures from 1 to 30 atmospheres. The drop in potential across the arc, other conditions being the same, increased with the pressure, an effect similar to that observed by Duncan Rowland and Todd on the carbon arc under pressures up to 10 atmospheres. At high pressures the voltage dropped as the current was increased until values of current of about 5 amperes were reached, after which the voltage rose with increasing current. This latter effect was probably due to the tendency of the arc to flare out to one side with larger currents, as well as to the increase of pressure in the tank caused by the heating of the gas.

Table I.—*Apparent Melting-point of Tungsten under Pressure.*

Pressure, atmospheres.	Red black-body temperature, $\lambda=0{\cdot}661\mu$.	True temperature.
1	3,138°K.	3,623°K.
4	3,129°K.	3,611°K.
8	3,116°K.	3,594°K.
11	3,113°K.	3,590°K.
14	3,107°K.	3,582°K.
18	3,099°K.	3,572°K.
21	3,092°K.	3,562°K.
28	3,093°K.	3,564°K.

Table II.—*Highest Attainable Temperatures.*

Pressure, atmospheres.	Red black-body temperature, $\lambda=0{\cdot}661\mu$.	Assumed absorption coefficient.	Computed true temperature.
1	3,559°K.	0·374	4,235°K.
8	3,794°K.	0·363	4,602°K.
15	3,907°K.	0·358	4,782°K.
22	3,982°K.	0·354	4,912°K.
29	4,022°K.	0·352	4,978°K.
33	4,086°K.	0·349	5,084°K.

* From the "Journal" of the Franklin Institute.

ELECTRIC POWER PLANTS OF THE MONTANA POWER CO.

The following interesting particulars of an extensive power supply system are taken from a publication recently issued by the General Electric Co. of America :—

Completed Hydro-electric Plants.	Installed capacity, kw.
Great Falls, on Missouri River	60,000
Rainbow Falls, on Missouri River near Great Falls, completed in 1910	27,000
Black Eagle Falls, on Missouri River near Great Falls, reconstructed in 1913	3,000
Black Eagle Falls, hydraulic power, 8,000 H.P.	——
Hauser Lake, on Missouri River, north-east of Helena, completed 1911	18,000
Canyon Ferry, on Missouri River, north-east of Helena, completed in 1898 and enlarged in 1901	7,500
Madison No. 1, on Madison River, 60 miles south-east of Butte, completed in 1901 and re-modelled in 1907	2,000
Madison No. 2, on Madison River, 60 miles south-east of Butte, completed in 1906	10,000
Big Hole, on Big Hole River, 22 miles south-west of Butte, completed in 1898	3,000
Livingston, on Yellowstone River, completed in 1906 and enlarged in 1908	1,500
Billings No. 1, on Yellowstone River, completed in 1907	1,080
Lewistown, on Spring Creek, completed in 1906 and re-modelled in 1913	450
Thompson Falls, on Clark's Fork of Columbia River	20,000
	153,530
Steam Plants.	
Butte, completed in 1907	5,000
Billings, completed in 1906	560
Conrad, completed in 1910	110
Phœnix, in Butte, completed in 1895	250
	5,920
Total	159,450

Hydro-electric Powers in Course of Development and Definitely Projected.	Capacity, kw.
Thompson Falls, on Clark's Fork of Columbia River, additional units to be installed in 1917	10,000
Holter, on Missouri River near Helena, under construction, to be completed in 1917	40,000
Total	50,000

Hydro-electric Power Sites Undeveloped.	
Site "C" at Great Falls, on Missouri River, between Rainbow and Great Falls	28,500
Below Great Falls, on Missouri River	28,500
On Missouri River about 30 miles north-west of Missoula	13,500
Madison No. 3, on Madison River	18,500
Black Eagle Plant, reconstruction	10,000
Snake River Falls, on Henry's Fork of Snake River, 20 miles north of St. Anthony, Idaho	22,500
Total	121,500

Summary.	
Completed hydro-electric and steam plants	159,450
Hydro-electric powers in course of development	50,000
Hydro-electric power sites undeveloped	121,500
Total	330,950

Summary of Transmission Lines in Service January 1, 1916.	
Steel tower lines, 100,000 volts	305 miles
Steel tower lines, 50,000 volts	35 ,,
Pole lines, pin type, 11,000 to 60,000 volts	635 ,,
Pole lines, suspension insulator type, 50,000 to 100,000 volts	512 ,,
Bridge type, 100,000 volts	341 ,,
Total	1,828 ,,

These water-power plants are so located at widely separated points that there is little probability of an interruption of the supply.

Available capacity of storage reservoirs in service is 447,150 acre ft., of which the largest, the Hebgen reservoir on Madison River, contributes 325,000 acre ft. There is a further undeveloped capacity of 78,500 acre ft.

THE ELECTRICIAN:

THE OLDEST WEEKLY JOURNAL OF ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE & FINANCE.
Published every Friday, Price Sixpence, Post Free, Sevenpence.
Editorial, Publishing and Printing Offices,
1, 2 & 3, SALISBURY COURT, FLEET ST., LONDON, ENGLAND.
(ONLY ADDRESS.)
Phone : City **4698** & **4699.** *Tels. :* ELECTRICIAN NEWSPAPER LONDON

All Letters relating to Subscriptions, Advertisements and other business matters to be addressed Publisher, "THE ELECTRICIAN," *Salisbury court, Fleet-st., London. Cheques and P.O.s to be crossed "Coutts & Co."*
All Editorial communications to be addressed to THE EDITORS. *Letters for insertion in* "THE ELECTRICIAN," *or containing questions, to be accompanied by name and address of the writer as evidence of good faith. No notice is taken of anonymous communications.*
"THE ELECTRICIAN" *offers exceptional advantages to Advertisers* **and has an influential and a World-wide circulation.** *This statement is guaranteed.*
Advertisement Rates, &c., forwarded on application.
TRADE ADVERTISEMENTS *intended for the current issue must reach the Office at latest by noon Wednesday.*
CONTRACTS *and other* OFFICIAL ANNOUNCEMENTS, AUCTIONS, APPOINTMENTS VACANT AND WANTED, *and all kinds of* SMALL ADVERTISEMENTS *are accepted up to* **First Post THURSDAY.** *It is requested that these be sent in, whenever possible, not later than Wednesday.*

The Rates for Subscription to "THE ELECTRICIAN" are as under :—

	YEAR.	HALF-YEAR.	QUARTER.	
United Kingdom ...	28s. 0d.	14s. 6d.	7s. 6d.	Post free, payable in advance
Canada	29s. 0d.	15s. 0d.	7s. 6d.	
Postal Union... ...	30s. 0d.	16s. 0d.	8s. 0d.	

(This charge includes all the numerous Supplements.)

New volumes of "THE ELECTRICIAN" *commence in April and October.* Vols. I. to LXXVI. can now be supplied. Price on application.

"THE ELECTRICIAN" SERIES OF
Standard Electrical Books

can be obtained of all Booksellers at Home, in the Colonies, and Abroad.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. Published annually in February, corrected to mid-February, 1916. Established 1882. A very valuable advertising medium, covering the entire Industry. Subscription price which is received *in advance* up to Jan. 31st in each year for the next following edition) 10s. 6d. nett, postage (U.K.) 9d. extra. Price, after Jan. 31st, 15s. nett, postage (U.K.) 9d. extra. After Oct. 30th in any year the price is reduced to 10s. 6d. nett. Postage of all copies to Continent of Europe, 1s. 8d.; Canada and India, 2s.; Australasia and South Africa, 3s.; United States of America and other Countries, 2s. 6d.
The **NEW (1916) EDITION** of the DIRECTORY & HANDBOOK is now available.

WIRELESS TELEGRAPHY AND TELEPHONY. Handbook of Formulæ, Data and Information. By W. H. Eccles, D.Sc. *Now Ready.* Price 12s. 6d. nett, by post 13s. *New Edition in preparation.*

THE LOCALISATION OF FAULTS IN ELECTRIC LIGHT MAINS. By F. C. Raphael. *New Edition Now Ready.* 8s. 6d. nett, post free 9s.

THE PRINCIPLES OF AUTOMATIC TELEPHONY. By W. Atkins. *New Edition Now Ready.* Price 2s. 6d., post free 2s. 8d.

THEORY OF THE SUBMARINE TELEGRAPH CABLE. By H. W. Malcolm, D.Sc. *Nearly Ready.*

PRIMARY BATTERIES: THEIR CONSTRUCTION AND MANUFACTURE. By W. R. Cooper. Price 10s. 6d. nett. *New Edition Nearly Ready.*

AITKEN'S MANUAL OF THE TELEPHONE. By W. Aitken, M.I.E.E. Price 18s. nett, postage 6d. (abroad, 1s. 4d.) *New Edition in preparation.*

ELECTRIC MAINS AND DISTRIBUTING SYSTEMS. By J. R. Dick, B.Sc., and F. Fernie, A.M.Inst.C.E. *New Edition in preparation.*

SIGNALLING ACROSS SPACE WITHOUT WIRES: THE WORK OF HERTZ AND HIS SUCCESSORS. With Chapter on Tuning. By Sir O. J. Lodge. Price 5s. nett.

BEGINNER'S MANUAL OF SUBMARINE CABLE TESTING AND WORKING. By G. M. Baines. Price 7s. 6d. nett.

THE MANUFACTURE OF ELECTRIC LIGHT CARBONS. 2s. 6d. nett, post free 2s. 9d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF GENERATORS. By R. Livingstone. 9s. nett, post free 9s. 4d.

STUDIES IN LIGHT PRODUCTION. By R. A. Houstoun, M.A., D.Sc., Ph.D. 5s. nett

ELECTRICAL ENGINEERING FOR MECHANICAL AND MINING ENGINEERS. By H. J. S. Heather, M.I.E.E. 9s. nett.

AMATEUR WIRELESS TELEGRAPH DESIGNS. By "Allrec" Very fully illustrated. Price 2s. 6d. nett, postage 2d.

THE MECHANICAL DESIGN AND CONSTRUCTION OF COMMUTATORS. By R. Livingstone. Price 6s. nett.

WIREMAN'S POCKET BOOK AND ELECTRICAL CONTRACTOR'S HANDBOOK. Compiled by A. W. Robinson and W. E. Warrilow. Price 5s. nett.

ALTERNATING-CURRENT MOTORS. By Dr. Rudolf Goldschmidt. Price 6s. 6d.

LIVINGSTONE'S DIAGRAM FOR THE EASY CALCULATION OF SHAFT AND BEAM DEFLECTIONS. By R. Livingstone. 2s. 6d. nett. By post in tube, 2s. 10d.

ELECTRIC BLASTING APPARATUS AND EXPLOSIVES: With Special Reference to Colliery Practice. By W. Maurice. Price 8s. 6d. nett.

THE SHOT-FIRER'S GUIDE: A Practical Manual on Blasting and the Prevention of Blasting Accidents in Mines, Quarries, &c. By W. Maurice. Price 3s. 6d. nett.

THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION. By John B. C. Kershaw, F.I.C. Price 3s. 6d. nett.

THE PRACTICAL WIRELESS SLIDE RULE. By Dr. H. R. Belcher Hickman. Price 2s. 6d. nett. *Reduction on quantity.*

Now Ready.

ELECTRIC SWITCH AND CONTROLLING GEAR
By C. C. GARRARD, Ph.D., M.I.E.E

FIRST EDITION: Price **15s.** nett, post free **15s. 6d.**

A COMPLETE CATALOGUE of "The Electrician" Series and other Standard Electrical Books will be gladly mailed on request.

SPECIAL NOTICE.

The present number of "THE ELECTRICIAN" completes Vol. LXXVII. The Index to the Volume will be issued (Gratis) on October 13th.

NEARLY READY.

Vol. LXXVII. of "THE ELECTRICIAN." Bound in Publisher's covers, Price 18s. Postage U.K. 1s. extra, abroad 2s. 6d.
Cases for binding Vol. LXXVII., price 2s. 6d.; post free, 2s. 10d.

THE UNION OF CAPITAL AND LABOUR.

There can surely be no thoughtful employer at the present moment who does not look forward with considerable misgiving to the future relations of Capital and Labour in this country, unless some basis of co-operation is found before peace is declared. For the time being there is amicable working. Although there has been endless friction in the past, at the present moment both Capital and Labour are working with the one object in view of winning the war. With that object the employers' profits have been cut down and Labour's output has been vastly increased. Trade union rules have been laid on one side, and many sacrifices have been made as being the only means of securing victory: but at the best this is only a temporary truce, and we are faced with the question:—What is to happen when peace reigns once more? What are we to expect in due course when the employer wants more profit, as he certainly will: when the employé restricts output and desires a higher wage, as will certainly be the case; and when the neutral Powers are far more favourably situated to compete against us than ever before?

These conflicting conditions may very well produce a calamity, and there is only one way in which such a calamity can be avoided. To this end Capital and Labour must come together: both must realise the indispensability of the other: that Capital without Labour is useless, and that Labour without Capital is powerless to produce wealth. This would seem the most elementary common sense, and yet, so far, the realisation of these principles has made very little headway.

Let us look at the difficulties. First, there is mutual distrust between Capital and Labour, and so long as this distrust exists progress is impossible. The employer has lost faith in agreements with his men, for he sees that even the leaders of the men are by no means always able to secure the adherence of their followers, and thus he is unable to secure stable conditions of working. Apart from this, the position of the employer is often one of great difficulty. He must take risks. He must pay his employés, whatever happens, whether he is successful or unsuccessful. If his business is to thrive he must pay reasonable dividends, and as often as not a high dividend only follows after years of no profits. He must meet competition, not only from firms in his own country but also from other countries where the price of labour may be much lower than that which he is forced to employ.

On the other hand the worker feels that pressure is the only means of securing a good wage, that a man's maximum effort may, in the long run, only be rewarded by lower rates of pay, and that a larger output per man may mean unemployment for many.

In our opinion the first step towards co-operation should be made by the employer, as he is possessed of more all-round knowledge of the situation. Capital must first of all appreciate the views of Labour and then Labour will the more readily understand the difficulties and limitations of Capital. The employer must be prepared to look at matters more from the point of view of humanity than hitherto and concede the right to live in its broadest sense, by which we

mean the right to a living wage, to reasonable leisure and to a future. In the main, all classes have the same aspirations, though these may differ in magnitude, and therefore it is unreasonable to expect the best effort unless this results in greater comfort, or in what is generally termed greater prosperity. It is only human nature to inquire what is the material advantage of a greater effort to the worker himself, more particularly as age advances. The best effort cannot be expected if the conditions of living are such that the effect on the physical state of the worker are bad, or if the conditions under which work is carried on are unsatisfactory. As an example of the latter, the efficiency of work on night shifts is not likely to be high if no means are provided whereby the men can obtain food during the shift. This fact has at length been somewhat appreciated, but only under war conditions.

On the other hand, the employé must realise that a high wage and reasonable hours can only be obtained if he helps the employer by putting forth an effort to achieve the maximum. He must appreciate the fact that increased output means a cheaper article and a larger sale. He must be prepared to abide by agreements and to realise some of the anxieties and responsibilities of management. Undoubtedly one of the greatest difficulties in the mind of the worker is the feeling that he ought to have some share in any increased profits, and that such profits should not merely go to the benefit of Capital. Up to a certain point we think this view is justified, but it is difficult to arrive at an equitable basis. It may be conceded that if the profits exceed a certain return on the capital the workers should have some proportion of the surplus. But if the profits fall below this figure, are the workers to share in the loss? In practice there can be only one answer to this question, and it serves to show the weakness of the position. There is also the question of fluctuating wages. Theoretically it is a simple matter to raise wages in time of prosperity and to reduce them in times of depression. But actually there is always resentment on the part of the workers at a reduction in wages. Possibly the best course would be to fix a minimum living wage and to supplement this by bonuses which would vary in amount with the state of prosperity of the particular business. Thus the wages would remain fixed, but the bonus would vary.

We quite admit that the subject bristles with difficulties, but do not let us accept that as a reason against tackling the problem. Let Capital and Labour come together, not after the war, nor even in six months' time, but NOW. It may not be possible to come to an immediate agreement; the war is not yet finished, and we do not yet know what will be the final conditions in this country. But these problems take time, and it would be a fatal mistake to wait until peace comes before we take them in hand. Let a start be made now, so that Capital and Labour may come to know each other better and realise thoroughly all the conditions. This is the first and most fundamental step.

In a very able speech at the Mansion House Meeting last week Mr. G. H. Roberts, the labour M.P., who is at present Lord Commissioner of the Treasury, remarked that the present was an opportunity for *rapprochement* that was not likely to recur, an opportunity which, if properly taken, might lead to conditions so much desired, conditions which would give justice to the employé, fairness to the employer and duty to the State. Do not let us allow this opportunity to escape. If old prejudices and mutual distrust can be put on one side, Capital and Labour in this country may yet combine, and we may live to feel that in one direction at least the great War has resulted in some good for humanity.

A NEW METHOD OF BRAKING CRANES.*

BY E. LUFT.

On the usual plan of braking the falling load, the motor is used in the first stages as a generator. The armature is disconnected from the supply network and short-circuited through a resistance and the field winding. If the load is capable of doing the driving the armature generates current and acts as a brake on the load. By altering the resistance the braking effect can be increased or decreased, and the speed can in this way be controlled. If the load should not be capable of driving, the motor must be able to produce a torque in the required direction; therefore, certain positions are provided on the controller through which the motor is connected to the network. In these positions the armature is in series with the field winding and a resistance; everything is the same as for lifting the load, except that the direction of the current through the motor is reversed. This method of braking has the following disadvantages: (1) The speed of falling varies very considerably with the load from one position on the controller to another. (2) Difficulties arise because the conditions are very different with heavy and light loads. (3) Heavy shocks on the mechanism can be produced if the passage from the network to the braking positions is not very carefully made. (4) There are also other conditions under which the load may take charge and the braking effect fail.

In order to avoid these disadvantages many plans have been devised; the main point about them consists in the partial excitation of the field from some external source. Figs. 1 and 2 illustrate diagrammatically the usual schemes. On both plans the field is partially excited from the network and the speed is regulated by a resistance in series with the armature. The motor then acts as a shunt motor. According to the magnitude of the load, it acts as

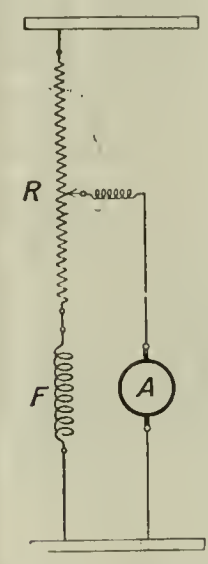


Fig. 1.—Ordinary Arrangement.

A=Armature.
F=Field.
R=Series Resistance.

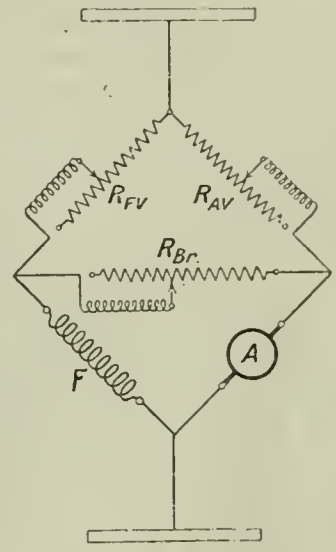


Fig. 2.—Moeller's Arrangement.

A=Armature Field.
R_{AV}=Series Resistance for Armature.
R_{FV}=Series Resistance of Field.
R_{Br}=Braking Resistance.

motor or generator. In both cases the connections are such that the armature, as generator, sends some of the current into the field winding; consequently the field is strengthened and a brake is provided. It is not necessary to enter into calculations; but it is evident that on this plan the motor endeavours to keep its speed constant even though the load varies over the widest limits. A nearly constant speed corresponds to each position on the controller. Thus the driver always has the load under control, and a sudden fall of the load or excessive speed of the motor is avoided. The plan, shown in Fig. 1, takes rather a large current, especially when the loads are below the average. The matter may be looked at in the following way. With light loads or with no load, the armature develops a torque and takes current from the network; with heavy loads it gives out current. In passing from one stage to the other the current in the armature will be zero. The current, taken from the network, will then depend entirely on the magnitude of the resistance in series with the field. The amount of this resistance can be determined as follows: For the acceleration of the armature of the motor and the driving mechanism, when there is no load to be lowered, a certain torque is necessary, if this is to be done in a prescribed time. Let us suppose that, in the first position with the armature at rest, the current is to be equally divided between the armature and the field winding. Let us assume, further, that with no load we need a torque of 25 to 40 per cent. to accelerate from rest

* Abstract of an article in the "Elektrotechnische Zeitschrift," Heft 20, 1916.

and to overcome the effects of friction ; then it becomes evident that in the first position when the armature is at rest a current of at least 100 per cent. must pass. From this we can deduce the ohmic value of the resistance. The essence of the plan, shown in Fig. 1, is that in all regulating positions the field winding must be joined to the network through this resistance. Now, on light loads of about 25 or 30 per cent. of the maximum load, the load is braked through the driving mechanism, and therefore the braking effect, provided by the motor, is very small or even zero ; therefore, on light loads, the current in the armature will be zero. The current in the field winding will therefore be equal to the ratio of the field network to the sum of the ohmic values of the field winding and the regulating resistance. This current will therefore differ only slightly from that which passes in the first stage through the motionless armature. The field current or the current absorbed on light loads will therefore not alter at all from one position to the next ; the speed will be the only thing that will vary with a change of position on the controller. The current, being invariable, is therefore unnecessarily high on light loads, and H. Moeller has, therefore, proposed the plan shown in Fig. 2. There is a special resistance both for the armature and field ; the braking resistance is also separately variable. In this case there is not the disadvantage of having a constant current on light loads for all positions on the controller. The speed of the armature can be increased by weakening the field, consequently the current-consumption is less. The advantages of this arrangement are well shown by the following facts, relating to a foundry crane: there is on light loads a smaller consumption of current. The lowerings of the load may be considered as follows ; 25 per cent. of all lowerings take place with maximum load ; of these, four times with slow speeds and once with average speed. Fifty per cent. of all lowerings are with light loads, on an average amounting to about 30 per cent. of the normal load ; of these, 25 per cent. are with low speeds and 25 per cent. with high speeds. Lastly, 25 per cent. of all lowerings are with no load, almost always at high speeds. We can therefore assume that on an average 70 per cent. of all lowerings with light loads (in which case the braking moment is zero) take place with a mean speed equal to about 80 per cent. of the normal speed. The conditions in most practical cases are similar, because the motor must be capable of dealing with the maximum loads, though these are seldom dealt with.

We shall now show how the various steps on the controller can be calculated. The same process can be applied in all cases ; all values are calculated on a percentage basis, as this much simplifies the process and gives a method generally applicable. A torque of 100 per cent. means the torque on the pulley of the motor when it is taking its normal input. A voltage of 100 per cent. means the network voltage ; a current of 100 per cent. means the normal current ; 100 per cent. resistance means the ratio of the network voltage to the normal current. The following notation will be adopted :—

v is the speed.
M is the torque on the pulley of the motor.
I is the current in the armature.
I_F is the current in the field.
I_{AV} is the current in the resistance in series with the armature.
I_{FV} is the current in the resistance in series with the field.
I_{Br} is the current in the bridge.
I_L is the current in the connecting cables.
R_{AV} is the resistance in series with the armature.
R_{FV} is the resistance in series with the field.
R_{Br} is the resistance of the bridge.
Φ is the flux.
E is the electromotive force.
U is the network voltage.

The flux characteristic will form the basis of the calculations, *i.e.*, the curve which shows the relation between the flow of the lines of force and the current in the field winding. Naturally the values would be shown as percentages. This curve is easily constructed for any motor, and is usually known for ordinary motors. We wish to limit the speed of lowering the heaviest loads, therefore this case must be considered first. We must remember that the greatest turning moment on the motor pulley during the lowering of the load may be estimated at 70 or 80 per cent. of the normal turning moment, the precise figure depends on the efficiency of the driving gear. Thus Φ ought to be as small as possible in order that the current-consumption may be low. The field current must not be too low, otherwise the starting torque might not be sufficient. Further *Example*. Having regard to the starting torque, we choose I_{FV} between 20 and 40 per cent., and remember that $I_{Br} = I_L - I_{FV}$.

In order to simplify the calculations we shall neglect the resistances of the armature and field. These are very small and scarcely more than 2 or 3 per cent. Therefore $E_{Br} = E$. I_{Br} acts in the opposite direction to the network voltage, and has always the same sign, seeing that the directions of turning and of the flow of the lines of force always remain the same. The current in the bridge flows from the armature to the field and is zero, when the armature is at rest. This assumes that the common point of armature and field is connected to the negative pole. Further,

$$R_{FV} = U / I_{FV},$$
$$I_{AV} = I_{Br} - I, \qquad (1)$$
and
$$R_{AV} = (U - E)/I_{AV}.$$

When E is greater than U. It may be further noted that I_{Br} is always less than I_L and I_{Br} is greater than I, so long as E is less than U.

An example may help to explain things further. In calculating for position I on the controller, one would assume that the speed for the heaviest load would be about 30 per cent. of the normal. Further, the flux Φ for the heaviest load would be assumed to be about 110 per cent. The current in the field winding would then be found from the characteristic to be 140 per cent. Assuming the greatest braking moment to be 80 per cent., the current in the armature would be the ratio of 80 to 110, *i.e.*, 73 per cent. The current-consumption on the maximum load in this position would be 140 − 73, *i.e.*, 67 per cent. With reference to the starting torque, the current in the resistance in series with the field winding would be taken at 40 per cent. The resistance in series with the field is the ratio of 100 to 40, *i.e.*, 250 per cent. The current in the bridge would be 140 − 40, *i.e.*, 100 per cent. $E = 30 \times 110$, *i.e.*, 33 per cent. The bridge resistance is 33 per cent. The current in the resistance in series with the armature is 100 − 73, *i.e.*, 27 per cent., whence we find that R_{AV} is 250 per cent. With a light load, with a braking moment of zero, we have the following conditions in position 1. The armature current is zero ; the current in the bridge is equal to that in the resistance in series with the armature, and this works out to about 35 per cent. The armature voltage is equal to the current in the bridge, multiplied by the resistance of the bridge, *i.e.*, about 11·6 per cent. The author gives other calculations relating to the solution of the problem which are not reproduced here. He also gives a schematic diagram showing the connections on the controller. The method has been protected by patent and is being exploited by the firm of F. Kloeckner, of Cologne-Bayenthal. An example, taken from a particular installation, may be mentioned in which the motor had a capacity of 11 kw.; the voltage was 220 and the current 60 amperes. The resistance, therefore, was 3·6 ohms. Therefore, in position 1, we have R_{AV} is 9 ohms ; R_{FV} is also 9 ohms ; and R_{Br} is 1·2 ohms.

CORRESPONDENCE.

THE 2000TH ISSUE.

TO THE EDITORS OF THE ELECTRICIAN.

It gives me great pleasure to offer my congratulations on the 2000th issue of THE ELECTRICIAN. During all of the 38 years which have elapsed since the first issue appeared THE ELECTRICIAN has taken a leading part in disseminating that knowledge of the electrical science, art and industry, which is the first essential to our utilisation of this wonderful embodiment of energy in the universe. The whole world has been enriched and enlarged by the continuous labours of THE ELECTRICIAN, as these 2 000 numbers have been compiled and distributed.

What a wonderful period these 2,000 issues cover! When the first appeared the electrical industry was almost entirely confined to telegraphy and galvanoplastics. Electric lighting, electric power distribution, electric locomotion and radio communication can be studied in their historical development by looking over the pages of the intervening numbers.

With this fine record of achievement we all hope that THE ELECTRICIAN will go forward towards its next "kilo-issue," with undiminished assiduity, and that its columns may convey many more records of electrical discoveries, inventions, solved problems, manufactures, enterprises and achievements.

Harvard University, U.S.A., Aug. 31. A. E. KENNELLY.

THE EVOLUTION OF THE ELECTRIC LAMP.

TO THE EDITORS OF THE ELECTRICIAN.

I have read with very much interest the excellent article on the above in your special issue of September 15th by Mr. Clifford C. Paterson. In respect to the efficiency of the tungsten lamps, Mr. Paterson makes the following statement :

"It has never been found possible to put tungsten filament vacuum lamps in general on the market at a higher efficiency than about 0·8 candles per watt."

This means an efficiency as usually expressed of 1·25 watts per candle.

This is one of those general statements which is not only misleading but is not a correct statement of the facts of the case. Mr. Paterson has only to consult the standard specifications for tungsten filament lamps in force to-day by the leading manufacturers in Great Britain to find that the following efficiencies are in force for standard types of tungsten filament vacuum lamps, and which are all of them better than the limits he places of 1·25 watts per candle. The following should be noted for—

100–130-*volt Lamps.*

Sizes in total watts.	Initial efficiency in W.P.C.
20 watts	1·20
30 ,, ...	1·15
40 ,, ...	1·15
60 ,, ...	1·10
100 ,, ...	1·05
150 ,, ...	1·0
200 ,, ...	1·0

200–260-*volt Lamps.*

Sizes in total watts.	Initial efficiency in W.P.C.
40 watts	1·20
60 ,, ...	1·15
100 ,, ...	1·10
150 ,, ...	1·10
200 ,, ...	1·10

Even still higher efficiencies than these are in force on tungsten filament lamps supplied in the United States and Canada, of which the following instances show materially better values than the limitations given by Mr. Paterson—

For 100–125-*volt Lamps.*

Sizes in total watts.	Initial efficiency in W.P.C.
20 watts	1·10
25 ,, ...	1·05
40 ,, ...	1·03
60 ,, ...	1·0
100 ,, ...	0·95

For 200–250-*volt Lamps.*

Sizes in total watts.	Initial efficiency in W.P.C.
25 watts	1·20
40 ,, ...	1·12
60 ,, ...	1·10
100 ,, ...	1·0

It should be noted that the lamps in the above efficiencies are offered in the best known makes of thoroughly reliable character and giving a useful life performance of 1,000 hours or more.

The above statement of efficiencies is not a paper statement or guarantee, but represents the actual values under which tungsten lamps are being regularly supplied to Government departments and other important purchasers, who verify the values by an initial test and inspection before the lamps are accepted or supplied.

Mazda House, London, Sept. 23. F. W. Willcox.

THE I.E.E. AND THE CITY AND GUILDS OF LONDON INSTITUTE.

TO THE EDITORS OF THE ELECTRICIAN.

We have heard so much in recent years as to what our Institution ought to do that we may, perhaps, be pardoned for adding another item to the list.

The various premiums offered by it (mostly due to legacies) are only obtainable by experts or by very promising students; and the A.M.I.E.E. examination is based on such a high plane that very few indeed are successful in scaling the heights. The actual number, we believe, is ridiculously small.

We are repeatedly told from various quarters how much more attention we shall in future have to give to technical education. This being so, we would suggest that the Institution might do something to aid general electrotechnical education. This it might do by founding scholarships and (or) offering prizes in the six electrical subjects (including Section B of *Engineers' Quantities and Estimating*) that are dealt with by the City and Guilds of London Institute, these main subjects covering over 20 separate examinations.

The prizes and medals awarded in these subjects have all along been given by the City Guilds and various City Livery Companies; but with the exception of those in telephony and telegraphy, the prizes are not definitely offered this coming session, probably on account of the war. Whatever the I.E.E. did should be in addition to the above, and would have the effect of reminding many heads of electrical engineering departments in technical colleges that these examinations merit much wider recognition than they seem to get in some quarters. The Society of British Gas Industries and various other trade associations encourage the learning of their respective subjects in various ways, so there is no want of precedent.

While the electrical subjects dealt with by the City Guilds are fully as important as those pertaining to any other department of science or engineering, the I.E.E. has no representation on either the Council, the Executive Committee, or the Technology Committee, although all three of these bodies include the presidents of the Institution of Civil Engineers, the Chemical Society and the Society of Arts, the president of the Royal Society being on the first two. Why should not our Institution ask to be similarly represented? It is true that Prof. T. Mather's name appears on the examination board, but that is not enough. It has not been instrumental, for example, in securing the revision of the peculiar lists of works of reference that appear after each syllabus. Consider, for example, that relating to Subject 40—*Electrometallurgy*. This includes eleven English books, seven German ditto and six periodicals. The *Telegraphy* list comprises about two dozen books. The list for *Electrical Engineering* enumerates some 45 books, many of which have long been either out of print or out of date. On the other hand, many recent works of acknowledged merit are ignored. These lists have been the subject of mingled indignation and mirth for years, and attention has been repeatedly drawn to their shortcomings. They ought to be revised annually, and would be doubly valuable if they were based on the recommendations of leading professors and teachers throughout the country.

Other lists which require overhauling are those of registered teachers given at the end of the City Guilds' "*Programme*."

London, Sept. 21. A. P. Lundberg & Sons.

VACUUM DETECTORS.

TO THE EDITORS OF THE ELECTRICIAN.

The article on "Vacuum Detectors" by Dr. Eccles, published in the August 4th issue, was read with great interest by the writer, who wishes to state that the fundamental of all the devices therein published was due to a party whom Dr. Eccles has failed to mention, and who is Dr. Lee de Forest, of the United States. Lee de Forest is the inventor of the original three-electrode vacuum detector.

All the devices described in the article are nothing more or less than an "audion," with perhaps a change in shape or manner in which the different electrodes are placed. It is for this reason that the writer does not see why credit is not at least given to Dr. de Forest for his laborious work which he has given in developing and inventing the audion.

One of the most important claims of all the De Forest patents, both in America and abroad, is that of the additional or third cold electrode which is perforated, and of the additional battery of high potential or the so-called "B" battery, as employed in the third or intermediate or wing circuit. The use of this "B" battery on the wing was originated by the mentioned inventor, and the sensitiveness of all the devices similar to the audion depend entirely upon the "B" battery. His early patents point out clearly the use of this high potential current on the wing.

It is, perhaps, unjust both to the inventor and to the public at large not to credit him, and also giving the public the proper data as regards the development of the three-electrode vacuum detector, and I trust that you will correct the matter by publishing something regarding the above in your journal, as I am a constant reader of your valuable paper. I have been in the radio field for a number of years, and follow up in detail the development of the vacuum tubes both as detectors of current, of radio frequency and as generators for sustained waves.

Brooklyn, U.S.A., Aug. 28. Samuel Cohen.

[We think that our correspondent has omitted to notice that the articles by Dr. Eccles appear from time to time, and consequently each article deals merely with the patents which have appeared in the preceding interval.—Eds. *E.*]

A ONE-TON ELECTRIC LORRY AT MANCHESTER.

When considering the advisability of substituting motor traction for horse vehicles, traders are frequently at a loss to find a suitable basis for a comparison of the performance of the two systems, and in addition they usually have but a hazy idea of the cost of their existing service. The following notes relating to trials with an electric lorry by the Manchester Corporation electricity works will, therefore, doubtless be of interest, as the method of comparison employed can be adapted to most cases where horse vehicles are employed.

Prior to the purchase of the vehicle illustrated in Fig. 1, which is built on a standard Edison Accumulator model G.M. chassis, supplied by Drake & Gorham (Ltd.), 47, Spring Gardens, Manchester, the carting work was carried out by light horse lorries supplied under contract at a very cheap rate. Until recently the charge made for a lorry with horse and driver was 1s. 4d. per hour, but this rate has now been increased to 1s. 6d. per hour. For the purpose of comparison, the lower figure has been taken, and it may be remarked that the charge is an extremely moderate one, even under pre-war conditions, and is possible only in similar cases, where a carting contractor carrying on business on a large scale supplies several vehicles for fairly regular duty. An examination of the delivery costs of a retailer employing several light horse vans will in many cases indicate a higher figure when all charges are taken into account.

The cost of running a horse vehicle can reasonably be stated as an hourly rate, as it is practically independent of the distance travelled —the horse requires feeding equally whether the greater part of its time is spent in actually travelling or in standing, for the purpose of loading, delivering, &c. A record of the work performed by the lorries hired in the case under consideration showed that on an average they travelled 2 miles per hour during the time actually paid for. This average effective speed may appear low at first sight, but when all standing time is taken into consideration, it will be found



Fig. 1.—View of the Electric Lorry.

to be approximately correct for many cases of town and suburban trade deliveries. Few horses on such duty cover more than 18 to 20 miles in a day's work.

Unlike the horse vehicle, the cost per hour of running a motor wagon of any description varies according to the distance travelled. It is made up of two components—the standing charges, which are, within limits, independent of the mileage; and the running costs, varying with the distance covered. In the case of the Manchester vehicle, the standing charges have been taken at £125, and are made up as follows:—

Interest on total capital outlay at 4½ per cent.
Depreciation on chassis and body, written down in 10 years.
Depreciation on battery, written down in 5 years.
Insurance and drivers' licences.

It will be noted that the allowance for standing charges is on a liberal scale, as the manufacturers anticipate a battery life approximately equal to that allowed for the chassis, viz., 10 years.

The total of £125 per annum spread over 2,500 working hours per annum gives a figure of 1s. per hour, to which 7d. per hour for the driver's wages should be added.

With regard to running costs, the vehicle has been found to take on an average 6·5 ampere-hours battery input per mile run, and including the loss in the motor-generator used for charging, the energy per mile averages exactly 1 kw. hour, for which the cost is taken as 0·5d. The cost of tyre renewals has been taken as 0·5d. per mile, while for maintenance, renewals and repairs 1d. per mile is allowed, which should prove ample. The total running costs are thus 2d. per mile.

The total cost of an hour's work during which a mileage of, say, 3 miles is covered, is therefore:—

	s.	d.
Standing charges	1	0
Driver's wages	0	7
Running costs, 3 miles at 2d.	0	6
Total	2	1

The curves in Fig. 2, which is due to Mr. H. A. Ratcliff, of the Manchester Corporation electricity works, indicate the relation between the horse and electric lorries in cost per hour and per mile for different average speeds. A is the cost per hour of the horse lorry, which is constant at 16d., and B the cost per mile for various average speeds. Similarly, C is the cost per hour, and D the cost per mile of the "electric" at different speeds.

As already stated, the average effective speed of the horse lorries has been found to be about 2 miles per hour, corresponding to a cost of 8d. per mile. It will be seen that to compete with this figure the "electric" must average about 3⅓ miles per hour, including all standing time.

The following schedule, supplied by Mr. S. L. Pearce, chief engineer of the Manchester Corporation electricity works, contains an analysis of the work of the electric lorry for the month of July last. It will be seen that the average effective speed has been increased to 4·04 miles per hour. This is due to the fact that although the maximum travelling speed is not greatly in excess of that of a trotting horse, the electric vehicle can be kept hard at work throughout the day;

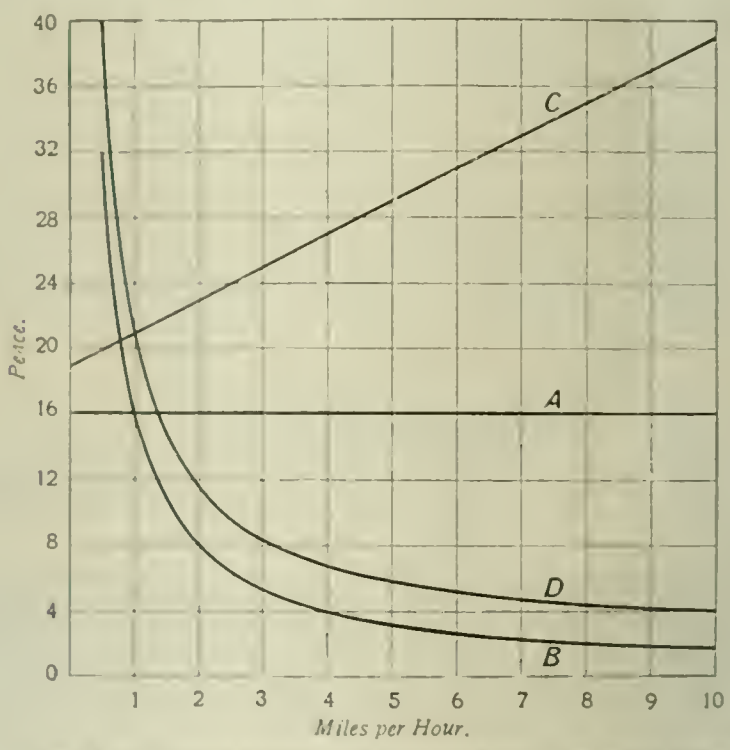


Fig. 2.—Curves showing Variation of Cost with Speed.

it does not require a "breather" after a stiff hill, nor a prolonged rest at mid-day. Two drivers are available and consequently time may often be saved by changing drivers in the middle of the day and running through without a break. This is in striking contrast to the horse-drawn vehicles, which have to be allowed a break of 1½ hours for baiting. It may be noted that the two drivers are rated as fitters' mates, and they can thus be kept fully occupied when not required on the lorry. Their experience in this capacity is also frequently of assistance in unloading motors, &c., and in certain cases makes it possible to dispense with an extra man.

The lorry has been in daily use for over five months and has replaced several horse vehicles. On mileage alone it is the equivalent of 2·4 horse vehicles, which on an average run about 100 miles per week. The work performed is mainly in connection with the mains, sub-stations and testing departments, and the material conveyed includes motors, switchgear, transformers, air compressors, cable, troughing and timber, bricks and tiles, cement and mortar, coke, sand, broken stone, castings and general stores. On a large proportion of the journeys made the lorry is working for more than one department, as indicated under references 10 and 11 on the schedule, and the improved organisation rendered possible by its employment has further increased the displacement of horse lorries, so that actually it is performing the work previously done by about 3½ horse-drawn vehicles.

Substantial evidence of this is provided by the reduction on the carting contractor's accounts, the difference between this reduction and the cost of the electric lorry being given by Mr. Pearce as over £5 per week. It should be remembered that this saving is effected

after full provision is made for capital costs and other contingencies, and it will be agreed that the electric has thoroughly justified itself. The results shown in the schedule are in no way abnormal and are being well maintained. So far, the maximum daily mileage has been 56·1, and this was attained with a mid-day boost of 120 amperes for half-an-hour, given whilst the vehicle was being loaded.

Analysis of Carting Results with Electric Lorry.

Particulars of carting.	Week ended July 8.	July 15.	July 22	July 29	Average of four weeks' results.
1. Total miles	210·7	231·4	260·7	253·3	239·0
2. Total hours	56·5	56.16	64·83	59·33	59·21
3. Total journeys	29·0	30·0	31·0	31·0	30·25
4. Average miles per hour	3·74	4·12	4·02	4·27	4·04
5. Ave. miles per journey	7·275	7·71	8·4	8·17	7·90
6. Average miles per day	38·4	42·1	47·4	46·1	43·46
7. Max. miles per day	48·6	45·5	56·1	52·9	50·8
8. Ave. hours per journey	1·95	1·87	2·09	1·91	1·95
9. Ave. journeys per day	5·27	5·45	5·64	5·64	5·50
10. Equiv. No. of departmental journeys	47·0	52.0	55·0	50·0	51·0
11. Ave. departments per journey	1·62	1·73	1·77	1·61	1·68
12. Ave. load "Out" (cwt.)	14·07	13·83	16·65	15·75	15·08
13. Ave. load "In" (cwt.)	5·73	4·13	5·52	3·39	4·69
14. Total average ton-miles	104·3	103·9	144·3	121·0	118·3
15. Average cost per mile	7·08d.	6·61d.	6·72d.	6·45d.	6·70d.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
16. Total cost per week	6 4 2	6 7 4	7 6 0	6 16 0	6 13 6

NOTE.—5·5 working days are reckoned to the week.

HIGHER HARMONICS OF INDUCTION MOTORS DUE TO WINDING DISTRIBUTION.*

BY A. H. MITTAG.

It has been found that induction motors with squirrel-cage rotors sometimes tend to stick at a sub-synchronous speed. This tendency to stick is caused by higher harmonics in the rotating field.

In order to produce a field which shall have a sine wave distribution, the magnetomotive force producing the field, or in other words, the magnetising current must have a sine wave distribution. Such a distribution of magnetising current is not obtained with the windings used in the primary of induction motors. It is more closely approximated in three-phase windings than in quarter-phase windings and more closely in quarter-phase windings having a fractional pitch than in those having a full pitch.

By making an analysis of the current distribution, it can be determined which harmonics are present and what their values are. Although the current is not uniformly distributed over the surface of the primary but is concentrated in slots, it has, however, been found to be sufficiently accurate to assume a uniform distribution. This is especially true for the larger harmonics, such as the third and the fifth which seem to be the only ones of any importance. The current per phase in a quarter-phase winding having 100 per cent. pitch can then be represented by a rectangular wave, such as shown in Fig. 1. The analysis of such a wave into sine waves is represented by the following series :—

$$\sqrt{2}y=\frac{4y}{\pi}(\sin x-\tfrac{1}{3}\sin 3x-\tfrac{1}{5}\sin 5x+\tfrac{1}{7}\sin 7x+\tfrac{1}{9}\sin 9x-,\ \&c.).$$

It will be seen from above that all the odd harmonics are present and that the value of the third is one-third of the fundamental, and of the fifth is one-fifth of the fundamental, &c. The fundamental and the higher harmonics up to the seventh are shown in Fig. 1. These sine waves are standing waves and all have the same frequency, that is, the frequency of the voltage impressed on the primary. The higher harmonics are not higher harmonics with respect to time but with respect to space. It is assumed that the current in the line and, therefore, also the current in the winding follows the sine law with respect to time. The waves shown in Fig. 1 represent the analysis of one phase and that of the other phase is, of course, the same, so that the two sets of sine waves produce travelling waves which are shown in Fig. 2 for the instant when the currents in the two phases are equal. Again the waves as shown in Fig. 2 can be expressed by a series which is

$$y=\frac{4y}{\pi}(\sin x+\tfrac{1}{3}\sin 3x+\tfrac{1}{5}\sin 5x+,\ \&c.).$$

* From the "General Electric Review."

The third and seventh harmonics travel in a direction opposite to that of the fundamental and the fifth and ninth harmonics in the same direction as the fundamental; thus the third and seventh harmonic fields will rotate in a direction opposite to the fundamental field and the fifth and ninth harmonic fields in the same direction as the fundamental field. From this it follows that the third and seventh harmonics will cause no trouble in starting a quarter-phase induction motor from rest since their synchronous speeds are at a point where the slip is more than 100 per cent., being at $133\frac{1}{3}$ per cent. slip for the third harmonic and at $114\frac{2}{7}$ per cent. slip for the seventh harmonic. If, however, it is desired to reverse the direction of rotation of the motor by applying power with reversed phase rotation, then the third and seventh harmonics may cause trouble. The fifth and ninth harmonics may cause sticking at speeds between 100 per cent. slip and synchronism since the fifth harmonic has its synchronous speed at 80 per cent. slip of the motor and the ninth at $88\frac{2}{9}$ per cent. slip. The synchronous speeds of the higher harmonic fields are determined by their frequency and number of poles, the frequency as already stated is the same as that of the fundamental

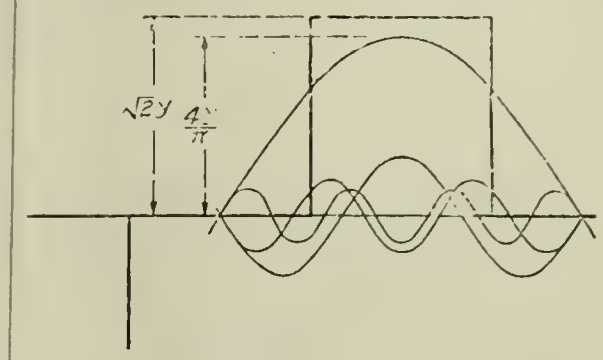


FIG. 1.

field, but the number of poles of the third harmonic field is three times the number of poles of the fundamental field and the number of poles of the fifth harmonic field is five times the number of poles of the fundamental field, &c.

These higher harmonic fields produce torques which come to a peak value near the points of synchronism of these fields and if these peak values are larger or nearly as large as the torque produced by the fundamental field at these points, sticking will result. Only the third and fifth harmonics are apt to cause trouble since the torques produced by the other harmonics are not large and in general negligible. The higher harmonic torques decrease in value if the resistance or reactance of the secondary of the motor is increased or if the magnetising current is increased.

So far this discussion applies only to a quarter-phase winding having 100 per cent. pitch, but it can easily be applied to a quarter-phase winding having any value of pitch. Let the analysis as shown in Figs. 1 and 2 be only for the currents in the upper half of the slots, then for the currents in the lower half of the slots there will be a

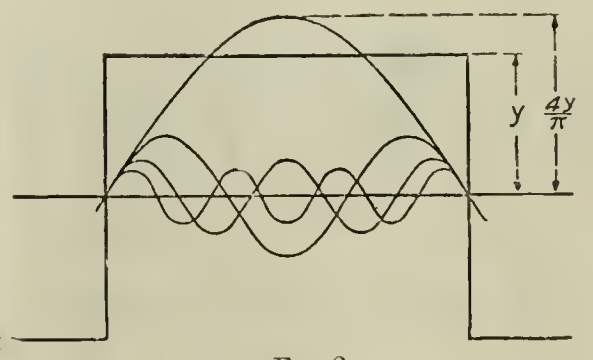


FIG. 2.

similar set of sine waves, but there will be a phase displacement between these two sets of waves equal to the amount that the pitch lacks of being 100 per cent. These two sets of sine waves can then be combined into a resultant set of waves. The relative values of the resultant fundamental and resultant higher harmonics for any value of pitch is given by the following equations :—

$$\text{Fundamental}=\cos[90\text{ deg. }(1-F.P.)]$$

$F.P.$ = fractional pitch.

$$\text{Third harmonic}=\tfrac{1}{3}\cos 3\frac{\pi}{2}(1-f_p);$$

$$\text{Fifth harmonic}=\tfrac{1}{5}\cos 5\frac{\pi}{2}(1-f_p);$$

$$\text{Seventh harmonic}=\tfrac{1}{7}\cos 7\frac{\pi}{2}(1-f_p).$$

It will be seen from the above equations that if a $\frac{2}{3}$-pitch winding is used, the third harmonic will be entirely eliminated, and if a

$\frac{1}{3}$-pitch winding is used, the fifth harmonic will be entirelyeliminated. Thus with a $\frac{1}{3}$-pitch winding there should be no troublem bringing a quarter-phase induction motor with a low-resistance squirrel-cage rotor from standstill to full speed.

A three-phase motor is not so apt to have sub-synchronous speeds as a quarter-phase motor. Fig. 3 shows the analysis of the current of one phase of a three-phase winding having 100 per cent. pitch up to the seventh harmonic, and this analysis is given by the following series:

$$y = \frac{2y}{\pi}[\sin x - \tfrac{1}{3}\sin 3x + \tfrac{1}{5}\sin 5x + \tfrac{1}{7}\sin 7x - \tfrac{1}{9}\sin 9x - , \&c.].$$

When this set of standing sine waves is combined with those of the other two phases, it will be found that there is no third harmonic, but there is a fifth and seventh harmonic and the ninth, as the third, is not present. The value of the fifth is one-fifth of the fundamental and of the seventh is one-seventh of the fundamental. The fifth harmonic field rotates in a direction opposite to the fundamental field and the seventh harmonic field in the same direcion as the fundamental field. The fifth harmonic will, therefore, caus no trouble in starting a three-phase motor from standstill as its synchronous speed is at 120 per cent. slip of the motor, but the seventh will cause sticking between standstill and full speed if it has a sufficient value of peak torque, since its point of synchronism is at $85\frac{5}{7}$ per cent. slip of the motor.

If a fractional pitch winding is used, the equations gven above for the relative values of the fundamental and the higherharmonics in a quarter-phase winding can also be used for a three-phase winding with the exception of that for the third harmonic, the third harmonic not being present in a three-phase winding. Then

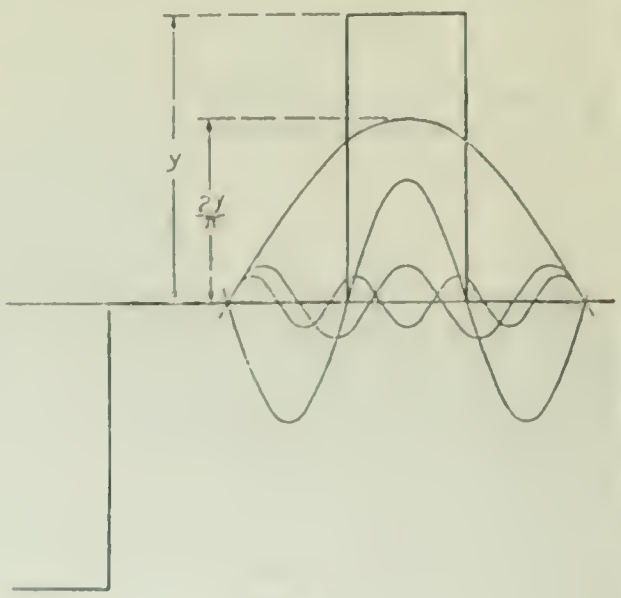


Fig. 3.

with a $\frac{1}{5}$ pitch winding the fifth harmonic will be eliminated and with a $\frac{1}{7}$ pitch winding the seventh harmonic will be eliminated. From this it follows that there should be no trouble in bringing a three-phase induction motor with $\frac{1}{7}$-pitch winding and having a low-resistance squirrel-cage from standstill to full speed.

AN IMPERIAL TRADE BANK.

The Committee on Financial Facilities for Trade has presented an important Report to the President of the Board of Trade in which interesting recommendations are made for the development of British trade and manufactures. It is suggested that a "British Trade Bank" should be constituted under the Royal Charter in order to fill the gap between the home banks and the Colonial and British-foreign banks and banking houses, and to grant facilities not provided by the present systems. The main features of the Trade Bank should be as follows:—

(I.) It should have a capital of £10,000,000. The first issue should be from £2,500,000 to £5,000,000 upon which in the first instance only a small amount should be paid up, but which should all be called up within a reasonable time. A further issue should be made afterwards, if possible, at a premium.

(II.) It should not accept deposits at call or short notice.

(III.) It should only open current accounts for parties who are preparing to make use of the overseas facilities which it would offer.

(IV.) It should have a Foreign Exchange Department where special facilities might be afforded for dealing with bills in foreign currency.

(V.) It should open a Credit Department for the issue of credits to parties at home and abroad.

(VI.) It should enter into banking agency arrangements with existing Colonial or British-foreign banks, and where such arrangements were made it should undertake not to set up for a specified period its own branches or agencies. It should have power to set up branches or agencies where no British-foreign bank of importance exists.

(VII.) It should inaugurate an Information Bureau.

(VIII.) It should endeavour not to interfere in any business for which existing banks and banking houses now provide facilities, and it should try to promote working transactions on joint account with other banks, and should invite other banks to submit to it new transactions which, owing to length of time, magnitude, or other reasons, they are not prepared to undertake alone.

(IX.) Where desirable, it should co-operate with the merchant and manufacturer and possibly accept risks upon joint account.

(X.) It should become a centre for syndicate operations, availing itself of the special knowledge which it will possess through its Information Bureau.

(XI.) It should receive Government assistance.

The members of the Committee are of opinion that there exists to a considerable extent at the present time in this country the machinery and facilities for the finance of home trade and large oversea contracts, and for carrying through much of the business which has been done by foreign banks, the Report states that our arrangements are faulty in not co-ordinating many of the facilities mentioned. The Report states:—

"We recognise also that the British manufacturer may be frequently in want of finance of a kind which a British Joint Stock bank with liabilities could not prudently provide, whereas the German banks in particular seem to have been able to afford special assistance at the inception of undertakings of the most varied description, and to have laid themselves out for stimulating their promotion and for carrying them through to a successful completion. We conclude, therefore, that there is ample room for an institution which, while not interfering unduly with the ordinary business done by the British Joint Stock Banks, by Colonial banks, and by British-foreign banks and banking houses, would be able to assist British interests in a manner that is not possible under existing conditions.

"Such an institution could also take a leading part in the inception of transactions and assist in connection with the machinery of overseas business.

"The institution must be equipped with an up-to-date information department, and this will of necessity play a large part in its usefulness and financial success. This might properly be called a Bureau d'Etudes, independent of the Commercial Intelligence Branch of the Board of Trade but in close touch therewith and under agreement entitled to all possible facilities. That such a bureau is essential has been made abundantly clear by the evidence given by witnesses we have heard and also by the evidence given before other Committees. It would not necessarily deal only with schemes in which the institution proposed to take financial interests, but might be made a centre for investigation of projects on behalf of others, and a considerable revenue might be obtained thereby.

"Nearly as important as the board would be the general staff. It is fair to assume that women will in the future take a considerable share in purely clerical work, and this fact will enable the institution to take fuller advantage of the qualifications of its male staff to push its affairs in every quarter of the globe. Youths should not be engaged without a language qualification, and after a few years' training they should be sent abroad. It could probably be arranged that associated banks abroad would agree to employ at each of their principal branches one of the institution's clerks, not necessarily to remain there for an indefinite period, but to get a knowledge of the trade characteristics of the country. Such clerks might in many cases sever their connection with the banks to which they were appointed and start in business on their own account. They would, however, probably look upon the institution as their 'Alma Mater.' Every endeavour should be made to promote *esprit de corps*, and where exceptional ability is developed, it should be ungrudgingly rewarded. If industry is to be extended, it is essential that British products should be pushed, and manufacturers, merchants and bankers must combine to push them. It is believed that this pushing could be assisted by the creation of a body of business young men in the way above described.

If financial assistance is given by the Government to undertakings in connection with what are known as 'key' industries, the business should, if possible, be done through the medium of the institution. In the financial operations of the institution the desirability of assisting British trade and of placing with British manufacturers orders in connection with new undertakings should be always borne in mind. We are of opinion that there are strong reasons why the bank should be formed without delay, so that preliminaries may be completed before the war is over. We believe that a bank constituted upon the above lines, with efficient management, should not only be a great boon to British trade, but should prove a commercial success."

The members of the Committee were:—Lord Faringdon (Chairman), Mr. B. P. Blackett, C.B., Sir W. H. Clark, K.C.S.I., C.M.G., Mr. F. Dudley Docker, C.B., Mr. Gaspard Farrer, Mr. W. H. N. Goschen, the Right Hon. E. Huth Jackson, Mr. Walter Leaf, the Hon. A. B. Mills, Mr. J. H. Simpson, Mr. R. V. Vassar Smith, and the Hon. R. E. Peckett. The Report is not signed by Mr. Gaspard Farrer.

EDUCATIONAL.

King's College (University of London).—The new term begins on Wednesday, Oct. 4th. The Faculty of Engineering have arranged courses of study extending over three or four years in civil, mechanical and electrical engineering for the engineering degrees of the University of London and for the diploma and certificate of the College.

The four years' course provides, in addition to the academic training, opportunities for practical training in works. Additions to the engineering department include a large drawing office and lecture rooms for the mechanical and civil engineering departments and a lecture theatre and rooms for research, including wireless telgraphy, for the electrical engineering department. There are well appointed laboratories for teaching and research work. Full information may be obtained from the Dean or the Secretary, King's College, London, W.C.

University of London, University College.—On Oct. 27th at 5 p.m. Prof. J. A. Fleming, M.A., D.Sc., F.R.S., will commence a series of six lectures on "Long Distance Telephony." Prof. Fleming will deliver a free public lecture on "Long Distance Telegraphy and Telephony" on Oct. 18th at 5:30 p.m. The course of six lectures will be open to members and non-members of the University, the fee being £1. 11s. 6d. Applications for tickets to the secretary, Mr. Walter W. Seton, M.A., D.Lit., Gower-street, W.C.

Armstrong College (University of Durham), Newcastle-on-Tyne.—The new session commenced on Sept. 25. Full particulars relating to the departments of mechanical, marine, civil and electrical engineering, naval architecture, mining, metallurgy, agriculture, pure science, arts and commerce may be obtained from the secretary, Mr. F. H. Pruen, M.A.

Royal Technical College, Glasgow.—The session 1916-17 begins on Sept. 26.

The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, &c. There are also full courses of instruction in the schools of navigation and wireless telegraphy, and both day and evening classes are held. The diploma courses extend over three or four sessions, and the average fee is £12. 12s. per session. The college is affiliated to the University of Glasgow, and the degrees of the university in engineering and applied chemistry are open to its students. Prospectuses from the Director.

Northampton Polytechnic, London.—In the day engineering college full-day courses in the theory and practice of civil, mechanical and electrical engineering will commence on Oct. 2 next. The courses in civil and mechanical engineering include specialisation in automobile and aeronautical engineering, and those in electrical engineering include radiography. Three entrance scholarships of the value of £52 each will be offered for competition at the entrance examination. The courses include periods spent in commercial workshops and extend over four years. They also prepare for the degree of B.Sc. in Engineering at the University of London. In the technical optics department there are full and part time courses in all branches in specially equipped laboratories and lecture rooms. An Aitchison scholarship (value £50) will be offered in this department at the entrance examination. Particulars as to fees, dates, &c., can be obtained at the Institute or on application to the Principal, Dr. R. Mullineux Walmsley.

It is announced that, in view of the continuance of the war, and the consequent absence of many students at the front or on special war or munitions service, the governing body of the polytechnic has decided to suspend the usual annual issue of the "Announcements," but is prepared to start and carry through in the session 1916-17 as many of the courses and classes announced for the preceding session as may be justified by the applications for enrolment received at the commencement of the session. The "Announcements" (as issued a year ago) include day and evening courses in engineering (civil, mechanical and electrical), technical optics and horology. The engineering courses include sub-sections in automobile work, aeronautics and radio-telegraphy. In addition there are evening courses in electrochemistry, metallurgy and domestic economy. Enrolments for the evening courses has commenced.

Manchester School of Technology.—Full courses, leading to the Manchester University degree in the faculty of technology, are provided in mechanical, electrical and sanitary engineering (including municipal engineering), the chemical and textile industries, mining, architecture, &c. During the session 1916-1917, first year courses will be specially adapted to the requirements of students who may wish to take commissions in H.M. Forces.

Battersea Polytechnic.—At this Polytechnic there are day course, in the electrical engineering department for the B.Sc. (Eng.) of London University and for the Polytechnic diploma. There are also evening courses in direct and alternating currents, electrical design, generation and transmission, electrical costs, electric lighting and illumination and electric traction. Sectional calendar 1d. (post free 2d.). Calendar of evening classes gratis on application to the secretary.

Bradford Technical College. The City of Bradford Committee has issued a pamphlet on "Industrial Chemistry and Dyeing as a Career for Men and Women."

The pamphlet, which points out the importance of the application of science to industry as shown by the war, states that there will be in the near future a great demand for highly trained industrial chemists; for women, too, there is likely to be an increasing field in analytical work. There are no standardised qualifications for the industrial chemist, but the essentials are a degree in chemistry of some university or a day diploma of one of the higher technical colleges, or the associateship of the Institute of Chemistry. Whatever course is taken by the student, a sound secondary education up to the age of 16 or 17 is of the greatest importance. The value of the appointment ultimately secured will depend to a large extent upon the soundness of the secondary education and upon the special course subsequently taken; it is, as a rule, only by taking a day diploma course extending over three or four years that the future industrial chemist can hope to fit himself for the higher positions in the industries.

The provision made at the Bradford Technical College for instruction in industrial chemistry would appear to afford a broad and sound training for students preparing to enter the chemical industries (including dyeing and textile chemistry). The pamphlet also gives particulars of fees, scholarships, &c. Further information may be obtained from the secretary.

LEGAL INTELLIGENCE.

Wireless Telegraphy Patents in U.S.A.

The important valve patents have been occupying the Courts of the United States for a considerable time in an action brought by the Marconi Company against Dr. Lee de Forest for infringement of their Fleming patents, and a counter-action by Dr. De Forest claiming damages for infringement by the Marconi Company. We are informed that judgment was given on the 21st inst. in favour of the Marconi Company. Dr. Fleming's patents were declared to be the master patents, and were not anticipated by De Forest or anybody else. The De Forest audion was held to be an infringement of the Marconi Company's Fleming patents. The Atlantic Communication Co. of America, a subsidiary company of the Telefunken Company, of Berlin, has (it is stated) infringed a number of patents in order to obtain a possible wireless service across the Atlantic, and fearing the action by the Marconi Company against them, which is pending, recently purchased the De Forest patents for $150,000. Dr. Fleming's "valve," and many infringements of it, have been largely responsible for the developments in the reception of wireless telegraphic messages over long distances. It was the introduction of these "valves" which gave a value to the Poulsen system, and has been principally responsible for such success as the Germans have obtained both abroad and at home in wireless telegraphy. The experiments recently carried out in wireless telephony in the United States, which gave sensational results, were achieved solely by the use of the Marconi Company's Fleming valve patents.

Alien Enemy Patent.

In the Patent Court on Friday the Controller of Patents (Mr. Temple Franks) and Sir Cornelius Dalton heard an application by Messrs. J. C. McQuilty (Ltd.) for licence to use the German patent 3,117 of 1911 for an electric motor and hammer for removing the incrustation in boilers.

It was explained that the hammer head did not itself strike: it contains a series of cogged wheels which were electrically driven, and when the hammer head was brought into contact with the incrustation tapped the scaling as they revolved, performing 1,500 taps a minute. The electric motor was simply coupled to the lighting or the electric power supply of the works, and the immediate result was an efficient mechanism which performed the work ordinarily done by four men. It got over the ground rapidly, did not mill, chip or injure the plating, and by reason of the flexibility of the attached tube reached awkward places and out-of-the-way corners. The motor was taken with the workman through the manhole into the boiler. The wheels had a hard bright surface and cut readily, and the electric hammer might be used equally well for cleaning tubes or for repairing mill stones. It worked without vibration, and was 40 times as efficient as any tool hitherto in use. It could be readily used by an unskilled workman.

Mr. McQuilty said that it was better than a chip or a pneumatic hammer, which would only deal with thick incrustation. The McQuilty Company was a limited company, privately constituted, having only three shareholders, and their business had always included that of millwrights and boiler scalers. The German patent was known as the Van de Voorde patent. He had already made two of those electric hammers experimentally, and he proposed to commission the British Westinghouse Co. to provide him with his electric motors. He was in negotiation with the patentee before the war broke out, but the negotiations fell through on a question of method of payment. The two experimental hammers worked quite efficiently.

The Controller said there might be trouble after the war over the two hammers Mr. McQuilty had already made unless he were protected

by the Board of Trade. He advised applicant to have his licence made retrospective, so that it covered the two hammers.

Mr. McQUILTY said he did not know that anyone else was making that type of hammer. There was no English manufacture. The Germans before the war, and before the prices of material went up, asked £22. 10s. for one of the hammers. He thought 25s. royalty on each hammer made would be excessive, considering the amount of experimental work he had had to do in perfecting the thing. He only got 20 per cent. profit at present on his labour in work he did for the Government.

The CONTROLLER said he would recommend the Board of Trade to grant Mr. McQuilty a licence, recommending at the same time that the royalty should be £1 on every machine made. He could still while charging the royalty to his customers get the usual manufacturer's 25 per cent. profit.

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

The following abstract from some of the specifications recently published have been specially compiled by MESSRS. MEWBURN, ELLIS & PRYOR, *Chartered Patent Agents, 70 and 72, Chancery-lane, London, W.C.*

Whenever the date applied for differs from the date on which the application was lodged at the Patent Office the former is given in brackets after the title.

1915 SPECIFICATIONS.

7,757 KETTERING & CHRYST. Electrical systems for use with internal-combustion engines. (24/6/14.)

8,012 [illegible] (Pierson Telegraph Transmitter Co.) Telegraph transmitters.

Relates to a telegraph transmitter wherein a keyboard, operating in conjunction with a motor, is adapted for moving character-forming elements into operative relation with a circuit making and breaking device to produce telegraphic impulses, the principal object of the invention being to provide a machine wherein the movements of the key levers are mechanically recorded in a storage element, and subsequently used to trip the character forming elements into functional position.

12,309 R[illegible] Step-by-step rheostat switches.

12,318 N[illegible] & N[illegible] Electrical heating and cooking apparatus.

12,444 B.T.-H. Co. (G.E. Co.) Systems of electric ship propulsion.

12,536 WALL. Method of generating high-frequency electric currents. (Cognate application, 12,834/15.)

Comprises the combination with an oscillatory circuit containing a pair of condensers in series, one of which serves as a spark-gap, of another oscillatory circuit in connection with the gap, the circuits being so adjusted that the current across the gap which is the resultant of currents in the two circuits exhibits the phenomenon of beats with or without a magnetic blow-out field at the gap.

12,541 B[illegible] & HELSBY CABLES (LTD.) & HARRISON. Telegraph systems.

12,564 B.T.-H. Co. (G.E. Co.) Wireless signalling systems.

Consists of the combination of a source of high-frequency energy connected to an antenna, an electron discharge relay, comprising a cathode, an anode and a grid enclosed in an extremely highly exhausted envelope, connections between said cathode and said anode and points in the antenna circuit between which there is a large difference of potential, means for varying the potential of said grid in accordance with current variations produced by sound waves, and a connection between the cathode and grid of said relay, which offers a low impedance to high frequency current, but offers a high impedance to the pulsating current produced by sound waves.

12,673 RELAY AUTOMATIC TELEPHONE CO. Automatic telephone systems. (17/11/14.)

13,042 [illegible] Fittings for electric lamps.

13,303 TURNER. Systems of distribution for electrically-operated railway trains.

[illegible] WHITE. Safety-starting devices for internal-combustion engines.

12,934 SMITH. Means for laying and collecting field telephone wires.

[illegible] I[illegible] ELECTRIC CO. (Cutler-Hammer Mfg. Co.) Driving and control mechanisms of planers and like machines.

1916 SPECIFICATIONS.

1,[illegible] B[illegible] (L[illegible]) & TWIST, G. V. Means for supporting and insulating electric [illegible]. (27/1/16.) (101,233.)

1,[illegible] S[illegible] G. H. Electric [illegible]. (3/2/16, addition to 9,964/15.) (101,237.)

4,[illegible] SALT, J. H[illegible] for incandescent electric lamps. (28/3/16.) (101,250.)

6,[illegible] WARRINER, V. G., & WARRINER, K. H. Means for telephonic communication to and from moving railway trains and the like. (11/5/15.) (100,453.)

9,[illegible] M[illegible]-JACKSON, W. J. (Western Union Telegraph Co.) Telegraph transmitting apparatus. (4/11/15, divided application on 15,579/15.) (101,278.)

11,[illegible] WARRINER, V. G., & WARRINER, K. H. Means for telephonic communication to and from moving railway trains and the like. (21/8/15.) (101,281.)

12,[illegible] MALONEY, M. Fire-alarm. (Addition to 4,777/12.) (1,499.)

101,103 I[illegible] ELECTRIC CO. (Cutler-Hammer Mfg. Co.) Means for controlling and regulating electric motors. (1,374.)

101,104 [illegible] Electromagnetic telegraph instrument. (1,483.)

101,[illegible] WA[illegible] H. (Ford, B.) Secondary or storage batteries. (2,085.)

101,171 HOWARD, G. H. J., & GAMAGE, A. W. (LTD.) Electric buzzers and the like. (2,400.)

101,[illegible] [illegible], L. Means for regulating the voltage of a direct-current dynamo. (3,114.)

101,[illegible] C[illegible], K. F. L. Sparking plugs. (6,603.)

101,[illegible] E[illegible], H. J., & B[illegible] & C. T. Electric furnaces of the electrode type. (Divided application on 3,[illegible]/16, 8,533.)

101,[illegible] S[illegible] & H[illegible] ART GO[illegible]. Electromagnetic relays. (6,541.)

[illegible] [illegible]. Means for simultaneously obtaining electricity from a moving picture film [illegible] the like. (6,[illegible].)

APPLICATIONS FOR PATENTS

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked * are open to inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When complete Specification accompanies application an asterisk is affixed.*

August 23, 1916.

11,[illegible] C[illegible] (L[illegible]) & SPENCER. Electrical equipment for [illegible] motor-cars.

11,[illegible] A[illegible], WHITWORTH & CO. & CHEETHAM. Mountings for electric, &c., lamps [illegible] filament.

11,[illegible] BATHAM. Electric flow-heaters, enclosed arc lamps, &c.

11,[illegible] BELL, DAVEY, & [illegible] TELEPHONE & ELECTRIC CO. Morse-signalling keys.

11,[illegible] PLATT. Sparking-plugs.

August 24, 1916.

11,936 BLUPTON. Method of obtaining motive power from wave movement of the sea.

12,013 BAXTER & CAUNTER & SUTER. Sparking-plugs for internal-combustion engines.

12,014 BIDDLE. Apparatus for actuating signals on trains, and for stopping trains independently of drivers.

12,015 BIDDLE. Means for producing audible signals on trains.

12,016 B.T.-H. Co. (G.E. Co.) Electro-magnetic switches.

12,019 NICHOLSON. (Antonoff.) Primary electric cells.

12,020 AGGERSBORG. Method of preparing radioactive mineral waters containing radium-precipitating acids. (24/8/15, Denmark.)

12,033 MARCONI'S WIRELESS TELEGRAPH CO. & PLETTS. Apparatus for wireless telegraphy.

August 25, 1916.

12,043 12,045 CRAWFORD & PRESTON & SANDERS. Electrical fuse boards or systems.

12,044 CRAWFORD & PRESTON & SANDERS. Electrical fuses, and parts appertaining thereto.

12,063 SOC. D'ELECTRICITE NILMELIOR. Electric machines. (27/8/15, France.)

12,066 THORLE. Mouthpiece for telephone transmitters, &c. (25/8/15, Norway.)

12,070 B.T.-H. Co. (G.E. Co.) Electric resistance elements.

August 26, 1916.

12,090 AUTOMATIC TELEPHONE MFG. CO. & SMITH. Telegraph systems and apparatus therefor.

12,099 TARVER. Dry cells.

August 28, 1916.

12,125 BRITISH INSULATED & HELSBY CABLES (LTD.). Annealing, reheating, &c., furnaces.

12,147 B.T.-H. Co. (G.E. Co.) Electric furnaces.

12,140 BROOKS. Device for heating water electrically.

12,148 BROOKS, FRANKS, READ & WALSALL HARDWARE MFG. CO. Electrical switches.

12,158 CHEVALLIER. Railway signalling apparatus.

12,160 BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. Vapour-electric converters. (28/8/15, U.S.)

12,162 GRAHN & RELAY AUTOMATIC TELEPHONE CO. Automatic and semi-automatic telephone systems.

12,169 COOK. Electric lamps.

12,168 TIETGEN. Insulation of electric cables.

12,170 KOSNICK. Rheostats for starting electric motors.

August 29, 1916.

12,210 B.T.-H. Co. (G.E. Co.) Electric furnaces.

12,231 PESTARINI. Induction electric motors.

12,237 MILLER & R[illegible]. Apparatus for controlling electric circuit of flash signs, &c.

August 30, 1916.

12,279 B.T.-H. Co. (G.E. Co.) Electric furnaces.

12,305 WANG. Apparatus for converting or transforming electric currents.

August 31, 1916.

12,316 WARS[illegible]. Trolley poles for electric cars, &c.

12,350 B.T.-H. C[illegible] & FARMER & HASTINGS. Systems of electric motor control.

12,352 TURNER. Automatic train control systems. (1/4/16, U.S.)

September 1, 1916.

12,372 BEIN. Electrical warning apparatus.

12,382 HUMPHREYS. Magnetic chucks.

12,395 SARNMARK. Means for operating apparatus at receiving station from sending station by electric pulsations. (7/9/15, Sweden.)

12,396 RENNERFELT. Electric furnace. (8/9/15, Sweden.)

12,399 AUTOMATIC TELEPHONE MFG. CO. & RAY. Telephone systems.

12,400 HOLMES & H[illegible] & HOLMES. Signalling apparatus for mines, &c.

12,406 GARRETT & PRATT. Safety controlling gear for electrically-propelled vehicles.

12,410 F[illegible]RSTER. Means for control electrically of signal indicators of mine hauling engines, winding engines, &c.

12,420 SOC. ANON. POUR L'EQUIPMENT ELECTRIQUE DES VEHICULES. Arrangement of regulator and circuit-interrupter fixed upon electric generators having a variable speed. (29/11/15, France.)

September 2, 1916.

12,441 B.T.-H. C[illegible]. (C.E. Co.) Measuring instruments.

12,446 THOMAS & THOMAS TRANSMISSION (LTD.). Method of cooling commutators.

12,454 BALLANTI. Regulating apparatus for alternating-current distribution systems.

12,456 BELL & DAVEY & STERLING TELEPHONE & ELECTRIC CO. Electric signalling systems.

12,461 HAYHURST. Protection of electrical apparatus, &c.

September 4, 1916.

12,487 HUGHES, STARLING & HUGHES & SON. Magnetic compasses.

12,496 YOUNG. Alarm for automatically announcing cutting-off of electric current.

12,505 DE FOREST. Radio-telephone transmitter systems. (4/9/15, U.S.)

12,517 BRITISH EVER READY CO. Dry batteries.

September 5, 1916.

12,528 SHEPHERD. Electrical generators and electric motors.

12,535 DAVEY & CO. & JAMES. Electric signalling lamps for ships, &c.

12,540 SUTCLIFFE. Sparking-plugs of internal-combustion engines.

12,552 CLAPP & SIMPSON. Electric arc lamps.

12,558 EDWARDS & LUCAS. Electro-magnetically-operated horns.

12,561 B[illegible]KS & HOLT. Dynamo-electric machines for combined electric lighting and ignition for motor vehicles, &c.

12,566 BLACKMORE, JENKINS, HOWARD & C.I. SYND. Electrolytic oxidation.

12,580 M[illegible] (S[illegible]) Apparatus for electrical precipitation of suspended particles from gases.

September 6, 1916.

12,609 T[illegible]. Wireless control systems.

12,616 AUTOMATIC TELEPHONE MFG. CO. (Automatic Electric Co.) Automatic telephone systems.

12,619 SIMPSON. Light projector.

12,619 SPARKBROOK. Water-power systems.

12,624 B.T.-H. C[illegible] (G.E. Co.) Systems of electric motor control.

12,646 GILL & GRANT. Electrical advertising device or sign.

September 7, 1916.

12,68[illegible] C[illegible] & MARTIN. Insulating material resembling vulcanite.

12,687 B[illegible] Electric furnaces.

12,734 F[illegible] Apparatus for producing unidirectional electric currents.

12,7[illegible] D[illegible] Apparatus for wireless telegraph or telephone systems.

September 8, 1916.

12,737 C[illegible] & CHRISTABLE & SANDS. Electric sparking-plug.

12,7[illegible] HEPWORTH TELEPHONE WORKS CO. & WAKEFIELD. Shoes or sockets for electric cable terminals.

September 9, 1916.

12,781, 12,782 REINZ & WESTERN ELECTRIC CO. Telephone systems.

12,793 B[illegible] & GIRARDEAU. Magnetos for lighting automobiles and starting internal-combustion engines. (21/10/15, France.)

COMMERCIAL & INDUSTRIAL SECTION.

CONTENTS.

Commercial Topics	957	Electrics and Petrol Supplies	1*
Imports and Exports of Electrical Manufactures	958	Electric Vehicles in China	2*
Business Notices	958	Street Watering by "G.V." Electric at Blackpool	2*
Electricity Supply	959	Manchester Municipal Electrics	2*
Traction Notes	960	The Swiss Electric Vehicle Problem	4*
Empire Notes	960		
The Round Table	189	Foreign Notes	961
Laboratory Ozone Generator	190	Miscellaneous Notes	961
Electrically Heated Japanning Ovens	190	Tenders Invited	961
New Carron Fire Catalogue. Illustrated	192	Tenders Received & Accepted	962
Tumbler Switch Control. Illus.	194	Municipal Accounts	962
Duntley Universal Electric Hammer Drill. Illustrated	196	Companies' Meetings and Reports	963
Electric Vehicle Progress Supplement—No. 32.		New Companies, &c.	963
The Electric Furniture Van. Ill.	1*	City Notes	964
		Electrical Companies' Share List	964

COMMERCIAL TOPICS.

British Companies and Enemy Influence.

Responsible financial and commercial circles in the City are at present discussing certain changes in the articles of association of companies upon which the Board of Trade is insisting in all cases in which the Public Trustee (as custodian of enemy property) is selling enemy controlling interests in English companies, and in the case of new companies formed to acquire such interests.

As the City correspondent of "The Times" points out, these changes at present apply only to the selling of enemy interests, and therefore their importance may be regarded as limited; but there is an impression that the changes will be made to apply subsequently to all companies registered under the Companies Acts. If this should prove to be the intention of the Government the changes will become a matter of great importance. The new articles are somewhat drastic and peculiar in their phraseology, and it is to be hoped that they will be carefully examined before legislative effect is given to them. Our contemporary states that business men who have examined the new provisions have intimated that they would infinitely prefer that it were made illegal for any German to be naturalised or to hold any property or to carry on business within this country than that they should be applied to all companies, British and German alike. A City lawyer, with great experience of the working of public companies and of company law, has also expressed wonder as to how any experienced person could have sanctioned the new articles or could have found any lawyer to take the responsibility of suggesting the placing of such an incubus upon our company system. The new articles prohibit the transfer or allotment of any shares to a foreigner or foreign corporation without the consent of the Board, and if a shareholder becomes in the opinion of the directors subject to foreign "influence" he may be required to sell his shares. A board's decision under the articles is made final and conclusive. The meaning of the word "influence" at once presents difficulties, and as it occurs in a document governing the daily conduct of a company's business, in which precision is the first essential, the position becomes serious. Much damage can be done to trade and commerce by hasty and ill-considered legislation, and it is to be hoped that most careful consideration will be given to any proposed alterations in our company law. Certain changes are, of course, necessary, but care should be taken that while these are effective in getting rid of German "influence," no serious damage is done to British interests.

* * * *

Our Commercial and Industrial Policy.

At the recent meeting of the Council of the Newcastle-on-Tyne Chamber of Commerce there was an interesting debate on the request of the Committee on Commercial and Industrial Policy to be furnished with a statement of any definite and detailed suggestions which the Chamber might desire to submit for consideration.

Mr. Renwick remarked that the trades mentioned by the committee were staple trades of the district, and that it was most desirable that they should not be excluded from their deliberations.

The chairman (Mr. J. H. Beckingham) remarked that the questions before them were intricate, complicated and bewildering—not only the questions of trade, but those of national finance. At present time the national debt was about 3,000 millions, and it looked as though it would be 5,000 millions before peace was proclaimed. That meant the raising of an enormous sum for interest, and, in addition, there were the pensions and allowances arising gut of the war to be considered. He did not think it was an exaggeration to say that we would have to face a budget of from 500 to 600 millions a year, and that would (he thought) tax the ingenuity of the Chancellor of the Exchequer and our fortitude.

Mr. Renwick thought it was, perhaps, more important to get on with the war than to talk about trade after the war. He could not see the end of the war; he did not think it was in sight. One of the most important questions to which they ought to give attention was that of shipping. They all knew the inroads the foreigners were making; they knew how the foreigners were scouring the world, and paying prices for ships we could not reach, and they were also reaping the advantage of the high freights.

After discussion a committee was appointed to consider the whole question of trade after the war, and to report subsequently to a representative meeting of the commercial community of the district.

* * * *

Australian Industries.

Strong efforts are now being made to move official as well as public feeling to a proper recognition of Australia's natural resources.

The report on which the Australian Postmaster-General has decided to establish works for the manufacture of wire cable and metal rope states that an expenditure of £250,000 will be needed to secure a turnover of approximately £1,000,000. Positions will be found for 1,000 workmen. Not more than 10 men will be needed from overseas, and all the raw products necessary can be obtained in Australia.

An Australian inventor (Mr. John Flint), of Sydney, claims to have succeeded in the world's search of synthetic rubber, and to have found a way of producing an efficient substitute for rubber at a very low cost. The substitute is an entirely Australian product, all the ingredients being obtainable in the Commonwealth, and successful experiments in the vulcanising process have already been carried out with it. The invention has been patented. The claim is made that it can be produced at a price of from 5d. to 6d. per lb., as against the present price of rubber which runs from 3s. to 4s. 2d. per lb.

Special attention is being paid to the science of dyes in Australia. At a meeting of the Royal Society in Melbourne, Mr. E. J. Hartung showed a series of synthetic dyes, and pointed out the relationship between chemical constitution, fluorescence and colour exhibited by certain of the dyes. Mr. Hartung also showed a new dye discovered in the chemical laboratory of Melbourne University, but not yet fully investigated.

Mr. Z. Kamiya, special commissioner of the Japanese Government to the South Seas and Australia, recently stated in Sydney that Japan would be one of the best buyers of zinc, and to a possibly lesser degree would be a buyer of copper and lead.

* * * *

Trading With the Enemy.

Further regulations have been made by the Foreign Trade Department of the Foreign Office with a view to preventing breaches of the Trading with the Enemy Acts and Proclamations.

All goods exported from the countries mentioned below on and after the 1st prox. to the United Kingdom, Australia, Newfoundland, New Zealand, Union of South Africa, all Colonies not possessing responsible Governments, and Protectorates, as well as India, must be accompanied by certificates of interest. These certificates will be issued by H.M. Consular Officers, who will require documentary evidence that no enemy or person with whom trade is for the time being prohibited (including persons on the Statutory List) has any interest in the goods. The following are the countries:—

Abyssinia, Argentina, Azores, Bolivia, Brazil, Canary Islands, Cape Verde Islands, Chile, Colombia, Costa Rica, Cuba, Danish West Indies, Dominican Republic, Ecuador, Greece, Guatemala, Honduras, Liberia, Madeira, Mexico, Morocco, Muscat, Netherland East and West Indies, Nicaragua, Panama, Paraguay, Persia, Peru, Philippine Islands, Portuguese East and West Africa, San Salvador, Spain, Spanish West Africa, Uruguay and Venezuela.

In the case of exports from Norway, Sweden, Denmark, Holland and Switzerland, where certificates of origin have hitherto been required, certificates of origin and interest will be required for goods exported on and after Oct. 1 on the same conditions, except that the additional evidence required for a certificate of interest will have to be produced to the Consular Officer to whom application is made for the issue of the

combined certificate. In the case of these five countries goods for which certificates of origin are not at present required will not have to be accompanied by the new form of certificate of origin and interest. All goods exported on and after Oct. 10 from these five countries to Canada must be accompanied by a certificate of origin and interest.

In other cases certificates are not compulsory. The period of validity shown on Certificates of Interest and Certificates of Origin and Interest will in no case exceed two months.

* * *

Employment of Aliens.

It is announced that the Aliens Restriction (Consolidation) Order, 1916, was extended by an Order in Council on September 7th, when the following article was added to the principal Order:

No. 22 B.: As from and after October 1, 1916, a person shall not take steps to obtain the services for work other than munitions work in the United Kingdom of aliens or any alien not in the United Kingdom except with the permission in writing of the Board of Trade, and subject to such special or general conditions as the Board of Trade may impose. It will be among the general conditions imposed by the Board of Trade that they shall be satisfied that labour is not already available in this country for the work in question, and that the prospective employer undertakes to offer to any alien who may be introduced conditions of employment not less favourable than those applicable to British workpeople similarly employed in the same district.

Applications for the permission required by the Order should be made on a form which can be obtained from the Employment Department of the Board of Trade at Queen Anne's Chambers, Westminster, S.W.

The engagement of alien labour for munitions work, which is defined as work in any controlled establishment or in any other establishment to which the provisions of sec. 7 of the Munitions of War Act, 1915, apply, is already subject to the instructions contained in the Order in Council of March 13, 1916. Information regarding the rules on the subject can be obtained from the Ministry of Munitions, 6, Whitehall gardens, S.W., or from the Employment Department of the Board of Trade.

* * * *

Trade After the War.

It is announced that the various Committees appointed by the Prime Minister to collect information on the subject of our trade relations after the war will present their reports before the end of the year. In another column we give an abstract of Lord Faringdon's Committee on financial facilities, but other Committees are dealing with shipping and shipbuilding, textile, iron and steel, coal, electrical and engineering industries.

IMPORTS AND EXPORTS OF ELECTRICAL MANUFACTURES.

From Sept. 16, 1916, *to* Sept. 22, 1916.

IMPORTS.

EXPORTS.

FRANCE.—*Dieppe:* Wire and cable, £126; unenumerated, £1,167. *Paris:* Unenumerated, £232. *Rouen:* Unenumerated, £73. *Rouen:* Elec. machinery, £245. *Dunkirk:* Elec. machinery, £410; unenumerated, £48. *Havre:* Telegraph material, £60.

PORTUGAL. *Lisbon:* Wire and cable, £400.

SPAIN.—*Bilbao:* Elec. machinery, £90; telegraph material, £780; unenumerated, £148. *Barcelona:* Wire and cable, £464; telegraph material, £30; unenumerated, £15.

NORWAY. *Trondhjem:* Elec. lamps, £44,500; elec. machinery, £3,061; unenumerated, £224.

DENMARK.—*Copenhagen:* Unenumerated, £120.

SWEDEN. *Stockholm:* Unenumerated, £158. *Gothenburg:* Wire and cable, £68; unenumerated, £19.

FOREIGN GOODS (duty paid and free).

Durban: Unenumerated, £331. *Dieppe:* Elec. machinery, £109. *Hong Kong:* Unenumerated, £278. *Amsterdam:* Unenumerated, £60. *Alexandria:* Unenumerated, £48. *Bergen:* Unenumerated, £188. *Bilbao:* Unenumerated, £49. *Buenos Ayres:* Unenumerated, £346. *Copenhagen:* Unenumerated, £56. *Christchurch:* Unenumerated, £11. *Cape Town:* Unenumerated, £47. *Colombo:* Unenumerated, £26. *Oporto:* Unenumerated, £30. *Rotterdam:* Unenumerated, £41. *Philadelphia:* Elec. machinery, £103. *Port Elizabeth:* Unenumerated, £40. *Singapore:* Glow lamps, 478; Wireless: Unenumerated, £42.

NOTE.—The large number of items in these official returns under the misleading heading "unenumerated" relate to what is described as "electrical goods" and "electrical materials."

BUSINESS NOTICES.

The Western Electric Co. (Inc.) has been authorised by the Argentine Government to establish a branch or agency in the Republic.

Mr. George Ellison, manufacturing electrical engineer, Birmingham, announces that his Yorkshire branch office has been removed from Sheffield to Standard-buildings, City-square, Leeds.

Mr. E. W. Abbott has taken over the management of the Newcastle branch of Messrs. Crompton & Co. (Ltd.) at 21, Pearl Assurance-buildings, Northumberland-street, Newcastle-on-Tyne. For many years he has been in charge of the contract department at Chelmsford, and has carried out the electrical equipment of many important main winders, rolling mills, coaling cranes, large haulage gears, &c. Mr. Abbott was responsible for the design and equipment of many of the early central stations in this country.

The directors of the British Engine, Boiler & General Insurance Co. (Ltd.) have established a larger office in London, with a complete staff for dealing with the inspection and insurance of all kinds of electrical plant. The guidance of the technical department has been placed in the hands of Mr. H. Llewellyn Foster, M.Inst.C.E., M.I.E.E., formerly chief electrical engineer of the company at their head office in Liverpool. Mr. H. F. Taylor, formerly secretary to the company, has been appointed to take charge of the new London office, and with him is associated as assistant manager Mr. W. J. Walsh.

Sale by Tender. Messrs. Wheatley Kirk, Price & Co. have been instructed by the Controller of the Electrical Company (Ltd.) (Mr. Maurice Jenks, F.C.A.) to offer for sale by public tender, as detailed in the lots of the catalogue, the entire stock of electrical supplies, equipment and accessories at the offices and showrooms, 122-4, Charing Cross-road, London, W.C. The stock includes generating and testing plant, motors, arc and incandescent lamps, fans, cable, insulators, carbons, meters, switches, electrical accessories, &c., and will be on view for two weeks commencing Monday, Oct. 2, from 10 a.m. to 5 p.m. daily. Catalogues from the selling agents, Messrs. Wheatley Kirk, Price & Co., 16, Watling-street, London, E.C., and at Manchester and Newcastle-on-Tyne. Tenders must be sent in to the firm at 16, Watling-street, E.C., by noon Oct. 17.

The Controller, Mr. Maurice Jenks, is prepared to receive offers for the trade and business connections as lately carried on by the Company.

Further particulars are given in an advertisement.

Plant for Sale. Messrs. Marshalls, Gainsborough, have a 2½ h.p. Wilson Hartnell electric motor and an E.C.C. compound-wound dynamo for sale.

Patent Development. The proprietor of patent No. 24,751/1912, for "Improvements in and relating to the synchronous running of electric motors," desires to enter into arrangements for the purpose of exploiting same in this country. Applications to Messrs. Haseltine, Lake & Co., Patent Agents, 28, Southampton-buildings, Chancery-lane, London, W.C.

The proprietors of patent No. 27,477/1913, for "Improvements in controlling devices for variable speed dynamos and their circuits," desire to enter into arrangements for exploiting same in this country. Communications to Messrs. Haseltine, Lake & Co., Patent Agents, 28, Southampton-buildings, Chancery-lane, London, W.C.

Increase in Prices. Owing to continued increase in the cost of freight, insurance and packing, the Western Electric Co. have been compelled to again raise the price of their Blue Bell dry cells.

The increased prices date from Sept. 25, and are as follows: Single cells, 2s. 6d. each net; in lots of 12, 1s. 10d. each net; in lots of 12-124, 1s. 6d. each net, in lots of 125-999, 15s. 6d. per dozen; in lots of 1,000, 15s. per dozen.

ELECTRICITY SUPPLY.

EXTENSIONS.

Aldershot.—The electric supply main is to be extended to Cargate Grove.

The Clerk and the Electrical Engineer have been instructed to present a full report on the present position and future requirements of the electric light undertaking.

Fulham (London).—The Borough Council is recommended to expend £1,000 on executing certain work in connection with underpinning the stores at the electricity works.

Poplar.—The Electricity Committee reports having considered a report of the electrical engineer (Mr. J. Horace Bowden) on extensions required to meet increasing demands for electrical energy.

The installation of an additional 6,000 kw. set is estimated to cost £76,500, of which £64,750 would be chargeable to loan account. As an alternative, Mr. Bowden suggests a proposal for linking-up with the London County Council tramway gererating station at Greenwich, which would involve a capital expenditure by the Council of about £8,100. If the alternative scheme were adopted it would be of advantage to both undertakings, the peak load at the two stations occurring at different hours. The committee is of opinion that it is undesirable at present to embark on the larger scheme if it can be avoided, and has authorised Mr. Bowden to continue negotiations with a view to adoption of the linking-up scheme.

The committee has approved a proposal for the provision of an electrical exhibit (jointly with Stepney Borough Council) at the National Economy Exhibition at the People's Palace. The cost of the exhibit is estimated at £39. 13s., which, in view of reduction in expenditure on other means of advertising, would be amply covered by the provision usually made for advertising expenditure.

On Mr. Bowden's suggestion it is recommended that a Lea recorder be provided for the turbines in the old engine room, at a cost of £112. 10s.

GENERAL.

Aldershot.—Last week the Council were informed that there was a bank overdraft of approximately £1,400, including £550 due to legal costs of the action brought by Mrs. Dexter for nuisance.

In order that proper provision might be made to meet the deficiency it was recommended that the proceeds of 1d. rate be transferred to electric lighting account from general district rate.

The chairman of the Electricity Committee (Mr. Calvert) said the bank was pressing them to adjust their finances. From the electric light reserve fund they had spent a certain amount on machinery, which had exhausted the reserve. Unfortunately a law case occurred afterwards and certain costs were incurred. Not having the money in reserve, they were obliged to ask the town to repay, by 1d. rate, the asset they had received from the department.

Ardsley.—The Urban Council has appointed a sub-committee to confer with the Yorkshire Electric Power Co. regarding a supply of electricity for Bredilley sewage works.

Bedford.—At the last meeting of the Council the Finance Committee reported that application had been made to the L.G. Board for sanction to borrow £4,900 for capital expenditure in connection with the electric supply undertaking, and sanction had been granted for £4,072. It would, therefore, be necessary to include the amount disallowed (£828) in the revised estimate.

As the amount will have to be provided for otherwise than out of capital, the Committee recommend that the present increase of 5 per cent. on the electric light charges be increased to 10 per cent. until further notice; but this recommendation has been referred to a Committe of the whole Council.

The Electricity Committee stated that inquiries were being made by contractors regarding a supply of energy for lighting, power and cooking purposes for a new factory, and when it was ascertained what would be required the matter would be laid before the Council.

As no reply had been received from the L.G. Board, and as the matter was urgent, the Electrical Engineer has been directed by the Committee to make house connections in all cases he deemed proper, on condition that the whole capital expenditure in connection therewith should be borne by applicants.

Bradninch (Devon).—The Council has decided not to renew at present its contract with the local electric supply company for lighting the streets, which expires at Michaelmas, in view of the lighting restriction order now in force.

Bristol.—The accounts of the Electrical Committee, which were abstracted in our last issue, were submitted to the Council on Tuesday and adopted.

Chatham.—The works Committee has notified the Chatham & District Light Railways Co. that the Council are desirous of entering into a new agreement for the supply of electrical energy to the street lamps.

Croydon.—Acting on a report of the Electrical Engineer the Lighting and Electricity Committee proposes to renew the h.t. feeder cable from the generating station to sub-station, at a cost of £1,425.

The cable is to be supplied and laid by Callender's Cable & Construction Co. The estimated net cost of the cable (less allowance for old materials will be £518; the cable joints, laying, &c., will cost £382, and conduits £195. Whilst the new cable is being laid provision will be made for street lighting at a cost of £110. The whole of the cost will be charged to reserve and renewals fund account.

Increased Charges for Electrical Energy.—The following increases are being made:—

The Notting Hill Electric Lighting Co. is increasing its charge from 5½d. to 6d. per unit from Oct. 1.

Bispham Council has decided to increase its charges by 1d. per unit for lighting and by 20 per cent. for other purposes.

Portsmouth Corporation is increasing its charges from Oct. 1 by 5 per cent. (making 20 per cent. over pre-war rates) for lighting, and by 10 per cent. (making 25 per cent. increase in all) for power and heating. No alteration is being made in the charge for current taken through slot meters.

Dover Electricity Committee has decided to increase the charges for current for light, power and tramways by ½d. per unit.

Torquay Electric Lighting Committee is increasing the charge for current supplied to private consumers from 4½d. to 5d. per unit.

Newton Abbott.—The local electric supply company offers to make a further concession of £153 on the contract for public lighting, which expires next June, in addition to the £215 a year already allowed.

Norwich.—The Electricity Committee recommends the purchase of premises in St. Stephen's Back-street for erecting a sub-station.

Poplar (London).—The Borough Council have decided to make a special record on their minutes of the bravery of Mr. A. J. Randall, an employé of the electricity department, who was recently awarded the military medal.

Rawtenstall.—At the meeting of the Council last week it was reported that the original scheme for the supply of electricity to Haslingden had been amended in order that the Rawstenstall electricity undertaking might be linked up with the Accrington electricity undertaking. A larger cable has been laid and additional switchgear will be provided at a cost of £400.

Shipston-on-Stour.—There is a movement in favour of forming a new company to amalgamate the electric and gas companies into one concern.

At a recent public meeting it was stated that a letter had been received from the secretary of the gas company, stating that the company would be pleased to entertain any proposal made by the electric light company and submit same to a meeting of their shareholders.

Mr. J. R. King, who had offered to get an independent expert valuation of the electric light works, said he congratulated the meeting on having got the letter from the gas company. The only way to make the thing a success was to combine the two companies. He did not think it would be business to read his report, and he recommended that a small provisional committee should be formed to go into details with both companies.

It was then decided that the report should not be read, and a committee was elected as proposed.

Southampton.—The Electricity Committee has asked the L. & S.W. Railway Co. to extend its line so as to enable more coal waggons to stand on the sidings.

The borough electrical engineer (Mr. H. F. Street) has reported that cable faults developed in the Western Shore-road recently, and examination showed that continuous flooding by sea water had caused deterioration of some of the cables. The greatest care was taken in laying those cables, but the action of salt water is very far reaching. As regards the renewals between the electricity works and the West Station gates, Mr. Street suggests that one cable be re-laid, at a cost of £275. The cables have been laid about 14 years. There was also about 300 yds. of a 0·75 in. cable that he would like to renew and also enlarge, but, as the present price of that cable was 25s. per yard, against 12s. 1d. when last paid, it ought to stand over till next year. A length of cable along the Western Shore-road towards the baths would cost nearly £300 to renew.

The committee has authorised the suggested renewals.

Southend-on-Sea.—Recently the Highways and Works Committee was asked, on the recommendation of the Economics Committee, to consider the question of substituting electricity for gas in those street lamps at present lighted by the latter illuminant.

The Highways Committee has decided to defer consideration of the matter for a report to be submitted by the Borough Surveyor.

The Electric Lighting Committee report the completion of the sale at £1,155. 4s. of the two 180 kw. dynamos manufactured by the British Thomson-Houston Co. After paying the contractors for the machines, storage, packing and carriage, the transaction has resulted in a profit to the Corporation of rather more than £200, which will be held against a probable increased cost of new machines when required after the war.

Watford.—At the meeting of the Council last week attention was drawn to a letter from the Tradesmen's Association asking them to reconsider the proposed increase in the charge for current to 5½d. per unit. The matter was, however, referred to the Electric Light Committee.

Mr. Goodrich said the price was raised for no other reason than that the Summer Time Act had adversely affected the undertaking, and not because of the increase in the cost of fuel. The price was increased before because of that. The Summer Time Act affected private consumers but not power consumers. Some power consumers were using the current for 24 hours.

Walsall.—At the last Council meeting a discussion took place as to the best means of dealing with the considerable deficit which is expected to result from the present year's working of the electricity undertaking.

Councillor D. HAYWARD (chairman of the Electricity Committee) explained that they were not losing money on the working of the station, but they had to pay about £2,450 in capital charges for the new station, although it would not be finished until next month—16 months after the time originally fixed.

Councillor THICKETT said the price of current was already too high. When there were profits it was soon a case of "hand it over to the ratepayers," so let the ratepayers stand any loss that was incurred.

It was decided to call upon the rates to make up any deficit at the end of the year.

Weybridge.—The Board of Trade has informed the Council that it has made an order varying the Weybridge Electric Lighting Order, 1906, by substituting 7d. per unit as the maximum price on and after Sept. 30.

Wigan.—In submitting the minutes of the Electric Light Committee to the Corporation last week the chairman (Ald. J. T. Grimshaw) stated that circumstances had developed at the electric power station in such a way that it was imperative to terminate the appointment of the electrical engineer.

Ald. GRIMSHAW said it was a grievous thing that he was called upon to undertake. It had been stated that he (the chairman) was partially responsible for the situation, and he felt that if such were the case the only honourable course for him to take was to offer his resignation. If he was partially responsible evidence ought to be produced from the minutes implicating himself, but he did not know that any such evidence had been obtained. Up to a certain point he had the greatest confidence in the ability of the management, and it was only quite recently—in fact, since the breakdown of the boilers—that he felt that matters were not quite as sound as they ought to be. He had performed no task so oppressively displeasing to himself as the task he had to perform then, and for the simple reason that if ever two men worked together comfortably the chief of the electricity department and himself had done it.

Ald. J. M'QUEEN said he thought in all fairness that the committee had been very precipitate in the matter. They might, at any rate, have waited until the report of the Inquiry Committee had been brought before the Council before taking action.

The minutes of the Committee were unanimously carried.

The Council also decided, in connection with the proposed supply of electricity in bulk from the Lancashire Electric Power Co., to apply to the L.G. Board for sanction to borrow £11,038 for cables, transformers and switchgear.

Worcester.—The Council has agreed to the Electricity Committee's proposal to increase the wages of 24 of the staff of the electricity department, the additional annual cost amounting to £146. 4s.

TRACTION NOTES.

Bradford.—A deputation from the Amalgamated Association of Tramway and Vehicle Workers waited upon the Tramways Committee last week in support of an application for increases in the scale of wages of the tramway employés.

The proceedings were adjourned for about a fortnight in order that the manager (Mr. C. J. Spencer) might report on certain aspects of the matter. The tramwaymen are receiving a war bonus of from 3s. to 4s. a week, and it is estimated that the increases proposed would absorb £21,000 a year. Over 1,000 employés are concerned.

East Ham.—The Council in committee have considered the reference to them by the Electric Lighting and Tramways Committee of the question of the abolition of ½d. tramway fares, and having heard the observations of the engineer and manager (Mr. W. C. Ullmann) thereon, to the effect that the London County Council had not arrived at any decision on the question, further consideration thereof was deferred, and the Mayor, the chairman of the committee and the engineer and manager were appointed to attend any conference of the Metropolitan boroughs that may be convened on this question.

The committee has considered a letter from the London Joint Committee of Coachmakers, Wheelwrights and Motor Body Builders' Trade Union asking that the current rate of 11d. per hour should be paid to the body makers, painters, smiths and trimmers employed in the tramways department, and the committee proposes to accede to the application.

Glasgow.—Drivers and conductors (men and women) employed on Glasgow Corporation tramcars held a meeting last week in the Central Halls, Bath-street, in support of their application for an increase of their wages by 6s. a week. Coun. Geo. Kerr presided, and referred to the recommendations by the Tramways Committee regarding wages and working conditions.

Mr. KERR said many of the employés felt that something ought to be done in view of the proposals by the Tramway Committee, and that steps ought to be taken to organise the drivers and conductors (men and women). They had applied for an increase of 6s. per week for men and women alike. In the Corporation there was a feeling that that was an unreasonable demand. In his view, if they had had regard to the increase in the cost of living since they received their last advance, they would have asked 10s. A resolution was adopted protesting against the alleged proposal by the Tramways Committee to increase the working hours and to differentiate between male and female employés in regard to an advance in wages, and requesting the Corporation not to approve of the recommendations, but to grant the same advance to women as might be granted to men. It was decided to send a deputation of 27 conductors and drivers to the Corporation, and that all tramway employés should be urged to join the Municipal Employés Association.

The Corporation discussed the subject on Thursday last. The Tramways Committee proposed to lengthen the working week by three hours during the war, to pay time and a half for the extra hours and grant 2s. war bonus to male and 1s. to female employérs. It was proposed to increase the week's work in the case of men working on cables and permanent way to 56 hours.

Mr. MONTGOMERY, in moving the adoption of the proposals, said the hours proposed would not bring the week's work up to the standard of similar undertakings throughout the country. The addition to the wages bill would be £44,408. The effect of the proposals would be an increase to 36s. 7½d. in the case of men at present receiving 32s. per week, making the increase of wages since June, 1914, 41 per cent. The maximum for drivers would be increased from 37s. to 43s. 3d.

The committee's proposal as to the hours was adopted by 55 votes to 20, but the proposal to pay 2s. bonus to men and 1s. to women was only carried by the casting vote of Bailie Maclure, who presided.

Luton.—An increased service will be given on the Dunstable-road tramway route.

Southampton.—The Tramways Committee proposes to double a portion of the track in High-street. Since the parcels charge was inaugurated on May 25 last 22,649 parcels have been carried, the receipts amounting to £94. 7s. 5d., or at rate of £375 per annum.

Southend.—The Light Railways Committee has instructed the electrical engineer and tramways manager (Mr. R. Birkett) to arrange for the display of notices in the tramcars indicating that persons detected endeavouring to evade payment of the legal fares would be prosecuted, and to report upon the desirability of employing during the busy periods two girls conductors upon such of the cars as it may seem desirable, with a view to ensuring the proper collection of fares.

Underground Electric Railways of London.—The increase of the war bonus to 10s. a week for all railway employés over 18 years of age and to 5s. for employés under 18, with certain exceptions, has been extended to the employés of all the London underground electric railways.

York.—Owing to the reduced street lighting the tramcars are to stop running an hour earlier each evening during the winter months.

Authority has been given to the tramways manager to cater for late traffic (if any) from the places of amusement.

EMPIRE NOTES.

Australasia.—Tamut and Tweed (N.S.W.) Councils have decided to establish electricity supply undertakings for their respective districts.

Burma.—Mr. H. L. Preston, chief engineer of the Public Works Department, Rangoon, in his annual report on the working of the Public Works Department of the Rangoon Municipality for 1915-16, observes that no important changes in regard to electric lighting had to be recorded. Three experimental half-watt lamps, each of 500 c.p., were erected, and four arc lamps were replaced by half-watt lamps.

73 lamps in East Rangoon were converted from high tension to low tension.

South Africa.—The formal inauguration of the municipal electric supply at Worcester took place recently.

FOREIGN NOTES.

Argentina.—The electrified suburban service of the Central Argentine Railway, between the Retiro terminus and Tigre (Buenos Ayres) stations, was inaugurated on Aug. 23. The first train consisted of five motor-coaches and five trailers.

The President of the Republic was present accompanied by his Ministers.

Sir Reg. Tower, the British Minister, who was also present, said he was proud that a British company had shown such resourcefulness as to be able to carry out such an undertaking during the war. The Argentine Republic had offered the two primary requisites for the investment of capital—productivity and security. The British investor was content with a low rate of interest from Argentine railways because he was sure of the safety of his investment. The Argentine people and Government, on their side, had had an opportunity of testing the character and methods of British enterprise. More capital must come, unless the work of the past years was to be largely undone. After the end of the present conflagration vast sums would be required for reconstruction, and there would be demands from all parts of the world for the resumption of suspended operations. Capital would not be abundant, nor disposed to take the same risks as in the past, and it would go where the greatest security is offered.

The report of the directors of the Compañia de Tramways Eléctricos del Sud (Buenos Ayres) for the year ended June 30 shows revenue $1,121,982.78 (m/n), against $1,111,295.93 in the preceding year. Passengers carried were 8,709,425, against 8,420,254. Working expenses were $1,078,005.35, against $1,037,710.13. The increase in working expenses is attributed to higher cost of coal and materials. Net profit was $49,469.78 (m/n), and there was a carry forward of $20,565.47. After making the statutory payments to reserve and contingency funds there remained $62,120.09 (m/n), of which $32,120.09 is placed to renewal fund and $30,000 carried forward.

Colombia.—The Municipal Council of Zaragoza (Department of Antioquia) has been authorised to raise a loan of 15,000 pesos gold (£3,000) for the installation of electric power plant and the construction of an aqueduct.

The Municipal Council of Mosquera (Department of Cundinamarca) has also obtained sanction to a loan of 10,000 pesos (£2,000) for an electric power installation and aqueduct works, and (2) the Municipal Council of Concepcion (Department of Antioquia) has received permission to borrow 5,000 pesos (£1,000) for an electric power plant.

Spain.—The concession for the construction and working of an electric tramway in Melilla has been granted to Don Ramon Prendes Rodriguez.

The concession for the construction and working of an electric tramway in Bilbao, connecting the existing system with the Irala-Barri district, has been granted to the Sociedad Tranvia Urbano de Bilbao.

MISCELLANEOUS NOTES.

Enemy Firms Wound Up.—Claims against the Bakelite Co. (Ltd.) are to be sent to Sir W. B. Peet, 11, Ironmonger-lane, London, E.C., by Oct. 12.

The shares of the Concordia Electric Wire Co. (Ltd.) have been purchased by an English syndicate from the Public Trustee. No contract for sale or purchase will be recognised by the company unless such contract is confirmed in writing by Mr. R. Belcher, a director of the company, and countersigned by Mr. L. T. Thornton, the secretary.

Exports to China and Liberia.—The "London Gazette" of Sept. 22 contains further lists of public bodies, persons and firms in China and Liberia to whom goods from the United Kingdom may be consigned.

The following are included: *Liberia:* Compagnie de Cables Sud-Americans, Liberian Government Departments, Liberian Rubber Corpn., Station Radiotelegraphique Française (Mouravia).

Kitchener Scholarships.—The Council of the Lord Kitchener National Memorial Fund have resolved to found a number of scholarships which will enable young Britons destined for a commercial career to travel, study and gain business experience in the countries of the allied nations, viz., France, Russia, Italy, Japan, Belgium, Roumania, Portugal and Serbia.

The original purposes of the fund will, however, remain unchanged. They are these: (1) To equip and endow for all time a home for disabled officers; (2) to establish a permanent fund for the purpose of relieving disabled officers and men in their own homes.

The scholarship scheme will supplement these personal benefits by a national service of the first order. The scholarships will be continued from year to year for all time and will be of the annual value of about £150 each. The scholarships will be for the sons of deceased and disabled officers and men of the Navy and Army and young men from 18 to 25 years of age who have served with the forces.

Siemens War Savings Association.—Some years prior to the outbreak of war a number of the employés of Siemens Bros. & Co. (Ltd.) formed amongst themselves a thrift club which has had a successful career. As a branch of this club, a War Savings Association has been organised at the Woolwich works under the name of "The Bowater War Savings Association."

The management of the association is exclusively in the hands of a committee of employés, and this committee is solely responsible for exact and regular administration. Since the inception in June last this association has made good progress, the membership having increased from 500 to about 1,400, and up to the present nearly 4,000 War Savings Certificates have been purchased under the Government Scheme No. 2A, by which all subscriptions, as soon as they are paid, are converted into War Savings Certificates, these being allotted to each subscriber in priority of completed subscription as and when the full value has been paid.

TENDERS INVITED.

Turbine-driven Pump.

MANCHESTER Corporation require tenders by 10 a.m. Oct. 9 for the supply and erection at Bloom-street station of One Steam Turbine-driven Boiler Feed Pump. Specification, &c., from Mr. F. E. Hughes, Town Hall, Manchester.

Coal Transporter Plant.

Tenders are invited for the supply, delivery and erection in MELBOURNE, of a Coal Transporter Plant of the travelling tower type and electrically operated. Tender form with specification can be obtained from the agents for the Melbourne City Council, Messrs. Mellwraith, McEacharn & Co. Ppty. (Ltd.), Billiter-square-buildings, London, E.C. Tenders by noon Dec. 11.

Carbons.

The VICTORIAN GOVERNMENT RAILWAYS DEPT. requires tenders by 11 a.m. on Nov. 1 for the supply of 50,000 Yellow Flame Arc Carbons. (Contract No. 30,405.) Specification, &c., from the Victorian Railway Commissioners, Spencer-street, Melbourne.

Tramway Track Work, Material, &c.

JOHANNESBURG (Transvaal) Municipality require tenders by noon Nov. 6 for supply of 18 Grooved 12 ft. Points and 24 Grooved 9 ft. Points and six Ordinary Crossings (contract No. 171). Specifications, &c., from the Municipal Offices (Room 53), Johannesburg.

The Madrid "Gaceta" of Aug. 4 notifies that tenders will be opened on Oct. 7 for the Construction and Working of an Electric Tramway in Barcelona, an extension to Sans of the lines of the Cia Nacional de Tranvias de Barcelona, which holds an option on the proposed concession. Minimum rolling stock required will be Two Motor Tramcars and Two Trailers.

Tenders will be opened on Oct. 11 for Construction and Working an Electric Tramway in Madrid, from the Calle de Alcala to the Calle de Diego de Leon. Minimum rolling stock Four Cars.

In both cases construction work must be commenced within three months and completed within 10 months and a year respectively from dates of concession. An option on the concession is held by the Sociedad Tranvia del Este, Madrid.

Telephone and Telegraph Material, Instruments, &c.

Tenders are invited up to Dec. 22 for the supply to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept., State of Western Australia, at the Telegraph Office, Eucla, of 340 Accumulators, with associated apparatus, as per schedule No. 492. Specification, &c., from the Commonwealth Offices. London. *See also an advertisement.*

Tenders are invited for the supply to the Postmaster-General's Dept., State of South Australia, of Telephone Material in accordance with schedule No. 428, and tenders are invited (up to Oct. 4) for the supply to the Postmaster-General's Dept., State of Western Australia, of Telephone and Telegraph Instruments in accordance with schedule No. 501. Tenders are also invited (up to Nov. 15) for the supply and erection at the telephone exchanges of Glenelg and Brighton, State of South Australia, of Automatic Switchboards and all associated apparatus (as per schedule No. 426). Tender forms, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, Melbourne, requires tenders by 3 p.m. Oct. 17 for supply of (1) Sleeves and Tapes (schedule 1,355) and (2) 3,100 Stay Rods with bow tighteners (schedule 1,359) for AUSTRALIAN COMMONWEALTH Postmaster-General's Dept. Specifications from the Deputy Postmaster-General, Melbourne.

The Public Service Stores Tender Board, WELLINGTON (N.Z.) require tenders by 4 p.m. Oct. 11 for supply of 1,000 Magneto Extension Bells and 4,000,000 Lead Seals. Particulars from the Controller of Stores, Post and Telegraph Dept., Wellington the Storekeeper Post and Telegraph Dept., Christchurch, or the Telegraph Engineers, Auckland and Dunedin.

The Departments de Fomento de la Mancommunidad de Cataluna, Barcelona, also require tenders by noon Oct. 3 for the installation of a Telephone System connecting the towns of GANDESA, FALSET and REUS, at an estimated cost of £3,100.

Tenders are also required by 3 p.m. Nov. 8 for the supply of Accumulator Parts (100 positive and 24 negative plates) to the AUSTRALIAN COMMONWEALTH Postmaster-General's Dept., Perth (W.A.). (Schedule No. 527, W.A.) Specification, &c., from the Deputy Postmaster General, Perth, Western Australia.

Cooling Tower.

GISBORNE (N.Z.) Council require tenders by noon Oct. 2 for the supply and erection of a Cooling Tower at the municipal electric power station. Specification from the borough offices, or from Mr. E. J. Fenn, consulting engineer, Auckland (N.Z.).

Electric Time-releasing Mechanisms.

The Victorian Railway Commissioners, Spencer-street, MELBOURNE, invite tenders (by 11 a.m. Oct. 18) for the supply and delivery of Electric Time-releasing Mechanisms (100 with two normal and two reverse contacts, and 50 with four normal and four reverse contacts) for automatic signalling. Specifications from the Commissioners, Spencer street, Melbourne.

Converter Plant, Batteries, Booster Plant and Switchboards.

SYDNEY (N.S.W.) Council require tenders by 3 p.m. Jan. 22 for (A) Converter Plant (three phase to c.c.), (B) Two Storage Batteries, with switches and accessories, (C) Booster Plant, (D) L.t. c.c. Switchboards. Specification, &c., from the General Manager of the Electric Lighting Department.

TENDERS RECEIVED AND ACCEPTED.

POPLAR (LONDON).—The Electricity Committee recently invited tenders from 15 firms for the provision of ash-handling plant at the generating station, but two tenders only were received.

Only one of the tenders received was complete. The most complete scheme was that of Messrs. Strachan & Henshaw, at a total cost of £3,855. An alternative scheme for loading into wagons only with grabs, but allowing in construction for eventual extension in accordance with the complete specification, had been obtained, the estimated cost (exclusive of foundations) being £1,418. With the foundations the total cost of the scheme would be £1,600. The plant was necessary to enable the motor wagons obtained for removal of ashes, and now loaded by manual labour, to be fully and economically utilised. The committee recommends that ash handling plant, as specified, be obtained and erected, at a total estimated cost of £1,600.

WAKEFIELD.—The Corporation have accepted the following tenders:—

Sturtevant & Co., new steel chimney, fan and motor, &c., £870; E. Green & Son, economiser and accessories, £2,675.

BARNSLEY.—The Council has accepted the tenders of Herbert Morris & Co. for the supply and erection of a crane, £405. 2s.; Needham Bros. & Brown for circulating pipes, £12 per ton; Thos. Lindley, for foundation for turbo-alternator, £206. 11s.; and Fred. Taylor, for removal of old engine beds, £149.

WOLVERHAMPTON.—The Council have accepted the tender of Strachan & Henshaw for supplying and fixing a coal conveyor plant at the electricity works, at £3,832.

Government Contracts.—The following tenders were accepted by the British Government Departments during September:—

War Office. British Insulated & Helsby Cables, General Elec. Co., W. T. Henley's Telegraph Works Co., Hooper's Telegraph & India Rubber Works, Johnson & Phillips, Liverpool Elec. Cable Co., Siemens Bros. & Co., and Ward & Goldstone, electric cable and wire; J. C. Fuller & Son and Siemens Bros. & Co., elec. cells; Ransomes & Rapier, alteration of cranes; T. De la Rue & Co., insulator cups; Petters (Ltd.), engine and dynamo; General Elec. Co., elec. light fittings; Aster Engineering Co., Austin Motor Co., W. H. Dorman & Co., Fyfe, Wilson & Co., and Keighley Gas & Oil Engine Co., generating sets; Clyse'co (Ltd.), General Elec. Co., and Pope's Elec. Lamp Co., elec. lamps; C. A. Vandervell & Co., magnetos; Elec. Construction Co., motors and starting panels, &c.; Hobson Mfg. Co., and Lodge Sparking Plug Co., sparking plugs; H. Lebus, W. H. Peal, W. E. Chivers & Sons, Clegg Bros., Cook, White & Co., Davey & Armitage, C. Jennings & Co., Mackenzie & Moncur, J. Parnell & Son, E. Pollard & Co., Sharp Bros. & Knight and Whitstable Shipping Co., wood poles; Automatic Telephone Mfg. Co., switchboard panel parts.

India Office.—General Elec. Co., cable and wire; Siemens Bros. & Co., cells; Creed, Bille & Co., receivers; F. Smith & Co., wire.

H.M. Office of Works. Colley, Meikle & Co., three boilers, pump, motor, &c., for Admiralty Buildings, London.

Post Office. British L. M. Ericsson Mfg. Co., telegraph and telephone apparatus and battery boxes; Telegraph Construction & Maintenance Co., telegraph cable; Siemens Bros. & Co., telegraph cable, dry cells and loading coils; Western Elec. Co., repeating coils; General Elec. Co., telephone lamps; Home Grown Timber Committee, poles; F. W. Cotterill, insulator spindles; Automatic Telephone Mfg. Co., telephones; British Insulated & Helsby Cables, bronze wire; Rylands Bros., g.i. wire.

Commissioners of Public Works, Ireland. V. G. Middleton, elec. lighting and bells at Labour Exchange, Dublin.

FINANCIAL MATTERS.

MUNICIPAL ACCOUNTS.

Aberdeen.—The accounts of the electricity department for the year ended July 31 show gross capital expenditure £462,620 (increase £8,017), of which £156,276 has been repaid, while the depreciation fund amounts to £64,512.

Revenue was £76,535 (against £69,693 in previous year), ordinary and casual expenditure amounted to £30,882 (£29,853), interest required £9,717 (£9,812), and sinking fund £18,183 (£17,755), leaving £8,752 (£3,320), which has been placed to reserve. Units generated were 15,014,420 (against 12,475,920) and sold 12,743,838 (10,463,269).

Mr. J. Alex. Pollock, city electrical engineer, says in his report the increased costs are principally due to the increased price of coal (£8,992), other supplies, maintenance, rates, &c., making up the balance. Power supply increased 36·10 per cent. Costs per unit were 0·7d. (0·45d.), and capital charges 0·52d. (0·64d.). The 3,000 kw. turbo alternator has been most reliable and economical. A second 500 kw. converter is (at July, 1916) being erected, and the Council has placed an order for a 5,000 kw. set

for 1917. Mr. Bell recommended that the rates for current be increased 10 per cent. for private and public lighting, and 15 per cent. for power and heating. The total horse-power of motors connected is 12,189 (against 10,083 last year), heating connections are equal to 49,838 (45,916) 33-watt lamps, and total connections, exclusive of tramways, to 592,408 (328,367). Maximum load, including tramways, was 5,274 kw. (4,560 kw.) and load-factor 27·50 (26·19) per cent.

Lowestoft.—The tramway receipts to Sept. 9 were £6,869, compared with £8,739 in 1915.

The Tramways Committee recommend that £750 be provided in the borough rate on account of the deficiency for the year ending Sept. 30.

From Oct. 1 the cars will be run into the depot at 8 p.m., and the Tramways Manager has been instructed to employ women drivers if necessary.

Wolverhampton.—A summary of the accounts of the electricity supply undertaking for the year ended March 31 has been issued.

Gross profit was £25,588. Interest required £8,759, sinking fund and repayment of loans £14,134, and income tax £837, and the net profit was £1,856.

COMPANIES' MEETINGS AND REPORTS.

CHADBURN'S (SHIP) TELEGRAPH CO. (LTD.)—Mr. W. Chadburn, who presided at the meeting on Tuesday, said that profits for the past year were £9,823, and dividends amounting to 8 per cent. were sanctioned, £5,524 being carried forward. He said the business had been taken over as a controlled establishment. The amount carried forward was larger than usual in order to provide for excess profit duty, &c. He regretted he was not allowed to give such details of what had been doing during the past year as would have been possible under pre-war circumstances, but he could assure them that they had been and were working at the highest possible pressure both in the works and on ships. At the same time it should be borne in mind that an increased output did not necessarily mean a corresponding increase in profits, since they had to reckon upon a very much higher cost of production, and they had to carefully regulate their prices proportionately to the increased cost of material and labour. The immediate prospects were satisfactory; the orders in hand were sufficient to keep them fully employed for the current year.

CLYDE VALLEY ELECTRICAL POWER CO.—The half-yearly meeting was held in Glasgow last week. Mr. F. C. Gardiner, who presided, said in moving the adoption of the accounts, the board had decided to transfer £17,500 to contingency fund for depreciation, bringing this fund up to £167,500, and they recommend that of the balance (after adjusting interest, amounting to £35,791) £3,835, be transferred to special reserve fund, bringing this fund up to £22,632; that the preference share dividend to Oct. 31, 1916, amounting to £9,000, be provided for; that a dividend of 1¼ per cent. on the ordinary share capital (tax free), amounting to £7,500, be paid; and that the balance of £15,456 be carried forward. The profit for the half-year was satisafetory, in view of the large increases in the price of coal and cost of labour and materials and the cost of repairs due to the heavy demands made on the company. The contracts for supply showed an increase during the half-year of 4,403 H.P., and connections to mains an increase of 7,544 H.P. It was expected that the new power station near Cambuslang would be in commercial operation by the end of October.

DIRECT WEST INDIA CABLE CO. (LTD.)—The report for the year ended June 30 states that the year began with a credit to revenue account of £64,219. 7s. 3d., to which has to be added the net result of the year's working, £14,705. 6s. 3d. (compared with £13,552. 12s. 2d. last year), making a total of £78,924. 13s. 6d. An interim dividend of 3 per cent. (tax free) was paid on March 1. A special interim dividend of £1. 5s. per share was paid on March 24, and at the same time a call of £1. 5s. per share was made, and it is now proposed to make a further payment of 3 per cent. (tax free). The balance to be carried forward is £53,399. 3s. 2d. The company's cable was interrupted between Bermuda and Turks Island for 54 days, and the insulation is still low; £7,375. 10s. 4d. has so far been paid on account of cost of repairs; the balance has not yet been ascertained.

The report and accounts were adopted at the meeting on the 21st inst.

DUNDEE, BROUGHTY FERRY & DISTRICT TRAMWAYS CO.—At the annual meeting of this company last week Mr. George Balfour, who presided, said the accounts showed that the company could not pay a dividend on the ordinary shares, but he hoped it would not be long before the declaration of dividend would be resumed. The drop in traffic was due to the lighting restrictions, a falling off in short-distance passengers' fares and unfavourable weather in the early summer.

HALIFAX & BERMUDAS CABLE CO. (LTD.)—The report for the year ended June 30 states that the net result of the year's working is a balance of £12,745. 10s. 3d., compared with £10,679. 2s. 9d. for the previous year. An interim dividend of 3 per cent. (tax free) has already been paid, and it is now proposed to make a further equal payment (tax free). The balance to credit of revenue account, which was last year £11,549. 1s. 9d., has had to be debited with the various items recorded in the revenue account for repairs, &c., and is now £7,710. 0s. 7d. The company's cable has worked efficiently during the year, except for a few days while being repaired in the Halifax Harbour.

The report and accounts were adopted at the meeting on the 21st inst.

UNITED ELECTRIC CAR CO. (LTD.)—At the annual meeting of this company at Preston last week Mr. R. B. Barningham said that throughout the past year the works had not been working at anything like full capacity, and only a very few small orders for tramcars had been received. They had had a fair share of Government work in motor and general service wagons and pontoons, but as this was competed keenly for very little profit could be obtained. He had hopes that they would be ultimately paid for the cars they had delivered mostly in South America, but the purchasers were chiefly in occupied territory in Belgium. It was proposed to pay the preference dividend and carry forward £5,269. He was satisfied that as soon as hostilities ceased there would be plenty of work in their line at home and abroad. The great bulk of the cars in this country must be renewed shortly. The report was adopted.

VICTORIA FALLS & TRANSVAAL POWER CO. (LTD.)—Mr. Arthur E. Hadley, who presided at the meeting last week, congratulated the shareholders on the very satisfactory result obtained during the year under review and the improved financial position of the company. Those results had been obtained through the company having brought into commission the further plant which was in course of construction during the previous year, and also to economies effected in the operation and working of the plant by their staff in South Africa. He had much pleasure in reporting a continuance of the progress during the current year; the earnings of the combined undertakings for the eight months ended Aug. 31 last showed the substantial increase of over £70,000 over those made during the corresponding eight months of 1915. After giving an analysis of the report and accounts, he said that the company's investment in the Rand Mines Power Supply Co. figured in the balance-sheet at £3,415,894. 10s. 7d., compared with £3,492,494. 0s. 6d. Their company held all the shares of the Rand Mines Power Supply Co. and was also a large creditor for loan in respect of which they held a first mortgage bond over the whole of that company's undertaking. The year's operations resulted in an increased profit over 1914 of £61,832, which had enabled them to pay the cumulative dividend on the preference shares and to clear off all arrears of dividend up to date. The accounts showed that the company had entered the stage when the earnings were more than sufficient to meet the 6 per cent. on the preference shares. The times they were passing through and the uncertainty of all financial conditions made it, in the opinion of the board, essential to conserve as far as possible their resources. Therefore, in respect of the past year, the board decided that it was in the best interests of the company to add that amount to the carry forward. The directors had in contemplation the payment at the beginning of next year of a full 12 months' dividend on the preference shares at the rate of 6 per cent. out of the profits earned during the present year. The prospects in the near future, judged by the progress made up to the present, were very encouraging. In endeavouring to look into the future it must be remembered that as the profits increased the amount payable as excess profits duty, as long as that tax remained in force, increased also. So far as was known, there was no reason to expect that the earnings should fall during the remainder of the year, and if that proved to be the case, and taxation was not further increased, the results of the present year should enable a start to be made in the payments of dividends on the ordinary shares and in the establishment of a reserve fund. The extensions to the Brakpan power station had been completed, and the whole of the plant ordered for all the power stations of the combined undertakings was now installed and in working order, and that plant, which had a capacity of 274,875 H.P., should enable us to meet normal increases in business without encroaching on the specified reserve plant. The chairman concluded by paying a tribute to the untiring loyalty of the staff, both in London and South Africa. Of a total number of 670 employees there were 210 serving their country.

NEW COMPANIES, MORTGAGES & CHARGES.

NEW COMPANIES.

McLEOD & SONS (LTD.) (144,891)—Reg. Sept. 20, capital £2,000 in £1 shares, to take over the business of manufacturers of ships' telegraphs and nautical instruments, marine, mechanical, electrical and general engineers and compass adjusters carried on as McLeod & Sons at Liverpool. Private company. First directors are J. Y. McLeod (managing director) and T.W. McLeod. Reg. office: 41, Castle-street, Liverpool.

SELSON ENGINEERING CO. (ITALY) (LTD.) (144,892)—Reg. Sept. 20, capital £3,000 in £1 shares, to carry on the business of mechanical, electrical and general engineers, manufacturers of and dealers in machines and hand tools, motor and engine builders, &c. Private company.

MORTGAGES AND CHARGES.

WALTERS ELECTRICAL MFG. CO. (LTD.)—A memorandum of satisfaction in full on various dates of debentures dated July 31, 1907, securing £2,000 has been filed.

CITY NOTES.

MEMORANDA (Sept. 27).—Bank rate 6 per cent. (since July 13, 1916). Consols 60⅝. Consols Pay Day, Oct. 4. Stocks and Shares Ticket Day, Oct. 12. Pay Days, Sept. 29 and Oct. 13. Price of silver, 32 15/16.

BAHIA TRAMWAY LIGHT & POWER CO.—A meeting of the holders of debentures will be held on the 18th prox. at noon, for the purpose of receiving from the trustees a report as to the present position.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units sold to consumers during the four weeks ended Aug. 25 amounted to 2,073,593, compared with 2,042,910 in the corresponding four weeks of 1915.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—Warrants in payment of the interim dividends on the preference and ordinary shares as already announced have been duly posted.

KALGOORLIE ELECTRIC POWER & LIGHTING CORPN. (LTD.)—The directors have declared a dividend on the preference shares at the rate of 4 per cent. per annum for the six months ending 30th inst.

MADRAS ELECTRIC TRAMWAYS (1904) (LTD.)—An interim dividend at the rate of 6 per cent. per annum (less tax) on the preference shares will be payable on Sept. 30.

STRATFORD-ON AVON ELECTRICITY CO. (LTD.)—At the recent meeting the report for 1915 stated that owing to abnormal expenditure on repairs to mains, coupled with the increased cost of materials and standing charges, the directors are unable to recommend a payment of any dividend.

METAL PRICES.

Messrs. J. B. Garnham & Sons, 132, Upper Thames-street, London, E.C., quote under date Sept. 26, the following as the present basis prices of—

New Metals.	per lb.		Per ton
Solid Drawn Brass Tubes	15½d.	English Lead	£31 5 0
Solid Drawn Copper Tubes	18½d.	Antimony	Nominal.
Brazed Copper Tubes	18½d.	Old Metals.	Per ton.
Brazed Brass Tubes	17½d.	Clean Copper Scrap	£104 0 0
Brass Wire	15½d.	Clean Brass Scrap	62 0 0
Copper Wire	18½d.	Brazlery Copper Scrap	90 0 0
Rolled Brass	15½d.	Old Lead	27 0 0
Brass Sheets	15½d.	Old Zinc	38 0 0
	Per ton.	Hollow Pewter	120 0 0
Copper Sheets	£157 0 0	Black Pewter	90 0 0
Spelter	52 0 0	Gun Metal	82 0 0

Mr. A. Joseph, Earl-street, London-road, Southwark, London, S.E., quotes under date Sept. 26, the following approximate prices of Scrap Metals:—

	Per ton.		Per ton.
Aluminium Cuttings	£110 0 0	Old Lead	£3 15. under English lead price
Clean Mixed Brass	65 0 0	Old Zinc	36 0 0
Clean Copper	108 0 0	Hollow Pewter	130 0 0
Brazlery Copper	88 0 0	Shaped Black Pewter	90 0 0
Gun Metal	84 0 0		

Mr. Joseph can supply solder at the following prices per ton: Plumber's Solder (in bar or strip), £80, Commercial Tinman's Solder, £97, Blowpipe Solder, £107.

ELECTRICAL COMPANIES' SHARE LIST.

We give below the latest prices at which actual transactions took place on or before Tuesday, Sept. 26.

Shrs.	Last Dividend	Name.	Price, Tues., Sept. 26	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply.		£ s. d.	
10	6%	Bournemouth & Poole E.L. Ord.	8½	7 1 2	Mar., Sept.
10	4½%	Do. 4½% Cum. Pref.	7½	5 16 2	Feb. Aug.
10	6%	Do. 6% Cum. 2nd Pref.	9½	6 1 6	Feb., Aug.
5	10%	Brighton & Rottingdean Ord.	6¾	7 6 9	Mar., Sept
5	7%	Do. 7% Pref.	7½	4 19 7	Mar., Aug
St.	4%	Central Elec. Supply Deb. St.	80	5 0 0	..
St.	4%	Charing Cross West End & City Deb.	80	5 0 0	Jan., July
5	7½	Do. 4½ Pref.	3½	6 10 11	..
5	7½	Do. Ord.	3½	6 17 11	Aug., Feb
5	4½%	Do. City Pref.	3½	6 18 6	Jun., Dec
5	4%	Chelsea Elec. Supply Co. Ord.	3½	6 .. 7	Mar., Sept
St.	4½%	Do. do. Deb.	85	5 5 11	Jan., July
10	8%	City of London Elec. Lt. Ord.	12½	6 6 4	Feb., Aug
10	6%	Do. 6% Pref.	10½	5 13 7	Mar., July
St.	3%	Do. 3% Deb. St.	97½	4 17 6	Jun., Dec
St.	4½%	Do. 4½ Debs.	89	5 2 6	Jun., Dec
10	7%	County of London Ord.	10½	6 9 6	Mar., Sept
10	6%	Do. 6% Pref.	10½	5 14 4	Feb., Aug
St.	4½%	Do. 1st Deb.	93½	5 4 0	Jan., July
St.	4%	Do. 2nd Deb.	84½	4 8 2	May, Nov
St.	4½%	Edmundsons Elec. Supply 4½% Debs.	92½	4 17 3	July
5	7%	Kensington & Knightsbridge Ord.	11½	6 11 9	Feb., Aug
St.	4%	Do. Deb. St.	99½	5 1 0	Jan., July
5	6%	London Elec. Supply 6% Pref.	11	6 9 9	..
St.	4%	Do. 4% Mort. Debs.	92	4 13 7	Jan., July
5	3%	Metropolitan E. Supply Ord.	5½	6 11 9	Mar., Aug
St.	4½	Do. 1st Mort. Deb.	90	5 11 6	Jan., July
St.	5%	Midland Elec. Corp. 1st Mort. Deb. St.	99	5 1 0	Jan., July
..	6%	Newcastle & Dist. E.L. 6% Red. Debs.	99½	6 0 6	Mar., Sept
St.	5%	Newcastle-on-Tyne E.P. 5% 1st Mt. Deb. St.	..	.. ..	Mar., Sept
1	6%	North Metropolitan E.P. Supply 6% Pref.	1½	6 3 10	Apl, Oct
4	5%	South London E.S. Ord.	2	6 10 ..	Mar., Sept

† Ex dividend or interest.

ELECTRICAL COMPANIES' SHARE LIST.—*Continued.*

Shrs.	Last Dividend	Name.	Price Tues., Sept. 26	Rate per cent. Yielded.	Dividend Due.
		Electricity Supply—*cont.*		£ s. d.	
£	8%	St. James' & Pall Mall Ord.	6⅝	6 5 6	Feb, Aug
£	7%	Do. do. Pref.	5⅞	5 19 2	Feb, Aug
St.	3½%	Do. do. Debs	74	4 14 8	Jan, Dec
St.	4½%	Urban Elec. Supp. 4½% Db. St.	72½	6 4 7	Apl, Oct
1	8%	Waste Heat & Gas Elec. Gen. Stations	1 3/16	6 14 8	Mar, Aug
£	7%	Westminster E.S. Corp. Ord.	6 5/16	5 10 11	Mar, Sept
£	4½%	Do. 4½ Cum. Pref.	4⅛	5 4 1	Jan, July
		Electric Railways and Tramways.			
St.	5%	British Elec. Traction 5% Debs.	86	5 16 3	Apl, Oct
St.	6%	Do. 6% Cum. Pref.	79½	7 10 11	Feb, Aug
St.	4%	Central London Guar. Assented Ord.	72	5 11 1	..
St.	4%	Do. do. Assented Def. Ord.	70⅜	5 13 8	..
St.	4½%	Do. 4½% Pref.	82¼	5 9 1	Jan, July
St.	4%	Do. 4% Deb. St.	76	5 5 3	Jan, July
St.	4%	City & S. London Deb.	74⅜	5 7 0	May, Nov
St.	5%	Do. Pref. 1896	70⅜	7 1 4	Feb, Aug
10	1½%	London Electric Ry. Ord.	2 3/32	5 10 7	Jan, July
St.	4%	Do. 4% Pref.	66	6 1 4	Mar, Sept
St.	4%	Do. 4% Debs.	75½	5 6 0	Jan, July
St.	1%	Metropolitan Ry. Con. Ord.	24½	4 1 5	Feb, Aug
St.	3½%	Do. 3½% Pref.	62⅞	5 11 4	Feb, Aug
St.	3½%	Do. 3½% Convertible Pref.	59	5 18 8	Feb, Aug
St.	3½%	Do. 3½% A Debs.	67½	5 3 8	Jan, July
St.	3½%	Do. 3½% Debs.	68⅜	5 1 8	Jan, July
St.	..	Metropolitan Dist. Ry. Ord.	18	.. ..	Feb, Aug
St.	4%	Do. 4% Prior Lien	75½	5 6 4	May, Nov
St	4½%	Do. 4½ First Pref.	73	6 3 3	Feb, Aug
St	6%	Do. 6% Perp. Debs.	109	5 10 1	Jan, July
St.	4%	Do. 4% Debs.	73	5 9 7	Jan, July
St	4%	Do. 4% Debs. (1903-5)	75	5 6 8	Jan, July
St.	4%	Do. 4% Guar. Stock	70⅛	5 14 2	Mar, Sept
		Electric Manufacturing, &c.			
1	15%	Babcock & Wilcox Ord.	3 1/16	4 17 0	Apl, Oct
1	6%	Do. 6% Pref.	1 1/32	4 9 4	Apl, Oct
1	7%	Brit. Aluminium Ord.	1 3/32	4 18 0	Mar
100	5%	Do. Prior Lien Debs.	93½	5 6 11	Jan, July
1	6%	Do. 6% Pref.	1/32	6 8 0	Jan, July
5	17½%	Brit. Insulated & Helsby Ord.	12¾	6 17 3	Aug, Feb
5	3/0	Do. 6% Cum. Pref.	5 1/16	5 15 8	Jan. July
1	6%	British L.M. Ericsson Mfg. Cm. 6% Pref.	1/32	6 8 0	Mar, Sept
St.	4½%	British Thomson-Houston Db.	91	4 18 11	Feb, Aug
2	7½%	Brit. Westinghouse Pref.	2 3/32	5 3 7	April
100	6%	Do. 6% Prior Lien Debs.	102¾	5 16 10	Apl, Oct
St.	4%	Do. 4% Mort. Deb. St.	68⅜	5 16 7	Jan, July
5	20%	Callender's Cable, &c., Co. Ord.	12¾	7 16 10	Jan, July
5	5%	Do. 5% Pref.	4¼	5 17 8	Feb, Aug
St.	4½%	Do. 4½% Debs.	87	5 3 5	June, Dec
1	6%	Dick, Kerr & Co. 6% Pref.	3/32	6 12 5	Sept.
5	..	Edison & Swan U. Elec. Lt. A. £3 pd.	1/32	.. ..	Feb, Aug
St.	4%	Do. 4% Deb.	61¼	6 10 7	Jun, Dec
1	7½%	Elec. Construction Ord.	2/32	8 5 6	May
1	7%	Do. 7% Cum. Pref.	1 3/32	6 15 9	Jan, July
St.	4%	Do. 4% Debs.	68	5 17 8	Jan, July
10	10%	General Electric Ord.	14¾	6 14 11	July
10	6%	Do. 6% Pref.	9 3/32	6 2 8	June, Dec
5	20%	W. T. Henley's Telegh. Wks. Co. Ord.	16 1/32	5 18 1	Feb, Aug
5	2/3	Do. 4½% Cum. Pref.	4	5 12 6	..
St.	4½%	Do. 4½% Db.	88½	5 1 8	Jun, Dec
10	10%	India Rubber, G.P. &c., Ord.	12½	8 4 11	Feb, Aug
10	5%	Do. Pref.	7¼	6 7 0	Apl, Oct
12	20%	Telegh. Con. & Main. Co.	39	6 3 1	Mar, July
100	4%	Do. 4% Debs.	95½	4 4 1	Jan, July
1	7½%	Vickers Ord.	1 3/32	3 16 2	May, Aug
1	6d.	Do. 5% Pref.	3/32	5 10 4	May, Aug
St.	4%	Do. 1st Debs.	81½	4 18 3	June, Dec
100	4½%	Do. 4½% 2nd Debs.	99½	4 10 8	June, Dec
St.	4½%	Willans & Robinson B. Cm. Pref.	41½	9 18 10	..
St.	4%	Do. 1st Mt. Deb. St.	56¼	7 1 0	..
		Telegraphs.			
St.	30/0	Anglo American 6% Pref. Ord.	101½	5 18 2	Fb,My,Aug,N
St.	1½%	Do. Def. Ord.	23¾	6 18 8	Fb,My,Aug,N
St.	4%	Commercial Cable 4% Debs.	71¾	5 11 6	Ja. Ap. Jly,O
10	5%	Cuba Submarine Ord.	8 3/32	6 0 9	May. Nov
10	10%	Do. 10% Pref.	15½	6 11 2	..
5	5/0	Direct Spanish 10% Pref.	7½	6 13 4	..
10	4%	Direct United States	6 3/32	5 19 1	Ja.Ap.Jly,O
St.	8%	Eastern Tel. Co. Ord.	145	5 10 4	Ja,My,Jly,O
St.	3½%	Do. 3½% Pref.	65	5 7 8	Ja.My,Jly,O
St.	4%	Do. 4% Debs.	79	5 1 3	May, Nov
St.	4%	Eastern Extension Tel. Co. 4% Debs.	78	5 2 7	Feb, Aug
10	8%	Do. Ord.	14½	5 12 3	Ja.Ap.Jly,O
10	22%	Gt. Northern Tel. Co. With Coup.	42½	5 3 6	Ja. My. Jly
25	13%	Indo-European	49¾	6 10 8	May, Nov
1	10%	Marconi's Wireless Tel. Co.	3 3/32	3 2 9	April
1	7%	Do. 7% Pref.	2 3/32	3 4 8	July
10	1%	West India & Panama Ord.	1 1/16	8 14 11	May, Nov
10	6%	Do. 1st Pref.	7¾	7 14 10	May, Nov
10	8%	Western Telegh. Co.	14¾	5 8 6	Mr, Jly, O, Dec
St.	4%	Do. 4% Deb. St.	77	5 3 11	June, Dec
..	4½%	Western Union 50-yr. Bds.	99½	4 10 10	May, Nov
		Telephones.			
1	7½	Monte Video Telegh. Ord.	5⅜	7 13 7	Nov
1	10%	Oriental Telephone Ord.	2 1/16	4 6 6	Apl, Oct
St.	4%	Do. Deb. St.	79	5 1 3	Jan, July
St.	4½%	Telegh. Const. Equip. Db. St.	83	5 8 5	Jan, July
5	8%	United Telephone Ord.	6¾	5 16 4	Apl, Oct
5	5%	Do. 5% Cum. Pref.	4 3/32	5 4 7	Jan, July
St.	4½%	Do. Deb. St.	85½	5 5 3	Jan, July
		Financial and Investment.			
10	6%	Globe Trust & Trust	12 11/16	4 13 8	Sp Dc.My Je
10	6%	Do. 6% Pf.	10¼	5 10 4	Sp.Dc.Mr.Jn
100	5%	Mexican Corporation Common	85½	5 17 6	Ja.Apl.Jly,O
..	4%	Do. $100 Pref.	70	5 14 3	Ja.Apl.Jly,O
100	6%	Submarine Cable Trust Certs.	125	4 16 0	Apl. Oct
		Colonial and Foreign Electric Supply, &c.			
5	3/0	Adelaide Elec. Supply 6% Pref.	4 1/16	6 1 6	Mar. Sept
St.	5%	Do. 5% Deb.	94½	5 5 10	Jun, Dec
10	6%	Bombay E. & T. 6% Pref.	10½	5 15 8	..
St.	4½%	Do. 4½% Debs.	83	5 8 5	Jan, July
5	6%	Calcutta E.S. Corp. Ord.	6 3/32	6 17 2	May, Nov.
5	5%	Do. 5% Pref.	4 1/32	5 12 8	Mar. Sep

† Ex dividend or interest.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—Torquay decides "that it is not entirely out of the danger zone with reference to aircraft"; electric lights in the streets will, therefore, be "doused" during May, June, July and August.

* * * *

"Nearly two million k.v.a.," says an advertisement head line. Yet I sometimes hear that one KVA is one too many.

* * * *

Dr. Ferranti has suggested that "a ring fence should be made round the Germanic Powers." Why not make it a ring main equivalent to the short-circuited winding of an induction furnace and thus make Central Europe too hot to hold—even the Huns!

* * * *

No comment other than the italic is needed upon the following extract from the April issue of the "Telegraph and Telephone Journal": "Twenty years ago *on April* 1, 1896, the State acquired by purchase the trunk lines of the National Telephone Co."

* * * *

The Budget is in every respect pro-electric; gas cars are heavily taxed, so that it will be cheaper to use an "electric," which is usually fitted with a 2 H.P. to 5 H.P. motor. Matches do not escape taxation, and "your gas will cost you more." I believe there will be a boom in electric gas-lighters! Oh, the pity of it!

* * * *

A Dewsbury correspondent writes me *re* "T.R.C.P.," the new Inst.E.E. abbreviation for "C.T.S.," and suggests that a useful alternative to "Tough Rubber Compound Protection" would be "The Right Conductor Preservative." I think "C.T.S." Brooking would regard it as rather a ponderous prefix, though its meaning may appeal to him. But before I can award the promised Hot-Plate I want a few more attempts, please.

* * * *

This week I am asked to introduce to Round Table readers Mr. Elasta, the latest missionary on behalf of Pope lamps.



I'M ELASTA.

From his portrait it will be seen that he is "bouncically resilient," and he has the appearance that no matter how much you sit on him he will always return to his original position.

An incident which should occasion considerable chagrin in gas circles is the report of the gas manager at Perth in which he states that "it will be cheaper to buy electrical energy from the local supply mains than to put down gas-dynamos at the gas works and generate their own current." Surely this is the writing on the wall.

* * * *

The Holborn Restaurant is a big place as the small number of Batti-Wallah's who turned up there on Friday last discovered. It did not seem to be clear that the rendezvous might be in one of three places according to the time of one's arrival; say, from 12 to 1 the short bar, from 1 to 2 the grill room, and from 2 to 2.30 the coffee room in the Council Chamber. The latter is time-honoured of many B.-W. concerts, and is a very good meeting place after lunch, but in spite of that, Frascati's is to be the B.-W. Friday meeting place.

* * * *

Lieut. A. R. Courtenay, recently acting publicity manager to the General Electric Co., and now with the Mediterranean Expeditionary Force, recently achieved an interesting piece of publicity work in Alexandria. His company, the Mechanical Transport A.S.C., runs its own Pierrot party known as the "EMPTIES," and at a concert given at the Alhambra Theatre



took over £100 in aid of the United Services Recreation Fund. Lieut. Courtenay was the "drummer" for the show, and one of his most attractive "stunts" was the sandwichmen shown in the photograph. Bill-board men had never previously been seen in Egypt, and their first appearance as the "EMPTIES" caused no end of excitement. At one time the Arabs got the letters badly mixed, but Lieut. Courtenay soon had them drilled.

* * * *

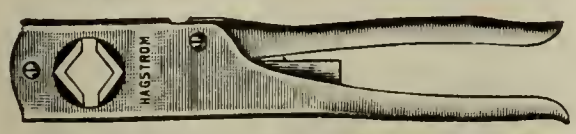
THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), April 5, 1879.]

ELECTRIC LIGHTING AT THE ROYAL ALBERT HALL.—The following curious letter has appeared in *The Times*: "I wish to enter my protest in *The Times* against the proceedings of the Royal Albert Hall Corporation in the matter of the electric lighting of that building. As an original seatholder, I object strongly to pay £2 annually on each stall for the current expenses. This is, however, in accordance with the terms of Lord Redesdale's Act of 1876, and it is not, perhaps, sufficiently known that the Corporation has power, under that somewhat tyrannical measure, to mulct us to the extent of £10 per seat in each year. In the accounts recently issued I find that the sum of £600 is put down as the estimated cost of the electrical lighting, which I am confident no seatholder really desired, and which I am equally sure most are agreed to declare a very ghastly and unpleasant innovation. The seatholders have had no voice in this matter, and it seems only fair that their views may be made known. For my part, I consider the whole proceeding both high-handed and quite unnecessary."

THE HAGSTROM ARC LAMP CARBON CUTTER.

Will sever carbon without crushing. Leaves straight, clean edge.
Adjustable and non-adjustable types supplied.



THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.
Phone: Regent 4346. *Code: ABC 5th Edition. Teleg.: "Engineyor, Westrand, London."*

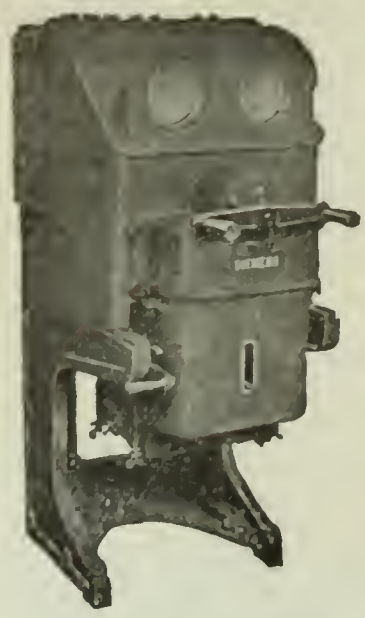
PLATINUM for WAR MATERIAL

supplied by permission of the
MINISTRY of MUNITIONS.

J. BLUNDELL & SONS,

GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golsilplat, Ox., London." 4746 Gerrard.

SIEMENS



IRONCLAD SWITCHGEAR FOR ALL PURPOSES

Control Pillars
Distribution Boards
Main Switchboards

Illustration shows our Standard Cast-iron Mining Pillar suitable for pressures up to 3,300 volts.

Write for particulars to —

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

ELECTRIC LIGHTING AT BALLATER AND ELLON.

Early in 1913 negotiations were opened between Mr. James Duncan, of Tillycorthie, Udny Station, Aberdeenshire, and the firm of T. C. Smith & Co., electrical and motor car engineers, Aberdeen, concerning the introduction of electric light into the burgh. After

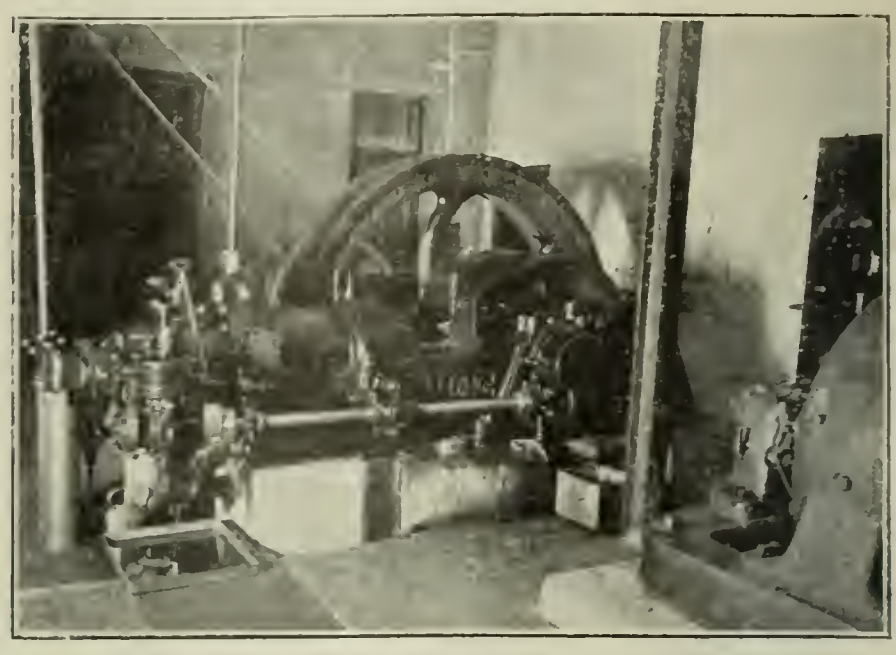


SUPPLY WIRES CROSSING TELEGRAPH WIRES.

certain guarantees had been asked and given, the arrangements were concluded in November of that year, and it was tentatively arranged that the water power of the River Garn should be utilised to drive the generating plant.

A Provisional Order was accordingly applied for, but some opposition was presented by the proprietors of the fishings in the river. The opposition, although it might have been overcome, determined Mr. Duncan to abandon the original proposal, and to install instead a suction gas plant.

In the generating station are installed two 68-H.P. anthracite suction gas producers and engines, by Messrs. Fielding & Platt, Ltd., Gloucester. The suction gas producers are interconnected by a flexible coupling in such a way that either engine can be run from



ENGINE ROOM.

either plant. The starting of each engine is by means of a high-pressure air self-starter. The engines are fitted with heavy flywheels suitable for dynamo driving and throttle governing. We understand that an extremely steady voltage is obtained. Each engine is directly connected by flexible split couplings to a 42-kw. 220/300-volt British Electric Plant, Alloa, compound-wound dynamo, with a single-pole switch direct on the frame to cut out the compound windings when the machine is charging the battery.



METHOD OF FIXING WIRES OVER ROOFS.

Considering the climatic conditions which prevail in this district in winter, the engineer decided to install Heenan & Froude water coolers, instead of the ordinary tank water coolers. We are informed that the engineers have now had considerable experience of these coolers and the results which they have given are highly satisfactory. They possess the advantages of producing a constant cooling effect

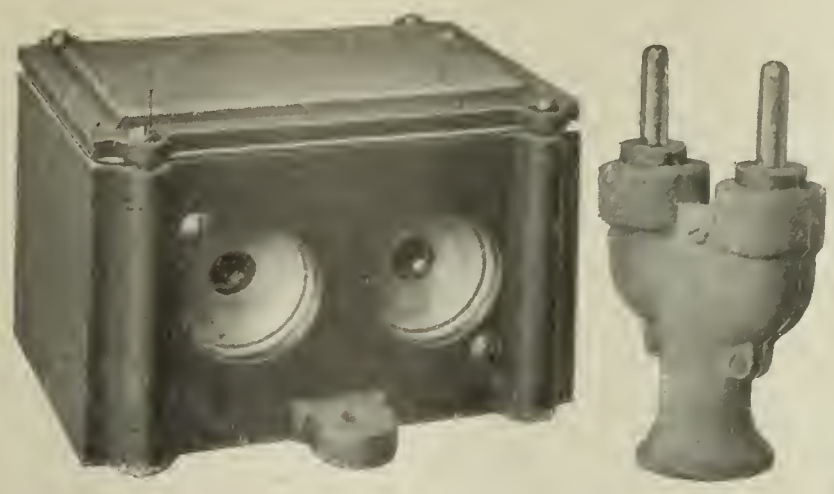
TINNING FURNACE
Hall's Patents
For COATING WIRES with Tin, Lead, etc. For use as a BATH.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
The only Tinning Plant on the World's Market with Automatic Heat Control.
Smaller Furnaces arranged in special cases.
MONOMETER MANUFACTURING CO., Ltd., 14, Whitehouse St., Aston, Birmingham

IRONCASED SOCKETS & PLUGS

FOR HARD SERVICE.

Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.

Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,

Ordsal Electrical Works,

SALFORD,

MANCHESTER.

independent of climatic conditions, and the space which they occupy is much less than that required for tanks.

Accommodation has been arranged on the lower floor for the attendant-in-charge, his quarters forming part of the generating station.

The whole of the electrical energy is controlled from a main switchboard, consisting of the usual dynamo, battery and feeder panels. The dynamo panels are fitted with volt and ampere meters, shunt regulator and single-pole maximum and reverse-current circuit-breakers. The battery panel consists of the necessary ampere meters, two 200-ampere 19-way charge and discharge switches, automatic cut-out and cut-in relay, and two 200-ampere S.P.Q.B. knife switches. An integrating recording ampere-hour meter and charge and discharge ampere-hour meters are also fitted. The main output panel consists of four 200-ampere meters and four 200-ampere D.P.Q.B. switches, and eight single-pole porcelain handle fuses.

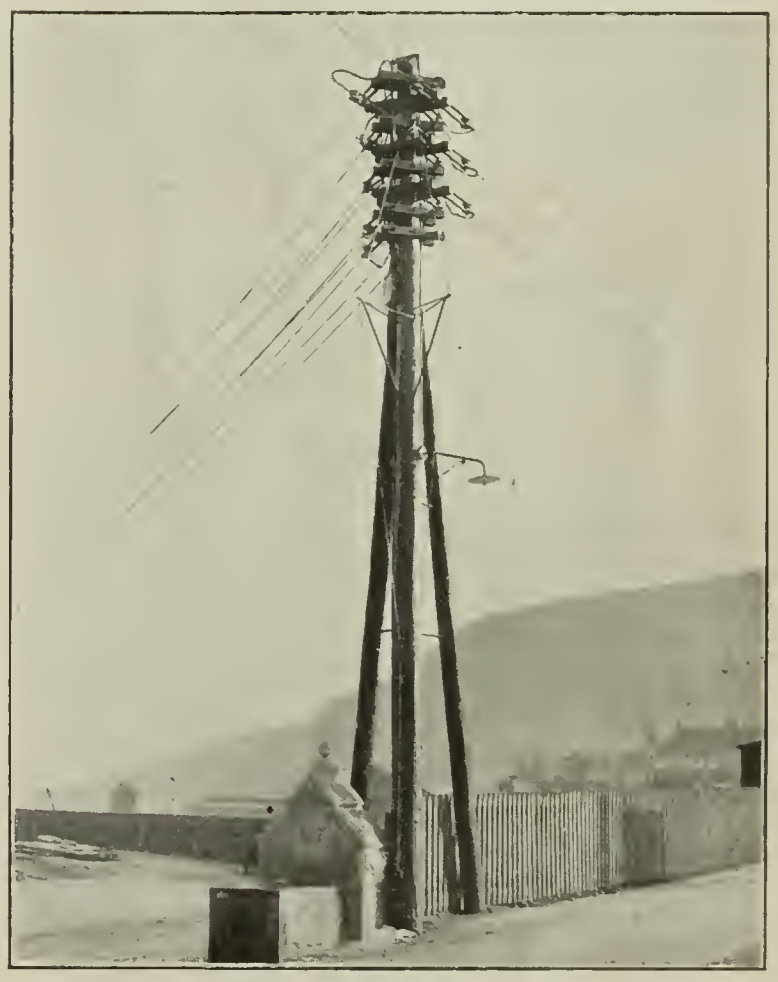
The battery consists of 120 cells of Chloride plantide type, with a capacity of 580 ampere-hours in five hours, down to 1·83 volts per cell, or 696 ampere-hours in 10 hours to 1·83 per cell. The plates are mounted in glass boxes. The wires leading from the regulating switches from the switchboard are suspended from the roof through special porcelain ceiling plates.

The main and sub-feeders are carried through the walls of the power station to a main pole, thence, overhead, throughout the burgh, on larch poles, and are erected on cross arms attached to insulators. The sizes of cables vary from 37/14 to 7/20. Where Post Office telephone and telegraph wires cross the supply mains underground cables were laid. On the top of each pole is a small zinc roof, and a galvanized wire leads from this to the bottom of the pole, serving as a lightning conductor. Lightning arresters have been erected outside the power station where the mains emerge.

The street lights are divided up into four circuits. The consumers' connections consist of aerial braided wire connected from the nearest pole either to upright or swan-neck insulators, erected either on chimneys or walls, thence a pair of wires of suitable size are led into a double-horn porcelain inlet, screwed into a galvanised tube terminating in a pair of ironclad fuses. It is worth mentioning that the inlet pipe leading in through the slates of the roofs is taken through sheet lead and soldered to the galvanised pipe, which makes the roof waterproof. The porcelain double-horn inlet was employed to obviate the risk of short circuit from the moisture, which in the autumn and winter condenses round the cable inlet. With the double-horn insulator the distance of the inlet is 4 in., and the wires are separated. When mositure gathers it acts as on an ordinary upright insulator. Over one year has passed since the completion of the installation, and we are informed that no trouble has arisen.



Feeders Leaving Power House.



Main Distributing Pole.

The work of the erection of the plant, mains and the wiring of houses was commenced in January, 1914, and the opening ceremony was performed on December 24 of that year. About 165 houses have installed the electric light and power to the extent of about 2,400 lamps. A similar installation for the town of Ellon, Aberdeenshire, was carried out by the company, under the subscriber's supervision, during the same period. The whole of the work was designed and supervised by Mr. M. K. Cooper, A.M.I.E.E., manager and engineer of the electrical department, T. C. Smith & Co., Aberdeen, to whom we are indebted for the foregoing particulars, and also for the supply of the illustrations.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK
CHARLES CLIFFORD & SON, Ltd.
BIRMINGHAM.

AUTOMATIC CONTROL FOR CAPSTANS AND WINCHES.

Efficient and reliable control gear of the automatic and fool-proof type is necessary for the successful operation of electric capstans and winches. It should be specially designed to withstand the severe conditions under which it will be used. The system should afford complete control by simply actuating a pedal switch, thus necessitating a minimum of attention from the operator, who can be free to deal with the slack rope.

The control apparatus described in price list No. 5,313 has been specially developed by the B.T.-H. Co. to satisfy the requirements of capstan and winch service, and ensures that the motor is automatically started up in the shortest time compatible with safety. The gear includes a pedal switch designed for use in a covered yard or on an exposed wharf, and an accelerating unit made up of a series of contactors all electrically operated.

It is claimed that owing to its robust construction, heavy contacts and absence of dash-pots or other small parts, the equipment will give satisfactory service without attention. It is recommended for installation in capstan pits and other underground chambers where opportunities for inspection are limited. The various parts of the capstan equipment need not, therefore, be separated.

The pedal switch does not carry the main current, but when depressed closes the operating coil circuit of the first or shunt contactor, causing it to complete the motor circuit through the starting resistance. The remaining contactors close successively, and each section of the starting resistance is cut out automatically immediately the acceleration of the motor has caused the main current to decrease to the value at which its contactor is set to operate.

The accelerating unit is a standard S.M.C. starter (Fig. 1), consisting of a shunt or line contactor and a number of series contactors, mounted on a slate base, which also supports the starting resistance. All contactors which break the main current are protected by magnetic blow-out devices. The starter is enclosed in a ventilated iron case having suitable openings for the cable conduits and corner feet for mounting on a wall or other support.

The standard equipments included in the list are suitable for continuous current non-reversing motors having shunt, compound or series windings. They are made in various capacities up to 25 B.H.P. and for use on circuits up to 550 volts. In the case of equipments exceeding 25 B.H.P. capacity, the starter is mounted upon pipe framework. Such equipments are, of course, unsuitable for installing in a capstan pit and should be made the subject of special inquiry.

The external diagram of connections of a capstan starter suitable for shunt motors is shown in Fig. 2. For series machines the shunt field connections are omitted, thus leaving an idle terminal on the starter.

The resistance units are made in tubular form, and consist of non-corrodible wire wound on enamelled steel tubes, the wire being only slightly sunk into the enamel and not embedded therein. A porcelain insulator is fitted to each end of the tube, and provides an efficient means of insulating the resistance units from the supporting frame. The resistance units are supported on steel side plates by means of rods passing through the tubes, and substantial leads connect the tappings from the resistance to the contactors. All the resistance units are moisture-proof.

Two forms of pedal control switches have been designed to suit different conditions of service.

The type P, form A, pedal switch is suitable for service in unexposed situations, and is sufficiently strong to withstand all the rough usage that may reasonably be expected. A locking collar is fitted to this type of pedal switch to prevent its use by unauthorised persons.

When the control switch is likely to be exposed to heavy rain or sea water, or is liable to injury by vehicles passing over it, the type P, form F, pedal switch, illustrated in Fig. 3, is recommended. The plunger passes through a water-tight gland, and when not in service the pedal portion can be disengaged from the operating mechanism



FIG. 1.—TYPE S.M.C. AUTOMATIC STARTING RHEOSTAT.

and dropped down flush with the ground. When in this position the pedal can be locked by a key inserted in the top portion. The opening provided in the capstan pit cover is sealed with jointing material, and the switch receives the same protection as that afforded to the motor and starter. A protecting cover is provided for the lower portion of the switch, but no attempt is made to render it water tight. The switch contacts close and open with a combined rolling and rubbing action, thereby ensuring a good contact.

An overload relay can be fitted to the contactor panel, so that when the motor is overloaded the relay operates and disconnects it from the line. As it is necessary to reset the relay before the motor can be restarted, special contacts are provided on the pedal switch without extra charge when overload relays are supplied. These

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire also for flexible leads, etc. AMPLE STOCKS.
H. HARTJEN & CO., 95/37, NOBLE STREET, LONDON, E.C.

FERRANTI LTD
Central House, Kingsway, London, W.C.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.
Write for Binder "N."



THE MAN WHO PINS HIS FAITH TO THE

POPE Elasta British Made Wire Lamps

—will find his profits mounting steadily up. Elasta Lamps are such a genuine proposition—an entirely British made wire lamp—Brilliant—Strong—Economical—Durable. Write to-day for particulars of the generous discounts—or better still—send a small trial order.

The Lamp with a living in it.

Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W.

contacts energise a special resetting coil on the overload relay which, in closing, disconnects this coil immediately the resetting operation is completed.

Control equipments for reversible capstans are similar to those already described. For this service special contactor panels are used in conjunction with two pedal switches, one for each direction of motion. The forward and reverse contactors are mechanically interlocked so that they cannot close simultaneously even when both pedal switches are depressed together.

A squirrel-cage motor has great advantages for operation in capstan pits, and can be connected direct to the line by using a triple-pole contactor. This type of contactor is mounted on a slate base with cover and fitted with a magnetic blow-out device on each pole. It is suitable for motors up to 25 H.P. and a voltage range from 220 to 550 volts. Overload protection is not provided when the motor is connected to the circuit by a single contactor. The contactor is enclosed in an iron cover, and feet are provided at each corner of the slate base for mounting on a wall or other support. The pedal switch for this equipment is the same as that used on continuous-current circuits.

The prices of complete capstan starter equipments are given in the list, a copy of which will be supplied on application to the British Thomson-Houston Co., Rugby.

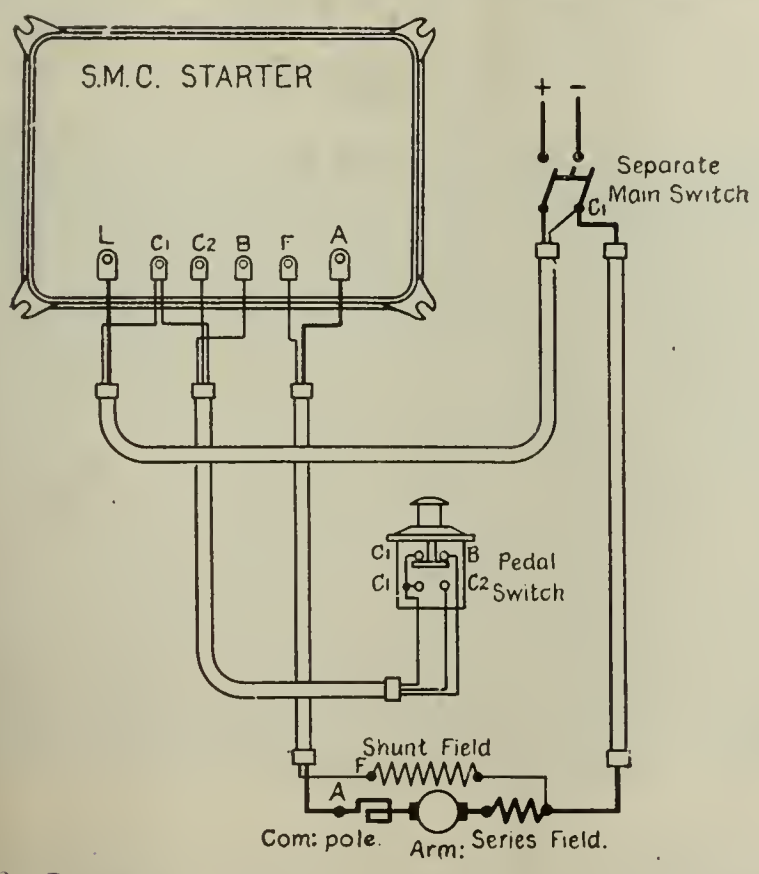


FIG. 2.—DIAGRAM OF CONNECTIONS FOR CAPSTAN CONTROL EQUIPMENT.

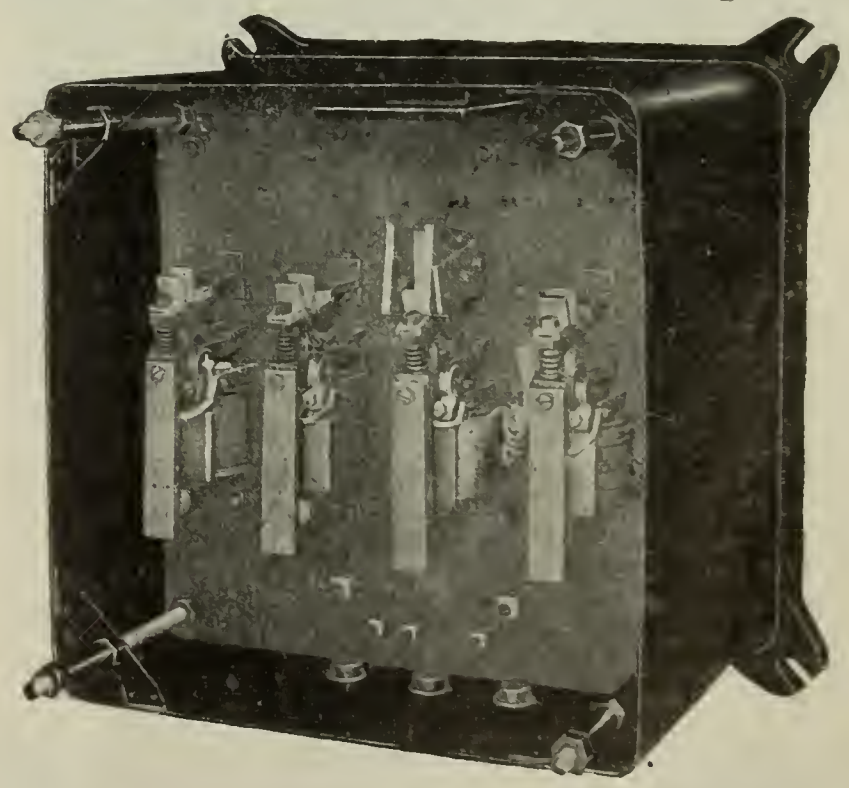


FIG. 3.—INTERIOR OF CAPSTAN PEDAL SWITCH, TYPE P, FORM F.

One, Two & Three Phase MOTORS.

LANGDON-DAVIES MOTOR CO.

Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

To DISTRIBUTION ENGINEERS. CABLE. &c., CONTRACTORS.

Regd.—**STREET STOVE**—*Prov. Pat.*

PORTABLE.—Packed 11 in. × 4½ in. Weight 6½ lbs.
ADJUSTABLE.—Open or Closed. Large or Small Fire.
INEXPENSIVE.—*Sample* —On Rail, London, C.F., 10/6.

Write—THE LAWRENCE PATENT WATER SOFTENER CO., Ltd.,
Parliament Mansions, Westminster.

CONCEALED LIGHTING IN A CHURCH.

Indirect or semi-indirect lighting is practicable in certain conditions of church interiors. Where the roof, however, is at a great height and has a dark surface that absorbs rather than reflects light, direct lighting must be adopted, but it does not follow that the lamps or their fittings should be visible. That satisfactory lighting can be secured with concealed light sources is proved by the scheme that has been adopted at St. Dunstan's Church, East Acton. This installation is of special interest, not only because the system employed is novel and most effective, but on account of the low cost at which it has been carried out.

When it was decided to replace gas by electricity for lighting the church the funds available were somewhat limited, and allowed of but a small margin for the purchase of fittings after the wiring costs had been met. The contractors for the work, Messrs. Duncan, Watson & Co., Berners-street, Oxford-street, London, W., after consultation with the illuminating engineering department of the British Thomson-Houston Co. (Ltd.), hit upon the happy idea of dispensing entirely with fittings as usually understood, and of lighting the church by trough reflectors concealed between the mouldings of the arches at the points where the latter spring from the pillar capitals.



Fig. 1.—St. Dunstan's Church, East Acton.
(Note the entire absence of visible fittings.)

Three Mi-olux extensive type trough reflectors, each equipped with two 60-watt standard Mazda lamps, are provided on the east side of each of the pillars on both sides of the nave. Persons passing up the church, therefore, can see neither fittings nor the light sources, the illumination being thrown forward and distributed evenly throughout the building. The lamps and fittings can be seen, of course, when passing down the building from the east end. The value of the illumination on the working plane *e.g.*, on the top of the pews—averages between 2·5 and 3 ft.-candles, which is well above the figure usually allowed for church lighting. This permits of the congregation following the service in comfort, even with hymn and prayer books printed in the smallest type. In many churches the light distribution is usually most uneven.

A telescopic standard carrying a conical reflector concealing a standard lamp is placed behind the vicar's stall, and this illuminates also the book on the lectern alongside. The music on the organ is lighted by a tubular lamp with adjustable reflector. The circuits are so controlled that almost any variation in the light can be secured at will. Thus, during the sermon, alternate fittings or individual reflectors in the groups in three can be switched out. Over the entrance to the lady chapel is a large cross worked in iron, which has been outlined with 12 small bulb lamps.

The installation was designed and carried out under the supervision of Mr. A. A. Blythen for the contractors, the wiring being enclosed in heavy gauge screwed barrel throughout. Although it has been fixed on the surface, especial care was taken to make the runs as inconspicuous as possible, and at a casual glance no evidence of the conduit is visible. Current is supplied from the direct-current mains of the Metropolitan Electric Supply Co., at 230 volts.

The accompanying illustrations have been reproduced from untouched photographs taken by the unaided light of the fittings



Fig. 2.—View of the Altar.

installed. Excellent as they are, however, they give but an imperfect idea of the effect produced. It will be seen at Fig. 1, which shows the nave looking towards the east end, that no fittings are visible: thus, the simple beauty of the architecture is preserved, the concealed lights throwing up every detail with remarkable clearness. Considerable light is thrown upwards on to the fine roof, but the photograph does not show this well. The character and intensity of the lighting in the chancel and of the altar can be judged



Fig. 3.—Showing the Lighting Arrangements.

from Fig. 2, which shows also the telescopic fitting behind the reading desk and lectern and the light over the organ. Fig. 3 shows the arrangement of the light units, the view being taken from the nave towards the north aisle. The neat manner in which the reflectors have been accommodated in the moulding and the skilful way in which the wiring has been concealed, can be well seen in the photograph.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Electrical Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, April 7, 1916.

THE ROUND TABLE.

By "KVA."

The "Wireless World" appears this month in a new and much improved form, upon which it is to be congratulated, but it repeats the ancient and a little irritating reference to the Institution of Electrical Engineers as the *Institute*. It always reminds me of Institoot, as the Americans will pronounce it!

* * * *

Alderman Tougher (I expect its pronounced Tuffer, though I don't know), Belfast, recently asked for an explanation of the failures of the electric service in the city, and wished to know if they could be prevented. Then the indignant Alderman asked: "Were they to go back to the use of candles?" But then he did not know that matches were going to be taxed.

* * * *

Speaking at the Royal Institution recently on artificial light and intensive culture, Prof. Frederick Keeble said "It would be a curious irony if in the next century the finest fruits of the early year were produced in the Black Country by the aid of electric power or electric light"

Certainly it would be; but if it can happen now my good friend Mr. Yeaman will have still further cause for extending his centralised power house in the Potteries.

* * * *

A correspondent tells me that the following story represents a true experience of a Mazda lamp:—

An elderly lady came into an electric shop with a burned-out lamp and asked for a renewal. The clerk took the lamp and, getting under a light, saw that it was a geometric problem to trace the filament, so, turning to the lady, he said: "You had this lamp burning in a large room?" The lady admitted the fact, and added that the lamp went out suddenly. The clerk then asked her if it was the only lamp burning at that time. The reply was "Yes," and the clerk said: "That accounts for the lamp going out. You tried to light a large room with a single lamp, and the strain on the filament was too great. What you need is more lamps in that room." It is rumoured that instead of replacing a broken lamp he sold her a dozen.

Some salesman, that!

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), April 12, 1879.]

THE WONDERFUL LAMP.—The "Daily News" of April 9th has a long article and a short leader on the Edison light. What a pity it is that the writer of the leader did not confer with some of the scientific men he tilts at before giving his lucubration to the world. We do not deny Mr. Edison's energy or the beauty of his lamp, or the amazement we labour under as discovery after discovery is hurled at us, but we do deny, till stronger proofs are forthcoming, that the electric light by incandescent metals is more economical than the arc.

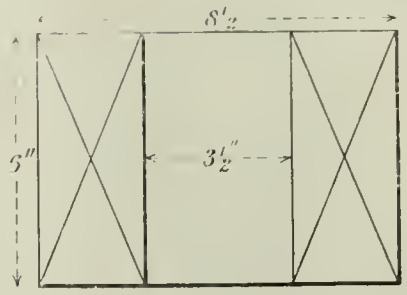
THE ELECTRIC LIGHT PRODUCED BY THERMO-ELECTRICITY.—We understand that Mr. Latimer Clark has taken up the question of applying a thermo-electric battery for the production of light. Several months ago we announced that M. Faure, the manager of the cotton-powder factory at Faversham, was engaged upon the same problem, and we may now add that he has overcome several of the most serious difficulties in the way of bringing this application within the domain of practice, and that his skill and perseverance would seem likely to be fully rewarded by success. In Paris also this important question is receiving considerable attention, MM. Clamont and Denayrouse being engaged in experimental trials with the the mo-pile devised by the former electrician.

AN IMPORTANT COIL-WINDING PROBLEM.

BY BY A. M. P.

(*Copyright 1914 in the United Kingdom, U.S.A., and Timbuctoo. Translation and dramatic rights reserved.*)

My master bids me wind my coil
(Dimensions in the sketch)
For fifteen hundred ampere-turns—
Out! out! ill-mannered wretch!
My slide rule that thou'st purloined hence
Return within this minute,
Or thou shalt get, about thine ear,
This inkpot: and what's in it!
Ahah! Thou shiverest, craven thief,
At that dread threat. I find . . .
Now, with my trusty, slithery friend,
The coil I'll quickly wind.



A sketch! my kingdom for a sketch!
I cannot do this task
Until a sketch there is, with full
Dimensions; all I ask.

INTERVAL.

(While we make a sketch.)
E.M.F. available, 500 volts.
Ampere-turns required, 1,500.

(NOTE.—The Press Bureau can find no official authority for the above statements, but has no objection to their publication.)

Haha! Hehe!! Hawhaw!!! Hoho!!!!
The time has come; the die is cast!
To-night! to-night!! then must I show
My homework (overdue) at last!

But to begin, let little *r* so small
Stand for, that is to say, impersonate
Resistance of the meanest turn of all;
That unique turn, which, by some chance of fate
Lies midway 'tween the outer and the in;
A representative of all the rest.
With *r*, I say, this wondrous thing begin;
For so to solve the problem it is best.

'Tis obvious, save to those bereft of brains
That, given *r*, resistance mean turn hight,
'Tis finished, all that thereto appertains,
And by inspection, all you wish, you write.

[NOTE.—Being unfortunately classed amongst those referred to above as deficient in grey matter, the author continues.]

Now, taking all the turns, of number *T*,
As with the mean turn wholly on a par,
Methinks—odsbodikins!—methinks I see
A method how to find elusive *r*.

Resistance to his majesty, King *E*,
Is *E* on *I*, by law of saintly Ohm.
Resistance also equals *r* by *T*.
(When I've done this I'll jolly well go home.)

Then, from the dread equation proved above
By substituting for *I*, *T* and *E*,
With no more trouble than a sucking dove
Doth give unto his dam, small *r* is free
So henceforth call itself by numeral name.
And as 0·33 ohm go down to fame.

And now, as we this point do thus attain,
Would that we could some handy pub. invade,
And, having come through peril, toil and pain,
Drown sorrow, for a time, in lemonade.

But no, we may not linger on our way.
This coil to bitter terminal we must wind,
And though the shades of fast-departing day
Draw close ('tis 4:15) we must not find
That darkness creeps upon us, ere we've done
Our noble work, this afternoon begun.

Thus having found, with many a mental strain
The smaller *r*, we then with heavy heart
Proceed to calculate, and not in vain,
The length of this same turn as at the start.

(*Continued on page* 8).



START AND STOP
BY PRESSING BUTTONS.

This neatly ironclad Master Switch may be used in conjunction with any suitable "IGRANIC" Self-Acting Starter, so that a motor may be started and stopped from any convenient point by merely pressing buttons.

"IGRANIC"
PUSH-BUTTON CONTROL.
IGRANIC ELECTRIC Co LTD
147, Queen Victoria Street, London.

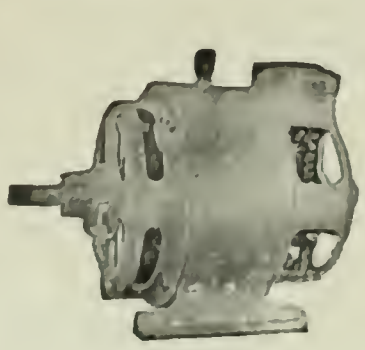
SPEED CONTROL
BY PRESSING BUTTONS.

Four simple buttons electrically connected with an "IGRANIC" Patented Compensated Solenoid Control Panel give complete control and speed regulation of variable speed D.C. motors. Write us for particulars.

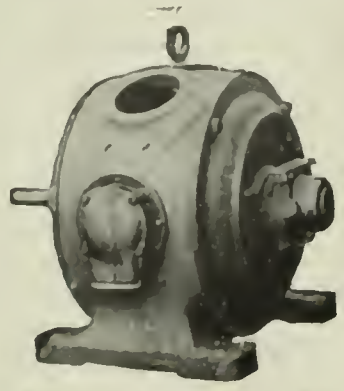


SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood Bldgs.
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

AN IMPORTANT COIL-WINDING PROBLEM—*continued.*

This done, we use the formula supreme—
The formula that enters every dream—
The formula that holds in day or dark
The formula that Noah used in the Ark—
The formula that, as we tramp along,
We weave into a wheezing, martial song—
The formula—Words fail me! Still, I say:
"Resistance *R* equals *Kl* on *a*!"

Now! now! Up! on it! The problem's end is nigh;
The area of the wire we soon can see;
And then, by making use of old friend π
We calculate the much-desired *d*!

It's done! 'tis done! The work is done!
No more the need to fret
For, though the problem hard may be,
No coil has baulked me yet.

And now with light and joyful heart
My things I gather up
For, when I reach my home to-night,
Untroubled will I sup.

(*Church Bells off the stage.*

Hark! [illegible]
St. Peter's tolls the Hour of half past four.
The students make a dash for home and tea;
Some born fool turns the light out at the door,
And leaves the room to darkness—and to me.

ROBEY SEMI-PORTABLE STEAM ENGINES.

We gather from an interesting publication (Catalogue No. 220) issued by Messrs. Robey & Co. that they have conducted a series of experiments, extending over a number of years, with semi-portable superheated steam engines. As an outcome of the experience they have built a number of types which range in output from 26 B.H.P. to 330 B.H.P. Advantage has been taken of the fact that the temperature of steam in a saturated state can be increased by reheating, thereby increasing the volume without increasing the pressure. Steam in this condition can be employed more advantageously in steam engines than in the saturated state.

The Robey superheated steam engines are built up with boilers of considerable evaporative capacity. The superheaters have a high efficiency, thus utilising the heat to the greatest extent in the boiler for evaporative purposes. We understand that the makers have succeeded in obtaining a high degree of economy in coal and steam consumption, and that they are able to produce plants which will compete favourably with other forms of prime movers on economical grounds alone.

Fig. 2 is a general view of one of these plants complete with boiler, engine and jet condenser. The boiler is of the tubular type, from which the firebox and tubes can be withdrawn. All plates are planed and turned on edge before being put together, and the riveting is done by patent hydraulic machinery. In the smaller sizes the firebox is of the plain circular type, and in the larger sizes it is corrugated. A standard grate is fitted for burning coal of fair quality, but an extension can be provided to allow for the burning of wood or inferior quality coal. By the use of a long extension, cotton stalks, maize, wood logs and bagasse can be used as fuel.

The superheater, an elevation of which is shown in Fig. 1, comprises steel tubes of small inside diameter, each end being fitted into collecting chambers. These latter are clearly shown in the illustration. The steam enters one of the chambers, passes through the

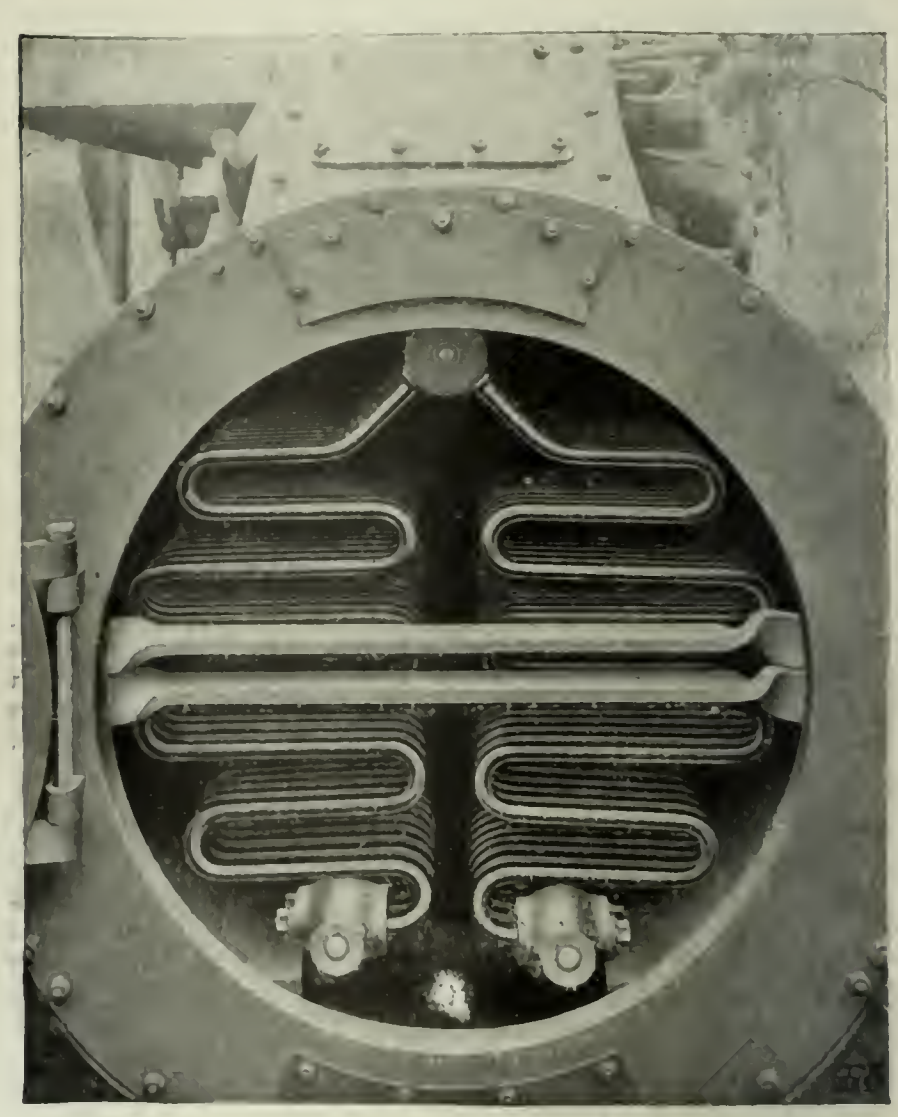


FIG. 1.—END VIEW OF SUPERHEATER.

superheater tubes, then enters the second chamber, whence it travels direct to the cylinder of the engine; the steam moves in a contrary direction to that of the hot gases. The superheater is so placed within the smoke box that it does not obstruct the boiler tubes, and cleaning operations are, therefore, as easy as those of an ordinary boiler. The condensed water can be entirely drawn off from the superheater by means of a cock provided for the purpose. Between the superheater and the steampipe is a special valve, the use of which ensures complete safety.

The engine is of the compound type, with side-by-side cylinders. The high-pressure valves are of the balanced-piston type, and the low-pressure cylinders are provided with slide valves of similar material to that of the cylinders themselves. They are accurately scraped up to the valve faces on the cylinders.

Each engine is fitted with the company's patent crankshaft governor, which is of simple construction, and acts on a balanced piston valve. It is claimed to be both sensitive and powerful, and a minimum variation of speed under extreme changes of load is assured. The crankshaft, which is of the balanced type, is made sufficiently long to carry two flywheels, one on each side of the engine, one acting as a driving pulley. In the smaller sizes of engine chain lubrication is fitted to the bearings, and in the larger sizes ring lubrication

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868.
Codes: 5th Edition A B C & Western Union.

EDISWAN EVERYTHING ELECTRICAL

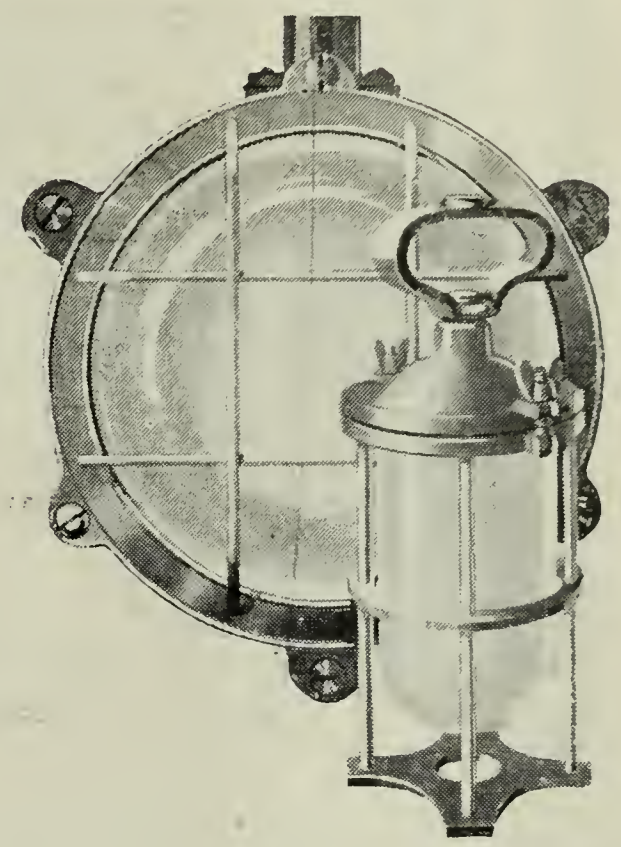
THE ALL-BRITISH HOUSE FOR ACCESSORIES

ROYAL
EDISWAN
DRAWN WIRE LAMPS

CATALOGUES ON REQUEST FROM THE
EDISON & SWAN
U·E·L CO., LTD.,
PONDERS END
MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06 - 27712/03 AND OTHERS

SIMPLEX WATERTIGHT FITTINGS.



Bulkhead Fittings and Hand-lamps manufactured at our Birmingham Works in cast iron or in brass.

Supplied to Admiralty, War Office, and other Government Departments.

Simplex Conduits Ltd.
Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd., W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

REGULATING RESISTANCES



ISENTHAL & CO.

(Department 4)

Denzil Works,

Willesden, London, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

NEW LIST NOW READY.

bearings are provided. This system of continuous lubrication confers the double advantage of regular and efficient oiling and also a considerable economy in oil consumption.

The feed water heater provided with the equipment is of the tubular type and raises water almost to boiling point. The feed water

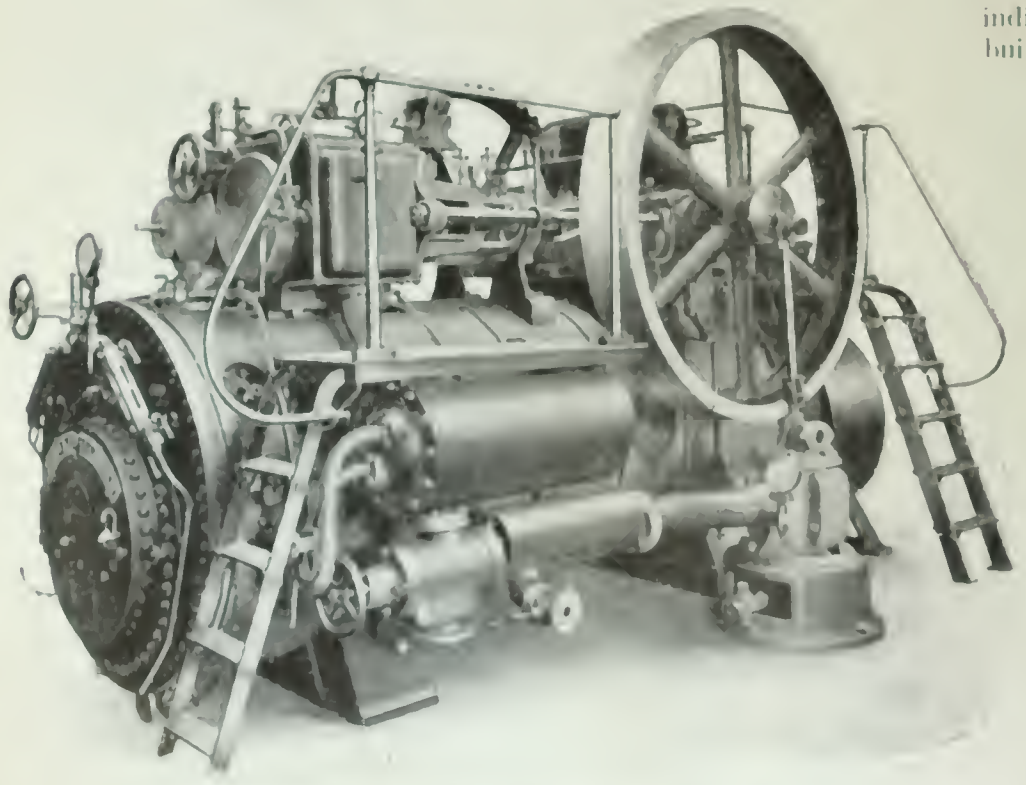


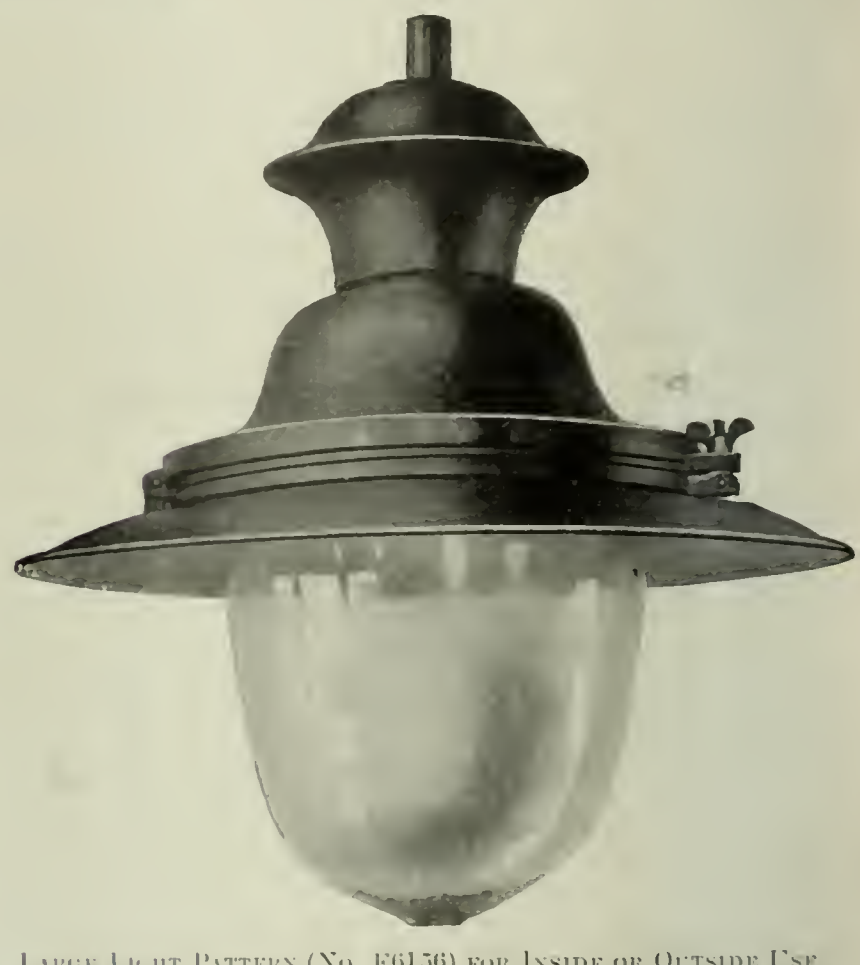
Fig. 2.—Complete Semi-Portable Steam Engine.

is not mixed with the exhaust steam, and it is, therefore, entirely free of oil. Jet condensers are fitted to these engines, and a special form of double acting air pumps is included, which is driven direct from the crank shaft. Powers, weights and measurements of the various sizes of these engines are given in both English and metrical figures. In the 30 H.P. size the flywheel is 5 ft. in diameter and has a width of 8 in., the speed of the engine being 220 revs. per min. The 330 H.P. size is fitted with a 9 ft. flywheel, 14 in. on the face, and running at 160 revs. per min. The 30 H.P. packed complete weighs 240 cwt., and the 330 H.P. weighs 1,280 cwt.

We understand that a copy of this interesting publication will be supplied on application to Robey & Co., Globe Works, Lincoln.

INDUSTRIAL LANTERNS.

Simplex Conduits (Ltd.) have just issued a list of lanterns and reflectors suitable for industrial lighting. Many types are illustrated, each specially designed for its own particular purpose. The



Large Light Pattern (No. E6156) for Inside or Outside Use.

enclosed type lanterns for half-watt lamps are of pleasing design, and are strongly made and well finished. There are also illustrated indirect and semi-indirect fittings suitable for offices and public buildings where the glare from high candle-power lamps would be an



Semi Indirect Half Watt Fitting. (No. E6318) for Large Areas.

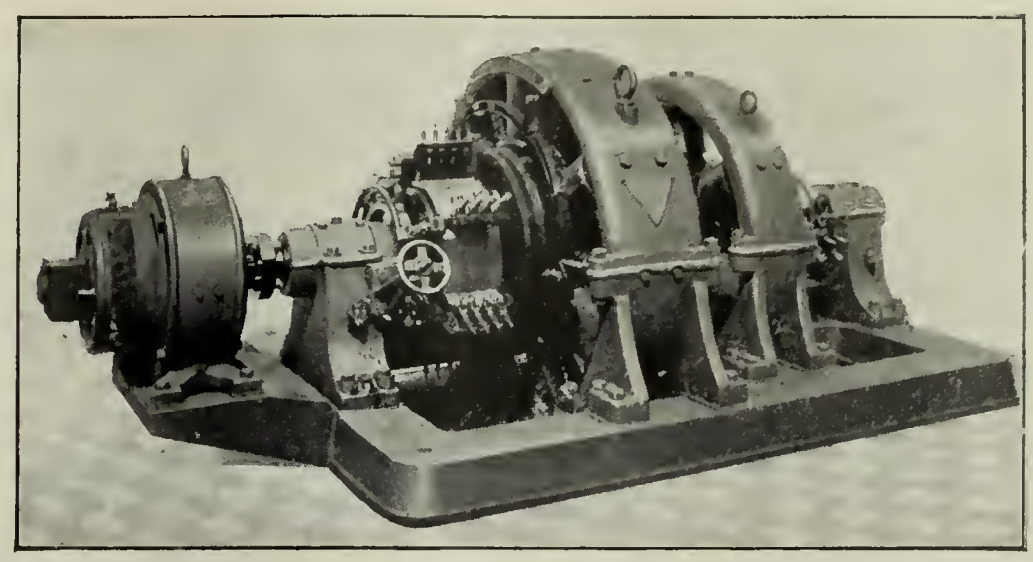
objection. A special point is made in the list of the inexpensive anti Zeppelin reflectors, of which the Simplex Company have, we understand, sold many thousands within the last few weeks. The new concentrating reflector specially designed for workshop and other local lighting is another useful and inexpensive type. There

VICKERS LIMITED.

Motors and Generators of all types.

Rotary Converters.

Complete equipment for the electrical lighting and driving of Machine Shops, Factories, Mills, etc



Patent Automatic Reversing Drive for Machine Tools.

250 K.V.A. Rotary Converter. 6 phase, 50 periods, 480/560 Volts. 1,000 r.p.m. Inverted type.

River Don Works, SHEFFIELD.

are also shown large reflectors for the larger types of half-watt lamps, specially made for positions where it is proposed to replace arc lamps.



Concentrating Reflector (No. E6333) for Workshop or Office Lighting.

The list is attractively printed, and will be sent on application for catalogue No. 620.

"REASON" MANUFACTURES.

A file containing copies of their latest lists of manufactures, with prices, descriptions, diagrams and illustrations, has just been completed by the Reason Mfg. Co. It is a substantial folder with thumb index, and its catalogue sections deal respectively with electrolytic meters, demand indicators, time switches, fuse boxes, miscellaneous products and street-lighting fittings.

The company's electrolytic meters are too well known to need description in our columns. They have been in practical use for so many years and are so much appreciated that their various forms have become widely known amongst central station engineers.

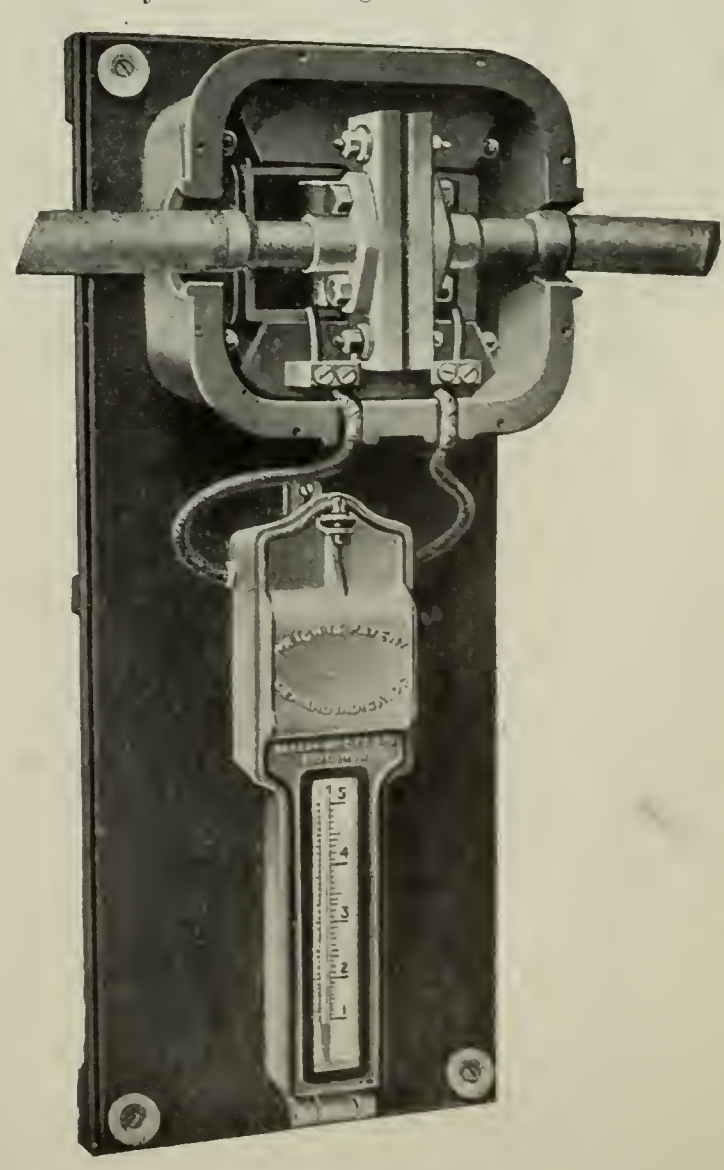
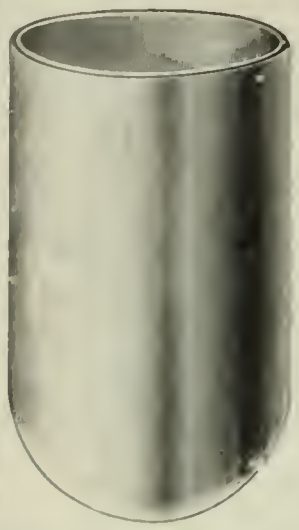


Fig. 1.—Demand Indicator with Current Transformer.



E. SHOWELL & SONS, LTD.,
STIRCHLEY, BIRMINGHAM.

Drawn Shell Work
IN BRASS, COPPER, and STEEL.
Any size
up to 8″ diam. × 4″ deep.

Sole Agent for the Electrical Trade:—
LIONEL ROBINSON, 3, Staple Inn, London, W.C.
TELEPHONE: *Holborn* 6323.

BELLING FIRES

Over 30,000 in use.

Tested by more than 400 Engineers during a period of 3 years, and generally recognised as being "The" practical and reliable electric fire.

A P.C. will bring our 40 page illustrated catalogue.

BELLING & CO., ELECTRIC HEATING SPECIALISTS,
DERBY ROAD, EDMONTON, LONDON, N.

They are sold under a five years guarantee, and are supplied from quite small sizes upwards. Much the same may be said for the Wright maximum demand indicators. These are of the thermal type, and are supplied in standard sizes for use on electricity consumers' premises and also for sub-station service. They are made in two and three-wire sizes, and also a pattern known as the Absorber demand indicator, which is designed specially for power uses. This is more sluggish than the standard type, the sluggish action being produced by a piece of iron placed in a pocket in the heating bulb. Indicators of extra heavy capacity for use on high voltage supply are fitted with transformers instead of shunts. The instrument shown in Fig. 1 is connected to a 750-ampere circuit. If it is desired for any desired period. A thermostatic cutout, which is of patented construction, is inserted for a protection of the solenoids, in case of any overload which would cause undue heating. The cutout comprises a resistance coil terminating in a bath cup filled with metal of a low melting point. There is a small spring above this metal which has its lower end in the metal, and should the metal be melted the spring is released, and the circuit is interrupted. The device can be re-set by re-heating the soft metal with a match and pushing a few turns of the spring below the surface, holding these in position until the metal has solidified in cooling. Fig. 2 is an interior view of a change-over switch (Type EW 1B). These switches can be supplied in cast-iron boxes and rendered completely waterproof. They

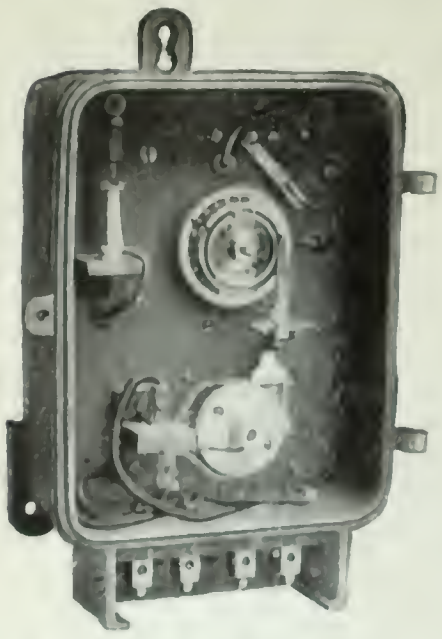


FIG. 2.—ELECTRICALLY WOUND CHANGE-OVER TIME SWITCH.

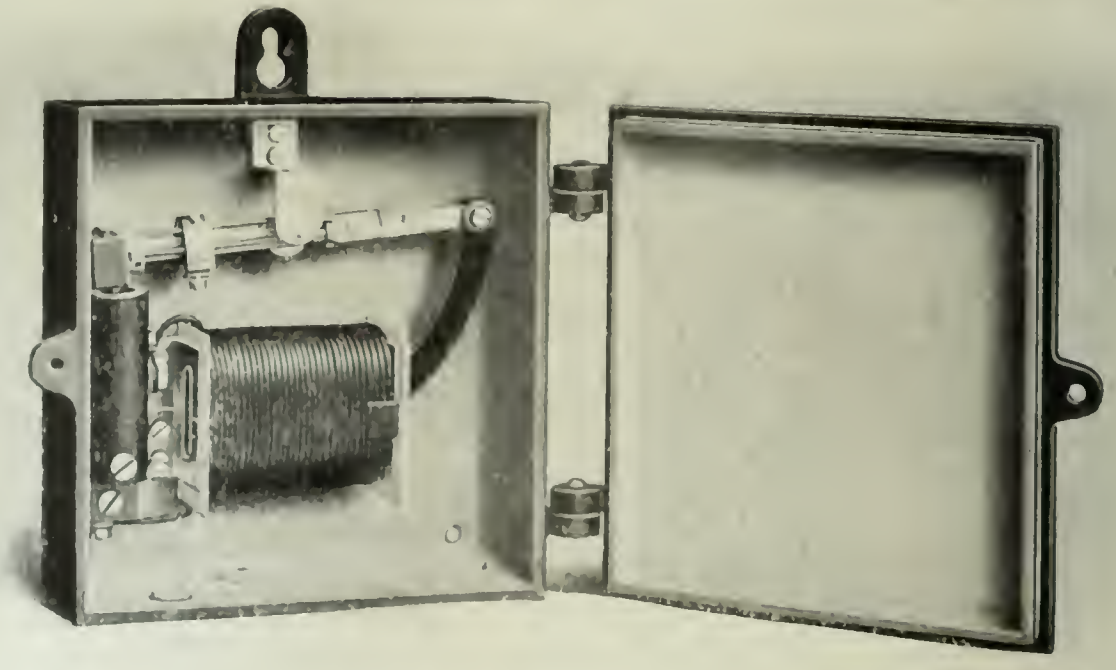


FIG. 3.—CURRENT LIMITER.

to obtain the load of a particular circuit during any specific period, the demand indicator can be employed in conjunction with a time switch.

A full range of time switches is offered by the company, and these may be divided into two principal classes—(1) electrical, (2) hand wound. The electrically wound pattern is suitable for automatic control of street lighting, for use in connection with electric signs, for restricted hour service supply and for two-rate meters. The standard switches are of 2 ampere capacity. The other sizes will interrupt circuit for 15 ampere and 25 ampere capacity. The action provides for both quick make and quick break. A selective device is provided whereby the switch can be rendered inoperative can also be mounted on boards in conjunction with circuit-breakers, meters or other devices. Where time switches for continuous current above 25 ampere capacity are needed, an electrically-operated circuit-breaker is included, and this is brought in and out of circuit by means of a time switch.

Section 4 of the catalogue contains leaflets dealing with Reason house service fuse boxes. These can be supplied one, two, three and four-way, and are fitted in cast-iron boxes with suitable bell mouth cable entries, or screw cable entry according to requirements. Capacities from 15 ampere to 250 ampere per way are manufactured. In each case the company's bridge fuses (Types PB 1 and PB 2) are utilised. In the same section are particulars of split sealing troughs

Draining of Cable Trenches, Transformer Chambers, &c.
SPECIAL
PORTABLE HAND PUMP.
All Brass with W.I. Tripod (hinged) and Base. Detachable Handle and Strainer
RELIABLE COMPACT SUBSTANTIAL.
THE LAWRENCE PATENT WATER SOFTENER, &c., CO., Ltd.
Parliament Mansions, Westminster

FURNACES for MELTING WHITE METALS, Etc.
Hall's Patents
AUTOMATIC HEAT CONTROL. MELT WITHOUT OXIDATION.
PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Also Heat-Controlled Furnaces for Heating the Moulds.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

FERRY | FERROZOID

CONSTANTAN | CHRONIC

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:
HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.
TELEPHONE: 6400 CENTRAL
TELEGRAMS "WIGGIN BIRMINGHAM"

AGENT:
LIONEL ROBINSON,
3, Staple Inn, London, W.C.
TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

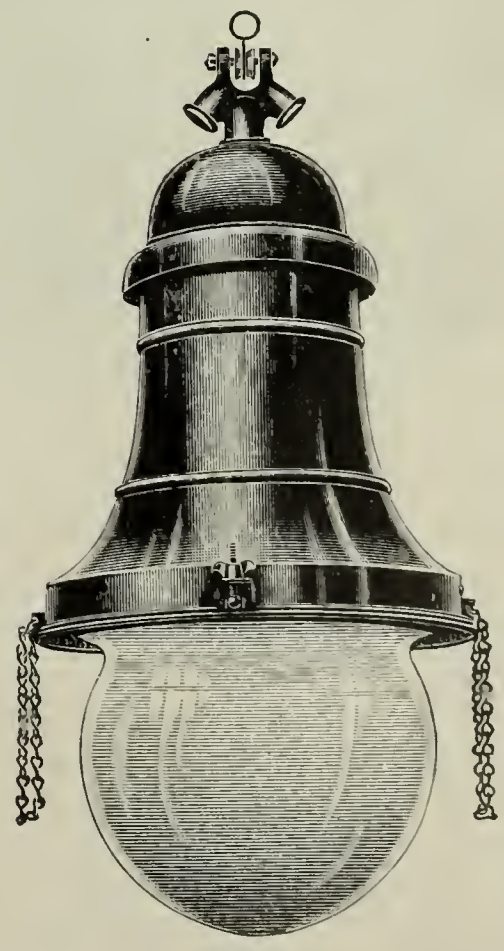
for twin cables, for concentric cables and for single cables, for use in connection with the wiring up of these fuse boxes.

Section 5 of the list contains pamphlets dealing with electro-magnetic current limiters. Fig. 3 is an illustration of the standard pattern of these instruments, which are made to deal with currents from 0·65 ampere to 12 amperes. The solenoid is connected in series with a pair of mercury cups into which a copper bridge at one end of a curved plunger is dipped. When the amount of current specified is exceeded the plunger is drawn into the solenoid, and the bridge is lifted clear of the mercury cups, thus breaking the circuit; this interruption de-energises the coil and the bridge again falls into the cups and re-establishes the circuit. This action produces a flickering of the lights, and is repeated until the current passing through the apparatus is reduced by turning off one or more lamps. The instrument is adjustable for current by movement of a pointer over a clearly marked scale. We understand that the insulation of the instrument is high, and that there is a very low voltage drop through it.

The complete file referred to above is obtainable on application from the company at their offices and works, Lewes-road, Brighton.

"EFESCA" LANTERNS.

The adjoining illustration has been selected from the new catalogue (No. 409) issued by Messrs. Falk, Stadelmann & Co., which describes a variety of lanterns for half-watt and high candle-power tungsten lamps for shop, industrial and open-space lighting. The lantern illustrated, known under the trade name of the "Gayton," is supplied with vitreous enamelled iron casing, dark-green outside with white enamelled internal reflector and opal globe. There is a ventilated globe-ring fitted with bolts and wing nuts, and safety chains are provided for lowering the globe for cleaning purposes or lamp replacements. This is offered in two sizes, one 20 in. long for one half-watt 500 watt lamp and one 29 in. long for one half-watt 1,500 watt lamp; in both inlets are screwed ½ in. This lantern gives



The "Gayton" Half-watt Lantern.

the maximum light at an angle of 50 per cent. to the vertical. In the same list are included particulars and prices of a number of other types of lanterns for one lamp or for clusters. They are offered suitable for attaching to screwed supporting stems or for suspension

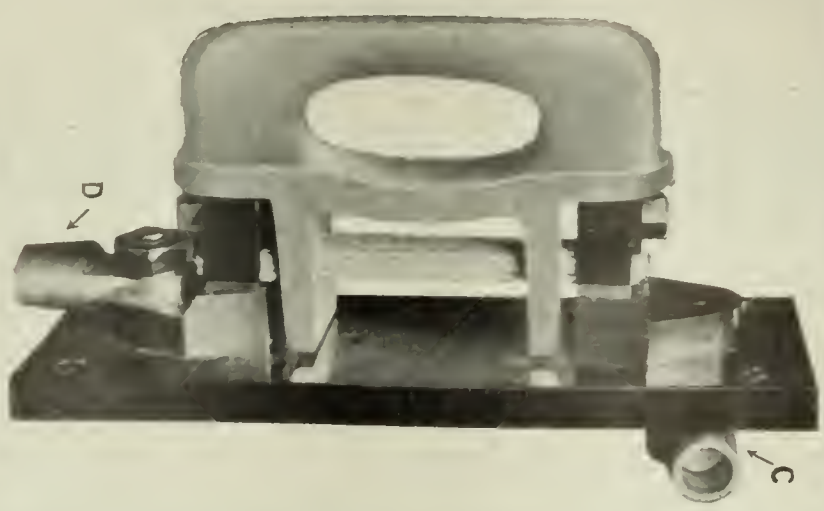
FERRANTI LTD
Central House, Kingsway, London, W.C.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.
Write for Binder "N."

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

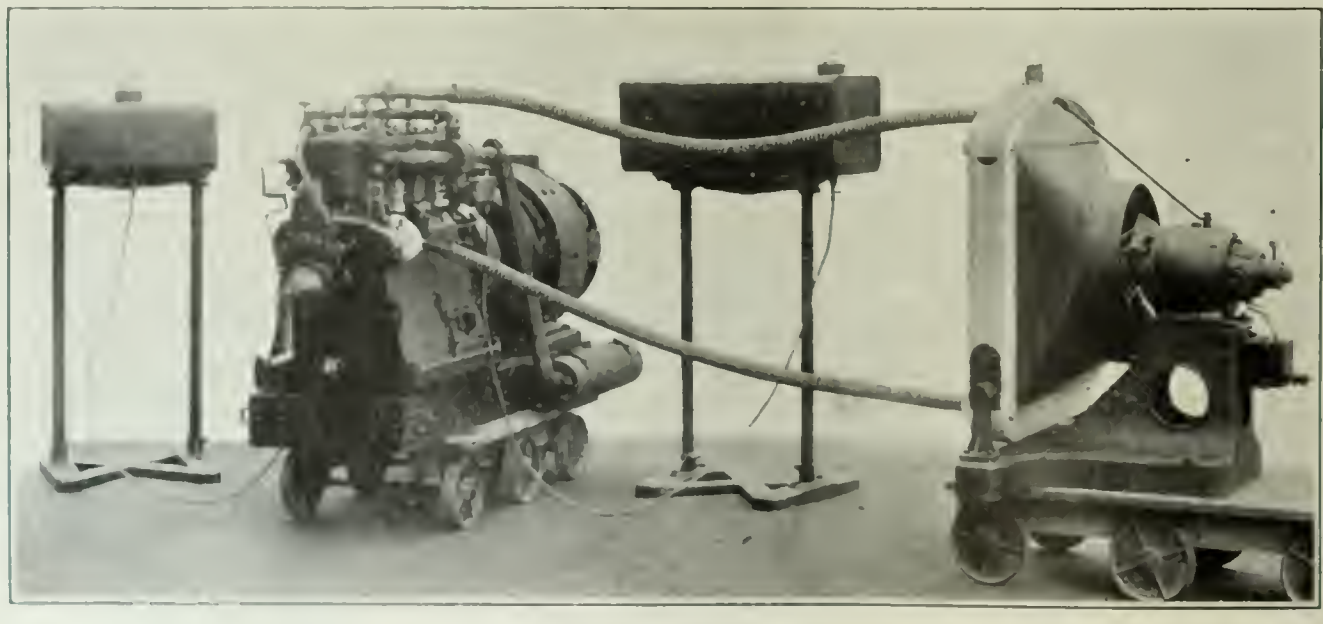
SALFORD, MANCHESTER.

from insulating hooks. A series of advertising screens, provided with hollow bars shaped to the arc of the reflector, can be supplied for use in conjunction with a number of these lanterns. The screens are semi-hexagonal and two sizes of panel are listed, one 10¼ in. deep by 8½ in. wide, and the other 4½ in. deep by 8½ in. wide.

Some rather attractive styles of ornamental brackets are included in the list and are recommended for hotels, public buildings and vestibules, &c. Amongst the accessories described and priced in the list are cast-iron water-tight shackles with and without insulated reels, ball joints, goliath and standard E.S. holders. There is also a page devoted to spare globes for the various types of lanterns dealt with in the catalogue.

AN INTERESTING PORTABLE PLANT.

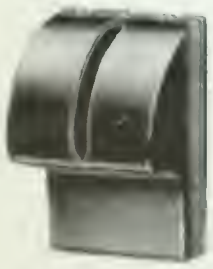
The uses of the petrol-paraffin engine have been considerably extended during the present war, and it is probable that the increased experience with this class of small prime mover will result in the introduction of important improvements which will make for increased economy and general reliability. There must be a considerable number of petrol paraffin dynamo engines being turned out every day for war purposes, but it is not expedient to refer to any of these and our readers must wait patiently until peace is declared for the fullest information. The chief problem of equipments of this character is to obtain the maximum amount of power while having the utmost regard for the complete portability of the plant. In a previous issue we described a unit in which engine, dynamo, fuel and lubricating tanks, switchboard and circulating water-cooling gear were brought within the compass of a single bedplate. We now illustrate another type in which engine, fuel and lubricating tank and radiator gear are for purposes of portability made independent of each other. This outfit is suitable for field workshop service and has a capacity of 18 kw. The dynamo is driven by a standard-type petrol engine fitted with four cylinders and usual governor gear for ensuring close regulation under varying loads. The lubricating oil and fuel tanks are each mounted separately on pillars rising from a heavy floor stand. The dynamo and engine are placed on a 6-wheel bogie. The radiator and cooling fan are also mounted on a similar bogie, and the fan is driven by a small electric motor, which derives its energy from the main dynamo. The inlet and outlet circulation waterpipes are connected with the top and bottom of the radiator case by flexible armoured hose. We are indebted to the Austin Motor Co., Northfield, Birmingham, the makers, for the illustration and the foregoing particulars.



Austin Portable Petrol Paraffin Set with Separate Radiator and Fuel and Oil Tanks.

H. Weidmann, Ltd., Rapperswil, Switzerland.

MAKERS OF PRESSPAN AND INSULATING MATERIAL.

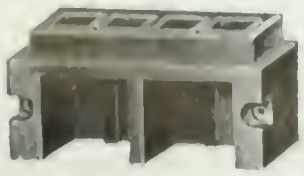


Pressboard Presspan in Sheets, Rolls and Tapes, Oiled Presspan, Black Presspan, Presspan Tubes and Stampings.

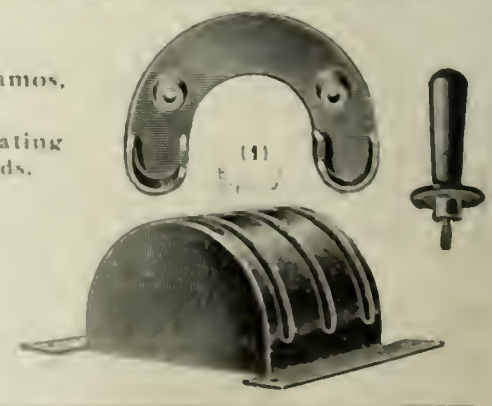
Amianite Vulcanised Asbestos Coil Frames, Spools for Apparatus, Dynamos, Motors and Transformers. Insulating Blocks, Tubes, Plates, Boxes, &c.

Bakelite & Cornite high tension material Handles of Switchgear and Heating Apparatus, Controller Insulation, Moulded Pieces, Terminal Covers of all kinds.

Asbestos-Cement in Plates, Arc Shields for Controllers, &c.



Mica and Substitutes, Insulating Pearls, Transformer Spools.
Japanese Felt and Paper in rolls and tapes.
Oil-Varnished Linen, Diagonal Tapes, Oil-Varnished Silk & Paper.
Artificial Leather Discs for Friction Drive.
Insulators for Electric Furnaces, Tramways, &c.



Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, April 14, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—The British Commercial *Gas* Association asks the public to apply to it for a Paper on "Colour Matching by Artificial Light," written by an Associate Member of the Institution of *Electrical* Engineers.

* * * *

It is reported the Wimbledon Corporation has decided that in future street lamps be turned out *at midnight each day.* Incidentally, this is the only way the Corporation can get even with the Government over the street darkening regulations.

* * * *

Thus the "Surveyor" (my italics): "Having regard to the difficulties which have recently arisen in connection with public lighting, we think it might be of interest to our readers to give some brief notes *as to the powers possessed* by local authorities for the lighting of streets.

* * * *

"Indian and Eastern Engineering" says:—

We understand that it has been decided to equip the Ordnance Quarters at Dum Dum with electric light and fans.

In other words, gas and other illuminants have been given the bullet.

* * * *

I am sure "C. T. S." Brooking will be amused at the following from a correspondent who attempts the solution of the "T.R.C.P." problem set by the Institution of Electrical Engineers in its new wiring rules: "Dear KVA.: *Re* 'T.R.C.P.' Brooking mentioned in issue of March 31, I do not know the gentleman personally, but it may be that 'T.R.C.P.' may aptly signify 'That Rather Corpulent Person.' I don't usually rise to such heights, but the war broadens one's views, and a Hot Plate in the offing would be welcome."

* * * *

Brooking is, or was, not corpulent when I saw him last, but he's certainly "chirpy," which will fit in just as well.

* * * *

My starting-place will be Ludgate-circus, where, it seems so many years ago now, the ever-changing red-white-and-green electric lights used to cheer us all up with the news that somebody's stuff was better than any one else's. Next I'll saturate myself in the floods of light from the newspaper and other offices in Fleet-street, work up the Strand, and revel in the blaze of light outside the theatres, bask in the brilliance of Leicester-square, then bathe myself in the blaze of Piccadilly-circus and the adjoining thoroughfares.

Then saunter slowly back to Ludgate-circus, all the time revelling in the fairyland of light that has suddenly appeared. Then back again, and back again, and back again, backwards and forwards, all the time that the blessed light lasts, bathing in it, plunging in it, swimming in it, winking at it, blinking at it, basking in it, gloating in it, throwing it over my head with both hands, saturating myself in it. Ah, life will indeed be worth living once again!

And when the happy lights have retired for the night, I will point homewards and board a tram in which, joyful in their release from ages of travelling in the Land of Shadows, the passengers will look each other in the face for the first time for many years, and say, "It's grand, isn't it, to be able to see one another again? To know who is your neighbour."

Don't be alarmed. The above is merely the idea of "Orion," in the "Daily Express," of what will happen in London on peace night. Personally I am quite unmoved, because I have a 7/16 service into my house and shall be able to outblaze all my neighbours.

I am asked to deny that Mr. S. L. Pearce (who is now consultant for Rochdale, Chesterfield and Stafford) has accepted the presidency of the Association of Consulting Engineers, otherwise known as the A.C.E. This does not mean, however, that he has got a handful of trumps.

* * * *

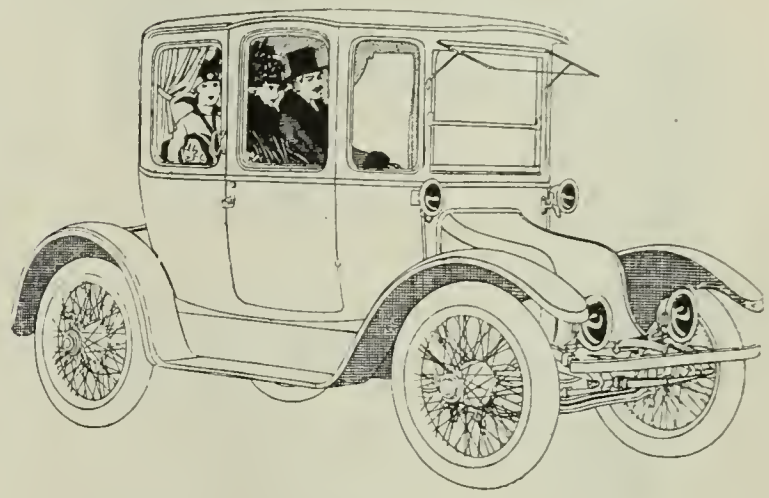
Quoth Z (a Briton who floated a mine,
And filled it with German machinery fine)
"Patriotism I have, and to spare,
But floating a mine's quite another affair."

When war broke out he was on the foam,
And bribed the captain to hurry him home;
But now he's down in the fathomless brine,
For his friend the Kaiser, had *floated a mine.*

[PABLO *in Glover's Almanac.*

* * * *

Why run a car with an 18-guinea tax when you can travel in an all-electric like this?



* * * *

OUR HOT-PLATES.

No. 207 to—

Mr. Rankin, B.Sc., for his "snap-and-ginger" Paper on "Speeding up in Factory Production," read before the Junior Institution of Engineers.

* * * *

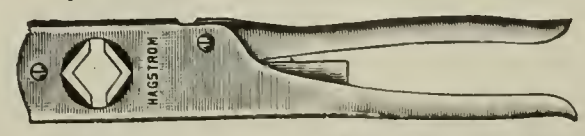
THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), April 19, 1879.]

THE TELEPHONE WITHOUT A DIAPHRAGM.—Some experiments bearing on the origin of the sounds produced in the telephone (a point much disputed lately) have been made by M. Ader, who says that he has not only been able to make a telephone speak without a diaphragm, but to make it speak louder and with less alteration of the voice than in the ordinary telephone. He reduces the dimensions of the magnetic core to those of a simple iron wire 1 mm. diameter; one end of which is fixed to a wooden board. A small coil of fine wire is added, and a microphone speaker is employed. Putting the board to the ear, speech is heard distinctly, but the sound is greatly increased if a metallic mass be applied to the free end of the iron wire: one can then hear at 10 cm. to 15 cm. If the iron wire be in contact at both ends with metallic masses, a better effect is obtained, but the two masses must not communicate with each other metallically. M. Ader also finds speech reproduced from a simple bobbin, without magnetic core; but the windings of the wire must be very loose, not pressed together. If they have been dipped in gum-lac no sound is heard, unless an iron wire or magnetic needle be placed in the bobbin, or a helix interposed in the circuit of the first, the ends of these organs being attached to the board on which the bobbin is fixed. M. Ader is led to agree with M. Du Moncel that the sounds produced by a magnetic core are probably the consequence of shortenings and lengthenings of the magnetic rod, through rapid magnetisations and demagnetisations.

PLATINUM for WAR MATERIAL
supplied by permission of the
MINISTRY of MUNITIONS.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golsilplat, Ox., London." 4746 Gerrard.

THE HAGSTROM ARC LAMP CARBON CUTTER.
Will sever carbon without crushing. Leaves straight, clean edge.
Adjustable and non-adjustable types supplied.



THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.
Phone: Regent 4046. Code: ABC 5th Edition. Teleg.: "Engineyor, Westrand, London."

SIEMENS

ELECTRIC MOTORS



Part of small Motor Shop, Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood Bldgs.
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

ELECTRIC SELF-CHARGER VEHICLE.

The electric car owner who knows anything about his property knows that if he could get his battery charged every few miles, or every time it needed it, or continuously charged, he would only need half as big a battery. Let him imagine, then, that he has discarded half his battery, and in its place installed a little petrol engine and dynamo to charge the remaining battery. The next obvious step would be to discard the dynamo and use the vehicle motor, driven by the engine, as a dynamo. Put the engine and motor-dynamo on the same driving shaft, with only a magnetic clutch between them, arrange the controller so that the car may be driven by either the engine or the motor, and that when the engine is doing the driving it is also driving the dynamo and charging the battery, and you have a general idea of the principle of the electric self charger.

Let the petrol car owner, on the other hand, look at it this way: He already has as part of his car equipment a small storage battery and a dynamo-motor which charges the battery and starts the engine. Let him imagine that dynamo motor increased in size until it is big enough to run his car, and the storage battery correspondingly enlarged. The petrol engine could then be much smaller, because it would not be used for starting and acceleration—the things that are responsible for all the excess power of the regular petrol car.

The new car is built on a wheel base of 110 in., with wire wheels and cord tyres as standard equipment. Under the rear hood is the 20-cell battery, with space left inside the hood for a spare tyre—an unusual but desirable location. Under the front hood, which is that of a streamline petrol car, are the engine and dynamo motor. The engine is a four-cylinder water-cooled unit of approximately 10 h.p.—which has proved ample for all conditions and emergencies, as will be explained later. It is direct connected through a magnetic clutch with the motor, both being on the direct driving shaft. This magnetic clutch consists simply of two iron discs. The one on the end of the engine shaft acts as a flywheel and the one on the motor shaft carries a small magnetising coil, a slight current through which effectually locks the two discs together—thereby coupling the engine and dynamo-motor and the transmission shaft of the car. The motor is a standard six pole machine of approximately the same size as is used in a conventional electric car. Its only peculiarity is its adjustment to operate as an efficient dynamo or generator when driven by the engine. It is permanently attached to the driving shaft, and runs—either as motor or generator—whenever the car runs. The battery has 20 cells of the standard size formerly used in the 40-cell straight electric, and therefore is just half the former size.

The control exactly resembles that of a petrol car. It consists, in its visible parts, of a sector with two finger levers mounted above the steering wheel. The outer lever is the electric controller, and the inner one controls the engine. The outer lever works directly through a rod in the steering shaft, on a rheostat controller which governs all the necessary electrical connections. The inner lever has one electrical function: As soon as it is moved up from the neutral or dead position it actuates the magnetic clutch and connects the motor and engine. The motor turns over the engine and starts it in the usual manner. As soon as the engine is running at speed it turns the motor into a generator and charges the battery. At the same time the engine drives the car. However, when both levers are up, the engine and motor both drive the car, giving sufficient power and speed for any occasion.

The motor can drive the car alone, while the engine is still. The engine, however, cannot drive the car without also running the motor-dynamo and charging the battery. All power not used in driving is stored in the battery; coasting either down hill or on the level charges the battery. Assuming the car to be standing still, the driver moves the outer, or electrical, finger lever, and the car starts as a pure electric, motor driven from battery. It quickly attains 15 or 20 miles an hour, or whatever the desired speed may be. The driver may then continue to drive electrically; or he may move the inner lever and so start his engine. Both engine and motor are now



AN AMERICAN PETROL-ELECTRIC PASSENGER VEHICLE.

driving the car. If road conditions are severe, or there is hill climbing to do, the dual drive may be continued. Otherwise the driver next moves the outer or electrical lever back to neutral. The engine is now driving the car and running the motor as a generator charging the battery.

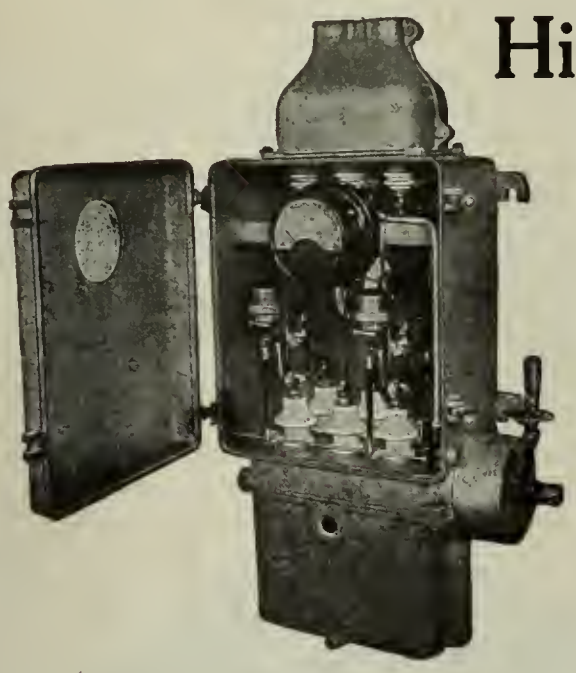
The driver wishes to stop. He presses on the single foot-lever which operates the brake. If the motor is driving, the first movement of this foot-lever shuts off the current. In any case it short-circuits the motor through a resistance, making a magnetic brake. Further movement of the brake-lever acts on the regular band brakes on the rear wheels and stops the car. If desired, the action of the car may be largely controlled with the foot-lever. There is, of course, no clutch lever, because there is no clutch in the ordinary sense of the word. And as there are no gears, there is no lever corresponding to the gear shift lever on a petrol car. Even the braking for most stops is amply provided for by the reverse magnetic effect of the short-circuited motor when the finger-lever is moved back. Reverse, which is purely electrical, is operated with a short heel-lever just back of the driver's foot. It simply reverses the electric motor without changing any shaft or gear connections.

The Woods test models which have been driven for hundreds of

LEAD MELTING FURNACES
Hall's Patents
For Cable and Pipe Presses, Accumulator Grids, etc.,
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
ENORMOUS SAVING IN RESIDUE.
Easy Payments arranged in special cases.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

The Electric & General Works, Ltd.,

15, Victoria Street, London, S.W.



OPEN.

High Tension Switch Boxes

for 3,000 and 6,000 Volts.

TRIPLEPOLE AUTOMATIC OIL-SWITCH.
DOUBLE INTERLOCKED DOOR.
OVERLOAD & UNDERLOAD RELEASE.
AMMETER.
INVERSE TIME LIMIT ATTACHMENT.
FIRE-DAMP SAFETY DEVICE.



CLOSED.

Other Types for all purposes.

ELECTRICAL APPARATUS up to 80,000 Volts.

Telephone: 5223 VICTORIA. **Telegrams: "GABIONAGE VIC. LONDON."**

miles into the country about Chicago in all sorts of weather and road conditions, have been making about 30 miles per gallon—and meantime charging the battery for an additional 10 or 15 miles on the same gallon. This economy seems extraordinary and almost incredible; but it will be understood by any one who is familiar with the reasons for the regular petrol car's extravagance. This preliminary description of the new Woods' car cannot pretend to be adequate, and will be followed shortly by a technical explanation, with photographs and diagrams. But even before that official article appears we think both electric and petrol-car men will agree that the Woods' "automatic" car is the most interesting development of the season; for it seems to discard the disadvantages of both types and combine their advantages with surprising results.—"Electric Vehicles," Chicago.

A.C. AND D.C. SMALL POWER MOTORS.

The small power motors described in List No. 7201 have been developed to meet the increasing demand for machines of small capacity, which are inexpensive in addition to being efficient and reliable in operation. These motors are compact and light in weight and are neat and attractive in appearance. Their design and construction render them suitable for service to which small motors can be adapted. It is stated that they have a liberal overload capacity, and will operate at their full rated load continuously with a low temperature rise.

These A.C. and D.C. motors are standardised for the following ratings:—

Circuit.	Type.	Horse-power.	Voltage.	Frequency
Single-phase A.C.	S A	1/50 to 1/2	110 and 220	50 cycles.
" " "	S D A	1/200 " 1/15	" " "	"
Continuous current ...	S D A	1/200 " 1/15	" " "	...
" " ...	S D	1/50 " 1/2	" " "	...

Standard motors are of the protected type, but for special conditions totally-enclosed motors can be supplied to order, and particulars of these can be obtained on application.

The type S D continuous-current motors shown in Fig. 1 are shunt wound for 1/50 H.P. to 1/10 H.P., and compound wound for 1/10 H.P. to ½ H.P. In practice, it has been found that compound-wound motors are a most suitable type for the majority of applications requiring continuous-current motors above 1/10 H.P., as they have a higher starting torque than shunt motors, while the speed regulation is sufficiently constant to satisfy all ordinary conditions of service Applications which require continuous-current motors below 1/10 H.P. may be served by shunt-wound motors, as the starting torque required is not usually large, and the initial current rush is not objectionable in the smaller motors. Series wound motors are used only in special cases where the load is constant and permanently connected to the motor.

The type S D A motors are designed with series characteristics, and are suitable for service in which the exact load to be connected to the motor is known. They are made in two forms, one for A.C. and one for D.C. circuits, and are similar in construction to the type S D motors, special care being taken in designing the core and windings to ensure good commutation. The starting current of these series motors is approximately three times the normal full load running current. The type S A alternating-current motors shown in Fig. 2 are of the split-phase induction type with rotating field, the primary winding being placed on the rotor and connected direct to the line while the secondary winding is placed on the stator.

All protected type motors are rated for continuous service with a temperature rise not exceeding 40°C. Totally enclosed motors are similarly rated but with a temperature rise not exceeding 55°C. All motors have a momentary overload capacity of 50 per cent. without injurious heating or sparking. Protected type motors have an overload capacity of 25 per cent. for half an hour. Totally enclosed motors are not suitable for other than momentary overloads.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK.
CHARLES CLIFFORD & SON, Ltd.
BIRMINGHAM.

The D.C. motors listed for 110 volts will operate satisfactorily on any voltage between 100 and 120, and those for 220 volts are suitable for 200 to 240 volts. The A.C. motors will operate satisfactorily if the variation in voltage or frequency does not exceed 5 per cent. above or below the rating given in the schedule above. It should be pointed out, however, that the output of a single-phase induction motor is materially affected by any variation in voltage, and a 110-volt motor used on a 100-volt circuit will only give 82·5 per cent. of its maximum output at the rated voltage.



Fig. 1.—Type S D, ⅛ h.p. D.C. Motor.

In the type S A motors the conductors forming the primary winding are wound directly into slots on the periphery of a laminated iron core.

The auxiliary or starting winding is connected in parallel with the main winding, and consists of a smaller number of turns of finer wire than the working coils. This auxiliary winding has a phase displacement from that of the main winding, thus giving the necessary torque to bring the rotor up to speed, when the rotating field will be maintained by the main winding. When this speed is attained the starting winding is cut out of circuit by an automatic centrifugal switch.

The stator is built up from sheet steel laminations firmly riveted together with the copper conductors of the squirrel-cage secondary winding. This laminated stator ring, which is carefully turned to ensure concentricity of parts, forms the main frame of the motor to which the malleable iron end shields are bolted. These end-shields contain the bearings and brushes, and are cast with ample ventilating openings to permit a free circulation of air through the windings. On motors up to ¼ h.p. the end shields are cast with supporting feet, while for the larger motors a special cast-iron base is bolted to the stator iron. The bearings are of the straight sleeve type, turned from phosphor bronze tubing specially selected to give long life and minimum wear. All bearings excepting those for ½ h.p. motors are fitted with pressed metal grease cups on the underside, arranged for the wick lubrication of the bearings. The ½ h.p. motors are fitted with oil ring bearings.

The construction of continuous current type S D motors is similar to that of the single-phase motors. The field frame is built up of laminations in the same way as the stator of the type S A motor, the field poles being shaped to secure the best flux distribution, so that the motor will have a strong torque and run in either direction without sparking. The commutator is constructed from best selected bar copper and micanite, the number of segments being sufficient to ensure good commutation. Motors up to ⅓ h.p. have the supporting feet cast on the end-shields, while larger motors have a special cast-iron base bolted to the frame.

Carbon brushes are used throughout and are held in stationary brush holders, no adjustable rocker being provided. The British Thomson-Houston Co. has found it inadvisable to equip small D.C. motors with movable rockers, and the brushes are, therefore, set permanently in the neutral position, the design being such as to ensure satisfactory commutation in either direction. Standard motors are made for counter clockwise rotation facing the commutator or collector ring end. The direction of rotation can be reversed in the D.C. motors by changing over the field leads, and in the A.C. motors by inter-changing the working coil leads. These latter can be distinguished from the starting coil leads by the copper connection clips, the starting coils having nickel-plated clips.

When totally-enclosed motors are required, solid end-shields can be fitted to order. The horse-power ratings of standard motors are not affected by the addition of these solid end-shields, but the temperature rise is somewhat higher, as shown by the following figures: Protected type, temperature rise at full load continuously, 40°C.; totally enclosed, 55°C.



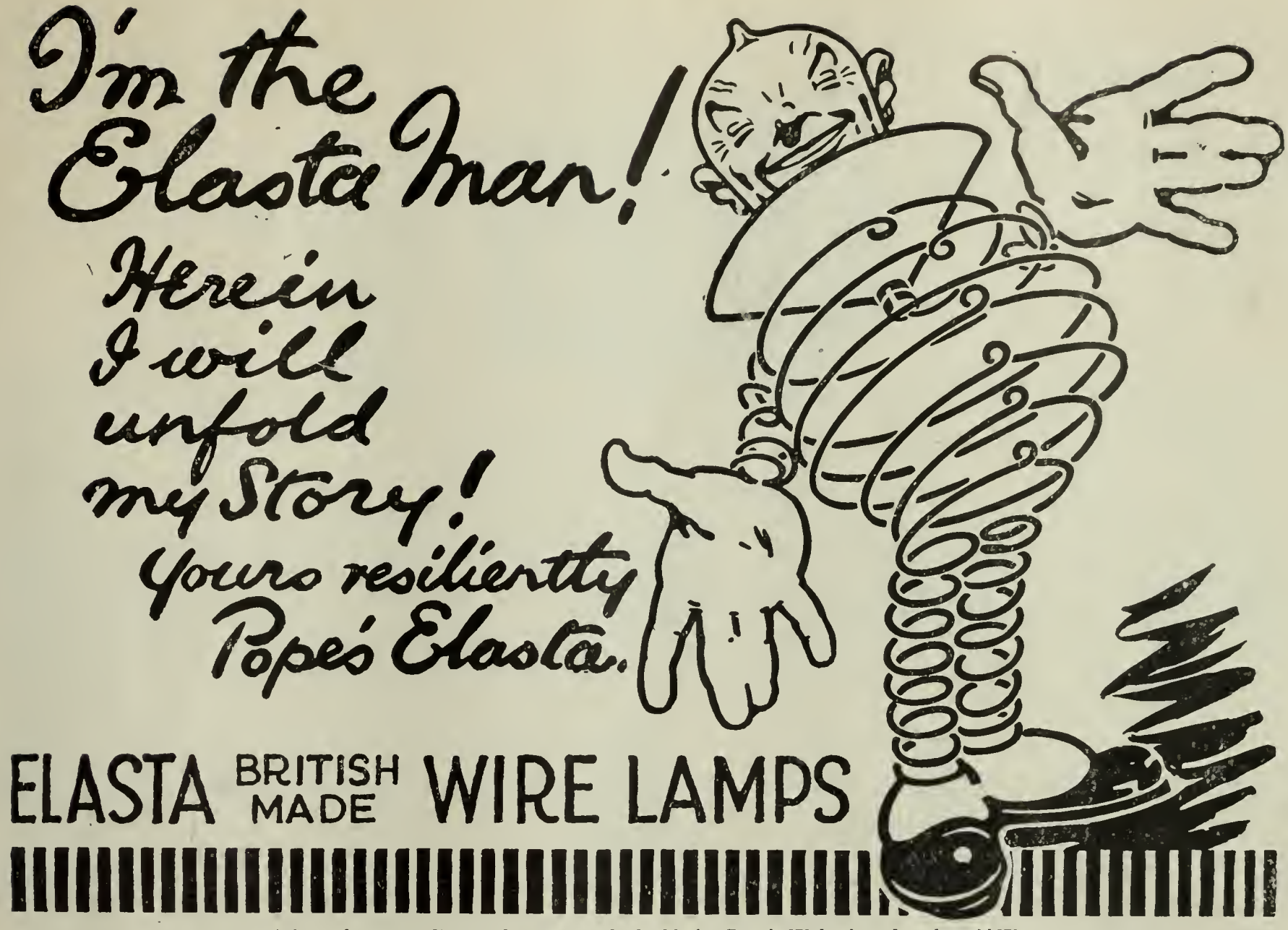
Fig. 2.—Type S A, ½ h.p. A.C. Motor.

"PREPAREDNESS."

The above is the title of a brochure which is being issued by the Greenly Advertising Service, 38, Strand, London, W.C., to remind advertisers and manufacturers of the need for "preparedness" in all their catalogue work and advertising copy. There is a need for improvement in trade literature production, and while the manufacturer knows his business regarding production and selling he does not always have at hand expert knowledge of types, printed matter, illustrations, lay-out, &c. Many publicity men have gone to the front, but the need for trade literature production is none the less urgent. There must be a considerable number of manufacturers who have the material for a catalogue almost in readiness, but have

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire; also for flexible leads, etc. AMPLE STOCKS.
H. HARTJEN & CO., 35/37, NOBLE STREET, LONDON, E.C.

FERRANTI LTD
Central House, Kingsway, London, W.C.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.
Write for Binder "N."



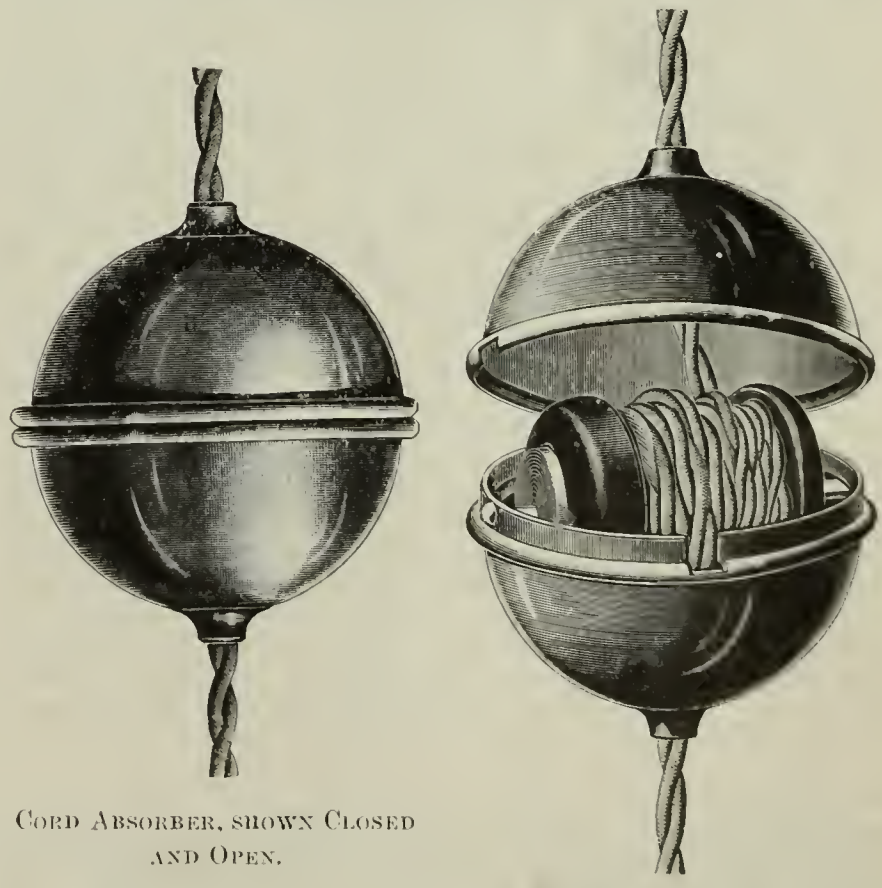
Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W. GREENLY.

set it aside until the return of more normal times. Greenly Advertising Service can be of value to such firms in advising upon and editing catalogue material, in writing "ad." copy and in preparing sketches and suitable illustrations. The brochure "Preparedness" is typical of what they can do, and interested manufacturers and traders should write and ask for a copy from the above address.

A NEW CORD ABSORBER.

Many electrical accessories have undergone important changes since the outbreak of war. In the majority of cases the change has been chiefly noticeable in the price of the article, which has been raised apparently out of all proportion to the value of the goods. The difficulty in obtaining materials, the increased price of metals, higher labour charges, and taxation all round are responsible as a rule for increased prices. An interesting feature of this development is the manner in which some accessories are experiencing a popularity which before the war would not have been considered justifiable. For instance, the cord absorber as compared with the ordinary counterweight was regarded as an expensive luxury in electrical accessories. It was admittedly the better of the two methods of taking up the surplus flex on an adjustable pendant, but where price was a consideration the counterweight, in spite of its ugliness, was usually installed. It would now appear that the cord absorber is going to be given a "show," and principally on account of its being less expensive and less difficult to obtain than the counterweight fitting. One of the principal reasons for the difficulty in the delivery of the counterweight fitting is the high price and the scarcity of common shot. This is the best material for loading the counterweight, and as much as 2 lb. of shot will be required for an ordinary fitting. The cost of this is greatly in excess of the figures prevailing before the war, and it is sufficient to make the price of the cord absorber rather more favourable by comparison.

Messrs. Sturge & Baker, Sheepcote-street, Birmingham, have specialised in cord absorbers for some time. Previous to the war they had a standard line, for which there was, however, only a comparatively moderate demand. Since conditions have become more favourable for the use of these accessories, they have modified the design considerably, and are now able to offer a reliable device at a moderate price. The absorber is Sturge's patent, and is made in two sizes, one 3 in. in diameter, wired with 6 ft. of 35/40 flex, and supporting weights between 6 oz. and 16 oz., and the other $3\frac{1}{2}$ in. diameter wired with 7 ft. of 35/40 "Manchester" flex, and suitable for supporting weights varying from $\frac{1}{2}$ lb. to $1\frac{1}{4}$ lb. The standard finish is polished brass, but other finishes, such as antique brass, oxidised copper, coinage bronze, oxidised silver and ivorex (resembling china), are offered. The absorber operates without



Cord Absorber, shown Closed and Open.

IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

pulleys and shot, there are no guide wires, and rubbing contacts have been dispensed with. The absorber reel, which is spring controlled, is contained within a hollow sphere, which is in two halves, having ornamental moulding on each half. This moulding serves as a groove which engages with bayonet pins on one-half of the sphere. The fact that the spheres are 3 in. and 3½ in. in diameter bears out the contention of the makers that the absorber is an ornament, and not an eyesore. Special attention is called to the fact that a good English clock spring is used on the absorber reel. The adjoining illustrations explain the simplicity of this device.

ENGINEERING WORK IN CHINA.

By Prof. Middleton Smith, in "Cassier's Engineering Monthly."

Those who are interested in maintaining the prestige of Great Britain and in extending her trade realise that overseas markets must be found and developed. It will be especially necessary to manufacture machinery in England. Large numbers of people have been compelled by the war to learn to earn their living in the munition and other factories. There is now a huge industrial machine, and when the war stops that must be kept moving.

China has, in common with the rest of the world, been affected by the rapid progress in methods of transportation. Until recently it was only along her extended coastline that the results could be seen. The steamship and the motor boat now penetrate for hundreds of miles into the interior, for China is a country of long rivers. The railway is also proving to the Celestials that man-power is not the best source of energy for travel purposes.

For at least 10 years before the war the Germans were causing anxiety to patriotic Britons in China. They seemed determined to do everything possible to fasten their commercial tentacles into the country. They did not play the straight game. They used their diplomats and their soldiers; they threatened and they bullied. They obtained financial interests in British companies, and they used the British colony of Hong Kong as a centre for many of their schemes of comercial aggression. They are still active in China. It is said that they are spending all of the money paid to them on account of the Boxer indemnity in order to push their political and trade propaganda in China. Just before the great war commenced a scheme was arranged to put a German lieutenant-general with a staff in Peking. Six hundred other Germans were to be scattered throughout the provinces in order to instruct Chinese troops. Krupps was to supply money and munitions, and we may be sure that they would obtain, with the active support of their Government, not only good security, but very remunerative terms. These 600 German officers in the provinces would have done something more than drill Chinese soldiers. They would have spread the gospel of German trade. In commercial rivalry these Teutons never played the game. They were quite unscrupulous in what they promised, and they were always very careful in the matter of bribery and corruption. For in China, it is true, if sad, that the crooked ways of commerce are not altogether disliked by the native. It is a country in which bribery is not a sin, but an art.

For nearly 50 years some enterprising parents have sent their sons abroad for a Western education. At first only a few went to Europe and America. Of late—before the war—thousands left China each year to study in Japan or Europe or the U.S.A. The students have come back to their own country. It must be confessed that they have not accomplished that regeneration of which they were sanguine. They have caused extreme political unrest. They have absorbed the political ideals of the West—that sort of thing seems to have attracted them much more than their technical studies. They have not, as far as the writer can discover, carried out or really initiated any really large engineering schemes. They have, however, to some extent, influenced public opinion. There is no longer hostility to railways and power development. Another influence has been effected by the emigrants who have come back from the Straits Settlements, America and Australia; they have also spread ideas in China which make the people rather welcome machinery. For beyond all else, the Chinese desire to make money.

In Hong Kong and the treaty ports it is now recognised that at the close of the war the trade in China will develop along new lines. It will be necessary to work inland. Europeans and Western-educated Chinese will have to convince the landed gentry and officials in the various provinces that they will benefit by using hydraulic turbines and electricity. The landed gentry will not come to the coast. The engineers must go right inland and see the local conditions and the local people.

The Kailan Mining Administration's mines in China have prospered wonderfully during the past few years. The history of that important commercial and technical concern points a moral. It has succeeded because it gave the Chinese shareholders and officials of the company an opportunity to make money. In the future there will be more co-operation between European and Chinese engineering interests.

It must be understood that those of us who live in the Far East are dealing with a people who have pride. We must recognise these at their full value. They esteem the friendship of the European, but they have an affection for their own people. They understand the Eastern outlook, and no Westerner can ever entirely succeed in doing that. It seems, therefore, that if engineering firms in Britain are to have the full benefit of the great market possible in China at the close of the war the Chinese themselves must become interested in creating the market. For that reason the writer hopes that manufacturers will offer good terms to young Chinese graduates from the British University of Hong Kong, so that they may be in the works for one or more years. That has been arranged in other countries. It is obvious that if a large electrical manufacturer had half-a-dozen of these youths he could make arrangements with some of them to work in conjunction with his English representatives in China. They would go inland to obtain the orders which he will need when the war is ended.

SMALL APPARATUS to obtain
DISTILLED WATER
FOR
BATTERY ELECTROLYTE, &c.
THE LAWRENCE PATENT WATER STERILIZER CO., Ltd.,
Parliament Mansions, Westminster.

One, Two & Three Phase
MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London. Friday, April 21, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—A highly qualified engineering student is asked to apply for a commission in the Royal Engineers.

* * * *

Anent my remarks last week regarding my 7/16's service and its use for a blaze of illuminations on Peace Night to the discomfiture of my neighbours who do not take a supply on the Norwich System, I have received the following from a neighbour whose capacity for response in an effective manner I had not suspected :—

DEAR KVA,

Don't you be so proud of your piece of 7/16 cable. I do not know what size my service is but, if I am alive and still in *your* road on Peace Night, I challenge you to a display, that is, provided the Order-in-Council has been removed by then, but I suspect it won't be for six months later.

Yours, M. J. E. T.

* * * *

The following from the current issue of the "Batti-Wallah Journal" is a very happy retort to that type of individual which will not let us get on with the war.

DEAR SIRS: We thank you for your letter of the 5th inst., and are glad to hear that you feel encouraged through seeing the drawing of the new type of machine.

With regard to your suggestion, however, that we should send one to you for show purposes at the present time of great rush, we would say that during this great war we have done many things that aforetime we had considered almost impossible.

We have turned our ploughshares into swords. Made night as day. Made bricks without straw. Turned water into wine, and ale into cutting-compound for the refreshening of labour. We have resurrected Lazarus-like machine tools, and taught them to rise up and sing. We have imported proud Americans. We have salvaged destitute Belgians. We have gathered in and utilised barbers, circus proprietors, evangelists, aboriginals from the antipodes and some of the best people.

We have made women into mechanics, and mechanics into supermen, such as may be found amongst machine tool dealers. We have diluted our labour, both male and female, until we have workers of the combined sexes, and of neither sex.

We have praised God, honoured the King, and strafed their common enemies, but we stand to-day hopelessly abashed before your suggestion that we should put through show machines when you are daily strafing us for late deliveries.—Yours faithfully,

(Signed)

* * * *

The respective uses of electricity and gas in the great war will doubtless, in the Censor's good time, be made the subject of an interesting volume. For the moment it is not a crime to state, as does the "Sanitary Record," that "the output of electrical cooking apparatus is entirely absorbed at the present time, we are informed, for use on submarines." Meanwhile gas continues to be used for asphyxiating purposes, in accordance with ancient tradition.

The Germans can quite easily adopt daylight saving methods because they do not mind getting up early. As a nation we are not attracted to the matutinal worm, even if Parliament gives us the bill with which to catch him. Ugh!

* * * *

The sketches reproduced are from the "Kansas Star" of recent date, and they can be read in two ways. They make a good pictorial argument for the electric battery vehicle, and they probably represent the state of mind of the man who is now confronted with that 18 guinea tax. Unless it's an electric, your car will cost you more!

* * * *



OUR HOT PLATES.

No. 209 to—

Councillor "Chris" Wilson upon his "elevation" to the seat of chairmanship of the Barnes Electricity Committee. ["P. F."* Davidson will now have to mind his "P.'s and F.'s."]

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), April 26, 1879.]

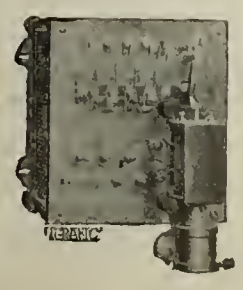
PROGRESS IN JAPAN.—According to the *Homeward Mail*, the telephone is now in general use in the public departments of Japan.

MAGNETIC VARIATION.—M. Flammarion calls attention to the singular fact that the daily variation in the magnetic needle recorded in Paris is different from that recorded elsewhere; that, in fact, the amplitude of the variation has remained stationary there while everywhere else it has of late years been gradually diminishing! Is it possible that magnetic observations are *not* "done better in France"?

REPAIR OF AN OLD CABLE.—The cable between India and Ceylon, thanks to the energy and perseverance of Mr. R. S. Brough, has been put into good working order. It is 30 miles in length, and is a Hooper's core cable, laid in January, 1867. Everyone else has condemned it as past repair; but Mr. Brough's belief was that if it were provided with new shore ends it would be all right, and the result has entirely justified his expectations. Its insulation originally was 7,000 megohms per mile, and it is now 2,550 megohms per mile, after being down twelve years, a fact interesting as showing the value of Hooper's proposed substitute for gutta percha.

* [Point Five.]

'IGRANIC'
SELF-ACTING STARTERS.
IGRANIC ELECTRIC Co LTD
147, Queen Victoria Street, London.



No. 29—1 Self-acting starter is a reliable and readily adapted starter for automatic and remote control of small D.C. motors up to 15 H.P., all voltages up to 500. May be operated by push button, tumbler switch, float switch, tappet switch, pressure regulator or other pilot device.

No. 30—1 Self-acting starter with self-contained and electrically interlocked magnetic main switch, is a robust long-service starter that is widely used for automatically controlling D.C. motors of capacities up to 20 H.P., maximum voltage 500. Fitted with renewable contacts to starter and main switch.

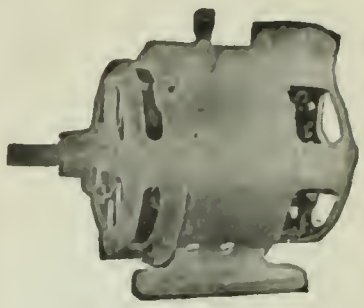
Write us for Leaflets.



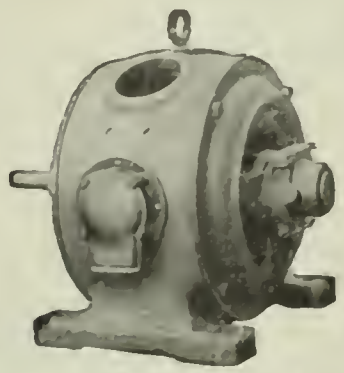
SIEMENS

STANDARD

ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED

HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."

Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."

HOME BRANCH ADDRESSES:

BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.

Branches in Principal Towns Abroad.

"MAZDA" SHADE FOR SUBDUED LIGHTING.

The more stringent regulations lately enforced by the authorities as to the lessening of outward illumination from shops, offices and private residences, have made it necessary for individual lamps to be shaded. It is no longer sufficient in private houses or offices to use light-coloured curtains or blinds, while in shops the source of light



must be so shielded that no direct rays can pass outside. Something safer, more durable and of better appearance than tinted paper around the lamps is called for in view of the prolonged period over which the restrictions seem likely to extend, and specially designed shades are needed. A neat and effective screen of attractive appearance is being issued by The British Thomson-Houston Co., Ltd., Upper Thames-street, E.C., and any number in reason will be supplied to business firms, contractors and retailers upon request.

The shade is posted flat, and is made up of stout dark-coloured card, with stencilled lettering backed by orange-tinted paper. From the illustration it will be seen that the shade can be placed over any electric lamp without removing the latter, while if an ordinary fancy glass shade is used, the "Mazda" shade will go over it. To place the screen in position, the two wings are locked together around the holder, this movement causing the shade itself to assume a curved form thus shutting off the direct light rays from about one-third of the circumference of the lamp. The wings are locked in the following manner: The right-hand wing is first inserted in the slit (A) provided in the other wing, the hooked end of the wing (B) being then held in a second slit (C). In this way the wings are held rigidly, and the shade cannot fall off, or open out accidentally.

ELECTRIC WINDING PLANT IN A SCOTTISH COLLIERY.

Electric winding plant is being installed in Scottish collieries and shale pits, and a recent adaptation is that at the Breich pit of the Pumpherston Co., near Edinburgh, where a Siemens-Ilgner system has been installed. One of the principal features of this plant is the inclusion of an effective system of remote control, which, in the event of anything unforeseen taking place, will automatically bring the cages to rest, and apply the brake in such a way as to preclude the possibility of injury to the plant.

As showing the advantage of the flywheel equaliser in this instance, it may be stated that, whereas the peak load on the winding motor at the end of the acceleration period is about 400 H.P., the maximum power demand on the generating plant never exceeds about 200 H.P. A further advantage of the flywheel is that in the event of the main supply failing at any time, sufficient stored energy is available in the wheel to complete one or more winds. The winder itself is of the

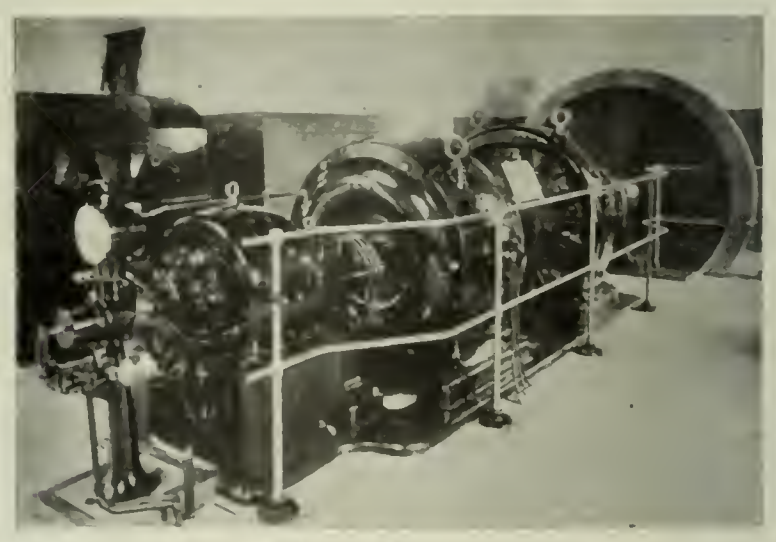


FIG. 1.—MOTOR GENERATOR SET.

ordinary parallel-drum type, with direct coupled winding motor, and winds from a maximum depth of 65 fathoms. The duration of one wind from bank to bank is 20 seconds, the period of acceleration being eight seconds, full speed run six seconds, and retardation six seconds. The average interval between winds for changing trucks is 20 seconds, and under these conditions the winder is capable of raising material at the rate of 112 tons per hour from the depth specified.

The power supply is taken from a three-phase high-tension line, conveying energy from the company's Deans Works power station at a pressure of 3,300 volts, 50 cycles. This supply, after passing through iron-clad switch panels fitted with the necessary protecting devices, &c., is carried to the alternating-current end of a motor generator set (Figs. 1 and 2), consisting of a 3,300-volt three-phase motor, a variable-voltage direct-current generator, a constant-voltage direct-current exciter generator, and a cast steel flywheel, which is capable, with a suitable reduction in speed of giving off the surplus energy required above the average when the winder is work-

FERRANTI LTD

Central House, Kingsway, London, W.C.

SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

Write for Binder "N."

TINNING FURNACE

(Hall's Patents)

For COATING WIRES with Tin, Lead, etc. For use as a BATH.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
The only Tinning Plant on the World's Market with Automatic Heat Control.
Gas Producers are used in special cases.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

ing to the specified conditions. The normal speed of this motor-generator-flywheel set is 750 revs. per min. (synchronous). The three-phase motor is of the ordinary slip ring type, and the necessary speed reduction, to enable the flywheel to give up its energy, is accomplished by means of an automatic slip resistance inserted in the rotor circuit. The variable-voltage direct-current generator is separately excited from the constant-voltage exciter, and is so arranged as to give an armature voltage varying between zero and plus or minus the maximum.

The winding motor (Fig. 3) is also separately excited, and has its armature permanently connected (electrically) to that of the variable-voltage generator. The speed and direction of rotation of the winding motor are controlled by regulating and reversing the excitation,

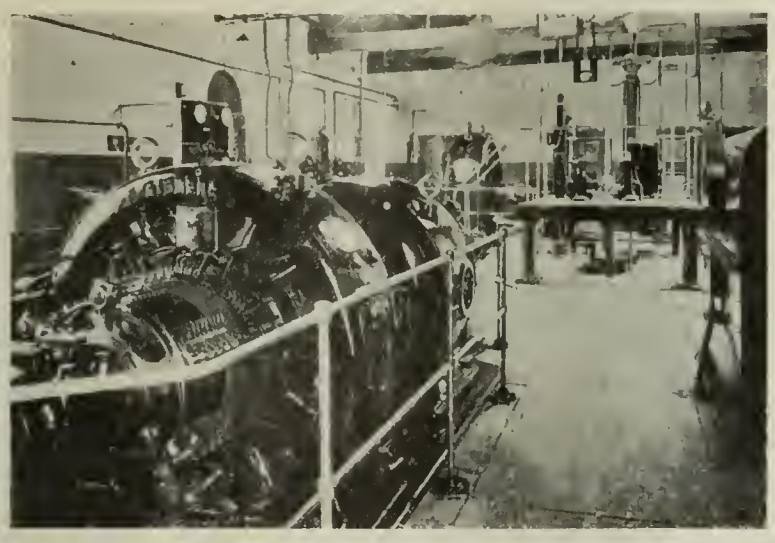


Fig. 2.—General View of Engine House; Control Gear in Background.

that is, the pressure, of the variable-voltage generator. The most important feature of this control is that the speed and direction of rotation of the winding motor are determined solely by the regulator, that is, by the position of the driver's control lever. This holds true, irrespective of the load in the cage, or of the direction of the torque, whether positive or negative, that is, whether loads are being raised or lowered.

Moving the operating lever towards the "off" position induces a strong electrical braking effect, the motor acting as a generator, and returning energy through the converter generator to the line. Energy is also returned to the line when loads are lowered. The low speed required for inspection purposes can be readily obtained by moving the operating lever only slightly from the "off" position. The controller, being only called upon to deal with the energy in the exciting circuit of the variable-voltage generator (about 2 to 3 per cent. of the energy consumed by the winding motor), is small and simple; and is therefore readily operated by the control lever without the use of auxiliary gear. The fact that any given position of the operating lever corresponds to only one speed and direction of rotation, makes it possible to provide safety appliances of absolute reliability.

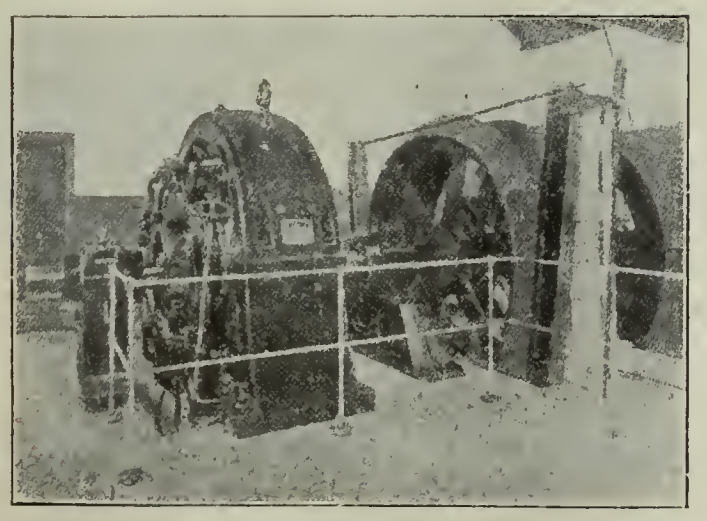
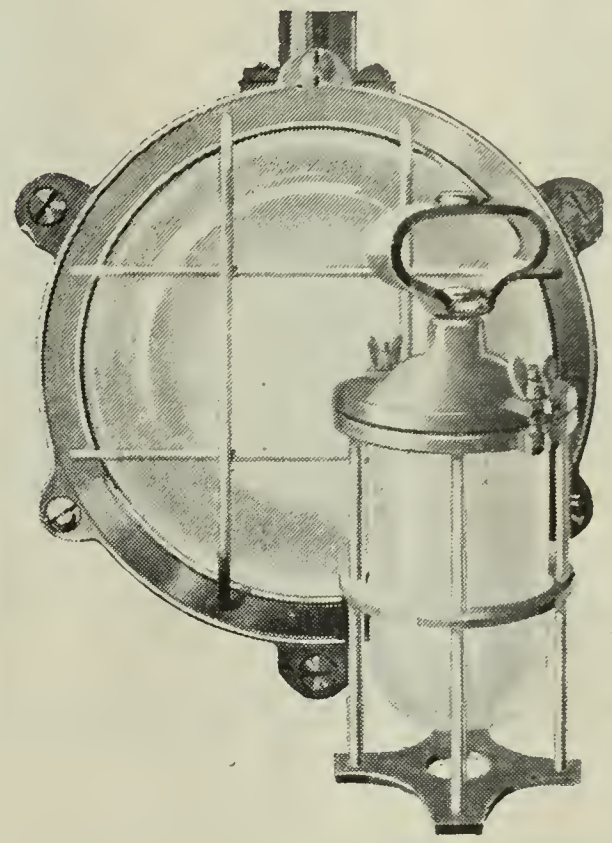


Fig. 3.—Winding Motor and Drum.

Braking is effected by ordinary post brakes operating on machined brake paths cast on the drum cheeks (Fig. 3), the brake blocks being held off the face by the piston of a compressed air cylinder, and applied by counterweights operating through a system of levers when the air pressure is released. In ordinary working, it is seldom found necessary to bring the mechanical brakes into operation, owing to the fact that the cages can be more easily and satisfactorily decked by means of counter-current braking. Compressed air for the brake engine is supplied from a separately driven air compressor in conjunction with a suitable reservoir. [From "The Colliery Guardian."

SIMPLEX
WATERTIGHT
FITTINGS.



Bulkhead Fittings and Hand-lamps manufactured at our Birmingham Works in cast iron or in brass.

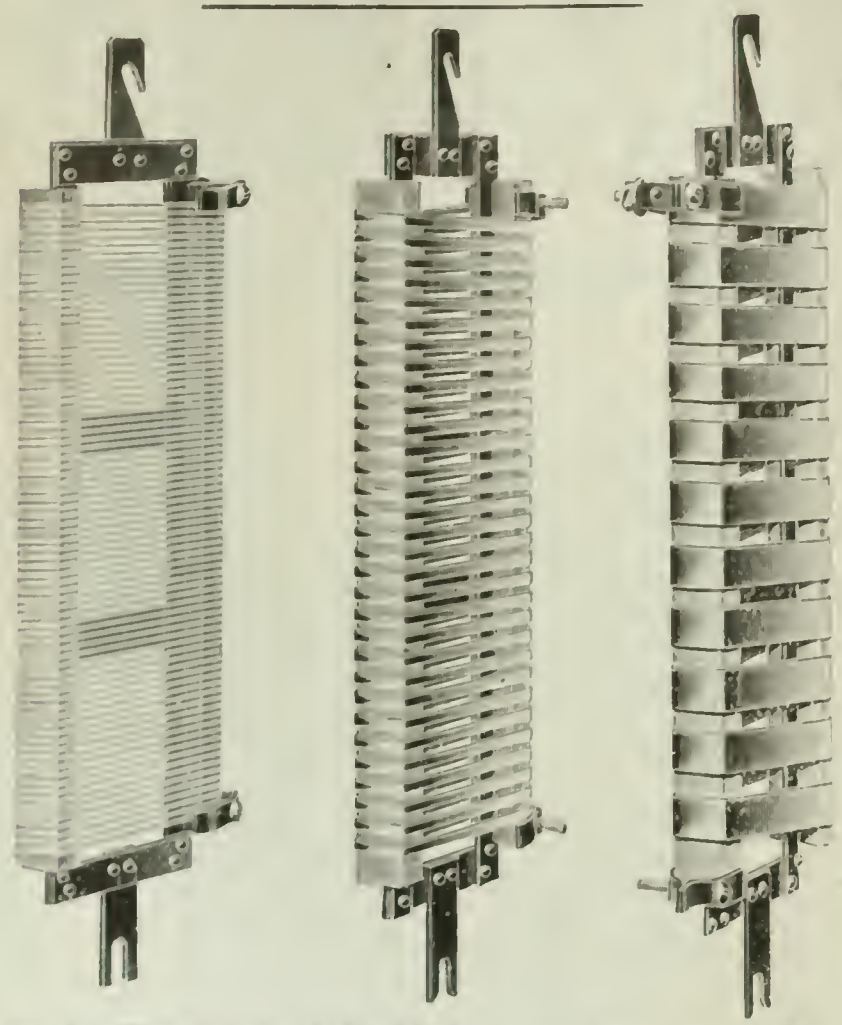
Supplied to Admiralty, War Office, and other Government Departments.

Simplex Conduits Ltd.
Garrison Lane, Birmingham.

London—
113-117, Charing Cross Rd., W.C.
Manchester—
16, Corporation Street.
Glasgow—
72a, Waterloo Street.
Bristol—
11, Denmark Street.
Newcastle—
61-65, High Bridge.
Leeds—
6, White Horse Street.
Liverpool—
96, Whitechapel.
Swansea—
14, Heathfield Street.
Cardiff—
4, Westgate Street.
Aberdeen—
1, Crimon Place.

RHEOSTATS

NEW LIST NOW READY.



ISENTHAL & CO.

(DEPARTMENT 4)

DENZIL WORKS, WILLESDEN, LONDON, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

ALTERNATING-CURRENT TWO AND THREE PHASE INDUCTION MOTORS.

A new list (No. E11A), issued by Greenwood & Batley (Ltd.), Leeds, contains details of standard alternating-current motors up to 100 h.p. The list has been made up with a view to assisting customers to choose motors they require quickly, and it only contains particulars of standard machines. All machines having the same size number are identical in weight and overall dimensions. The machines are cooled by natural ventilation, no fans larger in diameter than the rotor being used.

The frames of all sizes are cylindrical in shape, and are provided with end shields which carry the bearings. The machines can be supplied in the following types: (1) Semi-enclosed, (2) ventilated enclosed, having openings filled in with strong wire, (3) totally enclosed and dust proof, having solid doors fitted to all openings.

The machines dealt with in the list are wound for any voltage from 200 to 6600 volts, and they may be used without alteration on a voltage not differing from the rated voltage by more than 5 per cent. The motors are rated to give their output continuously, either as semi-enclosed, ventilated enclosed, or totally enclosed types. The temperature rise after six hours' running at the listed output and voltage will, it is stated, not exceed the following values, all temperatures being measured by thermometer: 72° F. or 40° C. for semi-enclosed type, 80° F. or 45° C. for ventilated enclosed type, 90° F. or 50° C. for totally enclosed type. The motors are capable of giving an overload of 25 per cent. for one hour, and 50 per cent. for short periods, without injury or undue heating.

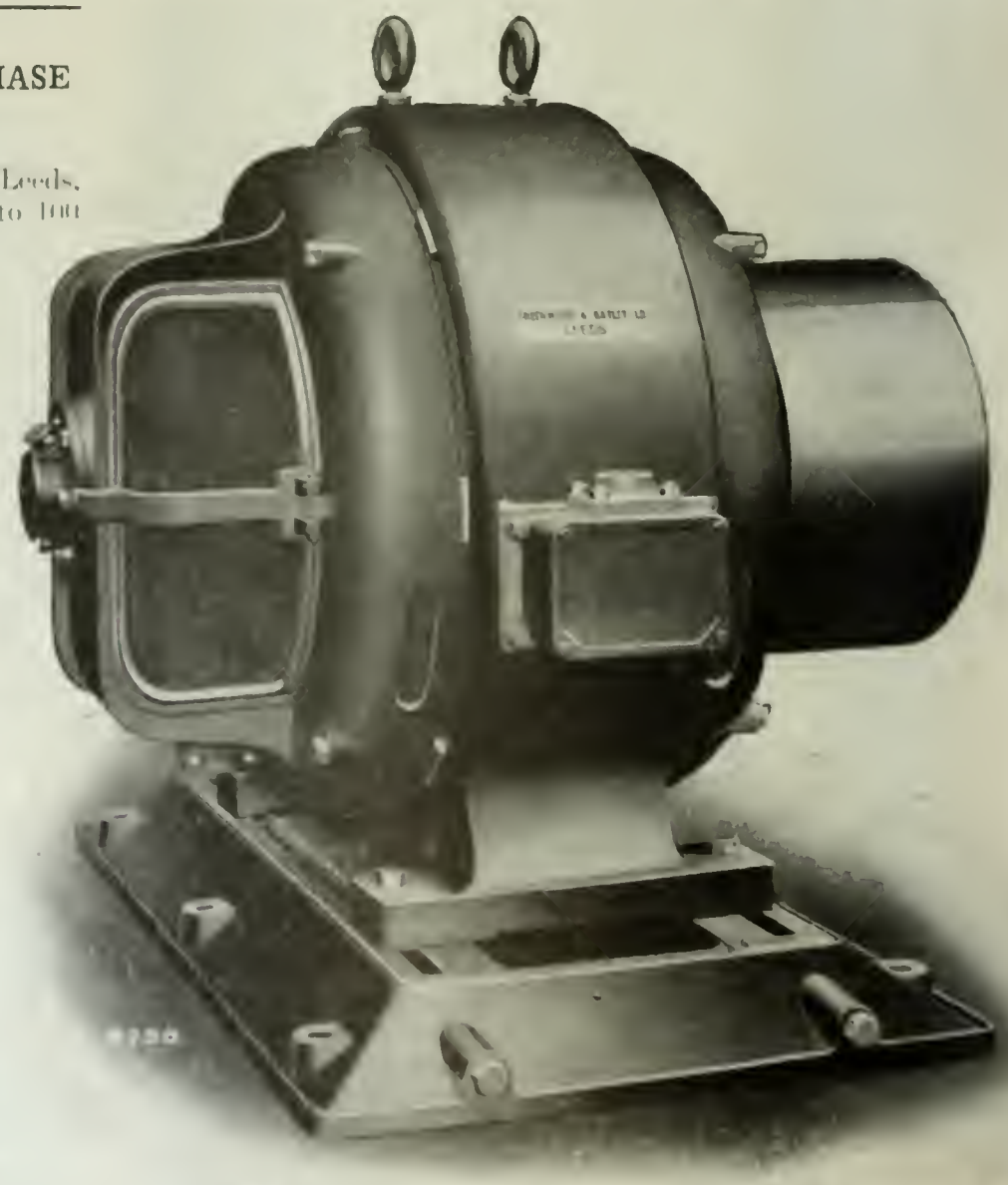
Motors for the standard frequencies of 50 and 25 cycles per second are dealt with. The motors may be used without alteration on frequencies which do not differ by more than 5 per cent. from these figures. The particulars given for output, speed, efficiency and power factor are based on frequencies of 50 and 25 cycles. The 50-cycle motors can be used for frequencies between 40 and 60, the output and the speed varying in proportion to the variation in frequency.

The stator is built up of best quality charcoal iron stampings, insulated from each other, and clamped together in a rigid cast-iron frame, the construction being such as to render them concentric and true with one another. After building, the slots are carefully dressed to remove any sharp edges or burrs, and insulated to receive the windings. Arrangements are made for ample and efficient ventilation to ensure cool running. The stator coils consist of high conductivity copper conductors and are embedded in semi-enclosed slots, thus ensuring a high-power factor. The coils are thoroughly insulated from each other and the frame, and dried in a vacuum chamber and impregnated with special insulating varnish. The rotor core is built up of best charcoal iron discs, insulated from one another, mounted on a cast-iron hub, and firmly clamped between rigid endplates. The hub is pressed on a mild steel shaft by hydraulic pressure, and further secured by a key.

The rotor winding consists of copper bars thoroughly insulated and pushed through the slot from one end only. The slot is lined with insulating material, and the coils are held firmly in place by fibre or hard wooden wedges. The windings of squirrel-cage rotors consist also of copper bars, carefully insulated from the iron, and connected together at the ends by rings of copper. The connections between the copper bars and the windings are made in the small sizes by rivets, and in the large sizes by screws. All connections are soldered.

The slip-rings are of hard gun-metal insulated entirely with mica, and mounted on a metal sleeve, which is keyed to the shaft. The machines above size 4A are fitted with a device for short-circuiting the brushes. This device slightly increases the efficiency. Brush-lifting gear is not fitted, as the company consider that this is an unnecessary complication, in view of the fact that the brushes are of carbon, the wear on which is negligible. Two brushes of best quality carbon are provided for each ring. The brushes slide in brass holders which are fitted with adjustable tension springs. A flexible lead from each brush carries the current to the holder, so that no current passes through the sliding contacts.

The shaft is of the best mild steel, of large diameter, and of ample strength and stiffness to resist flexure and vibration. The bearings are self-aligning and of ample size for continuous running without overheating. They are bushed with gun-metal, and are lubricated automatically by means of oil rings running loose on the shaft and



Large Size H.T. Slip Ring Motor with Roller Bearings.

FERRY | **FERROZOID**

CONSTANTAN | **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

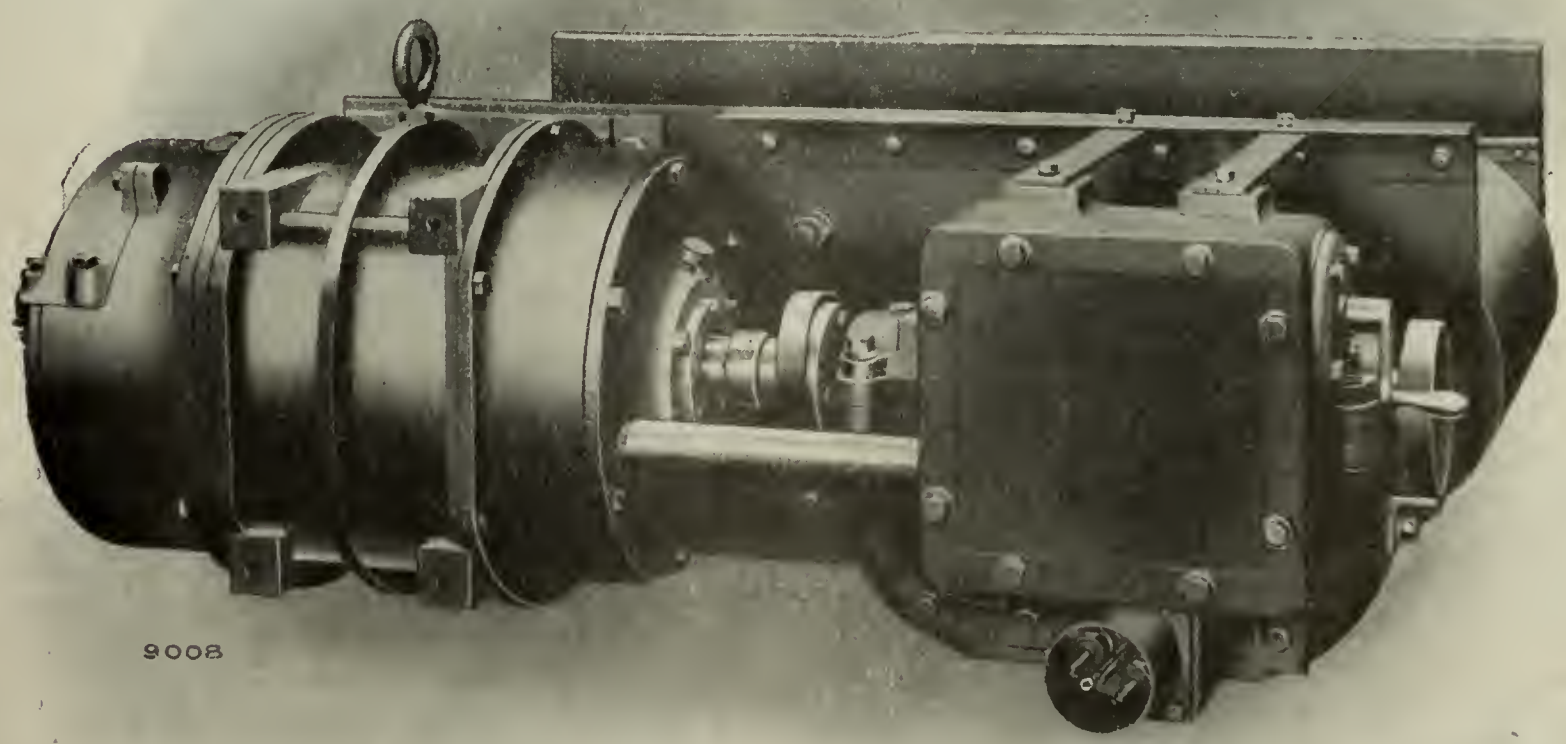
HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."



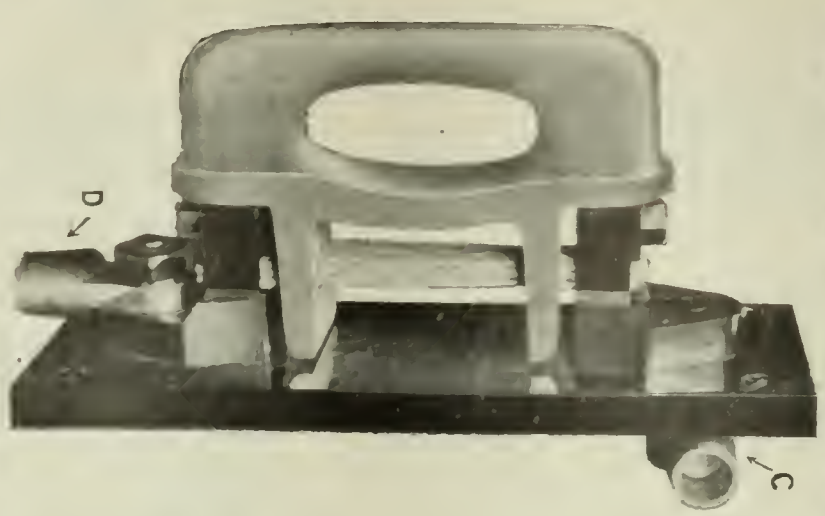
STANDARD FLAME-PROOF PATTERN CONVEYOR HEAD EQUIPMENT FOR MINING WORK.
(See opposite.)

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

dipping into oil reservoirs cast into the end shields. The bearings are fitted with draw-off cock and oil level gauge. The end shields are of cast-iron, and besides affording a support for the bearings, effectively protect the windings of the machine against mechanical injury. The end shields can be turned through 90 deg. or 180 deg., in order to fix motors to the wall or ceiling. The shaft must remain horizontal. Terminals with sweating lugs are provided in a convenient position and protected by an iron case.

The motors described in the list range in output from 2·5 H.P. to 100 H.P. A copy of the catalogue, which also gives prices and dimensions, may be obtained from the company on application.

A NEW COMBINED SWITCHPLUG.

The adjoining illustrations show a new pattern of combined switch and plug which is being made by Messrs. Sturge & Baker, at Premier Works, Sheepcote-street, Birmingham. Fig. 1, which is a half size interior view of this accessory, gives some idea of the constructional details. The switch movement is of the ordinary tumbler type with large china dolly, its actuation is controlled by a lever having a catch at one end and a flat plate (A) which can be depressed by one of the pins of the plug when the latter is inserted. This action raises the trigger and allows the switch to be put into the "on" position. The movement of the switch arm slides forward the link (B), which is on the opposite side of the switch to the trigger: at the lower end of this link is a keyhole which engages with a recess or groove in one of the pins of the plug. Both pins are grooved, so that the plug can be inserted either hand. The net result of these operations is that the insertion of the plug allows the switch to be put in and the circuit closed, and the movement of the switch to close the circuit locks the plug in: the switch must, therefore, be moved to the "off" position before the plug can be pulled out, and the act of withdrawing it sets up the trigger and prevents the circuit being made. The apparatus, therefore, automatically ensures that the plug contacts are dead when the plug is not in place. The plug itself is provided with a substantial cover which acts as a handle, and the flexible is taken in at the side so that it cannot be used to drag the plug out of its place.

This interesting accessory is made in four sizes, the capacity being 10 to 15 amperes in each case: (1) With white china base (as Fig. 2) and unbreakable cover: (2) with white china base, hardwood box and bronzed metal cover plate for flush work: (3) as (1) with independent action instead of interlocking device: (4) as (2), with independent action instead of interlocking device. The combined switch and plug can be supplied for use with iron boxes. Prices are given in a list which has recently come off the press, and copies of which can be obtained from the company at the above address.

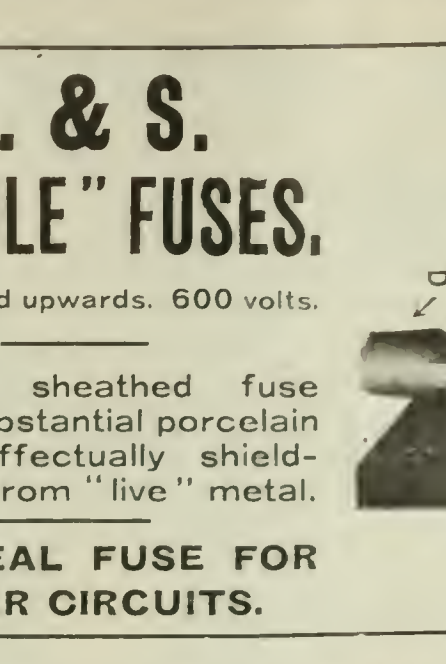


Fig. 1.—Combined Switch Plug, Open.

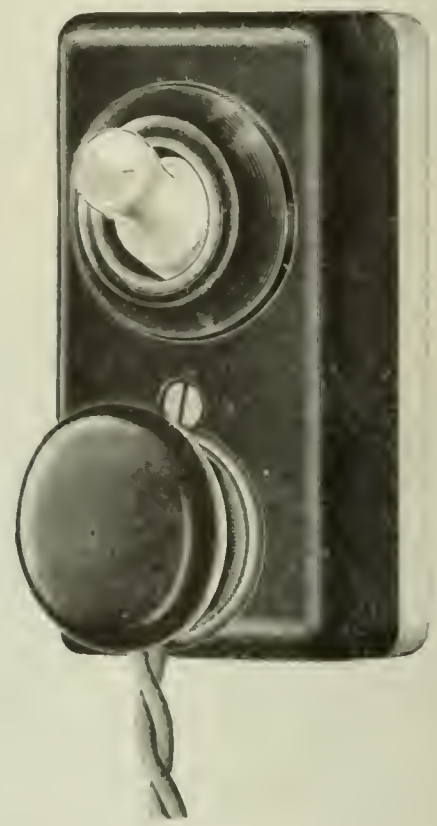


Fig. 2.—Combined Switch-Plug, with Cover in Place.

INCREASE STEAM CAPACITY OF BOILERS.

Water **HEATER-SOFTENER** Combined.

Utilise Exhaust Steam or Gases.

THE LAWRENCE PATENT WATER SOFTENER CO., Ltd.,
Parliament Mansions, Westminster.

"THOR" High Grade Specialities

CASING and CAPPING — CABLE CONNECTORS
CONDUIT — COMMUTATOR COMPOUND
CABLES — WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.

WRITE FOR TRADE DISCOUNTS.

HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

Printed and Published for the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London. Friday, April 28, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—A Midland Railway battery van with a "MEX motor spirit" advertisement on each side of it.

* * * *

One of our weekly gas contemporaries states in its columns, devoted to matters electrical, that "personally we have never been able to see that the electricity industry really required a publicity organisation." Which, being interpreted, means that the old proverb can now be adapted to read "good 'juice' needs no bush."

* * * *

"We cannot refrain from recalling the failure of electric taxicabs in Berlin," says the "Commercial Motor." We in turn (*i.e.*, r.p.m.) will refrain from recalling the many petrol vehicles *en panne* which it has been our lot to pass when afoot, a-wheel and in our electric-de-luxe on the road.

* * * *

The Grimsby Corporation has agreed with the recommendation of the Electric Lighting Committee that no new electricity consumers for lighting purposes be accepted during the period of the war. I hope that the local gas undertaking will be equally patriotic.

* * * *

The "Daily Telegraph," referring to the wireless message sent by the "Aurora," says :—

"The message which told of the 'Aurora's' ill fortune was, it appears *by a freak of nature* transmitted 900 miles with an apparatus normally suitable for about 200 miles radius."

The manufacturer of the equipment would, but for this somewhat unkind explanation, have put the achievement down to "good design and construction of the apparatus."

* * * *

"Mark Lane" writes in the "City Press" (London) that "on Wednesday morning I passed through Broad-street, Bishopsgate and elsewhere about 9.45 a.m. and those streets had absolutely the same amount of electric light being consumed as at night." I may remind "Mark Lane" (or should it not be "Mark Twain" ?) that there are many towns in the country in which the street lamps now consume the same amount of electrical energy in the daytime as at night—namely, no units per ann. (much to the joy of those who in the past have depended upon street lighting for the load factor; gas papers, please copy).

* * * *

I am the Lightning and the Light !
From the charged cloud I fling my Might,
To fright men in the lonely night.

* * *

I come from the magnetic earth ;
To earth return, land of my birth :
Yet do I never die.—I slay
My servants if they should delay
To keep my Laws and Testaments,
Or give me perfect instruments.
Though I'm the Stuff of matter all,*
When uncontrolled I shatter all
Material things that cross my path ;
I am the Ruthless and the Wrath.

"J. A. M." writes as above in Glover's Calendar; he might have been writing of a Zepp instead of our beautiful Electra !

* Her allusion is to the Electron Theory of Matter.

Commenting upon the success of the Edison battery dust vans as used by Mr. J. A. Priestley at Sheffield, the "Sanitary Record" says "that the only flies in the ointment are," &c. Now, there is some mistake here. I know that vaseline is largely used with lead batteries and distilled "make up" water with alkaline cells, but "ointment"—never !

* * * *

According to a gaseous contemporary : "Gas plant is not as a rule purchased abroad, but large electric generating sets and machines have had a considerable importation. A company once entered in a contract with German builders for a gas holder. The war intervened ; and the holder has not been constructed." Of course not. Hence the gas attacks on the Allied troops at the front.

* * * *

I have heard of and commented upon many electric costumes at fancy dress balls, but have not so far met with the individual who had the courage to disguise himself as a dry cell (and I have not a few Scottish friends in the electrical industry at that). The thing has, however, been done by Mr. W. E. Page, of the Western Electric Co., whose "portrait" (sic !) is reproduced herewith. For this complete disguise Mr. Page was awarded first prize at a carnival recently held at the W.E. Co.'s Works. He tells me that, despite the low internal resistance of the Blue Bell dry cell, he could neither dance or sit out any of the numbers on the programme. Absence of local action will perhaps be the best explanation of this. I understand, however, that, like the true Blue Bell, Mr. Page's voltage was well maintained throughout the evening, and there were no internal short-circuits !



* * * *

OUR HOT-PLATES.

No. **210** to—

Mr. James Cleary, electricity department, Brighton, for being the first consumer's engineer to entertain Royalty to an electric tea in a Servantless Flat. (See p. 30.)

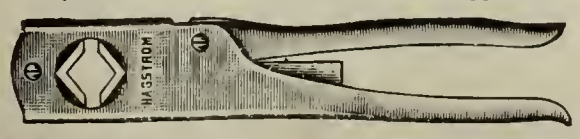
* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), May 3, 1879.]

THE BREAKING-IN OF HORSES BY MEANS OF ELECTRICITY.—According to *La Nature*, the General Omnibus Co. of Paris has for some time past made use of electricity for breaking-in the horses destined for the service of its vehicles. At a recent sitting of the *Société Nationale d'Agriculture*, M. Bella gave some interesting details in relation to this subject, from which it appears that vicious horses addicted to biting, kicking, &c., speedily submit and become inoffensive, so that they can be harnessed and groomed with safety, after undergoing the electrical discipline. To obtain this result a weak electric current was passed through the animal's mouth whenever it showed restiveness. The current was generated by a small Clarke magneto-electric machine, one of the wires from which communicated with the bit (one pole being, no doubt, put "to earth"). This idea has been suggested at the Paris Exhibition, where, in the Swedish section, was exhibited a small box containing a battery communicating with a bit by means of the reins. When the horse to which this apparatus was adapted showed any symptom of viciousness, the conductor was simply to press a small button, when the animal would immediately become subdued. The use of electricity is said to be much less liable to the charge of cruelty than are the means ordinarily adopted for the breaking-in of horses.

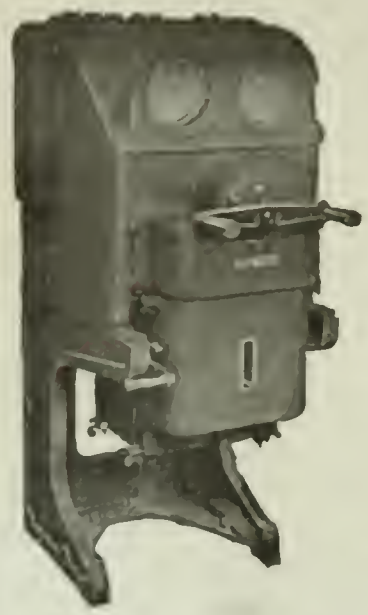
THE HAGSTROM ARC LAMP CARBON CUTTER.
Will sever carbon without crushing. Leaves straight, clean edge.
Adjustable and non-adjustable types supplied.



THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.
Phone: Regent 4346. *Code: ABC 5th Edition. Teleg.: "Engineyor, Westrand, London.*

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golslplat, Ox., London." 4746 Gerrard.

SIEMENS



IRONCLAD SWITCHGEAR FOR ALL PURPOSES

Control Pillars
Distribution Boards
Main Switchboards

Illustration shows our Standard Cast-iron Mining Pillar suitable for pressures up to 3,300 volts.

Write for particulars to —

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Hse., New St. | MANCHESTER—196, Deansgate.,
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—87, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

ELECTRIC LIGHT SWITCHING EXAM. RESULTS.

Heads of electrical engineering departments, especially those who —even before the war—had reason to deplore a falling off in the number of students, are in some measure indebted to Messrs. Lundberg for instituting their periodical examinations in electric light switching. These exams. attract and encourage many actual and potential electrical workers of all ages who would not—in the ordinary course—have anything to do with pen and paper tests. It may surely be assumed that a certain proportion of this type of examinee, having once learned to devote serious attention to an electrical subject will feel impelled to continue their investigations and so become members of electro technical classes.

The examinees in the subject are not all of the above type, however, as may be seen on referring to the recent results announced in an advertisement last week. These results have been considered so satisfactory (being a record, we understand) that a supplementary competition or exam. is to be set in training forthwith.

ELECTRIC DRILLS AND GRINDERS.

Although the portable electric drill and the electric grinder are not new tools, they have undergone continuous improvement since they were put forward some years ago for ordinary workshop use. They



Fig. 1.—Internal Grinder for Attachment to Lathe Tool Rest.

must be in considerable demand in engineering works at the present time, because the production of munitions requires the employment of highly accurate tools and the working to extremely fine limits. For operations of this class the electric grinder is an ideal machine. It is sufficiently light and portable to be attached to a tool rest in a lathe or other machine tool, and it may be utilised for both internal and external grinding. Fig. 1 is an illustration of a typical internal grinder. It will be observed that the motor is fitted with a long journal on one side, which allows of the passage of the grinding tool well into the depth of the work. The motor is of compact design, but is, we understand, well up to its work and capable of considerable overloads without excessive heating. It will be observed that the conducting leads are brought out through a bushed hole and are enclosed in a flexible metallic hose, which terminates in a combined switch and connector fitting. Fig. 2 is a side view of combined drill with an external emery wheel attachment for tool grinding and similar operations. Both the drill spindle and the emery wheel are

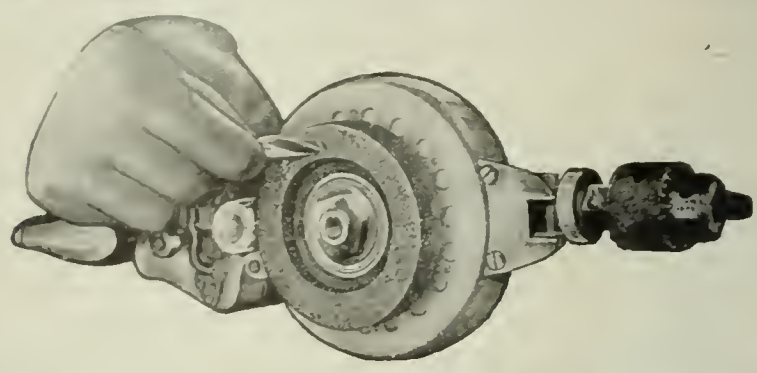


Fig. 2.—Side View of Combined Emery Grinder and Drill.

driven from the motor by means of an efficient gearing, which is totally enclosed and well lubricated. The spindle carrying the drill can, by means of a neat attachment, be turned a considerable angle to admit of the use of the machine for corner work. Aluminium is used as much as possible for the enclosure of the principal working parts, with a view to reducing the weight of the tool. We understand that the motors are designed for operating on continuous or alternating current, and can be supplied for any desired circuit voltage. These useful accessories form part of a range of modern electric tools which have been put on the market by Messrs. Brown Bros., Great Eastern-street, London, E.C. Particulars are given in a new list which will be supplied on request.

THE PLEXSIM ELECTRIC STILL.

The electric miners' lamp is simplified in use by the introduction of the Plexsim electric still, which makes the provision of distilled water so important in accumulators a simple and inexpensive matter. The action of the still, which can be gathered from the section drawing herewith, is absolutely automatic. Turn on the water tap and switch on the current and the still does the rest, and continues doing it until the current is switched off. The still is made by

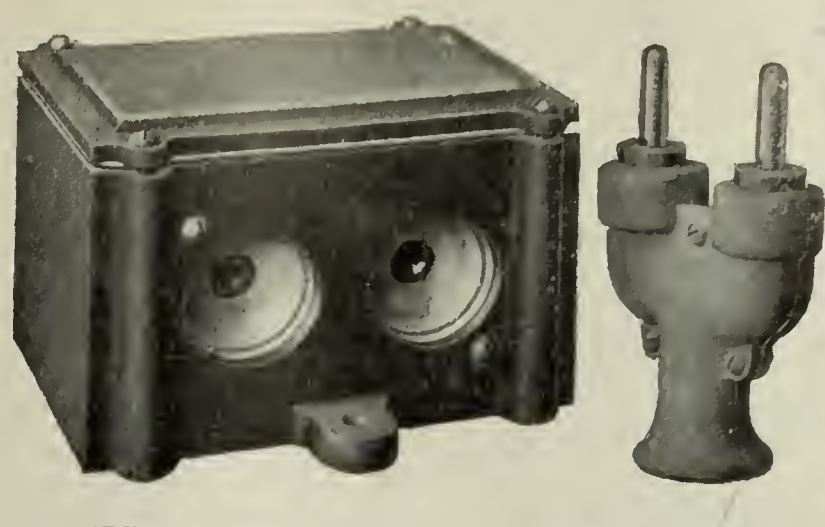


General View of Plexsim Still.

Simplex Conduits (Ltd.), Garrison-lane, Birmingham, who will be pleased to send particulars to inquirers.

The still is made of stout copper, tinned inside: in the larger size the boiler is of cast iron. From the sectional illustration it will be

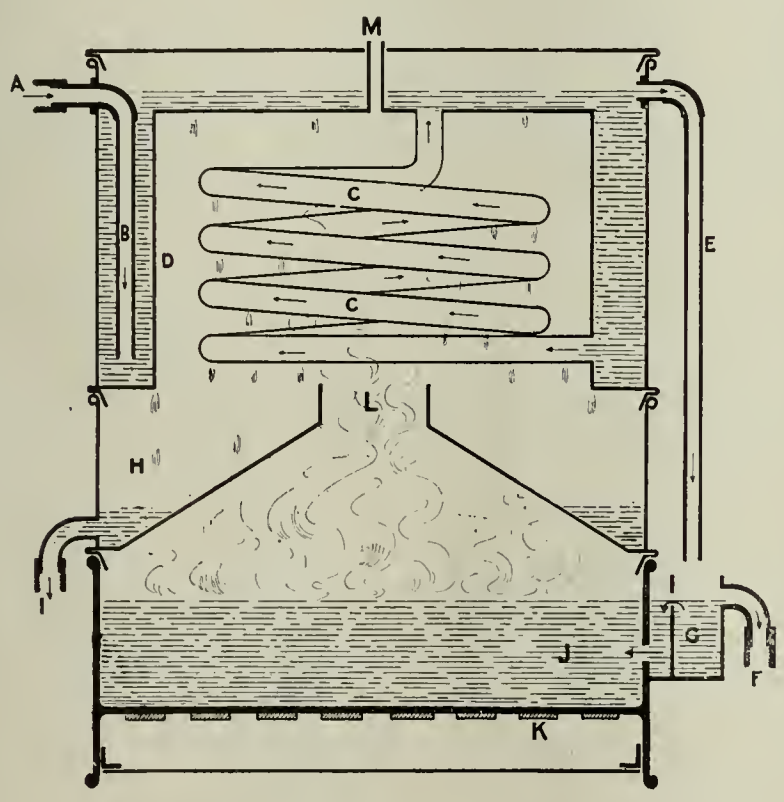
IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

seen that the cold water enters at (A), where it should be controlled by screw-down water tap. It passes through the pipe (B) to the outside of the condensing chamber and coil (C and D). After filling the tank and coil, the overflow water passes through the pipe (E) into the small feed tank (G), which is so arranged that there is no loss of heat at this point and no disturbance of the constantly boiling water in the evaporating chamber (J). The overflow water is taken by the pipe (F) to a suitable waste drain.

The heating elements (K) are mounted on the underside of the evaporating chamber, and when the water is flowing and the current is switched on the water rapidly boils. The steam given off rises through the cone (L) and impinges on to the various surfaces of the



Cross Section through Plexsim Still.

walls and coil in the condensing chamber, where it rapidly condenses, the drops of distilled water falling into the distillate chamber (H), from whence it flows through the outlet (I) into a suitable receptacle. The action is simple and automatic, and therefore no attention is required. So long as water and electric current are flowing nothing can go wrong. For economy in working, it is suggested that the flow of the feed water should be so regulated that the temperature of the waste water is about 150°F.; at this point the still is working at its greatest efficiency. All parts of the still are easily detachable and accessible, including the heating elements. Its construction is robust and it is designed for workshop use. The still should be of great value in laboratories, also in central stations where batteries are installed.

THE "EASY-CLIP" SHADE CARRIER.

We understand that Siemens Bros. Dynamo Works (Ltd.), of 38-39, Upper Thames-street, are just placing on the market a new shade carrier which is of neat design, and which greatly simplifies



Fig. 1.—The Easy-clip Shade Carrier.

the operation of shade fixing. The device is most ingenious, and can be used in any situation where shade carrier rings have previously been employed. For the larger installations, such as hotels, restaurants and theatres, where shades are regularly cleaned, the device



Fig. 2.—The Old Methods.

should effect considerable saving of time as compared with the operations needed when the ordinary shade ring is used.

The Siemens Easy-clip shade carrier has two sets of claw grips



Fig. 3.—The New Easy-clip Method.

(Fig. 1), the inner to engage the screwed part of the lamp-holder and the outer to grip the shade. Both are under spring tension, and the clip is readily inserted in the shade after compression between the

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire; also for flexible leads, etc. AMPLE STOCKS.
H. HARTJEN & CO., 35/37, NOBLE STREET, LONDON, E.C.

One, Two & Three Phase MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK.

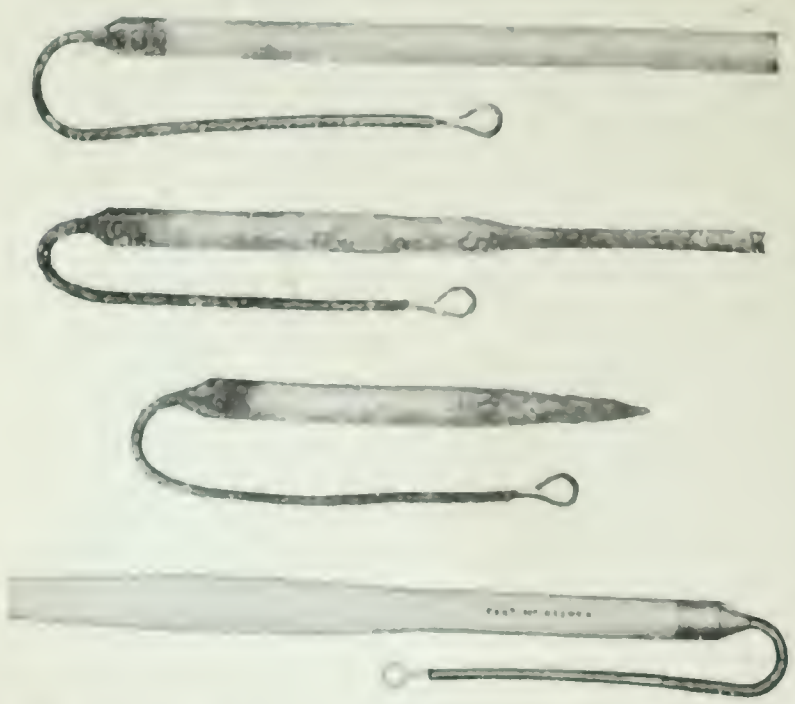

CHARLES CLIFFORD & SON, Ltd.
BIRMINGHAM.

thumb and forefinger. The inner claw grip is brought to the required tension when fixed in the shade, and the claws firmly engage the thread of the holder when it is forced through the grip. The Easy-clip shade carrier reduces shade fixing to two simple operations, and completely dispenses with the use of a shade carrier ring.

The shade is removed by unscrewing, and we understand that it is not possible to remove the shade by any other method, because the grips on the holder and on the shade are in opposite directions. With the introduction of the high-voltage tungsten lamp shades of greater length became necessary as a protection for the lamp. The fixing of such shades, however, presented increased difficulties, and special devices were needed to overcome them. The Siemens Easy-clip shade carrier does this most effectively. It is little deeper than the average shade carrier ring, is made of hard rolled brass (which may be finished to customer's requirements), will suit any design of fitting and any shade with $1\frac{1}{8}$ in. hole, does not deteriorate with age, and can be purchased at the moderate price of 3s. per dozen (subject). Trade quotations will be given on application to the company.

BATTERY ZINCS.

Pamphlet No. 877, issued by British Insulated & Helsby Cables (Ltd.), Prescot, describes and illustrates the "Helsby" zinc rod for Leclanché batteries. The adjoining illustrations, which are taken



from the list, graphically explain how the ordinary rod, which is of the same diameter throughout its length, is eaten away near the lower end and how the upper end of the rod suffers very little from the action of the battery. In the Helsby zinc rod the lower portion upon which the chemical action takes place has been considerably increased in diameter. The additional zinc at this part of the rod therefore materially increases the effective life of the rod, and also reduces the cost of the operation of the battery. Full particulars of this interesting battery accessory will be supplied on application to the company.

THE SERVANTLESS FLAT.

It is supposed by many persons, not a few of them electrical contractors, that the present higher prices of electrical energy will put a check upon the wider employment of those numerous domestic electrical appliances which have been perfected during the past five years. When the war broke out there was a prospect of a boom in vacuum cleaners, irons, electric cooking apparatus, fires, &c. While it is true that the necessities of the situation have compelled the supply authorities to raise prices, there is a factor which must be taken into account and which has arisen mainly as the outcome of the war. It is the difficulty, and it is daily increasing, of obtaining labour of any kind for domestic purposes. The servant problem is one of the most difficult which the householder has to consider, and after it has been solved the help which is obtained is high priced and usually unsatisfactory. Before the war the chief argument for domestic electrical appliances was based on the low cost of electrical energy. During the war the basis of the merits of these appliances has merely been shifted to the high cost and extreme scarcity of domestic labour. It may therefore be argued during the war, even more so than before it, that domestic electrical appliances are a sound investment.

These facts have evidently been appreciated by the Brighton Corporation electricity department. This undertaking, which is, as we need hardly remind our readers, presided over by one of the most progressively minded municipal engineers, Mr. John Christie, recently took advantage of the opportunity presented by a Patriotic Housekeeping Exhibition in Brighton to bring to the notice of the public the merits of domestic electrical appliances of all kinds. The design and arrangement of the exhibit was in the capable hands of Mr. James Cleary, the consumers' engineer, who worked upon the excellent notion of fixing up what was appropriately described as the "Servantless Flat." Although the space available for the exhibit was represented by only one room 30 ft. by 18 ft., the usual rooms found in a flat, dining-sitting room, bedroom, bathroom and kitchen, were arranged within this compass. Everything was done electrically. In the dining-sitting room a Belling "Renown" fire was introduced into a made recess under the window. The window itself was deep and large, and was tastefully finished off with palms and flowers. The hot-water supply was derived from a "Falco" heater, and with this the requisite quantity of hot water for the sink, lavatory basins and bath was given with the heater at "low"; only when successive baths were required was it necessary to switch over to "high."

The principal heating appliances were supplied by the Hotpoint Electric Co., and we understand that they attracted a considerable amount of attention. The "Hotpoint" irons were shown in operation, and these are noteworthy on account of the high loading. The 3 lb. iron is rated at 330 watts, the 5 lb. at 500, and the 6 lb. at 550 watts. The 10 years' guarantee offered with these irons proved a considerable attraction. The utensils for connection to lamp-holder sockets comprised "Hotpoint" coffee percolators and teapots, the "Hotpoint" 600-watt radiator for chilly evenings, immersion heaters and "El Comfo" hot pads. In the same range of 600-watt appliances is the "El Grilstovo" and ovenette, a cooking combination which has previously been exhibited in Brighton, and which, we understand, has been sold in quite large quantities. There was also a 600-watt small Bako provided with three-heat switch and the El Cooko, which is a 600-watt oven with three-heat control, but provided with $3\frac{1}{2}$ in. heavy mineral wool lagging all round the cooking space. This apparatus is designed for cooking by heat storage. It is stated that 4 lb. of beef, two vegetables and a pudding can be beautifully cooked at a cost of 0·6d. with electrical energy at 1d. per unit. The largest "Hotpoint" oven shown was the standard "Bako," loaded to 2,000 watts and provided with top and bottom heating in the oven, which measures $18\frac{1}{2}$ in. by 12 in. by 12 in. deep. The heat can be regulated by two three-heat switches, and by the use of the top heater alone a great many operations can be carried on.

We gather from the Press reports of this section of the exhibition, both in Brighton and London, that the electric idea has quite caught on. On Wednesday of last week H.R.H. Princess Louise, Duchess of Argyle, visited the exhibition and was particularly impressed with the servantless flat. She remained a considerable time and witnessed demonstrations of most of the appliances on view. To quote the "Brighton Herald," "the Princess showed the liveliest interest in everything, and was charmed with the artistic appearance of everything. She certainly made everyone feel quite pleased with her and pleased with themselves—one of the happiest prerogatives of royalty." She was, in fact, so gratified with the arrangements that she remained to tea, which was served in the flat by Mrs. Gathers, who was assisted by the Misses Wienholt. With her Royal Highness were Lady Louise Loder, Lady Brassey, Lady Chiches-

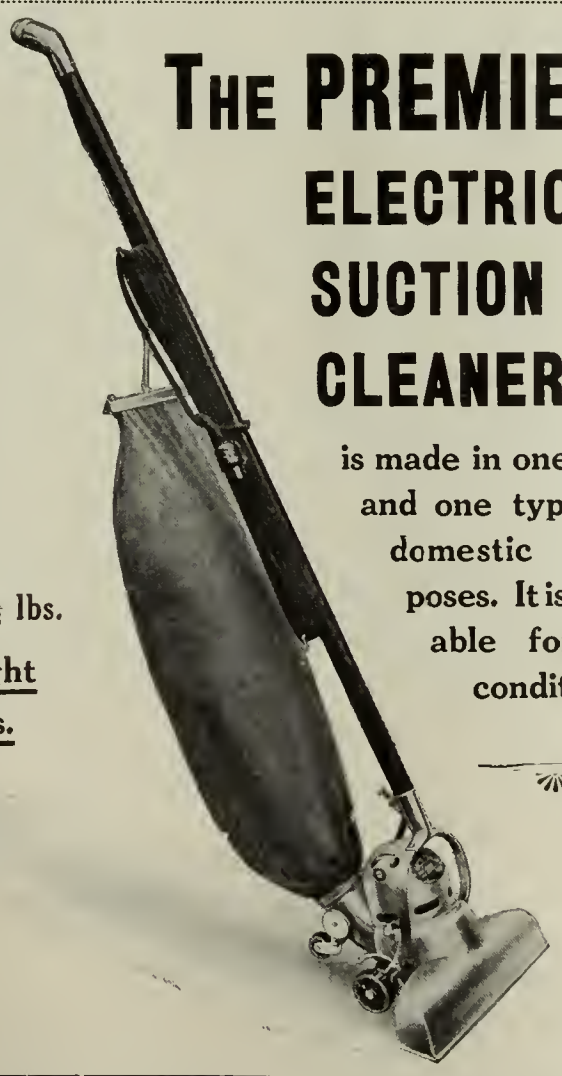


Strength?
Dont I look strong?
Jolts and Jars dont break me!
I vibrate—that's all!
Yours resiliently,
Pope's Elasta.

ELASTA BRITISH MADE WIRE LAMPS

Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, N.W.

GREENLY



THE PREMIER ELECTRIC SUCTION CLEANER

is made in one size and one type for domestic purposes. It is suitable for all conditions.

It weighs 9½ lbs.

Costs Eight Guineas.

ELECTRIC SUCTION CLEANER CO.

56, Victoria Street, London, S.W.

EDISWAN EVERYTHING ELECTRICAL

THE ALL-BRITISH HOUSE FOR ACCESSORIES

ROYAL "EDISWAN" DRAWN WIRE LAMPS

CATALOGUES ON REQUEST FROM THE EDISON & SWAN U·E·L CO., LTD., PONDERS END MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06 - 27712/03 AND OTHERS

H. WEIDMANN, Ltd., RAPPERSWIL, Switzerland.



WE ARE SPECIALISTS IN THE MANUFACTURE OF—

(3)

PRESSPAN

(PRESSBOARD)

Best Quality. Proved by repeated tests.

Sheets in thickness from 0·1 upwards.
Endless Rolls and Strips from 0·1 to 1 mm. thickness.

Presspan Coils and Tubes for Transformers.
Presspan Armatures, Discs and Shaped Articles.

VARNISHED PRESSPAN. OILED PRESSPAN. BLACK PRESSPAN. MICA-COVERED PRESSPAN. &c.

Silver Medal: Paris 1900. Grand Prix: Marseille 1908. Gold Medal: Berne 1914.

ter, Lady de la Warr and the Mayoresses of Brighton and Hove. To Mr. James Cleary fell the honour of explaining the electrical utensils and appliances to her Royal Highness and she expressed great pleasure with all she had seen in the flat.

HIGH-PRICED "GASOLINE" THE ELECTRIC'S OPPORTUNITY.

The following, taken from the "Electrical News," Montreal, reflects electrical opinion in Canada on the subject of the electric vehicle. In reading the article the word "gasoline" must be taken to read "petrol":

Little by little the electric range has been overcoming the lead of its strongest competitor, the gas stove, until it now stands, in many localities, in undisputed possession of the cooking field as regards both efficiency and cost of operation. And now, just appearing over the horizon, comes the electric automobile. Like the electric range, the two big obstacles have been the initial cost and the popular fallacy that electricity is too slow. The cost of ranges has gradually been reduced, and their speed has been improved, until they now compare favourably with their best competitors. Cost of operation is no longer a bugbear—it has become an asset. So with the gas car—a little more slowly, but just as surely, the electric is taking its place. It is being cheapened in first cost; it is improving its speed: for some time it has cost less to operate and maintain.

Generally speaking, the trend of prices of the things that enter into our daily needs has been upwards, without any cessation, during the past few years. The one big outstanding exception is the cost of electric current. At many points in Canada rates are anywhere from 10 to 20 per cent. of what they were 10 years ago. It is not infrequent that a rate of less than 1 cent. is obtainable by the householder. Still lower rates are available for power, especially at off-peak load. The small cost of electricity has become almost as wonderful as electricity itself.

The electric automobile has had an uphill fight with its gas competitor. Sentiment has been a considerable factor in this competition. The gas car is faster, and has a wider range of operations. The popular idea with regard to high speed is, we believe, entirely wrong, but it is nevertheless, difficult to overcome. A few years, no doubt, will teach the average motorist the folly of maintaining a 60 H.P. motor for a 15 to 20-mile rate of speed when a half or third as much power will do the work. The average gascar actually travels no faster than an electric around the city streets. We believe it is inevitable that when the thirst for high speed which seems to have taken possession of the modern motorist has been satisfied he will come to recognise that the electric car is fast enough for all reasonable and sane purposes.

And now comes a real boost for the electric in the rapidly increasing price of gasoline. The lower cost of operating the electric car has always been a talking point, and now it is more than that—it's an unanswerable argument. The difference should now be sufficient to convince, where formerly it served only to interest. For example, we are just in receipt of figures covering the operation of a 5-ton commercial gasoline truck which, operating under usual conditions, made 3½ miles on a gallon of gasoline. Assuming 15 cents for gas, this would represent a cost of about 4 cents per mile, and if the truck operated 35 miles a day gasoline would figure out $1.40. Compared with this, figures for the operation of a 5-ton truck by electricity show the cost of operation 4 1/16 cents per mile, or $1.43 for the 35 miles. These figures are pretty close, though the advantage is with the electric on account of lower maintenance. But suppose we figure gasoline at 40 cents—then the cost per mile of operating the gas truck becomes 11 cents, and the total cost $3.85. Thus the use of the electric represents a saving per day of $2.42, which in 300 days amounts to $726.

"FLUVENT" SWITCH-FUSES FOR HEAVY DUTY.

A complete range of "Fluvent" switch-fuses (which we described in a recent issue) is now made, and may be obtained from Parmiter, Hope & Sugden, Manchester. We understand that a large number of these switch-fuses has been in use on crane circuits for some considerable time under the worst conditions, and with entire satisfaction in operation.

A list shows a view of the standard double-pole switch-fuse open. In the standard form the fuses are at the bottom, and the switch at the top of the case. The switch is a modified form of the company's heavy duty Ajax "S" type switch, but built up on mica insulated steel rods, practically as Admiralty specification. The switch has a parallel break (*i.e.*, the blades leave all the contacts at the same moment on breaking circuit), and the contacts are of phosphor bronze mounted and supported in brass shoes. All moving parts are lock nutted and split pinned.

The "Fluvent" switch-fuses are supplied in four capacities, namely, 50 and 100 amperes, 200 and 300 amperes. The switch and fuse compartments are interlocked so that they cannot be opened until the switch is in the "off" position, and when open the switch cannot be operated. The lids are packed with asbestos packing, and further secured at four points by wing nut fastenings, ensuring a sound joint, clearance being allowed to provide for tightening down equally.

All "Fluvent" switch-fuses are fitted with removable extension trough, which allows ample room for cable entrances. Glands can be supplied for all types of armouring and sealing boxes for paper or other cables are provided for in the standard switch.

The list also shows a view of the 100 ampere standard three-phase "Fluvent" switch-fuse, and this particular fuse can be supplied with either the switch above or below the fuses as desired, at the same price. These switches are carefully made throughout, and they are designed to withstand the most severe working conditions.

Copies of complete catalogues dealing with these interesting switches may be obtained on application to the company at Hulme Works, Manchester.

FERRANTI LTD

Central House, Kingsway, London, W.C.

SWITCHGEAR, TRANSFORMERS, METERS, ELECTRIC HEATING & COOKING APPARATUS.

Write for Binder "N."

FURNACES for MELTING WHITE METALS, Etc.

Hull's Patents

AUTOMATIC HEAT CONTROL. MELT WITHOUT OXIDATION

PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Also Heat-Controlled Furnaces for Heating the Moulds.

MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, May 5, 1916.

THE ROUND TABLE.

By "KVA."

The following rhyme on the Daylight Saving Bill has been sent me by a Scottish reader, who appears to be opposed to the measure, judging by the suppressed tone in which it is written :

WAR TIME ECONOMY.

In war time things called orthodox
Frequently go upon the stocks ;
And Hudibras no doubt will rise,
Shouting his pæans to the skies.

* * * *

So now we cast out all the " crocks,"
And alter " Time " by means of " clocks,"
Feeding just so long as we please,
Like " monkey with the piece of cheese."
When " mobs " with science begin to play,
Will turn, we're sure, " night into day."
According to these silly fools,
We live by " Acts " and not by rules.
So be it, we shall " wait and see "
What " Nature's " " little bit " will be,
Convinced that Parliament and Acts
Can never alter " Nature's facts."
Fish will be taken from the sea,
To suit our clocks it seems to be ;
And pigs and animals must feed
Because it's written in the " Rede."
An Act of Parliament will cause
All Nature then to change her laws ? W. M.

* * * *

According to an advertisement in the " Merthyr Express," " Tenders are invited for *carrying out* additions to the transformer station at Treharris." And after they have been carried out they will be carried in, I suppose.

A switchboard attendant, who is evidently a bit of a dandy, writes in to ask me if the Daylight Saving Bill will apply to his " clock " socks.

* * * *

In a Paper read before the Engineering and Scientific Association of Ireland, on Small Electric Stations, the following passage appears.

" The town of Rathkeale, in Co. Limerick, affords an example of a place that abandoned a public gas undertaking for economic reasons and replaced it by an installation for electric lighting."

The gas industry and the politicians will note the significance in the name of the author of this interesting Paper. It is Mr. L. J. Lawless !

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), May 10, 1879.]

EARLY ELECTRIC AND MAGNETIC MOTORS.—In 1833 Mr. Sturgeon exhibited a small magnetic motor. It was capable of pumping water, sawing wood and drawing model carriages. It was but a small thing, but it showed the principle in operation clearly. In 1837, Dr. M. Connell, of Pennsylvania, made a small machine which caused a driving wheel to rotate 70 times a minute, carrying a load of 40 lb. through a space of 300 ft. per minute. The machine was 2 ft. high and 1 ft. broad, and weighed 17 lb. A year or two afterwards Mr. Davenport, of Vermont, contributed several electro-magnetic machines, varying the method of construction. With a small machine he obtained a horizontal rotation 300 times a minute, and lifted a quarter of a hundredweight. In 1840 Mr. Clarke, of Leicester, constructed an electro-magnetic locomotive, which ran on a circular model railway, drawing from 60 lb. to 100 lb. According to the late Prof. P. Forbes, Mr. R. Davidson, of Aberdeen, constructed a galvanic machine, and actually worked a small lathe. This machine generated sufficient power to draw a small carriage containing two persons over a rough floor. In 1842, with Mr. Davidson's apparatus, a railway carriage was impelled at the rate of four miles per hour during an experiment on the Edinburgh and Glasgow line. In 1839 Prof. Jacobi navigated a small vessel on the Neva by means of electro-magnetism. The boat was 28 ft. long, 7 ft. 6 in. wide, drawing nearly 3 ft. of water, and carried 14 persons. The rate of progress was three miles an hour. The Professor had tried an experiment in the previous year, but only obtained the result of about 1·5 miles an hour.





TWO VIEWS OF THE SERVANTLESS ELECTRIC FLAT AT THE BRIGHTON PATRIOTIC HOUSEKEEPING EXHIBITION. (*See* p. 40.)

OUR HOT-PLATES.

No. **211**, to—

Mr. T. H. U. Aldridge, electrical engineer, Shanghai, for his progressive conduct of the most flourishing electricity undertaking in the Far East.



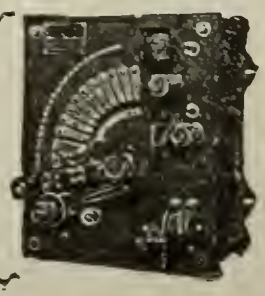
No. 27.—Patent "Inching" Motor Starter. All making and breaking of the main current takes place on the special interlocked magnetically operated circuit breaker. Overload protection during starting. Write for particulars.

IGRANIC ELECTRIC Co LTD

IGRANIC

No. 38. A combined Motor Starter and Shunt Field Regulator interlocked and thoroughly fool-proof : ensures full field at starting. No-volt and overload automatic releases.

147, Queen Victoria Street, London.

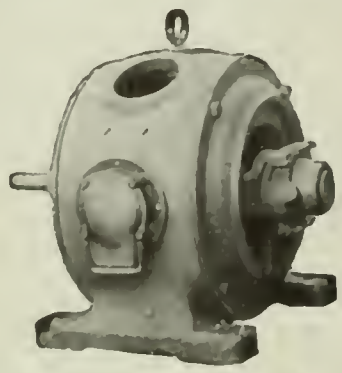


SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

NEW "IGRANIC" TWO-COIL MAGNETIC LOCK-OUT SWITCH.

This interesting switch is now being put on the market after practical tests under working conditions for about three years. A newcomer into a field already occupied must, of course, justify its

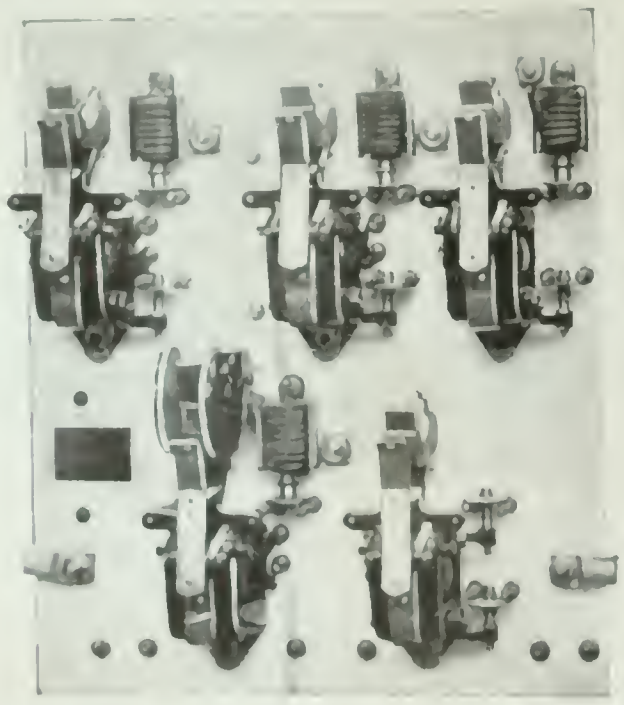


FIG. 1.—"IGRANIC" SELF-ACTING MOTOR STARTING PANEL WITH SHUNT-WOUND CLAPPER SWITCHES AND SERIES RELAYS.

appearance on the ground either of lower cost or improved efficiency, if it is to find a ready sale. This claim of greater efficiency and utility on behalf of the new "Igranic" series-wound magnetic lock-out switch is made on pamphlet No. 635. Some examination of the field for series-wound magnetic lock-out switches and some comparison with existing types may suitably be made.

For some years now, and for certain duties, it has been found convenient, in constructing contactor or clapper switch type self-acting motor-controlling panels, to adopt a device which makes the starting period dependent upon conditions in the motor, instead of using dashpots or other timing devices independent of the load conditions. At first this object was achieved by series relays (or current relays) in conjunction with shunt-wound clapper switches. The coils of the series relays were series wound and carried the main motor current. Such a system is used in the "Igranic" self-acting starting panel illustrated by Fig. 1. The series relays (one of which is provided to control each accelerating clapper switch) are so arranged that on closure of the motor circuit the initial current excites the first series relay, and by lifting its core causes it to keep open the coil circuit of the first clapper switch, which consequently cannot close to short-circuit the first section of starting resistance until the motor current has decreased to normal running value. When this occurs the relay releases its core, and the first accelerating clapper switch closes, and by short-circuiting a section of resistance permits the motor current again to rise to an abnormal value, thereby causing the second series relay to lift its core and keep open the second accelerating clapper switch until again the motor current has fallen to normal. This process is continued by successive series relays until all the starting resistance has been removed from the motor circuit by the closure of all the clapper switches. By this

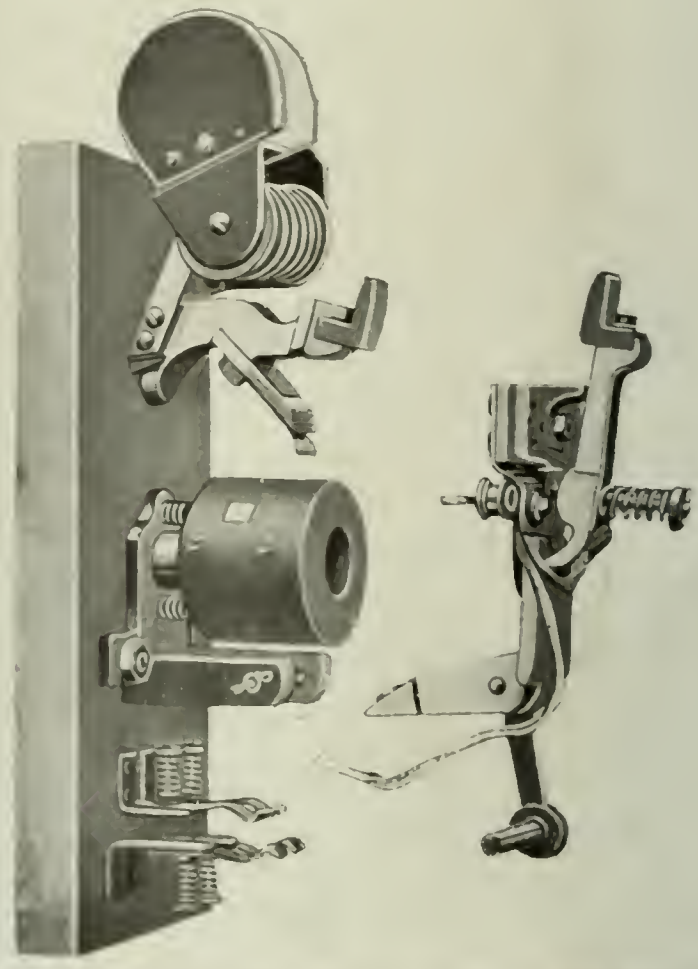


FIG. 2.—EXPLODED VIEW OF SHUNT-WOUND CLAPPER SWITCH.

system, if the starting load be light, the starting resistance is quickly cut out, whereas if the starting load be heavy the starting resistance is removed slowly. In such a system the clapper switches, as stated above, are of the shunt-wound type illustrated by Fig. 2, only the series relays that govern them having their coils in the motor circuit.

This method has not been improved upon or superseded for certain uses, as, for example, in those control systems where the operator is to have control of the speed of the motor, as well as its starting and stopping. For cases where speed control is not required another form of accelerating switch has been used in recent years, and has been aptly advertised as a series "switch." Two or three varieties of these series switches have been introduced by various makers, all of which (as their name implies) have their operating coils in series with the motor with which they are used. They all possess the characteristic of refusing to close so long as the current passing through their operating winding exceeds a predetermined and adjustable value. In consequence of this characteristic, a series of such switches when used for the removal of starting resistance from the circuit of a motor constitutes a self-governing current-limit acceleration control. The performance of this type of apparatus is fairly satisfactory for some classes of work, but its usefulness is limited to those control systems in which the operator is to be enabled to start, stop or reverse the motor, but not to regulate its speed, while the series relay and shunt-wound clapper switch are still

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston. Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868. Codes: 5th Edition A B C & Western Union.

BELLING

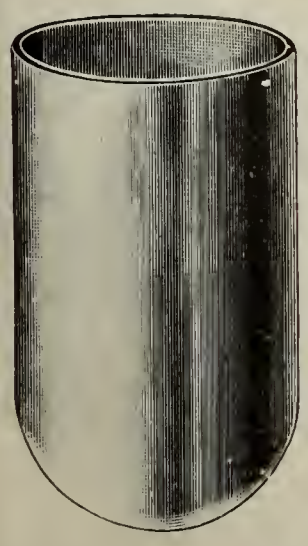
& CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialist, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,

STIRCHLEY, BIRMINGHAM.

Drawn Shell Work

IN BRASS, COPPER, and STEEL.

Any size up to 8″ diam. × 4″ deep.

Sole Agent for the Electrical Trade:—

LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.

THE PROTECTIVE COVERINGS OF Simplex Conduits and Fittings.

THE NEW RUST-PROOF PROTECTION.



ACID, ALKALI, CORROSION PROOF.

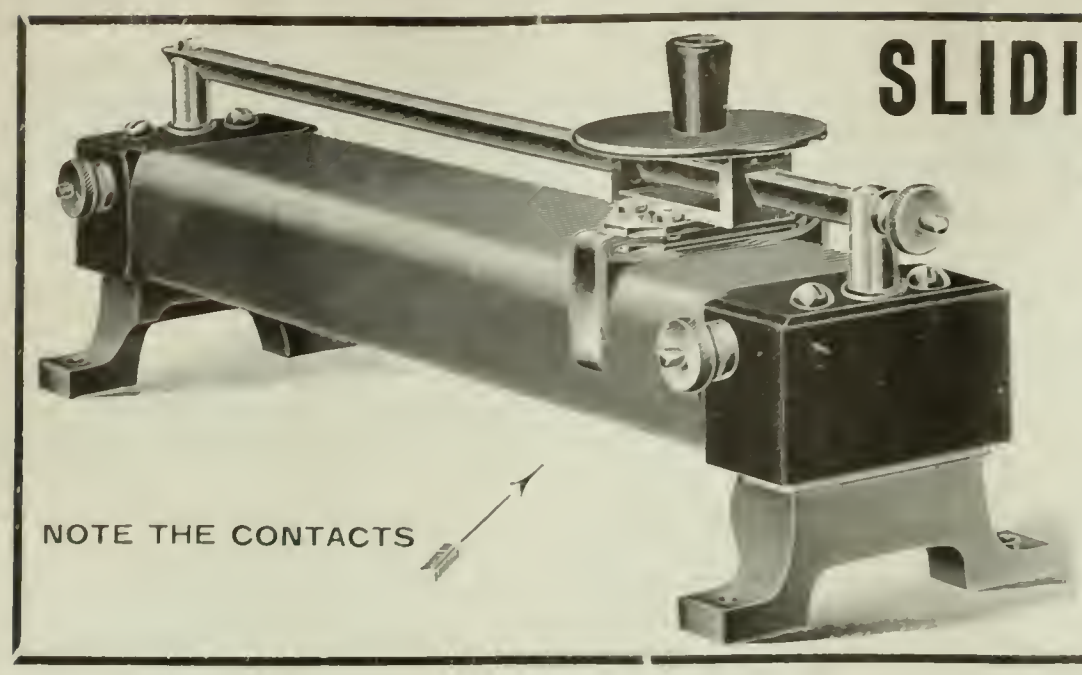
Write for booklet describing our new processes

NEGREX, ZENEX, ENAMLEX.

Simplex Conduits, Ltd.,

Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd., W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.



SLIDING RESISTANCES
FOR
LAMP TESTING
METER TESTING
LABORATORY WORK
ETC.
BRITISH-MADE THROUGHOUT.
New List now ready, post free.
ISENTHAL & CO.,
(DEPARTMENT 4)
DENZIL WORKS, WILLESDEN, LONDON, N.W.
Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

required for all control systems where the operator is to regulate the speed as well—such as on the hoists of cranes, &c.

Series switches have suffered from the fact that only one operating coil was employed, which had to perform the double function of holding the switch open while the current exceeded a predetermined value, and of closing the switch when the current in its winding fell to the predetermined value. In these single-coil switches the magnetic circuit enclosing the coil has to be designed so that two paths are provided for the flux produced by the coil. The distance between the two paths is varied by a screw adjustment. The area of the path which tends to close the switch is restricted in order to

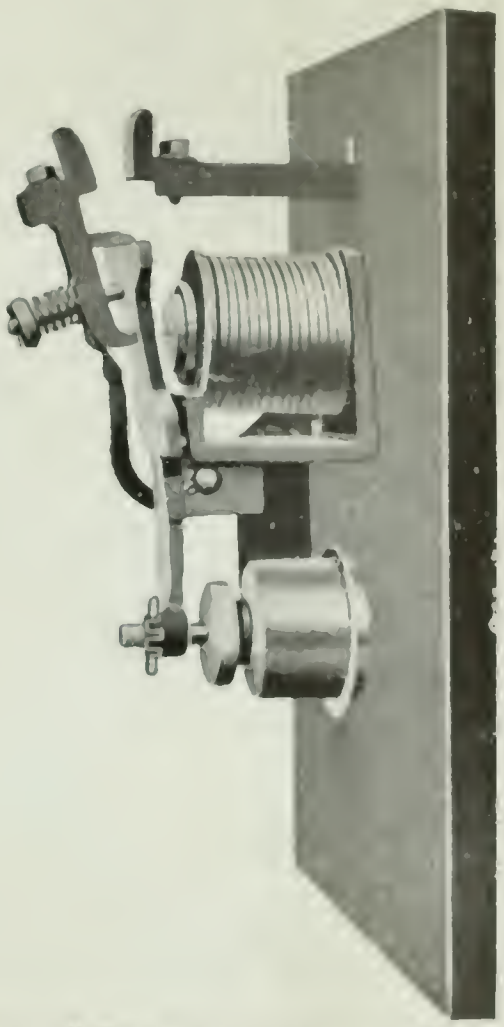


Fig. 3.—"Igranic" Series-wound Two-coil Magnetic Lock-out Switch.

limit the flow of flux through it to a specific value, while the lines in excess thereof are forced over the other path, which tends to hold the switch open. When a current exceeding the value predetermined by the screw adjustment is applied to the winding it creates sufficient flux not only to saturate the restricted path, but enough also in the second path to keep the switch in the locked-open position. When the current gets below the predetermined value the restricted section carries the proper proportion of the total flux to enable the switch to close. A disadvantageous feature of the use of a single operating coil is that the whole of the flux for closing the switch must pass through the restricted path, and this section is a limitation to the closing and sealing power of the switch with a given size of winding. The limitation is emphasized usually by the employment of a copper band encircling the restricted section, the office of which is to act as a momentary check to the flow of flux through the section. This checking of the closing and sealing power of the switch reduces the pressure between the contacts in the closed position and materially decreases the length of the sealing distance, which means that the life of the contacts is lessened, because they cannot be worn down as far as could those on a switch having a greater sealing distance.

In the new "Igranic" series switch (Figs. 3-4) are provided two entirely independent magnets or magnetic systems adapted separately to influence a movable switch member, but energised by a common current. There is an operating (or closing) magnet and a lock-out magnet, whose windings are connected in series, the arrangement being essentially such that the two magnetic circuits or systems are entirely separate and independent, so that each magnet is free to operate in accordance with its own magnetic characteristics, unaffected by the characteristics of the other.

In the "Igranic" series lock-out switch both the locking-out and the closing functions are rendered positive by the fact that the

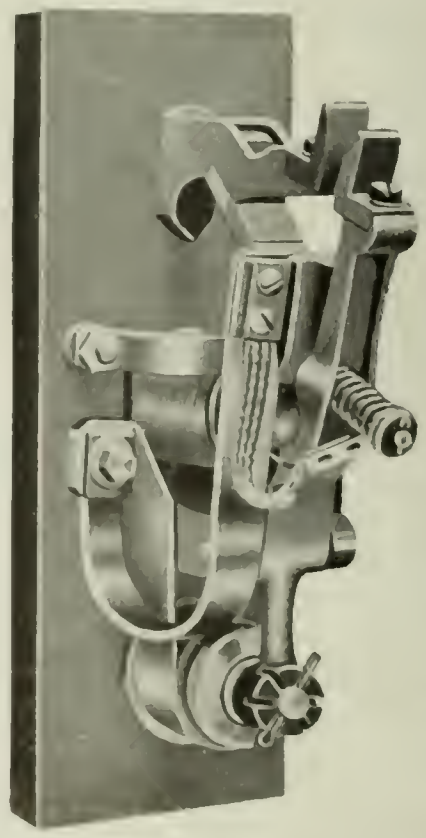


Fig. 4.—Series-wound Two-coil Magnetic Lock-out Switch.

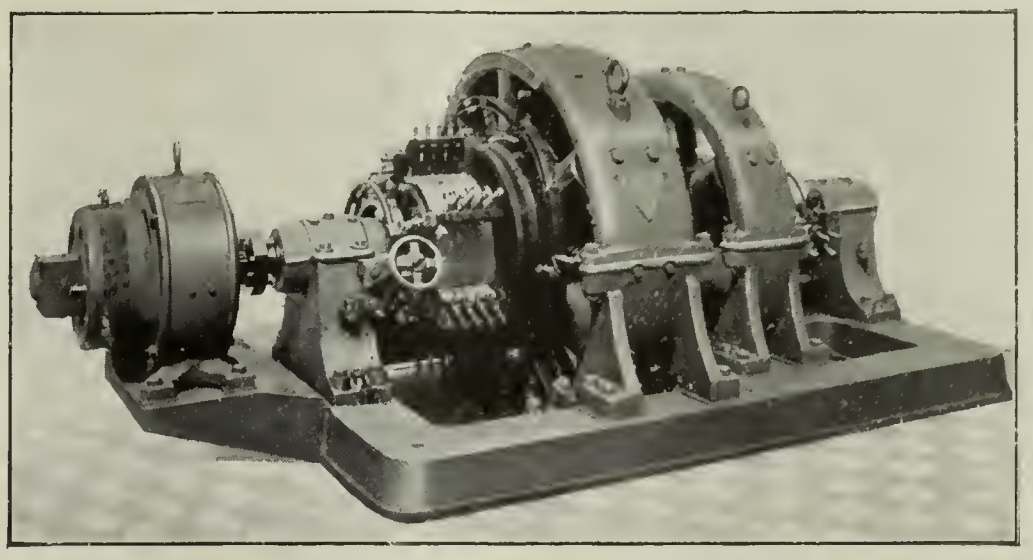
magnetic circuit around the closing coil is arranged to shunt a portion of the flux away from the switch arm while the switch is open. This shunted flux is passed through the switch arm as the latter approaches the closed position. When the arcing tips touch, the winding of the lock-out magnet and a section of the starting resistance are short-circuited. At this point a further additional impulse is given toward the sealing position, first by the entire removal of any restraining effect of the lock-out magnet on the arm, and secondly by the momentary increase of the current in the coil of the closing magnet by reason of the peak which results from the removal of the starting resistance from the circuit. There being, as stated above, no restriction in any part of the magnetic circuit of the closing coil, all the additional flux produced by increasing the current in that coil has a free path, and is used to advantage for

VICKERS LIMITED.

Motors and Generators of all types.

Rotary Converters.

Complete equipment for the electrical lighting and driving of Machine Shops, Factories, Mills, etc



Patent Automatic Reversing Drive for Machine Tools.

250 K.V.A. Rotary Converter. 6 phase, 50 periods, 480/560 Volts. 1,000 r.p.m. Inverted type.

River Don Works, SHEFFIELD.

obtaining a good pressure on the contacts and long sealing distance. The "Igranic" switch has all the characteristics of a shunt switch during the closing period. To compare the sealing power of another

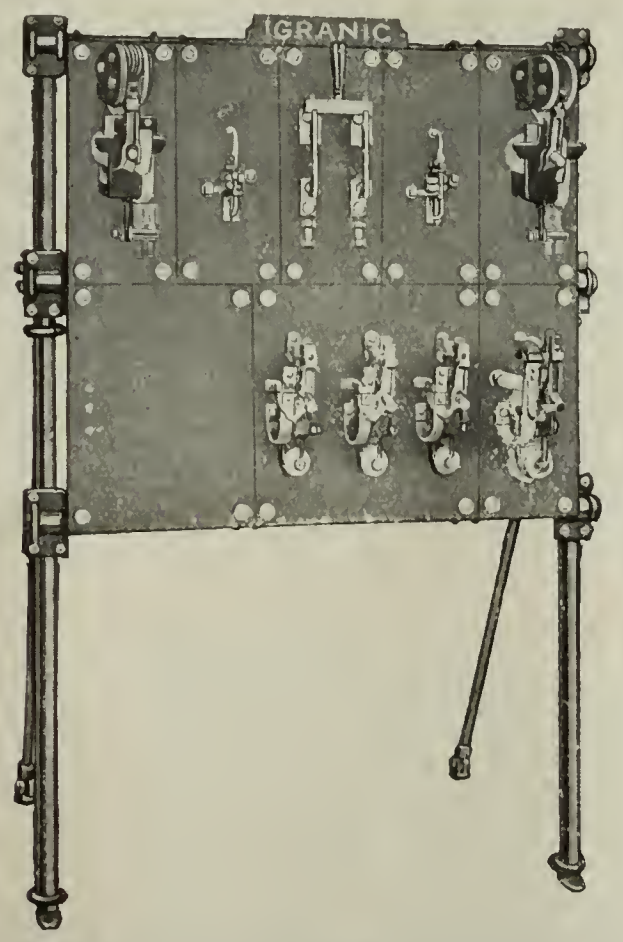


FIG. 5.—"IGRANIC" CONTROL PANEL, WITH SHUNT WOUND MAIN SWITCHES, SERIES ACCELERATING SWITCHES, OVERLOAD DEVICES AND D.P. KNIFE SWITCH.

type single coil switch rated for 100 amperes with an "Igranic" switch of the same rating, the contacts were removed from both switches, so that an accurate test could be made of their sealing power. With 100 amperes passing through their windings, 25 lb. was required to pull open the "Igranic" switch, as against 15 lb. on the other switch. This is mentioned to impress upon the reader the limitations which are placed on a magnetic switch having a restricted area in its magnetic circuit, and the sacrifices made to get a locking-out feature by such means.

Except in the smallest size, the "Igranic" switch has two sets of contacts—namely, a copper leaf brush pressing against a copper plate for the main contacts and solid copper renewable arcing tips to protect the main contacts when closing and opening the circuit, and as both contacts are vertical dust cannot settle upon them. A useful feature of the "Igranic" switch is the convenient means providing for adjusting the current limit at which the switch will close. This consists of an adjustable plug mounted on the lower end of the switch arm, by which the air-gap between the lock-out magnet and the lower end of the arm can be varied. This adjustable plug has a number of positions. Each position represents 2½ per cent. of the switch rating, thus providing means of adjusting the switch without using an ammeter. This is a patented feature of the switch. It should be understood that series lock-out switches are only suitable for use with direct-current motors, and are only applicable under conditions where the armature is always taking power from the source of supply and where the minimum current taken by the armature will always exceed the minimum current required to hold the switch closed. In cases where the armature current is reversed by generator action, or the current gets below the minimum holding power of the switch, the last switch can be shunt wound instead of series wound, or a series relay type of starter with shunt-wound clapper switches (as shown in Fig. 1) can be used.

A copy of the pamphlet may be obtained from the Igranic Electric Co. (Ltd.), 147, Queen Victoria-street, London.

LARGE CONTINUOUS-CURRENT SWITCHBOARD.

With the demand for electrical energy for lighting, power and traction in large towns, the switchgear and controlling apparatus for the current grows at a corresponding rate. Even though municipalities and supply authorities have adopted a high-tension system of distribution to sub-stations with a low voltage supply

from these stations, the size of the continuous-current switchboard necessary for this low voltage distribution now exceeds the size of the switchboards originally installed in the main power houses from which continuous current was supplied.

During the last few years the General Electric Co. have produced a number of heavy current switchboards for various municipalities, and a recent example of this class of board is shown in the accompanying illustrations. This board consists of 23 panels comprising

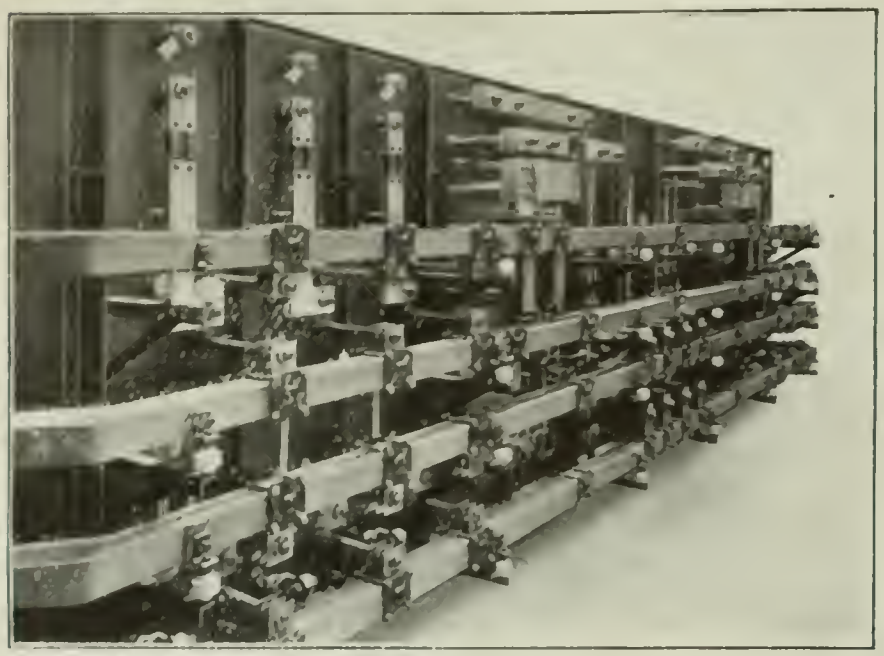


Fig. 1.—Back View of Middle Portion of Heavy Current Witton Switchboard for British Municipality.

generator panels for controlling the continuous-current side of two 1,620 kw. motor-generators with Witton-Kapp phase advancers, which are being manufactured by the G.E.C. at Witton. The board also includes a large number of feeder panels. The board has been constructed to the engineer's requirements in a form occupying three sides of a rectangle. Consequently it was not possible to obtain a complete photograph of the back of the board, but the two views given illustrate the middle portion and one side of the board. The panels have a thickness of 2½ in., being composed of oiled slate

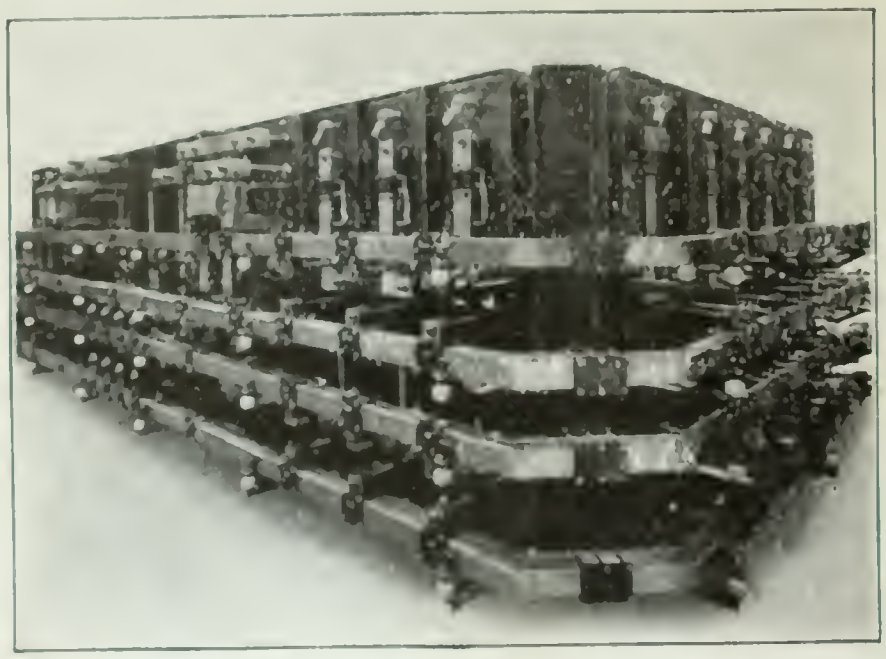


Fig. 2.—View of the same Board showing one of the Side Portions.

slabs, in addition all the circuit breakers are mounted upon their own slabs 2½ in. thick. The circuit breakers controlling the generators have a capacity of 10,000 amperes. Unfortunately, it was not possible at the moment to secure photographs of the front of the board, but when it is erected these will be published, and the heavy nature of the switchgear on the front will then be appreciated.

"THOR" High Grade Specialities

CASING and CAPPING CONDUIT
CABLES
CABLE CONNECTORS
COMMUTATOR COMPOUND
WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.

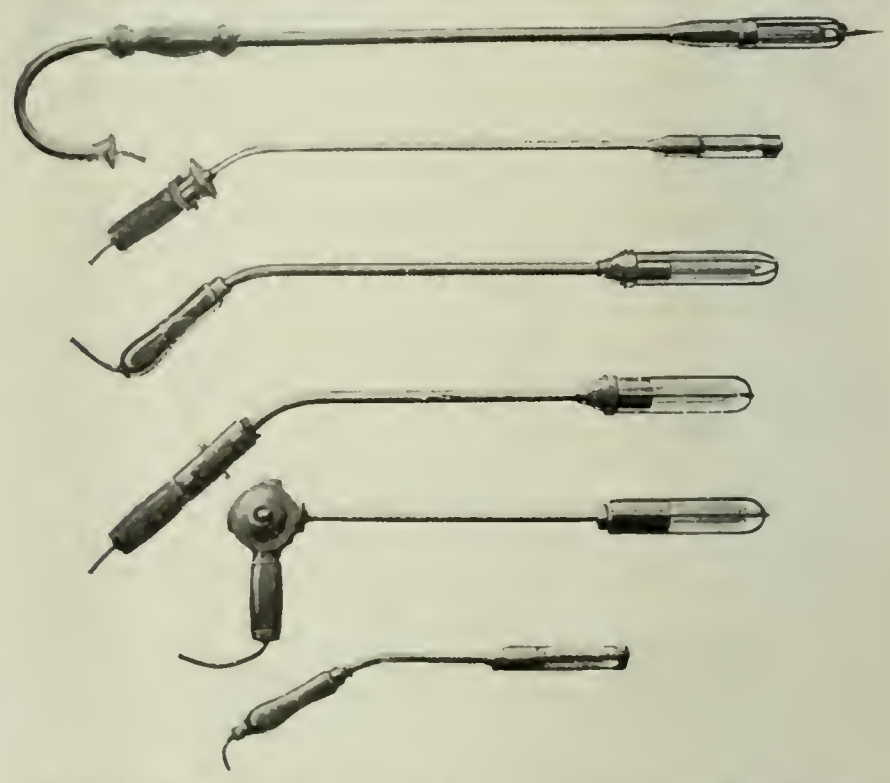
WRITE FOR PRICES & DISCOUNTS.

HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

Some idea of this can be gained from the size of the shunts and of the bus bars, the latter being composed of 24 strips of copper, each 4 in. by ½ in. thick.

SIMPLEX INSPECTION LAMPS.

We have previously commented upon the manufacture of shell inspection lamps by Simplex Conduits (Ltd.). They have also studied the question of inspection lamps for other articles, where it is necessary to inspect an interior and only possible to do so through small apertures, such as exist in casks, carboys, &c. List No. 627, just issued, deals with these lamps and several designs are illustrated herewith. The largest is designed for inspecting the interior of hogsheads, and is fitted with a spigot for removing stray corks. The smallest lamp shown is designed for the inspection of 18 pounder



Types of Simplex Inspection Lamps. The topmost one is for barrel inspection, and is provided with a spike for the removal of corks.

shells, or similar small work. Some of the lamps are fitted with small switches in the handles, and some are without switches; one type is fitted with a standard tumbler switch in a convenient position near the handle. This is a specially robust design for munition works. All the fittings are sent out complete with lamps and flexible, with earth wire connected.

The leaflet referred to will be sent on request to the company at Garrison-lane, Birmingham, or at branches in London and large provincial centres.

OSRAM-ATMOS LAMP NOT AFFECTED BY ATMOSPHERE.

A projecting bracket, beneath which was suspended an opal glass sign with the letters "G.E.C." upon it was blown down during one of the recent gales, outside the branch premises of the General Electric Co. at Swansea. As will be seen from the accompanying illustration, the bracket terminated in a hook bearing a reflector and

FERRANTI LTD

Central House, Kingsway, London, W.C.

SWITCHGEAR, TRANSFORMERS, METERS, ELECTRIC HEATING & COOKING APPARATUS.

Write for Binder "N."

LEAD MELTING FURNACES

Hall's Patents

For Cable and Pipe Presses, Accumulator Grids, etc.,

WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.

ENORMOUS SAVING IN RESIDUE.

Easy Payments arranged in special cases.

MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

EDISWAN

EVERYTHING ELECTRICAL

We are Manufacturers of Switchboards, Heavy Service Switchgear, Distribution Boards, Fuseboards, House Service and Motor Panel Boards, Cut Outs, etc., etc., and would esteem your next enquiry for anything Electrical.



ENTIRELY BRITISH

THE
EDISON & SWAN
UNITED ELECTRIC LIGHT CO., LTD.,
PONDERS END. ——— MIDDLESEX.

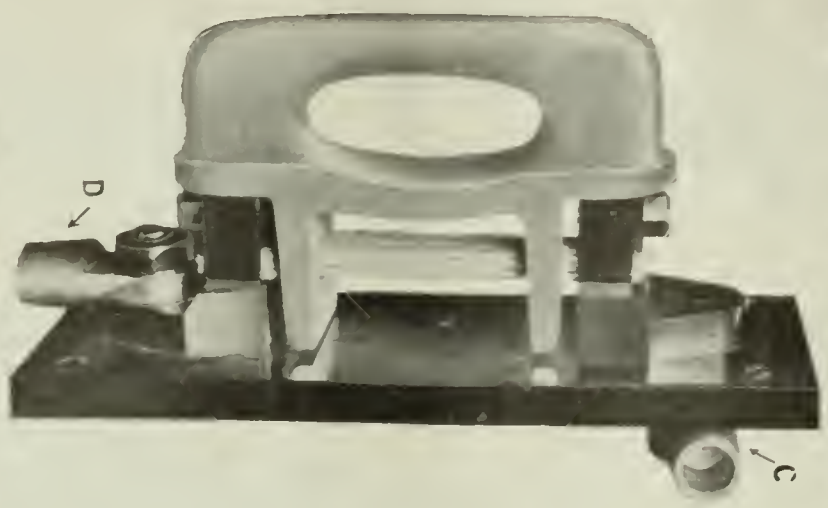
Telegrams - - - - "Ediswan, Enfield."
'Phone - - - - 520 Enfield.

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

an Osram-Atmos lamp. The opal sides of the sign are completely smashed, so that the impact with the pavement must have been considerable. In spite of the wreckage, however, the 1,500-watt Osram-Atmos lamp was found to be unbroken, and when tested burned as brightly as usual.



The Fallen but not Abashed Osram.

This is a striking testimony to the fact that the filament of the Osram-Atmos type lamp possesses the same remarkable toughness characteristic of the ordinary standard Osram lamp.

ELECTRICAL ACCESSORIES PRICE LIST.

An attractively prepared price list of the various lines of electrical accessories, which may be obtained from the Electrical Supplies Co., 233, Tottenham Court road, London, W., has been prepared, and may be obtained on application to the company. The cover is effectively filled with a sketch of a lighthouse, which is the trade symbol of the company. The accessories dealt with include adapters, bells, ceiling roses, cleats, conduits, counterweights, distribution boards, fuses, ironclad switches, enamelled ironshades, tumbler switches, wall plugs and wires and cables.

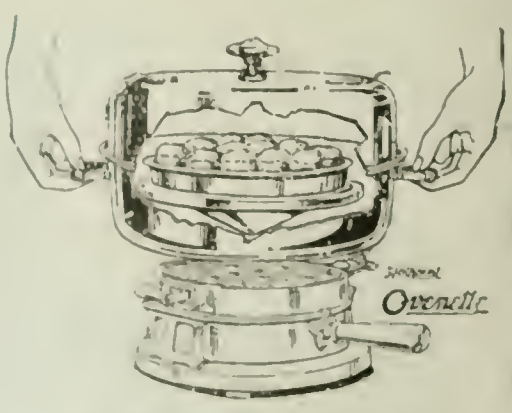
"HOTPOINT" AT BRIGHTON.

In our last issue we referred to the exhibit of "Hotpoint" apparatus at the Servantless Flat which was organised for the Patriotic Housekeeping Exhibition by the Brighton Corporation Electricity Department. It will be remembered that Her Royal Highness Princess Louise, Duchess of Argyle, visited the exhibition and took tea in the electric flat. She was particularly interested in the Hotpoint apparatus. The adjoining illustrations show two of the most popular forms of "Hotpoint" appliances exhibited. One of these is the "El Cooko," which is a heavily lagged electric oven designed for cooking by thermal storage. It should be particularly valuable at the present time, when there are many households in which the husband may be fighting at the front and the wife may be at work on munitions. It is possible to heat up this form of oven beforehand, and place in it a complete meal. The current, which requires to be on for about an hour, may then be turned off and the cooking proceeds by thermal storage. The oven is fitted with a 600-watt element, which is under the control of a three-heat switch. A 4 lb. joint, two vegetables and a pudding can be satisfactorily cooked in this manner, and at a cost which is considerably lower than that of gas. In fact, it is not yet possible to undertake this form of



View of "El Cooko" Oven, showing Lagging.

cooking with any gas oven at present on the market. The other illustration shows the "Hotpoint" ovenette, a form of cooker which is used on the "Hotpoint" 600-watt radiant heat stove. The ovenette is a detachable cooking combination which can be used either on the breakfast table or on a side table. The capabilities of this extremely handy form of cooker were demonstrated at the exhibition. The show was not the first occasion upon which "Hotpoint" apparatus has been brought prominently to the notice of the Brighton public, for the association of the use of electrical



The "Hotpoint" Ovenette.

energy in connection with economic housekeeping has, we understand, given quite a new idea to electricity consumers in the district, and it is highly probable that there will be a considerable local demand for these and similar appliances. Those of our readers who are interested can obtain particulars of the above and other "Hotpoint" specialities by applying direct to the company at 38, Poland-st., London, W.

Views of the Servantless Flat at the Exhibition referred to are given on the Round Table page.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, May 12, 1916.

THE ROUND TABLE.

By "KVA."

A correspondent tells me he recently received a "hurry-up" letter regarding some brushes wanted for a generator. The letter concluded—

"Please forward as quickly as possible as our *degenerator* is *stoped*."

* * * *

I take these two chestnuts out of the fire with acknowledgments to the "London Teacher":—

WOULD-BE MUNITION WORKERS.—(*a*) "Should I be suitable for training in munitions work? I have movable kidneys and other things." (*b*) "I am a domestic servant and earn £12 a year, but I should like to help my King and Country by earning £3 a week making munitions."

* * * *

The United States pays to Chili as much as a million and a quarter sterling annually for nitrates obtained in that country. It is estimated that half this sum would put down a hydro-electric nitrogen fixation plant large enough to supply all the Yankee farmers with fertilising material. This idea, when conveyed to the Chilians, will make them feel decidedly chilly.

* * * *

"Printers' Pie" is just out, and its contents prove that it was cooked by electricity; it is full of "extractives," and, instead of shrinking during cooking, it is actually larger than ever. Incidentally, there is no advertisement of British Commercial Gas Association in it to claim credit for the baking.

* * * *

But commerce apart, I have sampled the "Pie," and it is crammed with good things. Here is one of them:—

DOMESTIC ECONOMY.—The Eating House Proprietor: "Call yourself a cook? There's a way to send up a 'erring! W'y, you 'aint even cleaned it!" The New Cook: "Cleaned it? Not likely—not w'en it's spent all its bloomin' life in water."

Here's another which may be useful in case one is inclined to hurry the laggard waiter:—

WINGED REPARTEE.—"It's about time you came; you're very slow." "What do you expect with a two-shilling dinner, sir? One of the Flying Corps?"

The "Pie" is edited by Mr. Hugh Spottiswoode, who hopes that all copies purchased by our readers will be passed on to hospitals, canvalescent homes, camps, or to the front or the Navy. This request will, I am sure, be willingly complied with.

* * * *

"Printers' Pie" of course, must be electrically cooked. What modern printery is other than electrically equipped?

* * * *

"M.," writing to the "Architect and Contract Reporter," on the subject of the consulting engineer, says: "It saves trouble to have a consulting engineer from the first instead of paying him later for adjusting disputes about extras or defects." But what about the case in which the man who made the mistakes reports upon the report of the consulting engineer, and the man who didn't make the mistakes (but is blamed for them) reports upon the other two reports? A sort of an unbalanced three-phase problem. Eh?

"A Thousand and One Uses of Gas" is the title of a B.C.G.A. monthly publication, but "only one use for poison gas."

* * * *

"Belting Specifications" says a headline in "American Machinist." I know a number of manufacturers who would like to.

* * * *

As was originally intended, the Batti-Wallahs will now foregather on Fridays at the Holborn Restaurant, Kingsway, between 12.30 and 2.30 for lunch or coffee, or both. This means that they will in future forsake Friday fraternizing at Frascati's. I understand that Committeeman Lieut. E. E. Sharp was the attraction last Friday, his uniform being new or he being new to his uniform, whichever way you like to take it.

* * * *

The editors of provincial newspapers are apparently quite indifferent as to the construction that may be put upon the juxtaposition of headlines. Here are a couple of specimens:—

More Electric Light Troubles.
Uncultivated Gardens.

and here is another:—

Portsmouth Economy.
Quality of the Gas.
Lady Conductors at Night.

To those who only read headlines there may be some hidden meaning in such as these.

* * * *

According to a newspaper report:

"Bishop Stileman at the C. M. S. meeting at Church House yesterday said that our enemies had circulated many falsehoods among Mahometans. The Persian papers circulated the story that a giant German aeroplane equipped with a huge magnet had visited Petrograd, Paris and London, and that the huge magnet had succeeded in drawing up the Tsar, the French President and King George out of his bedroom in Buckingham Palace, and they were now all prisoners in Berlin."

Now here is a useful suggestion for the Igranic or Witton-Kramer lifting magnet people. Let them design an aeroplane electromagnet which will draw off the German mailed fist and the war will be over.

* * * *

THIRTY-SEVEN YEARS AGO.

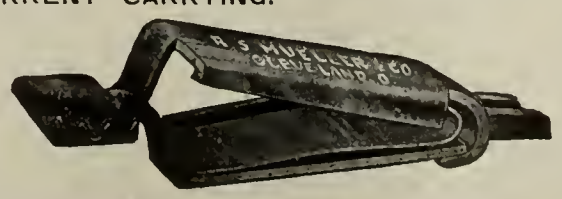
[From THE ELECTRICIAN (Second Series), May 17, 1879.]

SIEMENS ELECTRIC LIGHT.—Undoubtedly the most effective, and perhaps the most important, of the electric lights exhibited at the Albert Hall on the 7th and 8th inst. was the "electric sunlight," of Messrs. Siemens Brothers, which occupied the centre of the dome in this great building. The most pleasing feature of this "sunlight," constituted by five Siemens lamps, yielding in the aggregate an illumination equal to that of 35,000 standard candles, was its unobtrusiveness. The flood of slightly golden light was everywhere; the lamps themselves could be observed only by gazing aloft. We have characterised the lights as "slightly golden": the somewhat cold and apparently blueish tint of the ordinary electric light was, in fact, corrected by the device of gilding the "sunlight" reflectors. The light was surrounded by a shield of gauze—not, as was commonly supposed, for the purpose of catching any minute incandescent particles which might drop from the lamps, but mainly to obviate the effects of draughts of air upon the latter. The only drawback we could observe in this beautiful illustration of the capabilities of electric lighting was the noise made by the regulators of the lamps, which at one time was quite sufficient to interfere with certain of the musical effects at concerts. But, amongst the lamps exhibited, the Siemens lamp is not that which is most open to this objection.

The UNIVERSAL TEST CLIP
CURRENT CARRYING.

Time savers in any electrical work requiring quick temporary connections.

Best for every test—in the factory, or repair shop; in the laboratory, or in the field.



THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.
Phone: Regent 4346. Code: ABC 5th Edition. Teleg.: "Engineyor, Westrand, London."

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golsilplat, Ox., London." 4746 Gerrard.

SIEMENS

ELECTRIC MOTORS



Part of small Motor Shop, Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE. CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood Bldgs.
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

ELECTRIC HAND AND BENCH DRILLS.

The machines illustrated are designed for drilling, riming and tapping any kind of metal. The motor, switch and gearing are entirely enclosed, all gears are machine cut, the drilling spindle runs in a ball bearing thrust, and ball journal bearings are used throughout. Reversing switches can be supplied if required for tapping purposes.

A breast-plate is supplied for drilling holes up to $\frac{1}{2}$ in. diameter, but for larger holes the machines should be used in conjunction with the feed-wheel and spindle, which is furnished on request. The machines are geared to give, as a normal speed, about the number of revs. per min. recommended by makers of twist drills of the largest size drill they are capable of taking.

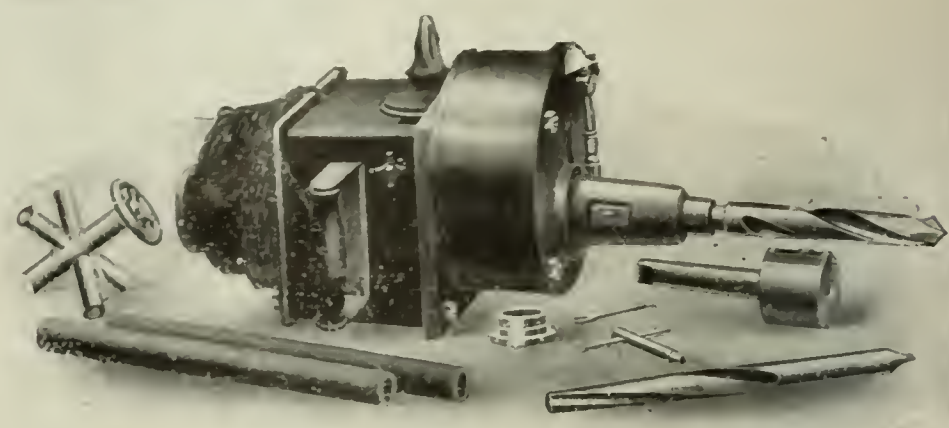
The table below gives particulars of the three sizes offered of the M type drills:—

Sizes	II.	IV.	VI.
Normal speed, revs. per min.	350	250	150
For drilling up to	$\frac{3}{8}$ in.	$\frac{7}{8}$ in.	$1\frac{1}{4}$ in.
For riming up to	$\frac{1}{2}$ ..	$\frac{5}{8}$ ..	1 ..
For tapping up to	$\frac{1}{4}$ ..	$\frac{3}{8}$ ..	$1\frac{1}{8}$ ..
Weight, approximate	17 lb.	30 lb.	45 lb.
Energy consumption	180 watts.	300 watts.	650 watts.

Dimensions.

Size.	A.	B.	C.	D.	E.	F.	G.	Morse cone.
II	18½ in.	21¼ in.	3½ in.	2¾ in.	6 in.	4¼ in.	4¼ in.	3⅜ in.	1
IV	20½ ..	23½ ..	4 ..	3 ..	6 ..	5¼ ..	5¼ ..	3¾ ..	2
VI	24½ ..	27¼ ..	5½ ..	3¼ ..	7½ ..	6¼ ..	6 ..	4¼ ..	3

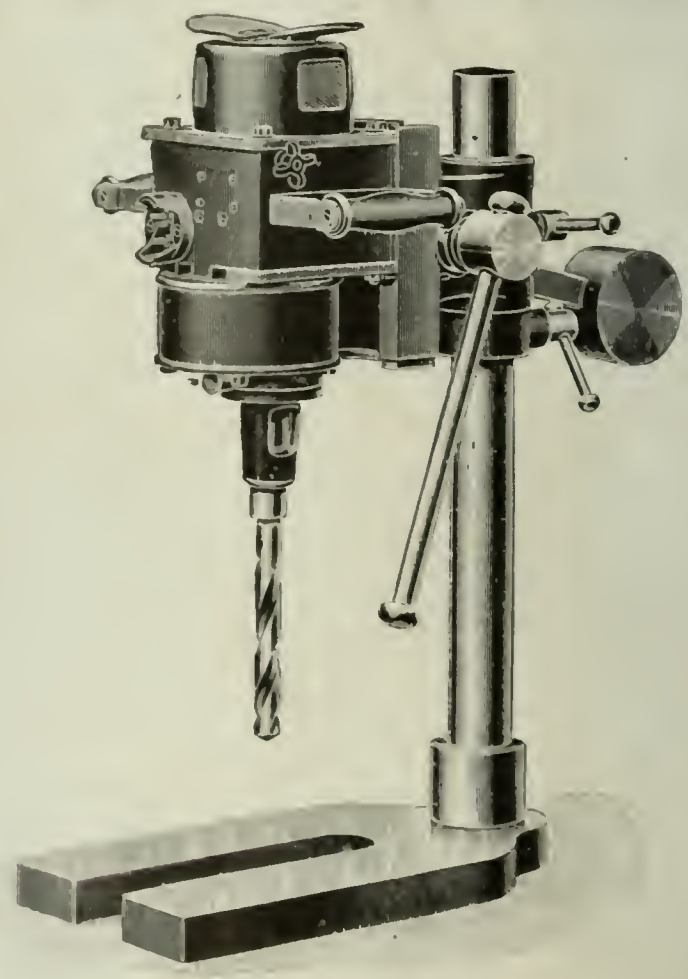
The bench and hand machine has been designed to provide a practical bench drill for shop use, and to permit the drilling unit to be instantly detachable for use as a hand drill. This machine is particularly useful in all engineering shops where a variety of work is undertaken, the machine may be used as a bench drill in the shops, and the drill unit may be used as a kind of screw feed drill on any constructional work that cannot be taken to the bench. The machine may be used where suitable current is available, enabling work to be undertaken on the spot which would otherwise have to be sent to the shop. The unit comprises a compound wound electric motor, with double gear reduction and single drilling speed. The armature is former wound, and fitted with large commutator. The armature and gear shafts are ground and run on ball bearings, and the gears are hardened and tempered and run in grease contained in the separate gear-box, which is entirely distinct from the motor unit. Drilling thrust is taken by a ball race of ample size, and the drilling spindle runs in two phosphor bronze bearings of such dimensions that a long life is assured before any wear takes place. Lubrication of the drilling spindle is positive, a forced feed screw grease cup being employed.



BENCH AND HAND DRILL.

The drill stand is of rigid construction, a hardened steel facing strip is fitted to the slide, and the vertical feed is effected by rack and pinion. The slide is adjustable for wear, and for removal it is only necessary to lift the drill unit clear of the slide; it can then be used as a hand machine, and replaced at any time without any further adjustment.

The above combination machine can be used for a great variety of outdoor constructional and repair work, and also for general shop



M-TYPE BENCH DRILL.

use, as by use of this type two distinct machines are available. The table shows the details of the two sizes of machine made:—

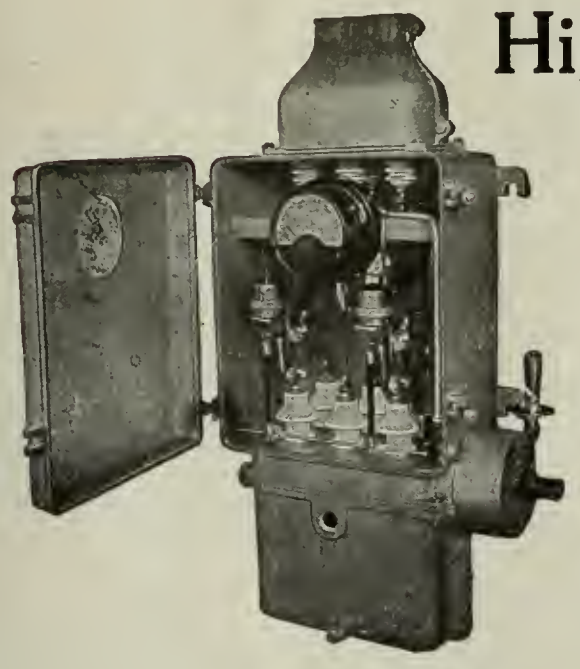
Sizes	M2B	M4B
Height from table to drill spindle	18 in.	17 in.
Radius from pillar to drill-spindle	9 ..	10 ..
Capacity in M.S.	$\frac{9}{16}$ ..	$\frac{7}{8}$ ..
Morse socket	No. 1	No. 2
Vertical feed by lever	4¾ in.	4¾ in.
Weight of drill unit (about)	24 lb.	36 lb.
Weight of stand only (about)	102 ..	102 ..
Size of table	12 in. by 9 in.	12 in. by 9 in.

Standard voltages, 100-120, 200-230 direct current. A self-centring chuck can be supplied if desired.

These machines are obtainable from S. Wolf & Co., Southwark-street, London, S.E.

The Electric & General Works, Ltd.,

15, Victoria Street, London, S.W.



OPEN.

High Tension Switch Boxes

for 3,000 and 6,000 Volts.

TRIPLEPOLE AUTOMATIC OIL-SWITCH.
DOUBLE INTERLOCKED DOOR.
OVERLOAD & UNDERLOAD RELEASE.
AMMETER.
INVERSE TIME LIMIT ATTACHMENT.
FIRE-DAMP SAFETY DEVICE.



CLOSED.

Other Types for all purposes.

ELECTRICAL APPARATUS up to 80,000 Volts.

Telephone: 5223 VICTORIA. **Telegrams: "GABIONAGE VIC. LONDON."**

NEW X-RAY REFLECTORS FOR HALF-WATT LAMPS.

We understand that a word of warning is necessary to users of X-ray direct lighting reflectors, in view of the recent additions to the range of half-watt lamps available. Those who have already experienced the benefits of good lighting using ordinary Mazda lamps in X-ray reflectors might feel tempted to economise still further by simply putting Mazda half-watt lamps in place of the lamps at present used. The makers recommend that this should not



"Jove" Type for Low Windows. "Jupiter" Type for High Windows. X-ray Silvered Glass Reflectors for Mazda Half-watt Lamps for Window Lighting.

be done, for the heat of the half-watt lamp would destroy the enamelled silver backing of the ordinary X-ray reflector and render it useless.

To permit advantage to be taken of the admitted merits of the X-ray lighting system, when using half-watt lamps for the direct lighting of shop windows or other interiors, the British Thomson-Houston Company have developed three new reflectors for use with Mazda half-watt lamps. These reflectors embody the same merits as the ordinary X-ray reflector in respect of scientific design, freedom from striation and high reflecting efficiency. The chief feature of the new patterns is the provision of a special backing to withstand the high temperature of half-watt lamps.

The "Jove" X-ray reflector, which is similar in appearance to the "Scoop" type, is intended for use with 100 watt Mazda half-watt lamps, and is suitable for windows of average proportions. It throws an equal amount of light back and down, which distribution is suitable for windows from one to 1½ times as high as they are deep. If the window height be about twice as great as its depth (measured from the front glass to the background), the "Jupiter" X-ray reflector in conjunction with a 100-watt Mazda half-watt lamp throws a powerful beam of light downwards, and this meets the needs of the case. In general appearance the "Jupiter" reflector much resembles the "Helmet" pattern of ordinary X-ray reflector.

The "Jumbo" reflector, for use with 500, 750 or 1,000 watt half-watt lamps, is another unique production. It is said to be the largest, one-piece glass reflector ever blown (16½ in. diameter, 13⅜ in. high), and is particularly suitable for the efficient direct illumination of very large interiors. This reflector requires a special metal hanger, at the top of which a special holder can be supplied with an adjustable feature, which makes it possible to obtain two or three degrees of spread to the light.

Further particulars can be obtained from the British-Thomson Houston Co. (Ltd.), Mazda House, 77, Upper Thames-street, London, E.C.

Why not a space like this under reading matter? The cost is purely nominal. Let us quote you.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK.
SEA CLIFF
CHARLES CLIFFORD & SON, Ltd.
BIRMINGHAM.

HORN TYPE SWITCH-FUSES.

The horn type fuses illustrated are designed primarily for the protection of the high-tension windings of static transformers and are intended for outdoor installation. The unit consists of a centre fuse insulator carrying conical shaped end-caps together with the arcing horns and fuse wire. The centre portion is carried on two upright rods, which at their ends form the terminals of the apparatus. These rods are rigidly clamped between the two halves of the insulator caps which are securely bolted to the heads of the outer main insulators. The main insulators are carried on steel pins, these pins being secured to the insulators with cement, the whole being mounted on a substantial strap-iron base.

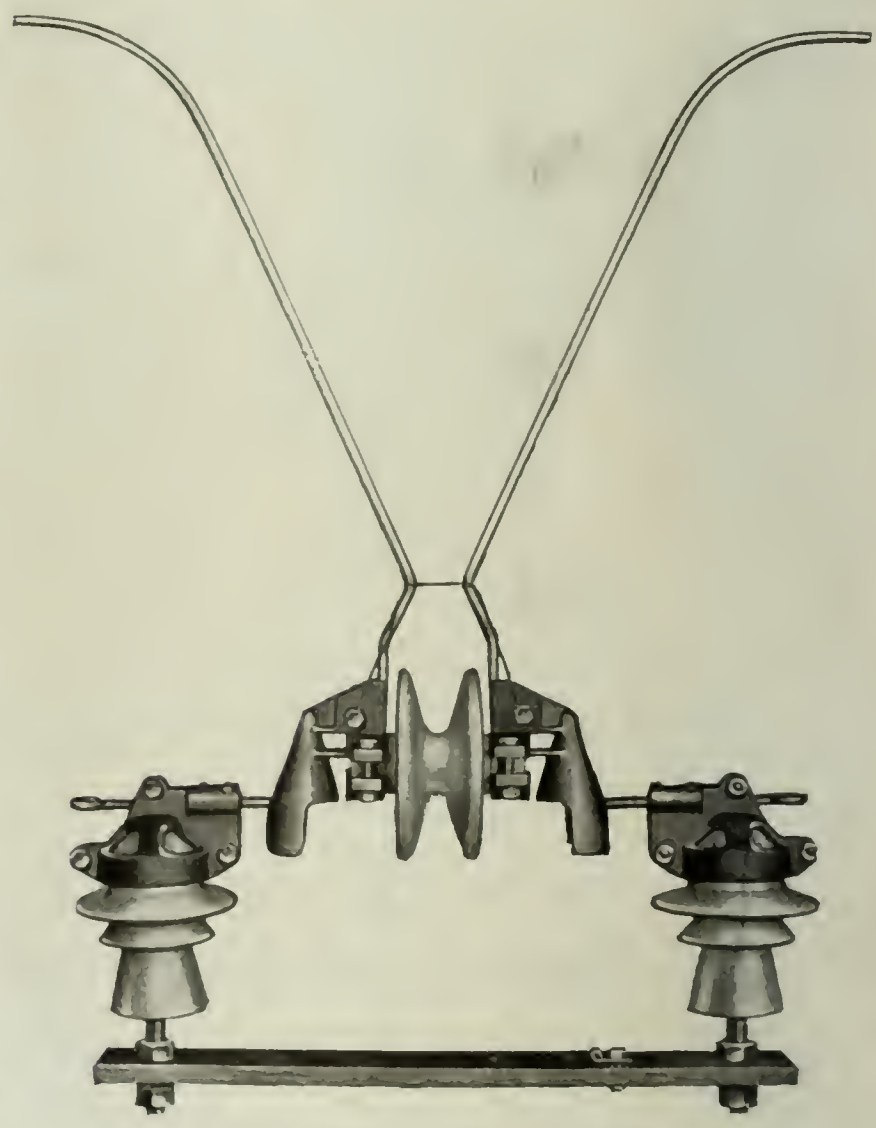
The chief feature of these fuses is their self-alignment. This is obtained by providing the hollow conical end-caps on the centre insulator with widely bifurcated extensions at their base; these embrace ample areas with which to engage the two rods. The inner surfaces of the hollow conical end-caps taper regularly from the base upwards and, because of this, no matter where the points of the rods strike the inner surface, the centre portion will adjust itself automatically to the correct vertical position. The arcing horns are designed to relieve the centre insulator from all mechanical strain set up by the high temperature of the arc.

Trouble is sometimes experienced with open fuses which have the arcing horns fixed permanently in line owing to the possibility of damage being caused to the fuse wire by contact with the arcing horns when re-inserting in the line. With the switch fuse illustrated the makers claim that the horns are an integral part of the fuse carrier and when re-wiring is necessary removal of the complete fuse carrier from the line is effected; in consequence of this, danger to the operator is eliminated. Further, no damage to the fuse wire through accidental contact with the fixed structure of the line is possible. The satisfactory operation of the apparatus is, we understand, practically unaffected by adverse weather conditions such as rain, snow, sleet or ice; the removable part cannot become frozen up, the supporting rods being enveloped by the end-caps.

The fuses are mounted complete at the makers' works, and only need wiring on site before being erected. The complete apparatus is best mounted on the pole cross-arm between the transformer and the overhead transmission line, and in such a manner that arcs generated from short circuits or overloads do not come into contact with the overhead wires. If placed *immediately below* the overhead wires a clear distance of at least 6 ft. for 6,000-volt, 9 ft. for 12,000-volt and 15 ft. for 20,000 volt systems, should intervene between the tips of the horns and the wires. If, however the fuses are erected to one side of the overhead wires, then these vertical clearances may be reduced. The apparatus is intended to be erected in such a manner as to be relieved of all mechanical strain due to tension of overhead lines. The spacing between phases when erecting horn-type fuses should be such that no short-circuits will result from the arcs generated coming into contact with those of another phase.

For re-wiring, the centre portion, complete with horns, is simply lifted from the supporting rods by means of a spring clip mounted on the end of an insulated bamboo pole. This is operated from ground or platform level. The jaws of the clip engage the fork of the centre fuse insulator, and, being drawn together by means of a strong spring, securely hold the fuse insulator and admit of the removal of the centre portion. The fuse can then be re-wired and dropped back into position by means of the pole, a sharp jerk disengaging the spring clip from the fuse insulator, at the same time leaving the fuse intact. The ease and facility with which these fuses can be inserted or removed from the line are features of the design.

Earthing terminals are provided to prevent the accumulation of an electrostatic charge on conducting parts other than those connected with the system. The dangers of bursting fuses is entirely eliminated with this type, and this added safeguard to operating linesmen will doubtless be appreciated. The fuse wire consists of an



Side View of Horn Type Switch.

alloy specially selected for the purpose of securing a smooth clearing of the overload or short-circuit. The insulators throughout are of vitreous porcelain, glazed white, and are of tested electrical and mechanical strength. The porcelain used possesses a relatively low coefficient of expansion, so that it remains unaffected by weather extremes.

All metallic parts liable to corrode are "sherardised," this being one of the most satisfactory processes yet devised for obtaining immunity from rust. The fuses are standardised for three definite voltages—viz., 6,000, 12,000 and 20,000 volts—and range up to currents of 25 amperes. The apparatus is recommended for temporary installations on account of the readiness with which it can be installed. The particular construction lends itself to be used as a switch-fuse unit if so desired.

Descriptive leaflet 312 3, issued by the British Westinghouse Electric & Mfg. Co., deals with these fuses, and prices will be furnished on request.

One, Two & Three Phase MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.
HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.



Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W.

GREENLY

J. P. DEVINE CO., BUFFALO.

MANUFACTURERS OF

Vacuum Drying and Impregnating Plant.

(PASSBURG SYSTEM.)

The Devine Co. are well known in the United States and Canada as the leading manufacturers and experts in Vacuum Drying and Impregnating Plant and have over 1,500 such plants in successful operation.

AIR PUMPS, COMPRESSORS,
VULCANISERS,
CONDENSING PLANT.

Solvent Recovery and Derisinating Plant a Speciality.

Sole Representative :

JAMES LIVINGSTON, LTD.,

30, GT. ST. HELENS, LONDON, E.C.

Telegrams and Cables: "CINERARY, LONDON."

Telephone: LONDON WALL 3151.

EDISWAN EVERYTHING ELECTRICAL

THE ALL-BRITISH HOUSE FOR ACCESSORIES

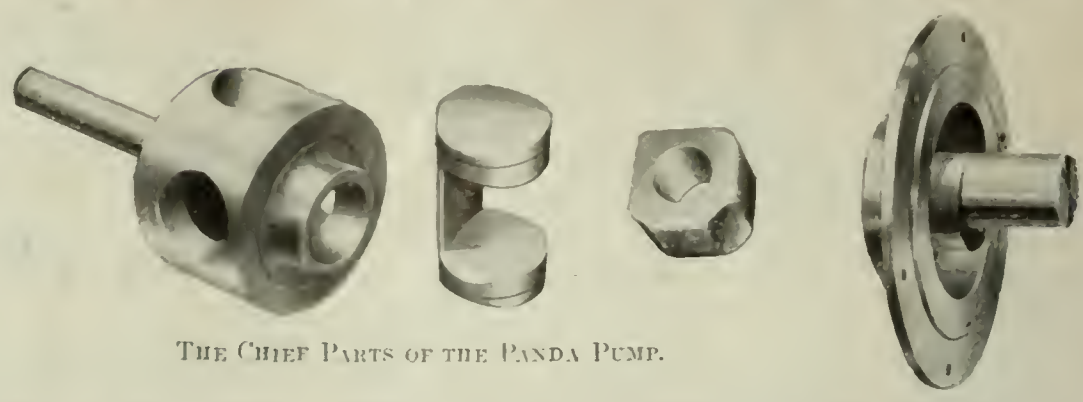
ROYAL
"EDISWAN"
DRAWN WIRE LAMPS

CATALOGUES ON REQUEST FROM THE
EDISON & SWAN U·E·L CO., LTD.,
PONDERS END
MIDDX.

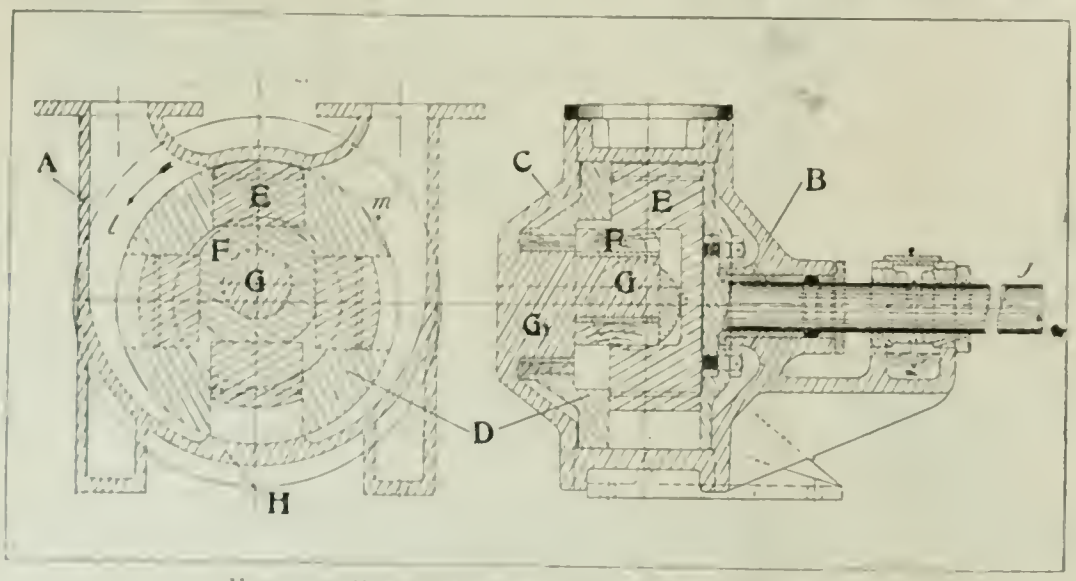
FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06 - 27712/05 AND OTHERS

THE PANDA PUMP.

This pump rotates contra clockwise, and owing to the relative positions of the centres of the shaft *j*, and an eccentric pin G, any one of the four plungers when passing the upper shoe must be in its extreme outward position. As this plunger moves down the suction side *l*, its movement in its cylinder is inward until on the completion of the half revolution it reaches the bottom shoe when it is at its extreme inward position. The result of this action is, of course, that while the plungers are passing down the suction side of the pump they draw in charges of water which are finally trapped as they pass the lower shoe. During the second half of the revolution while the same plungers are passing up the discharge side *m*, their movement is outwards and the water trapped when passing the lower shoe is expelled, the plungers again reaching the extreme outward position as they come to the upper shoe on completion of the revolution.

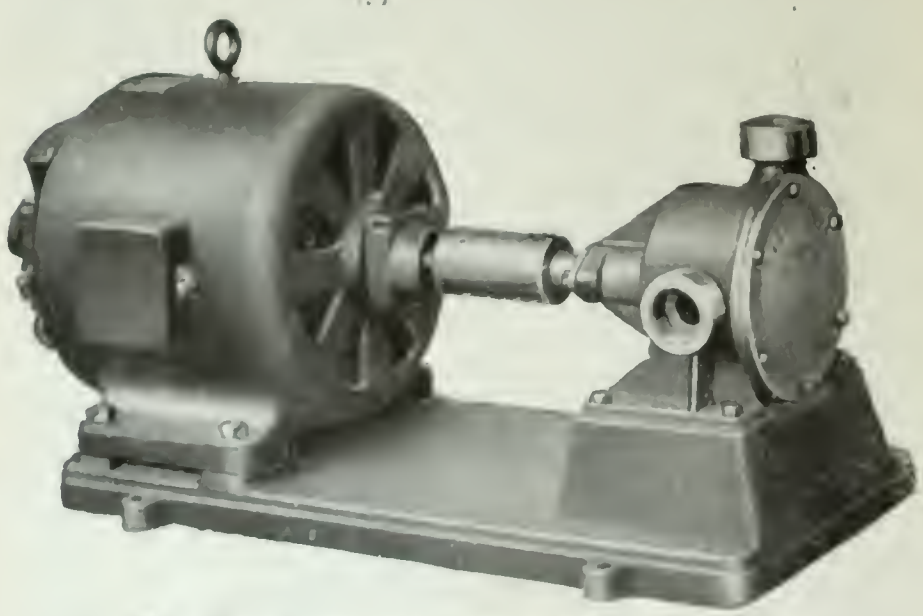


The Chief Parts of the Panda Pump.



End and Cross Sections of the Panda Pump.

The pumps automatically and efficiently lubricate themselves throughout with the liquid they are pumping, and it is only in the case of certain liquids that any grease lubrication may be necessary. The whole of the bearing surfaces are of generous dimensions, and this fact, with the automatic lubrication, ensures long life for the pump.



The Panda Pump direct driven by Electric Motor.

The pumps are built in such a manner that all parts are readily accessible for examination. On removal of the one cover the rotor and plungers can be withdrawn without in any way disturbing the pipe connections. A spigot on the cover ensures its going back into the correct position. The principle of the pump is naturally adapted to the creating and maintaining of a high vacuum, and except in the smallest sizes water can be drawn from a depth of 28 ft. without priming. The approximate normal speed of the smaller pumps is 500 revs. per min., depending upon the duty required. They are, therefore, well adapted for direct coupling to petrol and other engines.

The rotor is carefully machined to allow a small clearance between itself and the casing and covers. On the liquid reaching the pump these clearances are at once automatically sealed, thereby making the pump positive in action. Owing to the high vacuum which can be created and the entire absence of valves the pump is unique in its class. For the pumping of tar, sewage, molasses, oil, glucose, &c., &c., good results have been achieved, and a large business in this class of work is, we understand, now on hand.

The pumps can be supplied for hand or power, for direct coupling to an engine or motor or for a belt drive, and in many instances complete sets coupled to engines or motors and mounted on cast-iron bedplates, as shown in the figure, can be supplied to suit any requirements. A large number of these sets have already been supplied to the Government.

These pumps are supplied by Pooley & Austin, 25, Victoria Street, London, S.W., from whom prices and fuller particulars can be obtained.

LARGE IRONWORKS IN SWEDEN.

The ironworks at Oxelosund, an important port for shipment of Swedish iron ore, are, according to "Engineering," being pushed ahead as far as circumstances will allow, the war having caused considerable delay in the delivery of portions of the plant. The works are located at the Alo Firth, close to Oxelosund. The production of the new works is calculated to comprise 60,000 tons of foundry pig, 100,000 tons of coke, 6,500 tons of tar, 1,800 tons of sulphate of ammonia, 500 tons of benzole. One blast furnace and three stoves are erected and lined with fireproof Swedish material from the Hoganas-Billesholm Co. A coking plant with 60 ovens is approaching completion, and the installations for handling the auxiliary products will be ready within the next few months. The benzole and ammonia plant is almost ready. An electric power-station is being erected, with three three-phase generators, each of 1,500 H.P. capacity. The generators, from the General Swedish Electric Co., will be direct-coupled to gas engines. The gas engines come from abroad: only one has so far arrived, but the other two are shortly expected. A large crane is being erected for the handling of iron ore and limestone. For the supply of the coking ovens with fresh water, if such cannot be obtained from deep borings, a distillation plant for salt water is being erected with a capacity of 40 gallons of water per minute. There are two gas-holders—one for blast-furnace gas, has a capacity of 10,000 cubic metres, and the one for coke-oven gas of 1,000 cubic metres. There are two crushing mills for the blast furnace, with a capacity of respectively 60 tons and 100 tons per hour. All the machinery is being worked by means of electricity.

FERRANTI LTD
Central House, Kingsway, London, W.C.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.
Write for Binder "N."

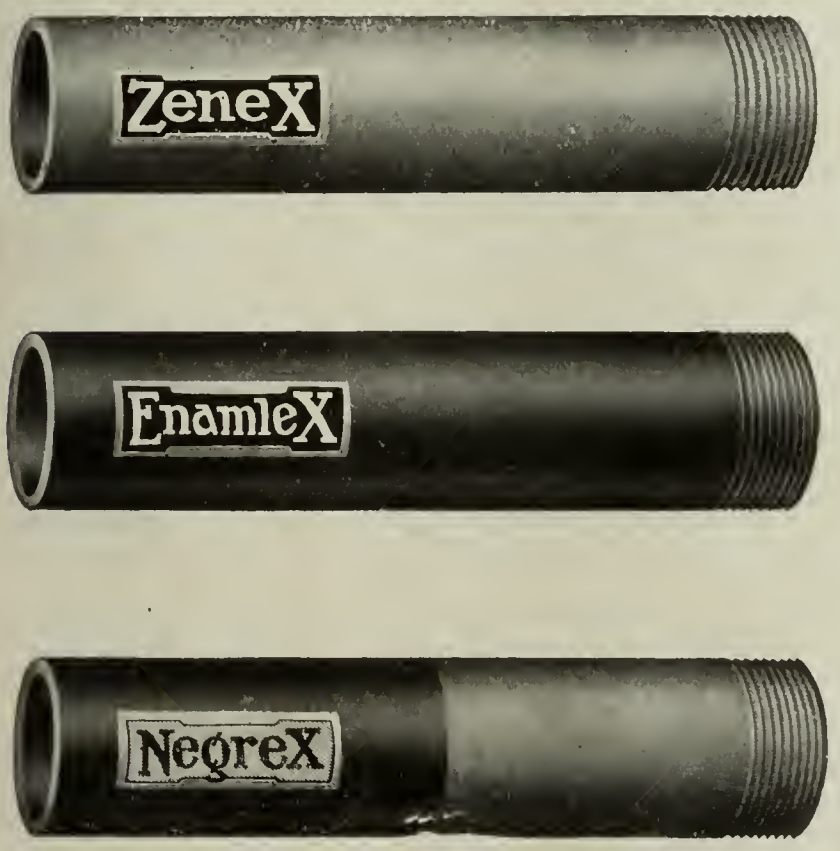
TINNING FURNACE
(Hall's Patents)
For COATING WIRES with Tin, Lead, etc. For use as a BATH.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
The only Tinning Plant on the World's Market with Automatic Heat Control.
Easy Payment arranged in special cases.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

"ZENEX" AND "NEGREX" FINISH FOR CONDUITS.

A new booklet Simplex Conduits have just issued deals with the protective covering of conduits. In addition to the treating and preparation of surfaces, the composition of the protective covering and the method of its application as regards its ordinary enamel finish, it also refers to a new pure zinc covering, to which the registered name of "Zenex" has been given, and also to the pure zinc finish subsequently treated with enamel, which is to be known as "Negrex."

The deterioration of steel and iron by corrosion where surfaces are left exposed or buried in chemical plasters or cements is far more marked than in any other material used in the construction of buildings. As a consequence, a large amount of time, money and intelligence have been expended on the question of efficient protection to the surface in order to retard the rate of deterioration, and so prolong the life of the material. Now that steel conduits are so extensively used for the purpose of enclosing and protecting wiring of all descriptions, a considerable amount of attention has been given to the most efficient methods for protecting the surface of the conduits themselves from corrosive influences.

Ten years ago the Simplex company carried out extensive trials and experiments in connection with this matter. In 1907 they published a booklet on the "Protective Covering of Conduits," dealing with the preparation of surfaces and the method of applying the enamel covering and stoving it in order to secure a flexible, acid-



resisting and protective coating. Under the most advantageous circumstances, it pointed out that an enamel covering can only afford protection in proportion to its adhesive properties, and so long as it is intact and kept free from mechanical damage. It is a well-known fact that pure zinc forms the surest protection for iron and steel surfaces, and the nearest approach to this in the past has been by the hot galvanising process. The zinc covering, however, so obtained is both impure and irregular.

Simplex Conduits (Ltd.) have recently installed at their Birmingham Works what is probably the largest automatic plant in the kingdom for dealing with the deposition of pure zinc on the surfaces of steel conduits, and all tubing treated by this process is known by the registered name of "Zenex." Although "Zenex" finish affords a sure protection to steel conduit, it is itself attacked by acids, and consequently it is recognised that in certain situations a further protection is requisite for the pure zinc covering. This is arranged for after special treatment by a flexible, acid-resisting enamel, and to conduits treated in this manner the registered name of "Negrex" has been applied.

In both the "Negrex" and "Zenex" finishes the interior surfaces of the conduit—which are not exposed to the same corrosive influences as the exterior surfaces—are treated with a high grade of flexible enamel, and this internal enamelling is carried out by a new improved process which ensures there being an homogeneous and continuous coating throughout. It is perhaps hardly necessary to go fully into the great advantages that are secured by efficient protective coverings such as those above described, but we gather that the extra expense involved in the initial outlay will be more than



The Lamp that stands the workshop test

THE vibration, and jolts and jars of a busy workshop form a very severe trial of durability for an electric lamp. Mazda lamps pass the test. The strength of their drawn wire filament enables them to withstand the sustained vibration of the heaviest running machinery. They are the "double-economy" lamps—they save on current AND on renewals.

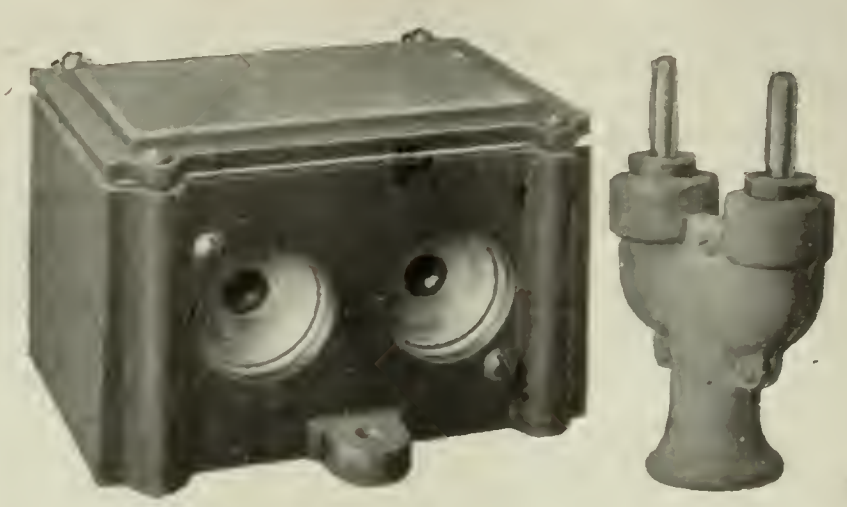
Perfect light and durability make Mazda Lamps ideal for factory lighting. Use them exclusively.

BRITISH MADE IN RUGBY, ENGLAND.

MAZDA
DRAWN WIRE
ELECTRIC LAMPS.

The British Thomson-Houston Co., Ltd.,
Mazda House, 77, Upper Thames Street, London, E.C.
Branches:—Manchester, Birmingham, Leeds, Sheffield, Newcastle, Middlesbrough, Glasgow, Swansea, Cardiff & Dublin.

IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



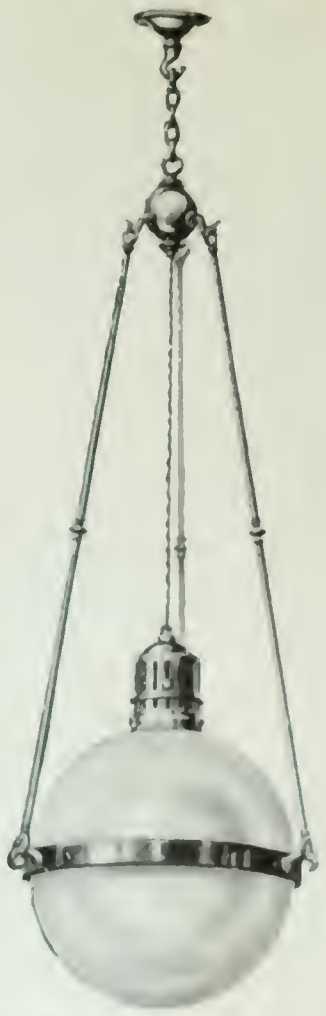
DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

compensated by the increased life and freedom from faults and breakdowns.

Simplex fittings are finished in exact conformity with the special "Zenex" and "Negrex" finishes of the conduits. The booklet referred to is now in circulation, and may be obtained on request to the company.

"VERILUX."

A long list might be made of the various devices which have been designed and tested to provide artificial illumination which will be equivalent to daylight. Until recently the best results were obtained by the use of arc lamps, preferably on the inverted principle;



A Typical Spherical Pendant Fitted with the New G.E.C. "Verilux" Glassware.

but the gradual disuse of the arc lamp before the growth of the drawn wire tungsten lamp has called attention to the problem as presented by an incandescent filament. The solution has been reached to some extent as the result of the attention paid to the development of special glass for diffusion and reflection. The treatment of the lamp and its globe as twin factors in producing a definite illuminating result has revealed the wide variety of effects which may be secured by glass of different compositions. Previous efforts towards daylight illumination were directed mainly to the treatment of the light source; now the method of approach is to treat the emitted light in such a way as to produce the equivalent of daylight.

Apart from the difficulty of getting any artificial light source to approximate closely to daylight, there is no certainty that such approximation, which must be of a delicate character, will be maintained. On the other hand, the combination of a tungsten lamp and a special glass is a stable one, and once the correct composition of the glass is determined the commercial conditions of the problems are fully covered. It is on this basis that Verilux glass has been invented, this being the new three-ply glass recently placed on the market by the General Electric Co. The inmost layer is a colour-straining medium, the next is a diffusing medium and the outside layer is of clear glass to provide the necessary "body" or strength. Light transmitted through this glass, it is claimed, emerges as a precise imitation of daylight, and is free from glare. There is no restriction as to the shape or dimensions of the globes made for this purpose, but of course the best results are obtained with the deep bowl or the spherical types, which ensure that practically all the rays are transmitted through the glass.

Owing to the high efficiency of half-watt lamps, the loss due to absorption by this glass is, for all practical purposes, negligible. In any case, the commercial value of artificial daylight is so high that a slightly lower efficiency should not affect the popularity of the "Verilux" glass. There are some industries which, for want of such an illuminant, can be carried on for only a few hours each day during the winter months. But apart from the enormous retail business in coloured fabrics, there are the wholesale trade, the textile manufacturing industry, dye works, chemical factories, paper works, printing works and many others where a daylight effect is invaluable. Again in picture galleries, museums studios and every industry connected with the fine arts, artificial daylight is obviously a boon. We are informed that "Verilux" was recently tested in an art gallery with excellent results.

In domestic and office lighting there is also a field which is worth cultivating. People have been so long accustomed to the loss of colour value by artificial light that they may be slow to appreciate the advantages of daylight after sunset; but householders who pride themselves on delicate colour schemes, and who have pictures which they like to admire during the hours which are generally the hours of leisure will realise the benefit of "Verilux" glass, when they have been made acquainted with it. Moreover, ladies who sew or do fancy work in the evening will greatly appreciate the advantages of daylight at command. In the case of offices the value of "Verilux" is perhaps more psychological than physical. Rooms lit by "Verilux" do not have the "seven-o'clock" feeling which is more restful than stimulating to people who work under its influence.

TURBO-ELECTRIC PROPULSION.

The efficiency and economy of the steamship "Mjölner," in which turboelectric propulsion is adopted, were recently commented upon by the "Motor Ship." The main machinery consists of two Ljungstrom double-flow turbines, each driving a 400 kw. generator, and delivering power to a single motor, which drives the propellor shaft through reducing gearing at 90 revs. per min.

It is now reported that there are about 20 to 25 steamboats under construction, in which similar machinery is to be installed, mostly of a low powered type, usually of about 1,000 H.P. The economy effected seems to be considerable as compared with reciprocating engines, although presumably the cost of installation is much higher

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, May 19, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—The B.T.-H. during the first week of Daylight Saving introduce a "Nite-lite" saving transformer lamp.

* * * *

The only things not disturbed by the new summer time are the cows and the street lighting time switches—these still work by the sun.

* * * *

We are asked to deny the rumour that Mr. A. P. Trotter is in any way connected with the fact that St. Paul's Cathedral clock struck 12 at 1 p.m. on Monday last.

* * * *

I regret to note that, owing to an error, the editorship of "Printers' Pie" was, in the last issue of the Round Table, attributed to Mr. Hugh Spottiswoode. That ever-welcome publication is now ably conducted by Mrs. Hugh Spottiswoode, the widow of the founder and organiser of the "Pie" publications.

* * * *

Thus the "Daily Telegraph" on electric clocks :

"From a mechanical point of view the electric clock is vastly simpler than its ancient rival. It contains no clockwork, as popularly understood, but *a mere handful of mechanism*, &c.

I can see Mr. Hope-Jones' electric clocks going black in the face at any such definition of their internal economies.

* * * *

A correspondent asks me if the elliptical shape of the bubbles in Guinness and bottled bass is due to electrostatic action. Perhaps those of my readers who affect these drinks can offer some explanation of this undoubted phenomenon. If it is true that the bubbles are elliptical, it will explain the difficulty of drinking these beverages in a hurry ; they stick in the throat because the bubbles must get cross-ways instead of vertical in the gullet !

* * * *

The Batti-Wallah Cabin Boy says : "Grub where you grubbiwell like, but have your Coffee with us."

Which is the place where Wallahs meet
On Fridays now, to take their treat,
Is it a place in Oxford-street ?
No, The Holborn !

Where is the "Holborn," quoted thus ?
It's served quite well by tube and bus,
You simply say, without much fuss,
"Whoa ! The Holborn ! "

What's to be done when you get there ?
You find a waiter and take a chair,
And order coffee, or what you dare,
Ho, The Holborn !

Whom will you see within your ken ?
You will see a lot of "Batti" men
You know, and then, and after then,
What-ho, The Holborn !

Sport your B.W. Badge.

An American contemporary holds the view that the electrical contractor "over yonder" is not always the man of business that he should be. This is evident from the following items of advice offered for his guidance upon how *not* to run the show : —

Allowing customers to ask to be served.

Trying to force a fly-specked or deteriorated stock on customers instead of sending it to auction.

Burning gas when electricity is a better servant, and does not vitiate the air.

Promising and failing to deliver goods by a specified date

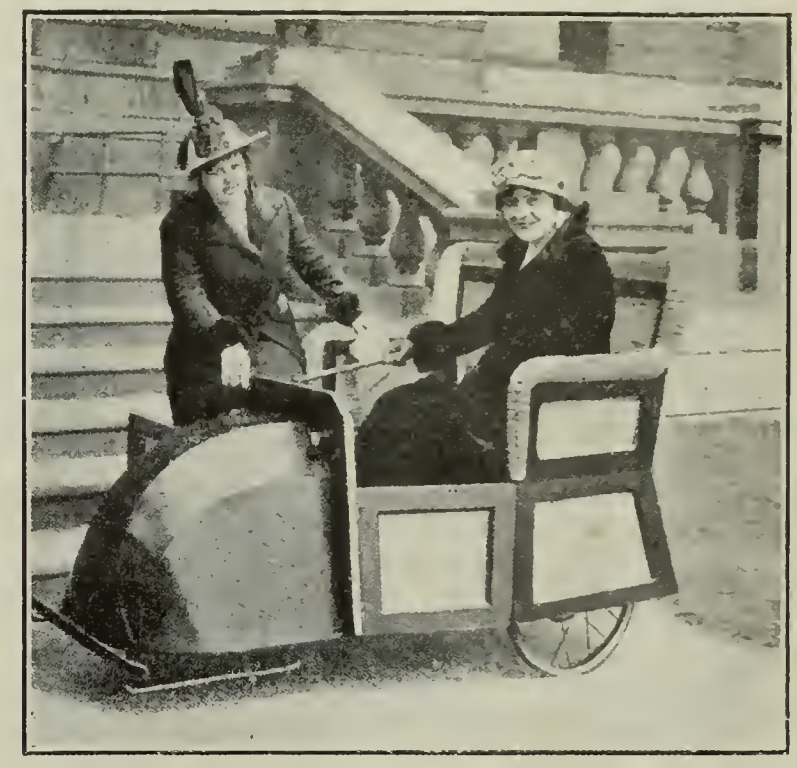
Employing cheap help.

Failing to advertise.

I can hear a few readers of the Round Table remarking that some such advice is not inapplicable to the British electrical contractor.

* * * *

Before the war the electric bath chair was used for pleasure somewhat as shown in the illustration. We may now expect



AN ELECTRIC WHEEL CHAIR USED AT THE SAN FRANCISCO EXHIBITION AND NOW LIKELY TO BE IN DEMAND FOR DISABLED SOLDIERS.

to see it employed only for the recuperation of wounded soldiers or as a means of travel for the crippled men from the war.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), May 24, 1879.]

ENEMIES OF TELEGRAPHY.—An official report from Sumatra states that frequent disturbances of telegraphic communication are caused in that island by elephants. During the three years 1875-78 there have been 60 serious interruptions traceable to this cause. As an instance, this report says : "On May 25, 1876, the Mnara-Dura-Lahat line was completely destroyed for a length of three pauls, and the wires and insulators were hidden away in a cane thicket. All the repairs executed during the day were regularly destroyed at night, and this for three nights running. Besides the systematic hostility of elephants, the numerous tigers, bears and white buffaloes make it both difficult and dangerous to keep an efficient watch on the telegraph lines, where they pass through thick jungle. Both the greater apes and the little monkeys seem to regard the lines as set up for the purpose of affording them the opportunity of practising special gymnastic exercises, swinging from the wires, breaking them, and carrying off the insulators."



TWO WELL BUILT AND THOROUGHLY RELIABLE STARTERS.

No. 10a.—Heavy Duty Starting Rheostat is designed to withstand very frequent starting and heavy starting loads. Auxiliary carbon rollers protect the renewable copper contacts. No-volt release fitted always, overload when desired.

IGRANIC

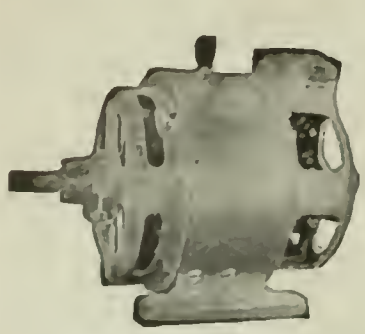
ELECTRIC CO., Ltd.,
LONDON and BEDFORD.

No. 10g.—Multiple Lever Starting Rheostat. The best starter for large motors. The toggle joint levers are interlocked to prevent starting up incorrectly. A special feature is the laminated brush contacts in the place of knife switches.

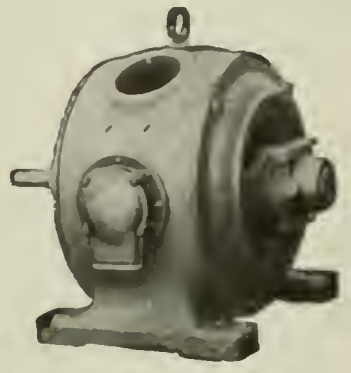


SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

SINGLE AND POLYPHASE BRAKE SOLENOIDS.

Some interesting details are given in catalogues recently issued by the British Westinghouse Co. of standard sizes of brake solenoids which they manufacture. Fig. 1 shows the pattern which may be used on single phase circuits or across one phase of two- or three-phase circuits, 25-60 periods up to 650 volts. These solenoids are suitable for the operation of mechanical brakes on cranes, hoists,

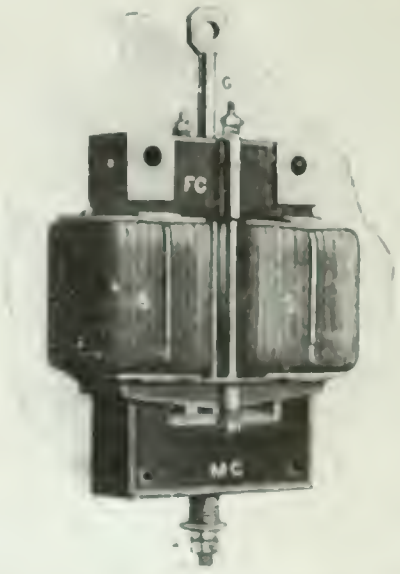


FIG. 1.—ONE-PHASE PULL MAGNET.

capstans and winches, and for any other purpose where it is desired to exert a definite pull through a limited distance.

The solenoid consists of two U-shaped laminated iron cores, one of which (FC) is fixed, while the other (MC) is movable and forms the armature. FC has short poles which just enter the ends of the coils of solenoids (SS), whose lower extremities are supported from the upper part of the fixed core by a bracket and two stay rods. The movable core has longer poles than the fixed core, and is connected to the brake gear by the guide rod G. When S and S are energising, MC is drawn up as shown. These solenoids occupy a minimum of space, but they give the maximum pull. The solenoids are fitted with a device to prevent chattering, and dash-pots are fitted on frames 4 and 5: these are not necessary in the smaller sizes. The solenoids are designed for intermittent service, such as obtains with cranes, and also for continuous rating. On the intermittent rating they can be left in circuit for five minutes out of every 15 minutes. In the table given below both ratings are listed.

The three-phase solenoids are also suitable for the operation of mechanical brakes on cranes, hoists, capstans and winches. They are of the three-limb type and are designed for use on three-phase circuits: they are also adaptable for service on one or two-phase circuits, but the pull obtainable is then approximately 30 per cent.

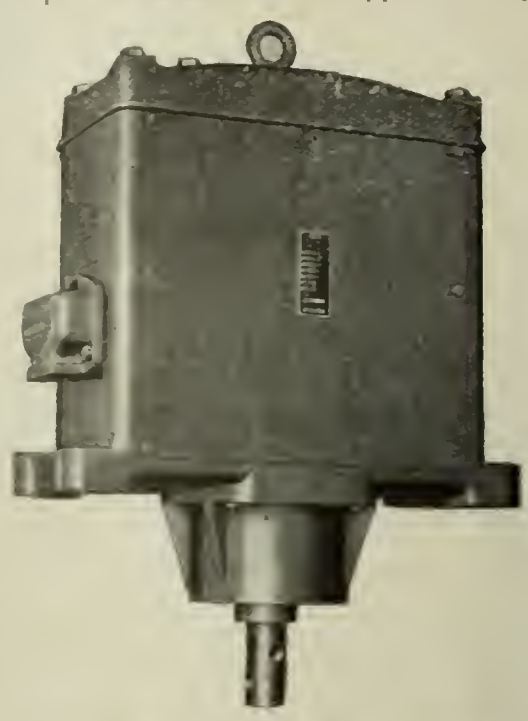


FIG. 2.—THREE-PHASE PULL MAGNET.

less. They are standardised in four sizes, ranging up to and including a maximum pull of 132 lb. through a stroke of 2 in.; the weight of the plunger is included in the pull of the solenoid.

The solenoid consists of a totally-enclosed cast-iron case from the top of which is suspended the laminated magnetic yoke. The plunger works in the dash-pot, which in turn is attached to the underside of the solenoid case. The dash-pot is readily adjustable by the manipulation of a screw, and the action of the plunger can thus be rendered air-cushioned.

Removable side-covers are provided, and the interior of the solenoid is easily accessible for inspection or other purposes. The terminal box is fitted to the side of the case and consists of an insulated block with a suitable cover. It is adaptable for conduit, or

Ratings, Weights, &c. Single-phase A.C. Brake Solenoids.

Cat. No. Crane rat'g [41 contin. rating 142	Approx. maximum capacity	Type or frame. No.	Pull, or total gross weight lifted, including plunger. Crane rating.†	Contin. rating.	Stroke	Approximate net weight. Plunger only.	Solenoid complete	Gross weight complete.
	lb. lb.		lb.	lb.	In	lb.	lb.	lb.
...29	32	1	16	10	1½	10	45	75
...30	32	1	16	10	2	10	45	75
...31	60	2	30	16	1½	16	60	95
...32	60	2	30	16	2	16	60	95
...33	90	3	45	22	1½	20	70	107
...34	90	3	45	22	2	20	70	107
...35	225	*4	100	50	2	36	105	167
...36	225	*4	90	45	2½	36	105	167
...37	225	*4	75	42	3	36	105	167
...38	485	*5	220	70	2	52	140	205
...39	485	*5	195	63	2½	52	140	205
...40	485	*5	150	55	3	52	140	205

* These are fitted with an dash pots.

† The rating for crane service is five minutes operation out of every 15 minutes.

FURNACES for MELTING WHITE METALS, Etc.

Wall's Patents

AUTOMATIC HEAT CONTROL. MELT WITHOUT OXIDATION

PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Also Heat-Controlled Furnaces for Heating the Moulds.

MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham.

watertight glands, when so required. The solenoids can be supplied watertight at a small extra cost.

This type of solenoid should be used in preference to the single-phase type for the following conditions: (1) For service where silent operation is required, such as for elevators. (2) For installation in exposed positions. (3) For frequent operation on low voltages.

Ratings, Weights, &c. Three-phase, Three-limb A.C. Brake Solenoids.

Cat. No.	Approx. maximum capacity	Type or frame No.	Pull, or total weight lifted, including plunger.		Stroke	Approximate net weight.		Gross weight complete.
			Crane rating.	Contin. rating.		Plunger only.	Solenoid complete	
	In.-lb.		lb.	lb.	In.	lb.	lb.	lb.
14249	25	AC 1	16½	8	1½	7·7	32	50
14250	66	AC 2	33	16½	2	12	46	75
14251	132	AC 3	66	33	2	24	103	160
14252	270	AC 4	132	66	2	54	193	290

The British Westinghouse Co. are the makers of these magnets and will supply details and prices on request.

THE G.E.C. CADET CORPS.

It is not improbable that one of the results of the present war will be the introduction of some form of Imperial military service, which



G.E.C. Cadet Corps. The Band.

will naturally include youths of 18 years of age. The introduction of compulsion and the enlistment of men so young as 18 has proved and is undoubtedly proving of immense physical benefit



G.E.C. Cadet Corps. The Signallers.

to the youth of the country. The boy scout movement has been responsible for the inculcation of the right idea into the young mind, and there are also various cadet corps which bridge the gap of age

Simplex

CONDUITS & FITTINGS

can now be supplied from stock, finished with our new processes.

As supplied to Admiralty, War Office and Government Departments.



Zenex finish is an external covering of chemically pure zinc on the prepared surface of a steel Conduit, the interior surface being coated with a flexible black stove enamel.

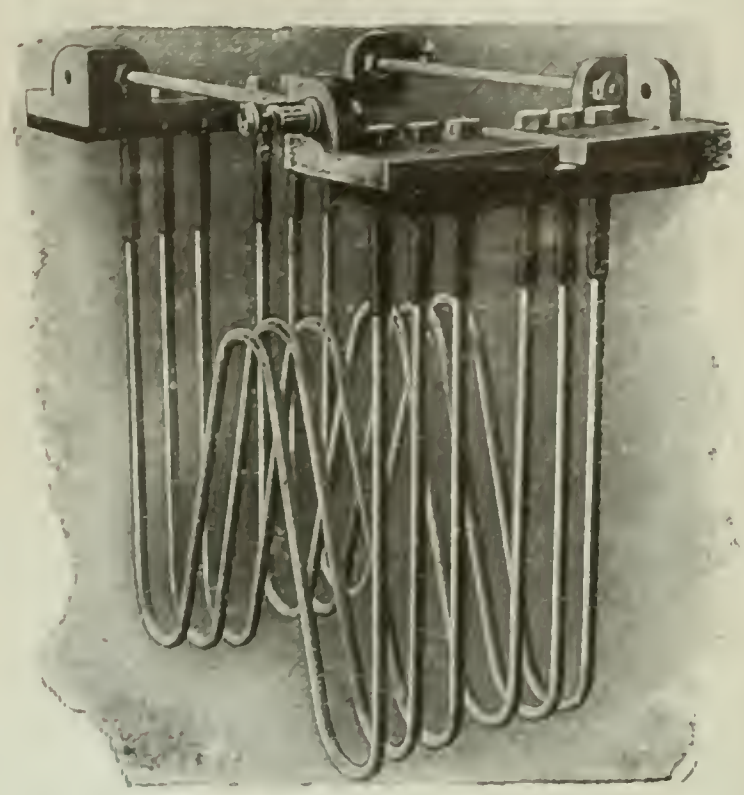
Negrex finish—The exterior surface is coated with a primary covering of chemically pure zinc, the galvanized outer surface and the interior being then covered with a flexible acid-resisting stove enamel.

Enamlex finish is a black stove enamel which has been applied to the prepared steel surface of Conduits and fittings, both inside and outside, whereby they present a homogeneous surface which is durable, flexible, acid-resisting, insulating and very adhesive.

Simplex Conduits, Ltd.,
Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

ELECTROLYTIC RECTIFIERS



Write for List "G."

ISENTHAL & CO.

(DEPARTMENT 4)

Denzil Works, Willesden, London, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

able difficulty in the formation of the Corps has thus been removed by the generosity of the Company, and the principal incentive to an outburst of youthful enthusiasm in this direction has thereby been supplied.

The first corps is commanded by Capt. E. A. Joyce, who has on his staff 1st Lieut. A. V. Cannon and 2nd Lieut. W. F. Arnold. We



G.E.C. Cadet Corps. The Officers.
Capt. Joyce (left) and Lieutenants Cannon and Arnold.

between the oldest boy scout and the youngest soldier eligible for active service.

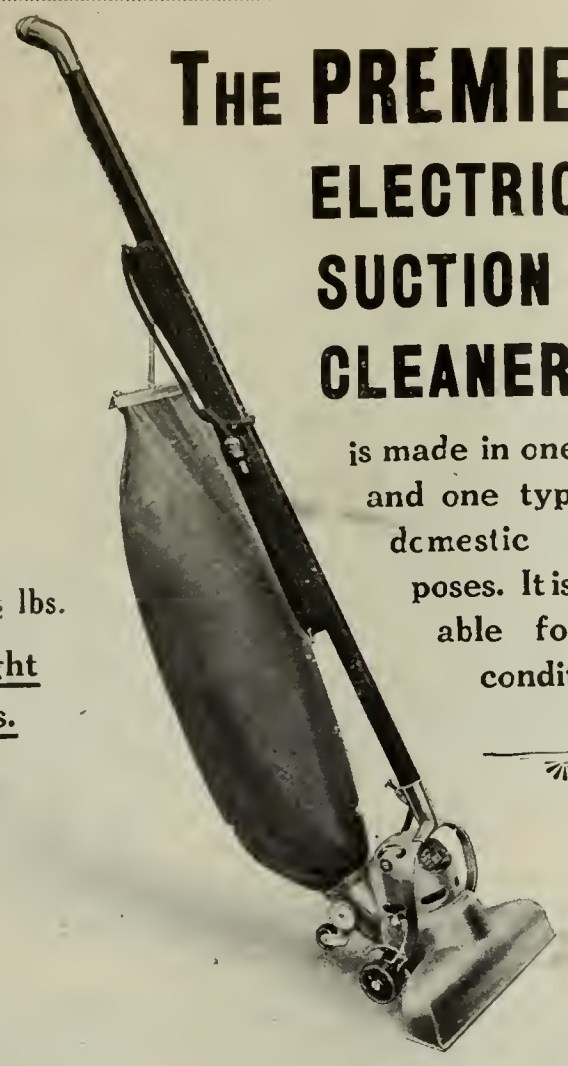
In most of the large industrial concerns in the country there are employed considerable numbers of youths between the ages of 15 and 18 years. Many such youngsters have been boy scouts, and if they are given the requisite encouragement they will also take an active part in making themselves fit for military service when they reach the legal age for enlistment. It is, however, desirable that this encouragement should take the form of practical support from their employers, and undoubtedly much good work can be done to establish an active cadet corps among the youth of manufacturing undertakings and commercial houses. It is of interest to note that Mr. H. Hirst, the chairman of the General Electric Co., has instituted the G.E.C. Cadet Corps (attached to the Sussex Yeomanry) which has now been on an active footing for nearly two months, and which we hear is already at "full strength." The uniform and equipment, comprising khaki tunics, breeches, caps, belts, haversacks and puttees have been supplied to the Corps by the Company without charge. What may have proved an insuper-

reproduce a portrait of these officers herewith. This cadet company is attached to the 1st Cadet Battalion of the Sussex Yeomanry, and is 112 strong, consisting of two platoons. Khaki uniform is worn, and both officers and "men" are recognised by the War Office.

The training is given in accordance with the 1914 Infantry Training Regulations, and we understand that the corps, although it has been in existence a comparatively short time, is already displaying marked ability. We reproduce groups showing the Signalling Section and the Drum and Bugle Band. We gather that the cadets are put through a regular course of shooting once a week at the 10 target range at the Cripplegate Institute. Squad and company drill are undertaken on Friday evenings at the Institute, and on Saturdays the Corps, by permission of the Inner Temple Gardens Association, drill in the Temple Gardens, which should prove an ideal ground for the purpose. It will be seen, therefore, that the movement is proceeding upon "regular" lines, and that the training will be of immense value as preparatory work to that which will be undertaken when the cadets come to be called up. It may be added that the progress of the Cadet Corps has the fullest sympathy of Lord



The G.E.C. Cadet Corps.



THE PREMIER ELECTRIC SUCTION CLEANER

is made in one size and one type for domestic purposes. It is suitable for all conditions.

It weighs 9½ lbs.

Costs Eight Guineas.

ELECTRIC SUCTION CLEANER CO.

56, Victoria Street, London, S.W.

EDISWAN EVERYTHING ELECTRICAL

THE ALL-BRITISH HOUSE FOR ACCESSORIES

ROYAL "EDISWAN" DRAWN WIRE LAMPS

CATALOGUES ON REQUEST FROM THE EDISON & SWAN U·E·L CO., LTD., PONDERS END MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06-27712/03 AND OTHERS

By Appointment.

Carron quality will secure you Sales.

Carron quality will bring you more custom and yield you large profits because it can be depended upon *every time* and and *all the time*. Carron Electric Appliances represent the standard in reliability and efficiency. No higher standard is obtainable — *anywhere — at any price.*

¶ *Get into touch with Carron now, and get a free copy of their illustrated and fully descriptive Catalogue.—A Touch of the Switch does it.*
It is a most useful list and should be in the hands of all interested.

CARRON COMPANY Works: INCORPORATED BY ROYAL CHARTER 1773

CARRON, Stirlingshire.

Branch Works: **Phoenix Foundry, Sheffield.**

Showrooms:—London—City and West End. Liverpool, Manchester, Bristol, Birmingham, Newcastle-on-Tyne, Edinburgh, Glasgow and Dublin.

Established 1759.

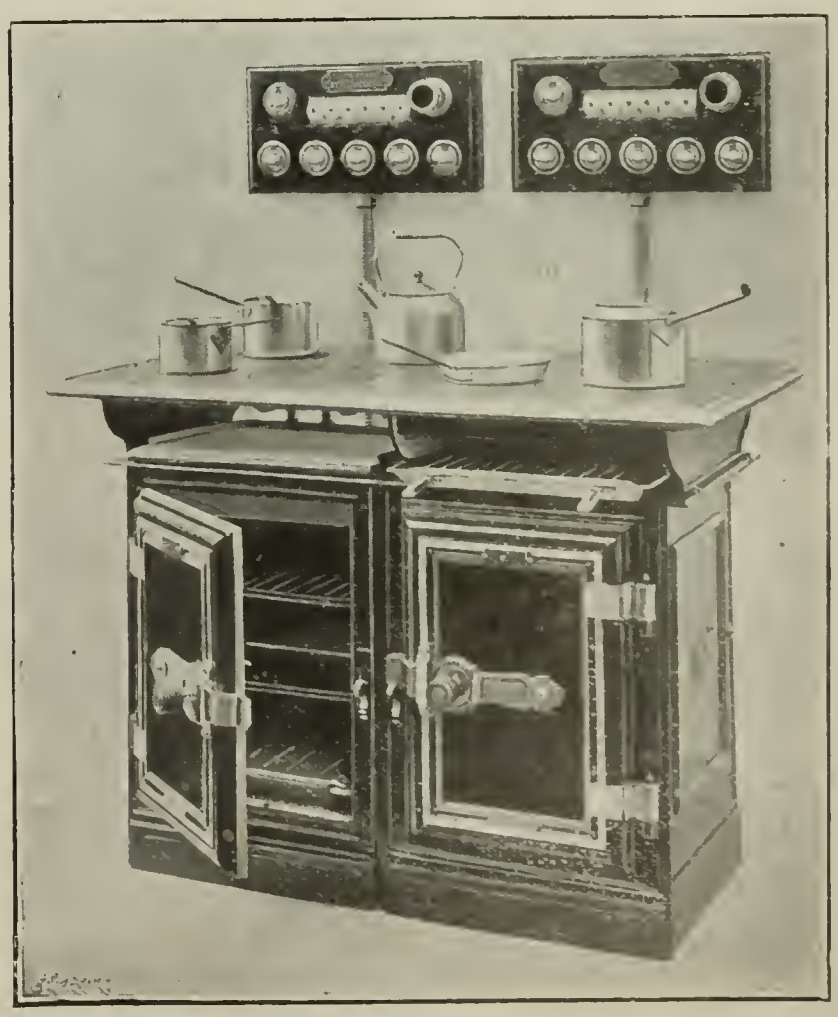


Illustration shows double-oven Electric Range, having two ovens each being double cased, packed with non-conductor and having easily removable standard elements fitted top and bottom. Cast-iron polished top is fitted with Boiling Plates and Grill. All elements are separately controlled by special indicating switches, the two main switches being fitted with pilot lights which show at a glance whether current is off or on.

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868.
Codes: 5th Edition A B C & Western Union.

Kitchener, the Lord Mayor of London, and many important public men.

More than ordinary interest attaches to the Corps, because it has been brought into existence by the help of the management of the General Electric Co., who inform us that not only is the training of immense value in developing the physique of the lads, but it contributes considerably towards increased efficiency in business by making them take a greater interest in themselves, by accustoming them to discipline, by improving their manners, and last, but not least, by the establishment among them of esprit de corps. It may be supposed that a cadet movement of this kind is an over emphasis of the military spirit, but if the enthusiasm of the lads is anything to judge by—and it should be the only standard by which such corps should be judged—then there cannot be the slightest doubt that it is proving in every way beneficial to them, and, what is more to their benefit, must also be of advantage to the country and to industry.

BENJAMIN ELECTRIC WORKS, LONDON.

There are comparatively few makers of electrical accessories who have their works in the heart of London, and who carry on there an extensive output of specialised lines of apparatus for use in lighting installations. The growth of the illuminating branches of electrical work has been considerable of later years, and arising out of it there has agreeably noticeable demand for standardised equipment which can be applied to one specific branch or other of illumination work. A company which has worked considerably for many years past to improve the methods and material of illumination is Benjamin Electric (Ltd.), who commenced manufacture in this country now, we understand, some seven years ago. We were recently afforded an opportunity of inspecting the works which the company have had in operation for the period mentioned at Rosebery avenue, London, E.C., and were much impressed with the extent of the factory and the class of work which it regularly turns out.

In the main the chief product is a line of steel reflectors, which, after being pressed, are aluminium finished inside and enamelled outside. In the production of these reflectors quite large presses are employed, and also a number of spinning lathes at which the final shaping up is done. This work is most interesting to watch, and much of it can only be undertaken by "craftsmen" who have an almost natural aptitude for the work. During our visit we



Assembling Department.

saw one man in particular working upon the spinning of some deep aluminium pans from discs of quite large diameter, work which requires four distinct spinning operations to complete. To witness



Illuminating Engineering Department.

this class of work being done is to feel that the master hand of the craftsman has not entirely been removed from the fashioning of metals to the service and requirements of men.

The spinning lathes and large presses, which, like the rest of the



Electrical Accessories Department.

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

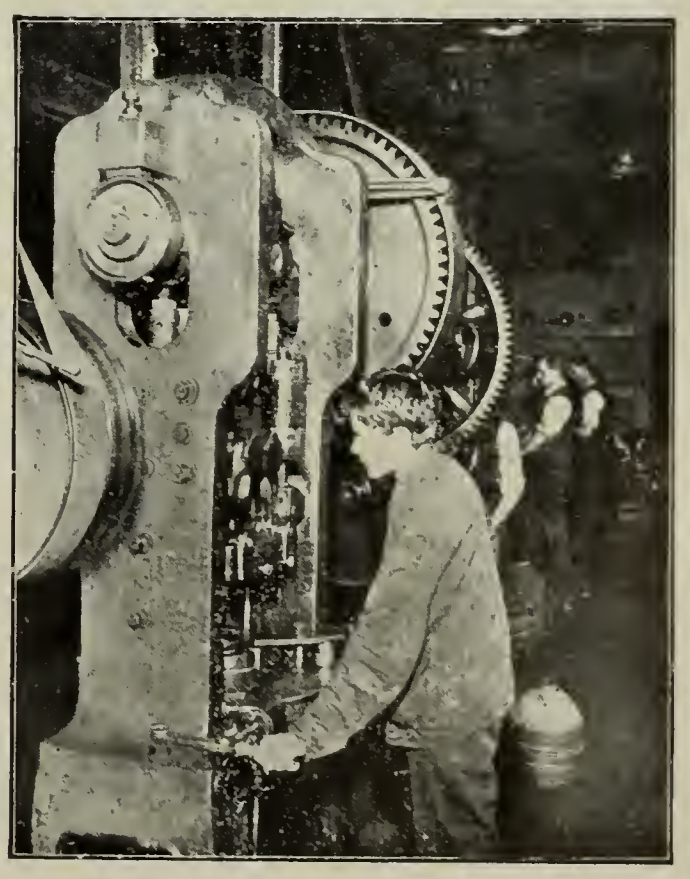
works, are naturally electrically driven, are accommodated on the ground floor; there is also on this floor a complete enamelling and stoving plant which is kept constantly at work upon reflectors and other parts into the production of which the enamelling process enters.

The illustrations of the various departments of the works, which we reproduce herewith, serve in some measure to indicate the layout of the shops and the general organisation of the work of production. The illumination material such as reflectors, &c., is designed on research work in the company's "lab." and not on "cut and try" methods which so far have been proved to be unsatisfactory. In this department is also kept a record of the work done in a similar field by experiments made by various authorities in different parts of the world.

Into the product of Benjamin accessories, such as the Benco holder, wireless clusters, adaptors, twin holders, hand lamps, &c.,



A Corner in the Spinning Department.



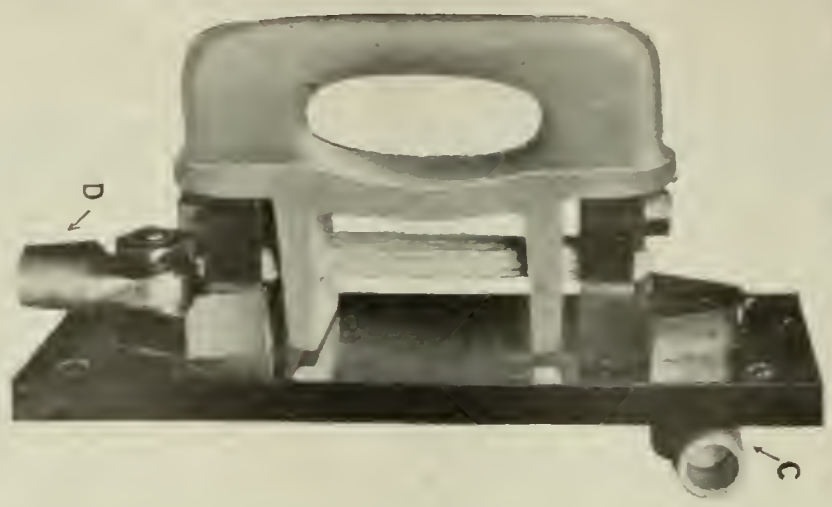
One of the Large Power Presses.

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works

SALFORD, MANCHESTER.

as much care and thought have been put as into the manufacture of the reflectors themselves. In particular we think the company has done good work in establishing satisfactory standards of industrial fittings and reflectors, which have in their turn made the electric lighting of factories a much less costly affair, and a much more efficient matter than when destructible shades and ineffective lampholders were used.

A feature of the works with which we were impressed is its inherent possibilities of extension to cope with that class of competition which the Germans fostered before the war, and with which they made such havoc of the installation trade. We were informed by Mr. Guy Campbell, who took us round, that in one line alone, the Edison screw Goliath lampholder, which in pre-war days was almost exclusively supplied by the enemy, the Benjamin Electric has supplied virtually tens of thousands since the war, and from their London works alone.

In the course of a short article we cannot expect fully to describe this interesting factory, but we understand that the courtesy of a look round will be accorded to any contractor or prospective user of installation material, and especially one who has the impression that Benjamin Electric specialities are not made in this country.

AN ECONOMICAL NIGHT LIGHT.

Many contrivances have been devised for the production of a dim light for such purposes, but some of them introduce complications in house wiring, and are more or less costly to instal, while few are electrically efficient even if they serve their ostensible purpose. One of the few efficient methods from an electrical point of view is to put two adjacent lamps in series. This involves alterations to the original wiring and pre supposes the existence of two lights in a room, a special switch being needed to place the lamps in parallel or in series, and to give an "off" position.

On direct current supplies waste of current cannot well be avoided if a light of smaller value is required than that furnished by the lowest efficient unit obtainable for the main voltage. On alternating current circuits, however, it is possible with the aid of transformers to obtain candle powers as low as may be desired. Since the development of the metal filament lamp made possible units for high voltage supplies to give candle-powers as low as 12, the need for a transformer to reduce the pressure throughout an installation has ceased to exist. Lamps of 12 c.p., however, are too bright for use as night lights, something in the neighbourhood of 3 c.p. or 4 c.p. is needed. Recognising the demand for lamps of such low power for use in hospitals, nurseries, sick rooms, passages, cellars, and so forth, the British Thomson Houston Co. (Ltd.), Mazda House, Upper Thames-street, E.C., have put on the market the "All-nite-lite" transformer, a miniature unit that can be inserted in any lampholder. The device has a cylindrical body terminating at its upper end in a standard bayonet lamp adapter, and at the base in a small bayonet lampholder. Its primary can be wound for any voltage between 100 and 250, the secondary having an output of approximately ½ ampere at 6 volts. A 6-volt 3 c.p. battery lamp with tungsten filament (taking about 3 watts) is employed, the light given being ample to permit of objects in the room being seen plainly, yet not too bright to disturb the rest of patients or children. The running cost of the "All-nite-lite" is trifling, working out at 1d. for 60 hours, with current at 5d. per unit. The transformer can be inserted in or removed from a holder in a moment, and is, of course, available for use at any point where a lamp exists in a house supplied with alternating current. The device measures only 3¼ in. over all, and is of neat appearance.



B.T.H. "All-nite-lite" Transformer and Miniature Mazda Lamp. (Full size.)

"THOR" High Grade Specialities

CASING and CAPPING — CABLE CONNECTORS
CONDUIT — COMMUTATOR COMPOUND
CABLES — WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.

HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

FERRANTI LTD

Central House, Kingsway, London, W.C.

SWITCHGEAR, TRANSFORMERS, METERS, ELECTRIC HEATING & COOKING APPARATUS.

Write for Binder "N."

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, May 26, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—The Daylight Saving Act produces an outcry against the increased cost of electricity and gas.

* * * *

The public, after a week of summer time, are coming to realise that with the threatened increased charges for electricity and gas, daylight saving is now simply a matter of the Bill!

* * * *

My attention has been called by a correspondent, "somewhere in the Eastern Counties," to the fact that all Government confidential papers are now sent out bound up with *white* tape. Can it be that the German aniline dye industries were really at the back of all our official and legal red tape?

* * * *

A correspondent in the "Edinburgh Evening Post" says "electrical engineering is a comparatively recent trade, and there are practically no old men in the business." I know a few electrical men with grey hair and white beards, and they will, I am sure, be pleased to hear that they, like the industry they adorn, are "still in their infancy."

* * * *

I am now doing 36 hours a week as a munition worker, and among my various jobs is one of soldering over a table which holds a dozen shell heads. *Under* each is a gas burner "doing its bit" to help win the war; *over* each at *n* moments is my scarred visage. The net result is I am acquiring what I had perhaps better call "the CO_2 face." It must be for my sins in slanging gas all these years that now I am condemned to taste it; for I must open my mouth to—swear sometimes!

* * * *

An Eltham reader writes me as follows :—

DEAR KVA,

ELECTRIC WHEEL CHAIRS.

Your issue of yesterday's date, Electric Vehicle Supplement (xxxiv.) :—

"The cells provide sufficient energy for a run of 30 to 40 *miles per hour*."

"Some battery."

"Some chair."

"Some nervously inclined person."

"Some general smash up," but not much "Safety first."—Yours, H. G. W.

It looks as if we ought to award ourselves one of our own hot plates!

* * * *

The editor of the "Bath Herald" evidently uses electric light, for he writes as follows of the recent fire at St. Mary's, Bathwick :—

Two explanations of how the fire originated have been made, one being that the electric wires fused. The other explanation is far more likely. It seems that, unknown to the sacristan, a flexible gas tube has been fixed to the gas bracket left in the gallery in case the electric light failed, and the cleaning woman was yesterday boiling her pail of water on a gasring at the back of the gallery in order to save going downstairs. The gas was turned out at the end of the afternoon, but experts say that boiling a pail on the gas would have flung the heat down into the floor, which was very dry, and although it might not have been noticeable at the time, it might have been smouldering underneath, and the slightest draught would set it going.

Our contemporary "Syren and Shipping" recently had a little editorial talk with its readers about the wiring of ships. It seems a little doubtful about the correct phrascology to adopt and proceeds warily, but at the end of the article gets its feet badly entangled in the fuse wires; thus :—

Trouble too often arises through a fuse wire being used for the wrong sectional area. If too large, what may happen is that it may cease to be a fuse, and may result in burning into the armature or field coils.

* * * *

This week's (Bearded) Chestnut :—

A jovial Jack Tar saw an announcement in an ironmonger's shop the other day as follows: "Iron Sinks," and he went in and told the man that he knew iron sank.

"Yes," said the man, "and time flies, wine vaults, grass slopes, and music stands. Niagara falls, moonlight walks, sheep run, Kent hops, and holiday trips. Scandal spreads, standard weights, india-rubber tyres, the organ stops, trade returns, and the whole world goes round."

The bluejacket bolted. But he came back at once, put his head in at the door, and remarked: "Yes, I know; and marble busts."

* * * *

"DON'T USE A MOTOR CAR FOR PLEASURE" shout all the hoardings; therefore use an electric for business. But "W.W." in the "Illustrated London News" also has his eye on the passenger electric, for he writes as follows :—

With the motoring community aghast at the ever-increasing rise in the price of petrol, car owners are on the look-out for substitutes. George Heath (Birmingham) is such a sportsman that I feel that his latest scheme, 'motoring without petrol,' deserves notice, especially as these electric coupés run 50 miles for 1s. 6d., while the tax is only three guineas. Anyway, as far as town use is concerned, electric motor carriages are quite as useful as any other means of circumlocution, while they are the easiest of owner-carriages to look after. George offers trial runs free to any prospective purchaser."

And the electric which was nearly "shrapnelled" out of existence two years ago is likely to come into its own, in spite of everything.

* * * *

OUR HOT-PLATES.

No. 212 to—

Mr. H. Ambrose Carney for the following aphorism in his letter replying to Mr. Rankin in last week's issue :—

"The man who accepts his stop-watch records, however skilled the observer may be, without this check, is acting *by rule of thumb*."

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), May 31, 1879.]

WIRE BINDERS.—Numerous complaints have been made by millers again and again regarding the wire bands used by reaping machines in America and elsewhere. A committee of the American Millers' Association has been testing with some success an apparatus for separating the pieces of wire from the corn. The apparatus consists of two trains of horseshoe magnets placed in a spout through which wheat mixed with wire passed. Every piece of wire from pieces $\frac{1}{8}$ in. to 1 in. length was removed. The device was not patented, and the resolution of the millers, to which we have previously referred, against wire binding has been substantially withdrawn. A patented invention for the same work is described as consisting of a revolving iron cylinder through which the wheat is passed. During each revolution of the cylinder it is twice automatically connected with and disconnected from an electric battery. Inside this cylinder an endless apron is run lengthwise. Each time the "circuit" is broken the cylinder is for a moment demagnetised, and the particles of iron it has picked up drop upon the endless apron and are carried out. To remove the little pieces of wire from cattle feed is as important as to abstract them from milling corn, and some apparatus for this purpose will have to be devised before all objection to wire binding is removed.

"DURADUCT."
The most durable flexible Woven Conduit made for protection of Electrical Conductors.
HIGHLY FLEXIBLE. LESS COSTLY THAN OTHER TYPES OF CONDUIT.
GREAT MECHANICAL STRENGTH AND INSULATING RESISTANCE.
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golslplat, Ox., London." 4746 Gerrard.

SIEMENS



IRONCLAD SWITCHGEAR FOR ALL PURPOSES

Control Pillars
Distribution Boards
Main Switchboards

Illustration shows our Standard Cast-iron Mining Pillar suitable for pressures up to 3,300 volts.

Write for particulars to —

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 870. Telegrams: "SIEMPRATUS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 3450. Telegrams: "SIEMENS CENT., LONDON."
HOME BRANCH ADDRESSES
BIRMINGHAM—Central Bldgs., New St. | MANCHESTER—1 W. Desperate.
BRISTOL—30, Baldwin Street. | NORTHAMPTON—22, High St. [Bldgs.
CARDIFF—40, St. Mary Street. | SOUTHAMPTON—44, High Street.
GLASGOW—47, Waterloo Street.
Branches in Principal Towns Abroad.

SWITCHING UP-TO-DATE AGAIN.

BY W. H. BEAVEN, A.M.I.E.E.

Mr. X. was a very proud man. He had just removed into new offices, which had been thoroughly redecorated, fitted with electric light, and tastefully furnished. In his private room the floor was covered with a fine and expensive carpet.

Mr. X. felt, however, that the crowning glory of this room was the electric light. So proud and pleased was he, that no matter who came to see him, up he would jump, rush to the switch, and turn on the electric light, so that his visitor might be properly impressed. When the visitor left, Mr. X. had to make another journey over his carpet to turn off the light, because the switch which controlled it was placed at one of the doors, a door—by the way—that he seldom used.

Sometimes, when in the very busy, and dark clouds made it necessary to turn on the light, Mr. X. would feel somewhat peevish at having to leave his work to walk over to the switch, and at having to repeat the operation to turn the light off when the clouds had rolled away. When he left at night, and had to stumble across the dark room from the switch to the door that he did use, colliding with unexpected items of furniture, he had to exercise all his fortitude to refrain from shouting. Though things were infinitely preferable to the old office with its gas jet and frequent hunting for matches, Mr. X. felt that there were drawbacks.

Some months later he was very interested to notice that the continual perambulations to and from the switch were wearing a distinct track across his fine carpet. He felt that he could not have it ruined in this way, but only one remedy suggested itself, viz., to have the light on more or less constantly. He still ran into the furniture when leaving in the dark; and when the next quarter's electricity account came in, well! he really did wonder.

One day an appointment took Mr. X. to the office of a Mr. A. During the interview, the latter having become overcome by a slight cough was heard, and behold! the office was all lit up.

"My word!" said Mr. X. to Mr. A., "how did you manage that?"

"Oh, I have a switch here at my desk," replied Mr. A.

"That's very fine, and must save you a lot of trouble, but at night, when you go home, and have to turn off that switch, isn't there a risk of your falling over something in the dark?" Mr. X. [illegible] somewhat sympathetically.

"Oh no," replied Mr. A., "I don't put the light out till I get to the door, where there is another switch. This arrangement—you see—gives me complete control both at my desk and at the door."

Mr. X.: "What a splendid idea! Who put you up to it? At my place I only have one switch, and have actually worn a track across my carpet in going to and from it. Do you think I could have a similar arrangement?"

Mr. A.: "I cannot say myself, but the man who fixed me up could tell you. He is what I call a 'real live man,' and has made a serious study of what he calls *the art of switching*. Get him to call on you; here is his card."

(Later in the day over the telephone.)

Mr. X.: "Hullo! That you Smith? Mr. X. speaking."

SMITH: "Yes, sir."

Mr. X.: "I have just been to a friend's office, and I find he has a much better method of controlling his electric light than I have. He can do it either at his desk or at the door, whereas, if you remember, you fitted my private office with one switch only, which—by-the-by—you fixed at the wrong door. What I want to know is, can I have switches like these at my friend's?"

SMITH: "I'm sorry about the switch, sir. As regards the other arrangement, though I don't say it's impossible, I think it would be a very difficult and complicated matter. It would cost a good bit anyhow, and making the alterations would knock the place about. If you take my advice, sir, you will leave things as they are. After all, you have got a switch *in* the room. Sometimes I fix them outside."

Mr. X.: "Oh, do you? Well, it seems I must be thankful for small mercies. I won't detain you any longer. Good day!"

(Next day. Over the telephone.)

Mr. X.: "Hullo! Are you Mr. Brisk? My name is X., of ——— Street."

Mr. BRISK: "Yes, sir. What can I do for you?"

Mr. X.: "I saw Mr. A. of ——— Street yesterday, and he informed me that you do his electrical work. Do you think I could have electric switches fitted in my office like you have arranged his?"

Mr. BRISK: "I cannot say off-hand that the arrangement in Mr. A.'s office would be the most suitable for your's, sir; but it's very probable it would. Shall I look in and see you?"

Mr. X.: "I shall be glad if you will do so right away."

(Later. Mr. X.'s office. Enter Mr. Brisk.)

Mr. BRISK: "Good afternoon, sir. I am Mr. Brisk."

Mr. X.: "Well, Mr. Brisk, you see what I have got here. Only one switch, and that at the door that's least used. Can't you fix up things as you did at Mr. A.'s?"

Mr. BRISK (*taking in the situation at a glance*): "Well, sir, I wouldn't advise exactly the same arrangement. I would suggest you having a switch at your desk and also one at the other door there."

Mr. X.: "What! Control from *three* positions? Well that would be grand."

Mr. B.: "That's it, sir, it can be done right enough."

Mr. X.: "Would it be a very expensive affair?"

Mr. B.: "Oh dear no. It is really quite a simple arrangement; and very little alteration will be necessary."

Mr. X.: "Would you have to knock the place about much?"

Mr. B.: "Not at all, sir. We shall not touch the decorations, and it's only a matter of a few hour's work."

Mr. X.: "In that case you can do the job as soon as you like. Out of office hours, of course."

(Six months later. Over the 'phone.)

Mr. X.: "Are you there? Is that Mr. Brisk? Mr. X. speaking. I've rung you up just to tell you that in comparing my electricity bills, I find my account for the last six months shows a saving over the previous six months."

Mr. B.: "Glad to hear that, sir."

Mr. X.: "Yes, and what is more important, I consider the convenience and the saving of time and temper paid for the little job long ago. I should like you to call one day next week about some proposed alterations in my general office here, and at my private house. Any day and time between 1 and 1.30."

INSULATION BEADS

The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.

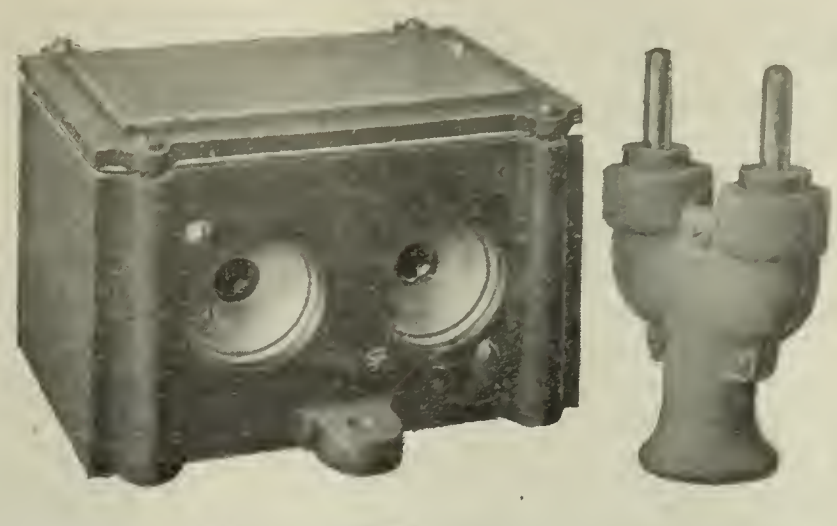
HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.

IRONCASED SOCKETS & PLUGS

FOR HARD SERVICE.

Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.

Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,

Ordsal Electrical Works,

SALFORD,

MANCHESTER.

OSRAM "ATMOS" TYPE LAMPS FOR STREET LIGHTING.

Lighting authorities now feel the need of a lamp which, in these days of labour scarcity, does not require regular attention ; and the recent appeal of the Board of Trade for a 10 per cent. reduction in coal consumption has emphasised the importance of using the most economical sources of light. A necessary condition of the change is that the half-watt lamp should be adapted, both artistically and from the illumination point of view, to the arc lamp standards. The accompanying photographs prove that, at least as regards the first point, the conditions can be met. They illustrate the "Boro" type of lantern, containing Osram "Atmos" type lamps of 300 or 500 watts, installed for the Kensington Borough Council on existing arc lamp-posts. The outside dimensions of this lantern are equivalent to those of the arc lamps displaced, so that there is no sense of incongruity in the substitution. Moreover, the lantern contains an automatic cutout and substitutional resistance to enable any number of half-watts to be run in series. The resistance and cutouts are completely wired and connected up to the two terminals in the top crown. Special care has been taken to provide adequate ventilation. The position of the lamp is accurately fixed in relation to correctly-designed reflectors, so as to secure the proper distribution of light at the mounting height. The lantern itself is made of vitreous enamelled steel to withstand all weather conditions, and the globe and reflector, which are fixed together, are hinged and held by fly-nuts, so that they may be readily swung clear for cleaning or for replacing the lamp. The "Boro" lantern is one of the various types manufactured by the General Electric Co. (Ltd.) for use with Osram "Atmos" type lamps.



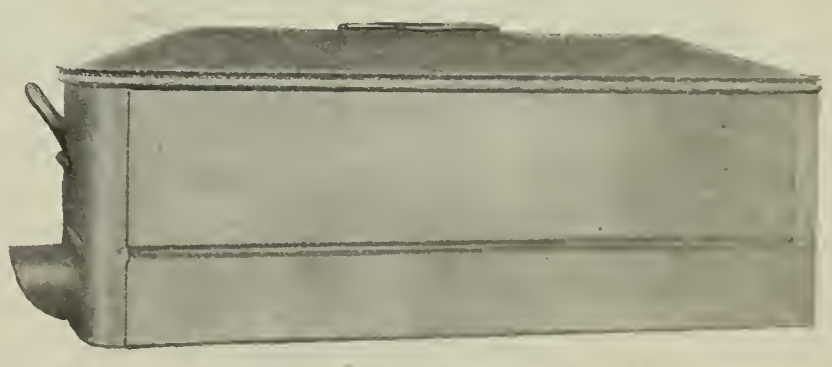
A Near View of Converted Lamp-post.



Lamp-post in Kensington High-street, with Osram "Atmos" Lamp in "Boro" Lantern.

SIMPLEX ELECTRIC STERILISERS.

As might be expected in a world war, sterilisers for surgical instruments have been very much in demand, and as the electrically-heated steriliser has many outstanding advantages, this is another of the little ways in which the industry has been of service. Messrs. Simplex Conduits (Ltd.) are making quite a large number of these articles, and their experience in industrial electric heating stands them in good stead. Electric sterilisers for hospital work must be robust and reliable, and as hospital equipment is always of a light standard, the workmanship and finish must be of the best. These are points where, we understand, the Plexsim steriliser excels. They are made in three standard sizes, but special sizes can be made if required.



One Pattern of Steriliser.

One, Two & Three Phase MOTORS.

LANGDON-DAVIES MOTOR CO.

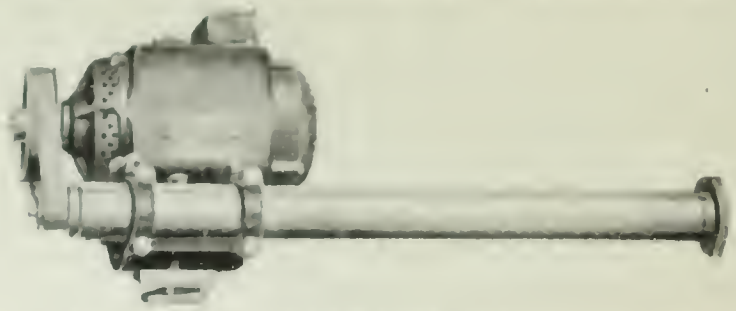
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
CHARLES CLIFFORD & SON, Ltd.
BIRMINGHAM.

TRADE MARK.


ELECTRIC PRECISION GRINDER.

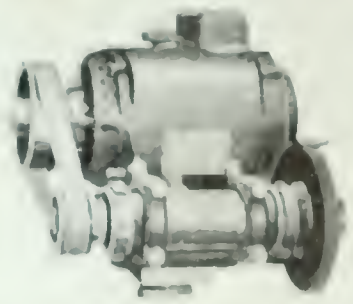
Built for a wide range of accurate work, the grinder illustrated has embodied in it some novel features. The lower side of the frame is turned and rests on a convex washer, to be clamped to the tool post of the machine tool on which the grinder is to be used. Thus, the centre of the grinding arbor may be raised or lowered to the proper height by simply pushing the grinder forward or backward on the convex washer and tightening the clamping bolt. This permits the tool to be used on lathes as small as 10 in. swing and as large as 30 in.



GRINDER WITH LONG ARBOR FOR INTERNAL GRINDING.

The arbor for external grinding carries a 5 in. wheel and is provided with split sleeve bearings, tapered on the outside, which can be accurately adjusted for wear. The cap screws securing the straps which hold the arbour to the frame of the machine protrude slightly beyond the arbor housing itself, which permits the emery wheel to be worn down to a small diameter and also allows sufficient clearance for the grinder back of the tail stock of a lathe. This is an important feature, and one which we understand is not found in most grinders of the tool post type.

The arbor for internal grinding runs on high grade ball bearings located at each end of the arbor, providing a support close to the wheel and the driving pulley. Several sizes of internal arbors adapted to grind holes as small as $\frac{1}{4}$ in. and as large as 3 in. can be



GRINDER WITH EXTERNAL GRINDING SPINDLE.

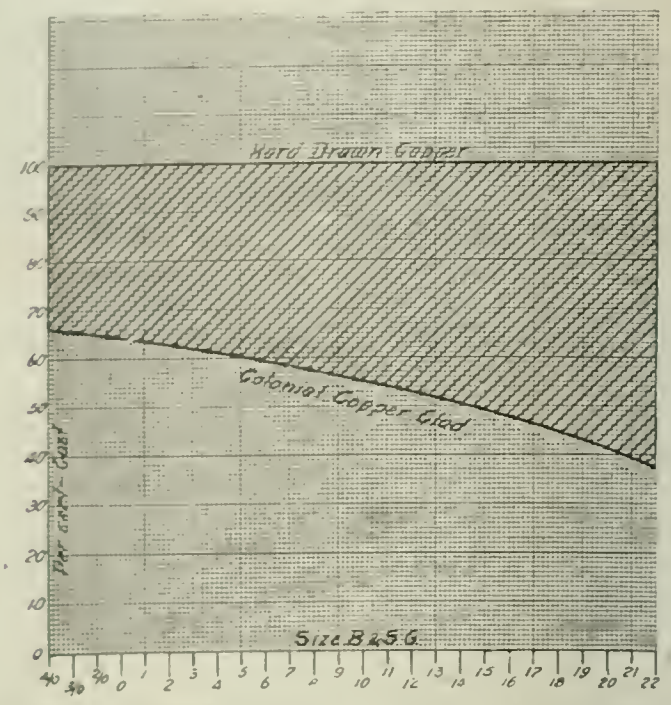
supplied. The speeds of these various arbors are arranged to give the proper cutting speed for the size of wheel carried. The arbors can be changed on the grinder in a few minutes, by simply removing the four screws holding the caps which clamp the arbor to the frame.

The motor is mounted on a hinge pin, which permits it to be swung back to tighten the belt. Pulleys of proper size are furnished with each arbor and with the motor, to give the proper cutting speed to the wheel. The standard motor furnished with this grinder is known as No. 2 size and is furnished in the universal type only for operation on either direct or single phase alternating current.

These interesting machines are made by the Chicago Pneumatic Tool Co., Chicago and New York.

COPPER CLAD WIRE.

Standard colonial copper clad or C.C.C. wire consists of a steel wire covered and protected throughout its length by a welded coating of copper, the metals being by the process of manufacture, which is, we understand, peculiar to C.C.C. wire, welded together so as to form a material so united that the product can be drawn down to the smallest sizes in which copper or steel wires are used. It combines the strength and elasticity of steel with the conductivity



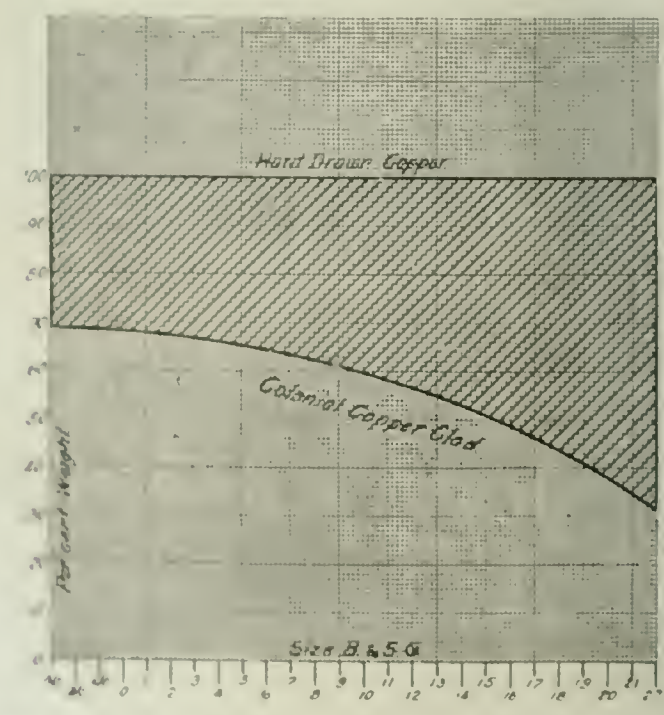
COMPARISON OF COSTS FOR EQUAL STRENGTH. (Bare Wire—Hard Drawn.)

For equal strength values, this diagram gives the approximate relative cost per mile of the two materials in bare form, hard drawn.

and rust-resisting qualities of copper and meets the demand in many branches of the electrical industry for a wire in which strength and durability are of greater importance than conductivity.

Uses: The wire has been in successful use for many years past in the following classes of service: (1) Telegraph and telephone systems; (2) transmission systems for electric light, power and railway; (3) signal systems for railroad, police and fire alarm; (4) bond, messenger, guy and tie wires and other miscellaneous uses.

Telephone and telegraph systems frequently employ large sizes of hard-drawn copper wires on account of the relatively low tensile



COMPARISON OF WEIGHTS FOR EQUAL STRENGTH. (Bare Wire—Hard Drawn.)

For equal strength values, this diagram gives the relative weights per mile of the two materials in bare form, hard drawn.

strength and low elastic limit of the copper being unable to withstand the mechanical stresses on the line. On account of the relatively high cost of copper this renders the first cost of such installations high without reducing in a corresponding amount the maintenance cost. The use of iron or steel wire in such cases is usually not practicable, since the saving in first cost is insignificant when



Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W.
GREENLY

compared with the high maintenance cost that results from the comparatively short life (even when galvanised) of such material under practical working conditions.

C.C.C. wire is offered as the solution of this problem. It is claimed that it has high tensile strength and elasticity; has a conductivity in standard grades equal to 30 and 40 per cent. of that of copper of the same cross-section and length and over double or treble the conductivity of iron; and so long as its copper covering is maintained intact will not rust or corrode. There is a considerable saving in first cost of C.C.C. wire as compared with hard drawn copper, and also there is a much greater saving in maintenance cost and operating expenses.

C.C.C. wire is manufactured by inserting a steel bar of suitable composition, size and treatment, into a seamless copper tube of equal length, the diameter of the steel bar and the thickness of the copper tube being accurately predetermined so as to produce the desired proportion of steel and copper in the finished produet. This is then in turn subjected to special processes and treatments and rolled into bars and rods, and drawn into wire which may be supplied bare in a variety of sizes or insulated with rubber or with weatherproof braids.

C.C.C. wire is exclusively the product of the Standard Underground Cable Co. and the Colonial Steel Co., and combines the knowledge and experience of those habitually accustomed to the careful exactions of wire manufacture for electrical uses and the preparation of steel products best adapted to unusual or high grade uses. This specialised knowledge and experience with more than one "copper clad" product during a period of over 10 years has, we understand, produced a copper-clad wire which has been sold to large and discriminating buyers in quantities aggregating millions of pounds annually for many years past.

The wire is normally furnished in two standard stock grades which combine such proportions of copper and steel as to give an average conductivity of 30 and 40 per cent. respectively of a soft drawn copper wire (Matthiessen's standard) of the same cross-section and length.

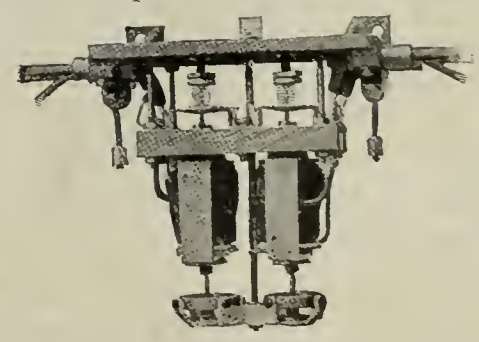
The wire is manufactured under various processes and United States patents owned by the Colonial Steel Co.

Since both the conductivity and rust-resisting qualities of any copper-clad wire depend largely upon its copper coating, every precaution that painstaking care, skilful workmanship and frequent inspections and tests can provide, is taken in the manufacture of C.C.C. wire to have not only the wire itself but the copper exterior perfect. Purchasers and users are cautioned that greater care is necessary in the handling of copper clad wires and strands than in handling copper wires, since any injury or abrasion to the copper envelope must tend to affect its life or usefulness just as, in the case of a galvanised wire, the destruction of the galvanising hastens the deterioration of the wire, or as an injury or break in the lead cover of an electric cable affects the life of the cable.

The foregoing details are abstracted from a pamphlet just issued to the electrical trade by Messrs. Edward Le Bas & Co., Dock House, Billiter-street, London, from whom a copy of the publication can be obtained.

OIL-IMMERSED AUTO-STARTERS.

The type EA auto-starters made by the British Westinghouse Co. are designed for use with constant-speed squirrel-cage induction motors. The essential parts of an auto-starter are two auto-



Type H Overload Relay, Oil Tank Removed, showing Mechanism.

transformers, which reduce the voltage at starting, and a switching mechanism for connecting the motor primary first with the auto-transformers and then directly to the line. The auto-transformers are mounted in a cast-iron case forming the upper part of the starter, and below this is fixed the oil-break switching mechanism fitted with a removable oil tank.

All type EA auto-starters are fitted with a no-voltage release

LEWIS'S SCIENTIFIC CIRCULATING LIBRARY.
ELECTRICAL, MECHANICAL & GENERAL ENGINEERING TEXT BOOKS & TECHNICAL WORKS.
New Works and New Editions can be had from the Library immediately on Publication. Telephone: MUSEUM 1072.
SUBSCRIPTION, Town or Country, from ONE GUINEA. READING ROOM open Daily to SUBSCRIBERS.
H. K. LEWIS & Co. Ltd., 136, GOWER STREET, and 24, GOWER PLACE, LONDON, W.C.

attachment, and where overload protection is required a type H relay is recommended. These relays are supplied as a separate item, and interconnections are not included. The relays operate by opening the circuit of the no-voltage release coil, and are fitted with an adjustable inverse time element device. This device operates instantaneously on large overloads, but the time lag of the relay gives an interval in which less serious overloads may "clear" themselves. The standard connections give 65 per cent. of the line



TYPE EA AUTO-STARTER, WITH OIL TANK REMOVED.

voltage at starting, while by means of extra tappings either 50 or 60 per cent. of the line voltage can be obtained. Tests should be made during installation, and the tapping for the lowest voltage at which the motor will start should be used.

The switch consists of two sets of butt-type contacts—copper rods abutting against brass rods. One set of contacts is closed for starting and the other for running. The movable contact rods are supported by coiled springs which are compressed when the switch is closed, so that excellent electrical contact is assured. The switch contacts are arranged to operate in oil, the oil being contained in a tank arranged for convenient removal. The working parts of type EA auto-starters are few in number, and are strongly constructed so as to make injury either to the starter or motor practically impossible.

PERFORMANCE OF BRITISH WESTINGHOUSE TURBINES.

We are asked to call attention to the tables below, as indicating the excellence in regular performance which turbines of British Westinghouse manufacture attain. The first schedule gives the running statistics of a turbine installed in the Port Dundas power station of the Glasgow Corporation. This turbine, which is of the Westinghouse-Rateau high-pressure impulse type, is rated at 6,000 kw. running at a speed of 1,500 revs. per min. The alternator generates current at three-phase 25 periods 6,600 volts, and has an overload of 25 per cent. for two hours and 50 per cent. for half an hour. This unit is complete with direct-coupled exciter. At the present moment there is in course of manufacture another 6,000 kw. set, together with surface condensing plant which will be to all intents and purposes a duplicate of the set above described.

The second table gives particulars of running of a 300 kw. mixed pressure direct-current turbine, which is also in service in the Glasgow district. This turbine is of the Westinghouse-Rateau mixed pressure impulse type, rated at 300 kw., and running at a speed of 3,000 revs. per min. The generator develops full-load at 460 volts, and is of the three-wire type. The commutator is of the well-known radial type, the design of which enables sparkless commutation to be obtained at all loads at high speeds. The condensing plant is of the multiple jet type, working in conjunction with a natural draught cooling tower.

Running Statistics of No. 1 Turbine, Port Dundas.

Date.	Units generated. Duration of period.	Total output of station.	Proportion generated No. 1 turbine.	Percentage of total output of station.	Percentage of possible output of turbine.	Hours run. Average load.	Possible.	Actual.	Per-centage of possible.
Feb. 3, 1914, to July 23, 1914	5 months, 20 days.	25,511,089	10,125,400	39·6	41·12	5,300	4,104	1910-75	46·6
July 24, 1914, to Feb. 10, 1915	6 months, 17 days.	35,933,557	22,646,100	63·0	77·85	5,465	4,848	4144-75	85·5
Feb. 11, 1915, to Oct. 31, 1915	8 months, 20 days.	48,944,089	30,206,400	61·7	79·76	5,540	6,312	5450·0	86·3
July 24, 1914, to Oct. 31, 1915	15 months, 6 days.	84,877,646	52,852,500	62·2	78·93	5,510	11,160	9594-75	85·9

52,852,500 ÷ 100 = 78·93 per cent.
11,160 = 6,000

300 kw. M.P. Direct-current Turbine Installed in the Glasgow District.
Hours in service. Turbine started Jan., 1910, up till June, 1910, adjusting plant, also testing turbine, cooling plant, &c.

Date.	Possible hours.	Actual hours.	Hours off.	Mean kw.	Max. kw.	Remarks.
July Dec., 1910	4,380	4,142	238	80	150	.....
Jan. Dec., 1911	8,760	8,482	278	85	155	.....
Jan. Dec., 1912	8,784	9,704	80	94	165	.....
Jan. Dec., 1913	8,760	8,672	88	115	185	.....
Jan. Dec., 1914	8,760	8,411	349	170	240	230 hours due to damaged impeller.
Jan. Dec., 1915	8,760	8,612	148	207	273	66 hours due to grinding commutator, &c.
Total	48,204	47,024	1,181			

Spare plant consists of two belt driven dynamos, total output of approximately 100 kw.

LEAD MELTING FURNACES
For Cable and Pipe Presses, Accumulator Grids, etc.,
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
ENORMOUS SAVING IN RESIDUE.
Cost Expenses arranged at once.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

FERRANTI LTD
Central House, Kingsway, London, W.C.
SWITCHGEAR, TRANSFORMERS, METERS.
ELECTRIC HEATING & COOKING APPARATUS.
Write for Binder "N."

Printed and Published by the Proprietors, "THE ELECTRICIAN" PRINTING AND PUBLISHING CO., LTD., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, JUNE 2, 1916.

THE ROUND TABLE.

By "KVA."

All honour to the memory of the brave, "and the engineers" who have fallen in the great naval fight.

* * * *

BON MOT OF THE WEEK. "If mixture of blood be a shame, we have purchased at the price of blood the glory of catholicism, and I know of nothing more false in science or more actively poisonous in politics or in the arts than the assumption that we belong as a race to the Teutonic family."—Sir Arthur Quiller-Couch in "On the Art of Writing."

* * * *

In an article on "Women in Industry," "The Times" has a sub-heading entitled "Gas Women," following which is the quite apt remark, "What one notices especially is the 'patchiness' of the situation in the gas industry." I also have noticed the same patchiness on the brass work immediately over an inverted gas mantle.

* * * *

Next week but one the I.M.E.A. Convention; and it does not seem a few weeks since the last one. Among the Papers to be read is one by Mr. W. T. Kerr, Hereford, on "Electricity in Agriculture." Doubtless it will help to elucidate some of the problems of the "milking" booster and the growing of figs on thistles.

* * * *

This is an engineers' war, so I am told, yet where are the engineers in the Honours List? The qualifications of many of the honoured read somewhat as follows (vide press) :—

"A keen sportsman, the new peer is prominent in yachting, hunting and fishing circles."

"The new peer comes of an old ——shire family."

"A prominent sportsman, Mr. —— is well known as a keen polo player."

* * * *

The British Westinghouse Co. is now sending out its usual April-March calendar. The copy which I have received bears an excellent photo-reproduction of Miss Gladys Cooper, and just the words "Westinghouse, Manchester," in the left-hand top corner. The accompanying letter trusts that "you will accept same with the compliments of the Company." Most of the other calendars are tendered "with the compliments of the season." But then the "times are out of joint," so what does it matter.

* * * *

The following epic is by "J. A. M." in "Glover's Almanac":

Thy Swiftness, thy Elusiveness, thy Might;
Thy magic Power, thy heritage of Light;
Thy Hands etheral which hold the Stars
Whose beams illumine all the ways of men,
Are yet too dimly seen as through a veil,
Inscrutable thou art; but still we hope
By sacrificing at thy mystic Shrine,
By thinking, toiling, doing thy behests,
Someday perchance to glimpse thy shining Face.
We know full well thou are the hidden Source
Of yet more Power and Light and Usefulness;
Of Beauty, Leisured Hours and Thankfulness.
Inspire us, then, O Goddess whom we fear,
To be thy honoured Servants and to spread
Thy Glorious Gifts to men o'er all the World.

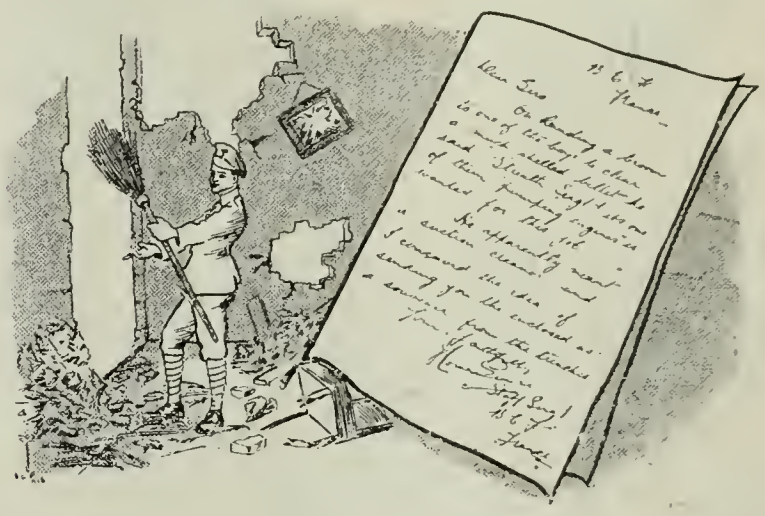
Humour may evidently be unconsciously introduced into such tragic occurrences as boiler explosions. In the 61st annual report of the Manchester Steam Users' Association appears the following comment on 18 explosions which occurred during the past year in the U.K.:

Of these, 19, killing 12 persons and injuring 21 others, may be termed "boiler explosions proper," while the remaining 29, killing 10 persons and injuring 33 others, may be termed "miscellaneous" explosions.

Personally, I should not incline to a preference for either.

* * * *

Electrical men of all classes are in the firing line in France, and some of them are still able to associate the "situation" as they find it with things at home. The little sketch reproduced from a recent advertisement of Scholey & Co., the electric housemaid specialists, was done by Sergt. J. Conway



Price, the erstwhile electrical advertising penman, "Mr. X.," of the "Star," and the Brimsdown pavement artist. He has been with the Welsh Guards in France for some time, and the intrusion of a Boche shell into his billet, quite a common occurrence, I understand, suggested the couplet which, with the sketch and letter, formed the centre piece of the advertisement.

Oh, would you were a "Premier,"
And not a useless broom,
In half a shake
I'd jolly well make
A difference in this room.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), June 7, 1879.]

HYDRO-ELECTRICITY AND HYDRO-MAGNETISM.—M. C. A. Bjerknes reports to the French Academy the results of experiments for verifying his theories. The experiments were performed in the physical cabinet of the University of Christiana, with the aid of M. Svensden, and resulted in the complete verification of his theories. They embraced, first, the action between two pulsating bodies; second, between a pulsating and an oscillating body; third, between two oscillating spheres. In every instance, even when it was necessary to place the vibrating bodies where it was suspected that the disturbing action of secondary forces would become very strong, the results conformed to those of the analytical researches whenever the vibrations were regular and had a nearly uniform intensity. The attractions, the repulsions, the normal displacements from the central line, and even the deviations around the centres of the oscillations were such as his formulas had announced.—*Comptes Rendus.*



A COMPLETE RANGE OF SHUNT FIELD REGULATORS.

"Igranic" Convertible Plate Type Rheostats are standardised in over 300 sizes for Dynamo and Motor Field; Voltage and Speed Regulation.

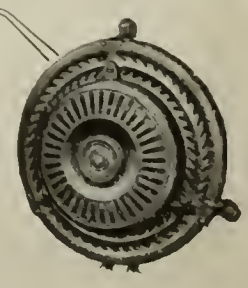
Unit and Grid Type Rheostats for very large motors or special duties.

Numerous contacts are provided for fine regulation.

IGRANIC

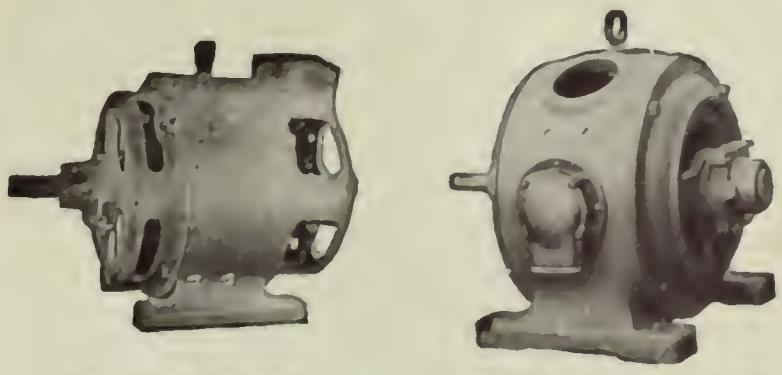
ELECTRIC CO., LTD.,
147, Queen Victoria Street,
LONDON. Works: BEDFORD.

Open and Protected Type Rheostats for Front of Board or Rear of Board mounting. The plates are built up of insulating units with the wire resistance reflexed for expansion and embedded in the unit, thus providing perfect insulation, radiation, and protection against corrosion. Full particulars of the complete range given in Pamphlet No. 631.



SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current. For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central H., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood Bldgs.
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

WINDOW DRESSING—NEW REFLECTOR.

Window dressing is an art, and until the advent of electric light, it was for the most part an exclusively daylight art. To some extent the metallic filament lamp for interiors, and the arc lamp used externally, mitigated the barbarities of artificial illumination by older methods, but not until quite recent times was any serious and well-thought-out attempt made to light a shop window in a manner which would display the goods to the fullest advantage. The excellence of the results obtained by concealed electric lamps, fitted with various kinds of reflectors, stimulated both the lighting expert and the window-dresser to further endeavours. It gradually became recognised that a shop window might be even more effective as an advertisement by artificial light than by daylight, owing to the precision and flexibility with which the illumination could be arranged. But the tendency in most cases was for the lighting expert to suggest to the window dresser the disposition of goods which would give the best effect. A compromise was generally arrived at between the arrangement which the window dresser would have adopted if daylight alone had been considered, and the arrangement which would have simplified the problem for the illuminating engineer.

Considering the variety of conditions which have to be dealt with, the demand for an unusually efficient mode of shop window illumination might seem beyond the range of practical engineering. But a method has been devised for illuminating the typical deep shop window in such a way that every article placed in it, in any position, is lit to the best advantage. The means by which this result is obtained will be clearly understood from the accompanying diagram.

Concealed reflectors of the ordinary type throw the rays of light at varying angles on one side of a vertical line. A certain harshness is unavoidable with this arrangement, owing to all the rays falling directly on the front of the articles. Moreover, this system defines a certain line of trim which must be adhered to more or less closely to get satisfactory results. The diagram shows how these limitations are avoided in a new system of reflectors that has just been brought out by the General Electric Co., Ltd. By arranging plain mirror reflectors of certain dimensions and at certain angles in a conchoidal curve, with lamps about 18 in. apart at the foci of the curve, a complex system of direct and reflected light is obtained. The multiplication of reflectors at different angles prevents the streakiness which is usually the result of using plain mirrors; and the general effect is that articles set in any position within the window are bathed in light from every side. At the same time no light, either direct or reflected from the mirrors, falls in front of the window line; nor are the lamps visible to the public. The stage effect so much sought after is thus retained with a complete absence of glare or harsh shadows. It will be seen from the diagram that, from the point of view of effective illumination, it is a matter of indifference how the articles in the window are arranged. The window dresser is free to follow his fancy, and to alter the character and arrangements of his display at any time with complete assurance that the illumination will remain uniform.

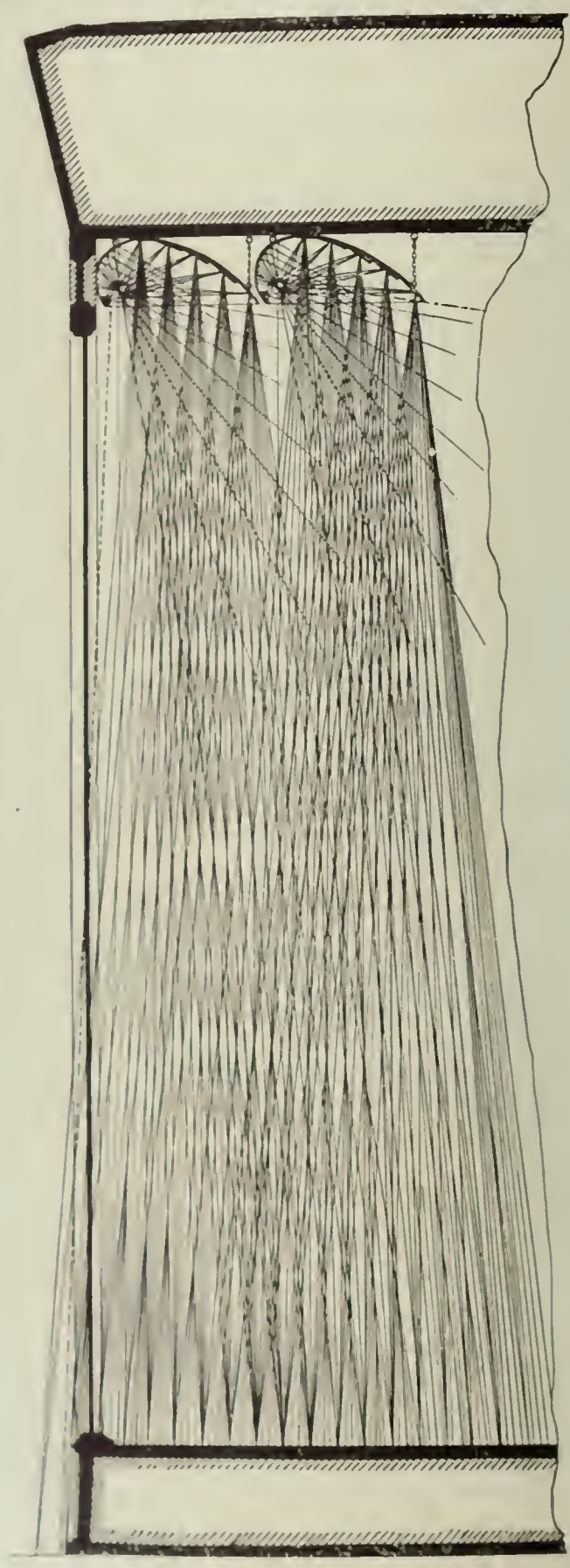


DIAGRAM SHOWING REFLECTED LIGHT RAYS IN THE G.E.C. NEW REFLECTORS FOR SHOP-WINDOW LIGHTING.

This method of lighting has, we are informed, already been put to the practical test in the window lighting of large drapery establishments, and has proved quite successful. It provides, in the simplest possible manner, an ideal mode of illumination which could not otherwise be secured without complex equipment, and would, moreover, require to be adjusted every time the dressing of the window was changed. It is also adapted to the present lighting regulations, which prohibit the overflow of light on to the pavement.

Numerous other applications of this ingenious system of reflectors might be suggested. Stage lighting is one of the most obvious; and in happier times than the present it will no doubt find its use for poster and sign illumination.

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston. Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868. Codes: 5th Edition A B C & Western Union.

BELLING

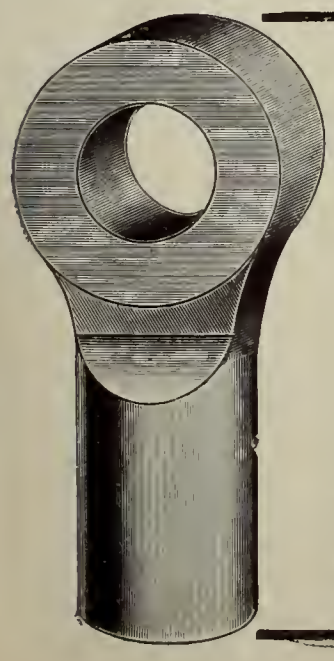
& CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialist, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,

STIRCHLEY, BIRMINGHAM.

Cast Cable Sockets.

Suite E74. Made in all Sizes.

Type A.—Straight.
,, B.—Offset.
,, C.—Right angle.

Illustrated Dimensioned Showcard for Drawing Office use supplied free on application.

Sole Agent for the Electrical Trade:—

LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.

CONSIDER THIS ABOUT

SIMPLEX CONDUITS

They are made entirely by a British firm who possess the largest Works of any manufacturer of Conduit Wiring material.

The only firm supplying from stock ZENEX finish Conduit.

Every possible type of fitting supplied for a complete wiring installation.

Skilled advice is always obtainable where laying down plant and Country house installations, etc.

The Simplex Conduit Wiring system makes a thoroughly sound engineering job, complying throughout with all mechanical and electrical requirements.

Booklet describing our new processes sent on request.



Simplex Conduits, Ltd.,

Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd., W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

LOAD AND EXPERIMENTAL

RESISTANCES

MADE TO ANY SPECIFICATION.

Particulars of Standard Types will be found in our New List, to be had on application.

RAPID DELIVERIES GUARANTEED.

ISENTHAL & CO.,

(DEPARTMENT 4)

Denzil Works, Willesden, London, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster General, etc.

HOTPOINT ELECTRIC RANGES.

The design of electric cookers is naturally still a matter for development, and this fact adds interest to this branch of the electrical industry, because it indicates the presence of a desire to avoid slavishly copying the methods employed by the gas cooker makers. A point in cooker construction at which a number of makers have aimed is the raising of the oven to such a level that it can be tended with comfort and convenience by the cook or housewife. When gas cookers were first introduced the manufacturers were almost compelled to put forward something on "coal" lines, hence the gas oven of to-day must be stooped down to when putting in or taking out dishes. The stooping conditions necessary with coal ranges have thus been passed on into the gas generation, and it remains to see what the electrical men will do with it. Admitting that the average cook is disinclined to be converted to anything new, certainly her more modern prototype (who under war conditions is the housewife) has an eye to personal comfort and convenience rather than to the preservation of a tradition. It is to the class which we believe to be on the increase that the breast-high oven appeals, and the makers who have offered this design of cooker in the past have abundance of evidence of the high appreciation in which it is held by the persons chiefly concerned the cook and the housewife. The existence of proof positive of the logical nature of the design is, therefore, the manufacturers' justification for proceeding with it even in the face of coal made and gas revived traditions.

The new designs of ranges which the Hotpoint Electric Co. are putting on the English market embody this valuable feature of the oven at a height which obviates the need for stooping. The adjoining illustrations show two patterns of range which will meet the requirements of a small and a large household. In Fig. 1 is shown model "H" range, which requires a floor space 33 in. by 17 in., the oven interior measuring 16 in. wide by 11 in. deep by 12 in. high. The range is finished in black enamel throughout, the interior of the oven is aluminium painted. Top and bottom heating elements are used in the oven, each of 1,000 watts rating, and each under the control of a three-heat switch. The door to the oven is of the fall down type, and it may be used as a shelf upon which to rest dishes which are being taken out of or put into the oven. Above the oven is a table equipped in the centre with two boiling plates loaded to 1,500 and 1,000 watts respectively; these also are each under the control of three-heat switches. The boiling plates are of the radiant heat type, and are interchangeable and replaceable with a minimum of fitment. The coils of the hot-plates are designed to glow at a red heat some 30 seconds after switching on, so that no other index of the current being turned on is needed. The hot plate table itself is hinged, so as to give ready access to the hot plates and their connections.

The illustrations show that in the centre of the door of the hot point oven is a circular dial which is the heat indicator. The dial is marked with the figures 1 to 12; these numbers do not signify anything in themselves, but are indices of certain temperatures which correspond to the oven conditions suitable for the classes of cooking



FIG. 1.—TYPE "H." HOTPOINT RANGE.

indicated on the chart which the makers issue with each range for the guidance of the user. For instance, the index 7 shows that the oven is suitable for the baking of white bread, and that this temperature (or number on the index) be maintained for 40 minutes before the bread is ready to take out. This figure is not arbitrary, and the cook will by the use of the range get to know what slight variation may be needed either way to secure correct results. The provision of such an indicator in conjunction with a cooking chart has, we understand, been found to be a useful guide to the intelligent use of the range.

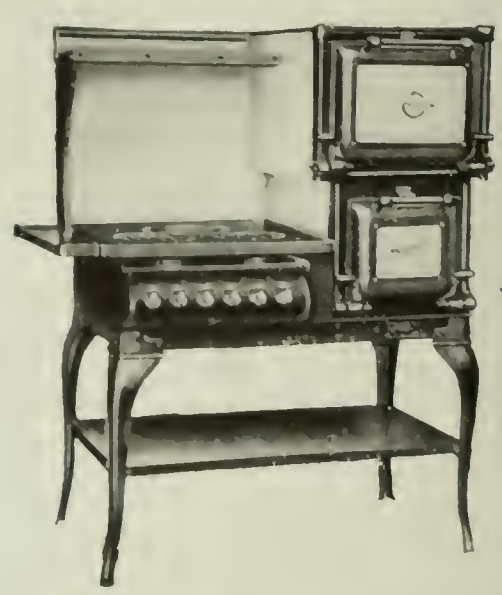


FIG. 2.—TYPE "E." HOTPOINT RANGE.

In Fig. 2 is shown a rather larger type of Hotpoint range, Model "E," which requires a floor space of 49 in. by 26 in., which, like the range above described is finished in black enamel; in addition the door panels are white enamelled. The ovens, of which there are two, are lined with rust-proof aluminium-treated steel, and the walls are heavily lagged with mineral wool. The upper oven is the baking oven, and is fitted with two 1,000-watt three-heat controlled elements; it is provided with fall down hinged door, and the interior

TINNING FURNACE

Hall's Patents

For COATING WIRES with Tin, Lead, etc. For use as a BATH.

WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.

The only Tinning Plant on the World's Market with Automatic Heat Control.

Easy Payments arranged in special cases.

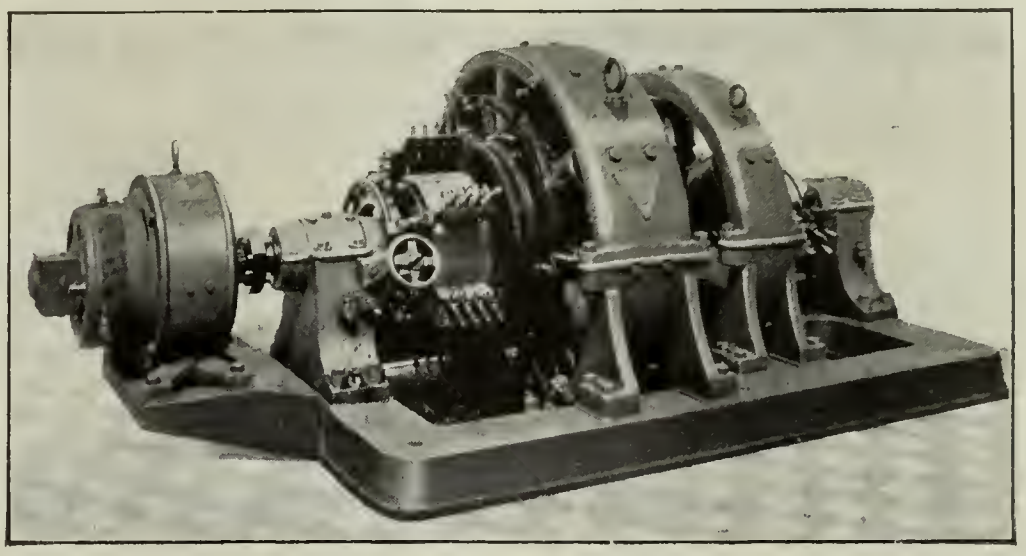
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

VICKERS LIMITED.

Motors and Generators of all types.

Rotary Converters.

Complete equipment for the electrical lighting and driving of Machine Shops, Factories, Mills, etc



Patent Automatic Reversing Drive for Machine Tools.

250 K.V.A. Rotary Converter. 6 phase, 50 periods, 480/560 Volts. 1,000 r.p.m. Inverted type.

River Don Works, SHEFFIELD.

dimensions are 16½ in. wide by 16½ in. deep and 11½ in. high. Immediately below it is a warming oven, which measures 12 in. wide by 16½ in. deep by 10½ in. high. This also has a fall-down door, but it is heated by means of the heat from the upper oven, which passes through a damper provided for the purpose.

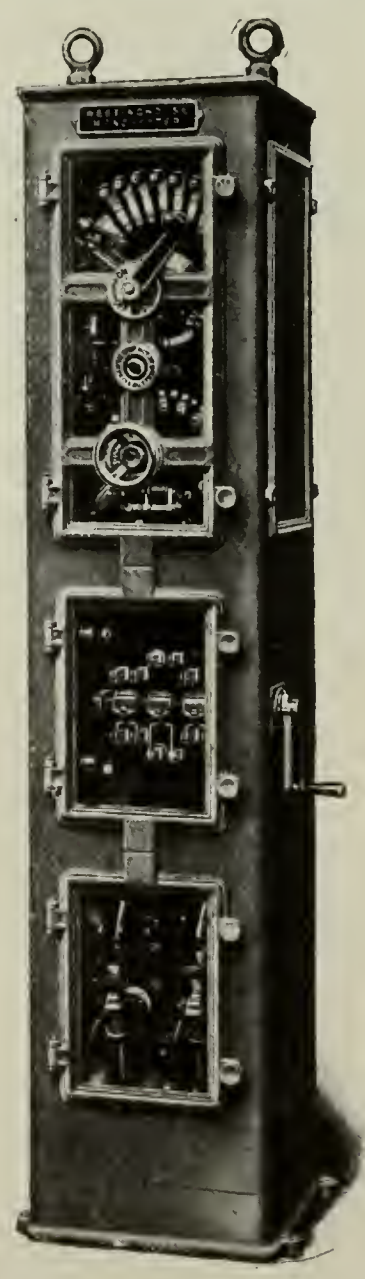
Adjoining the ovens and on the left-hand side is a three-plate table fitted with one 8½ in. hot plate, one 7½ in. hot plate and one 6½ in. hot plate; the first is loaded 1,500-750-375 watts, the second 1,200-600-300 watts, and the third 800-400-200 watts, under three-heat control, as will be apparent. It will be observed that the switching arrangements are embodied as an integral part of the frame of the range. This makes for convenience in handling, but, of course, it requires that the internal connections be grouped and protected from the heat of the range.

A fully-illustrated catalogue and price list of these ranges can be obtained from the Hotpoint Electric Co., 38, Poland-street, London, W.

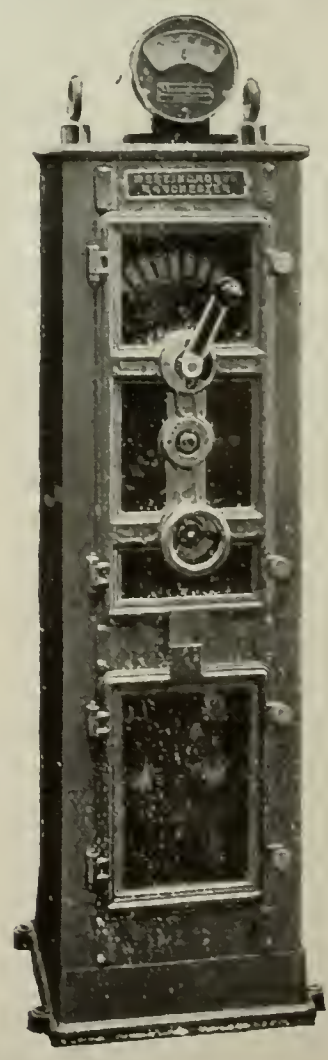
DIRECT-CURRENT MOTOR CONTROL PILLARS.

Twelve standard combinations of control pillars are listed in pamphlet 91/2, issued by the British Westinghouse Co. The design is such that almost any combination of control apparatus can be arranged for, and the company will be glad to submit quotations of other arrangements to meet customers' requirements.

The general construction consists of a cast-iron base which supports the frame on which the switch panels are mounted; the top also is of cast iron, and the sides are enclosed in a sheet-steel case with hinged glazed doors in the front. The cables enter through a large hole in the base casting, which necessitates the provision of a cable trench; but, alternatively, the base can be drilled to receive conduit or gas pipe, or cable clamps for armouring. The standard arrangement of one large hole in the base will be supplied unless otherwise specified. The whole construction can be made dust and weather-proof, suitable for installation in the open, providing the apparatus is not likely to be subject to immersion. All internal wiring is complete, and the only connections to be made on site are those directly to the supply mains and motor, terminals for which are situated at the bottom of the pillar and on the front of the base, so that the connecting up can be effected quite easily.



The main switches have two breaks per pole, no current being carried through the hinge; they are quick break and of the knife pattern. The fuses are the porcelain handle type, and as mounted comply with the latest Home Office requirements. They are fixed



Two Types of Ironclad Control Pillars.

EDISWAN
EVERYTHING
ELECTRICAL

THE ALL-BRITISH
HOUSE FOR ACCESSORIES

ROYAL
"EDISWAN"
DRAWN WIRE LAMPS

CATALOGUES ON REQUEST
FROM THE
EDISON & SWAN
U·E·L CO., LTD.,
PONDERS END
MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos. 2151/04, 2777/05 AND OTHERS

on the front of the switch panels in accessible positions, so that they can be easily renewed.

Instead of a combination of hand-operated loose-handle circuit-breaker and starting switch, a combination of starting switch and two magnetically-operated switches—*i.e.*, contactor-type circuit-breakers interlocked with the starter—have been adopted. This arrangement provides all the features of a loose-handle circuit-breaker, with the advantage that only one operating handle is required, and all circuit making and breaking must be done on the contactors. A slow motion gear on the starter is unnecessary, as any attempt to cut out the starting resistance too quickly will at once open the circuit-breakers. The fact that all current making and breaking must be done on the circuit breakers lengthens the life of the contacts on the starting switch. The interlocking device is such that any backward movement of the starting switch will at once open the circuit breakers. Thus "pitting" and "burning" of the starter contacts are reduced to a minimum. The starter handle will only close the contactors when it is in the off position. The contactors are of substantial construction, provided with renewable contacts and a magnetic blow-out on both poles where all current interruption takes place.

The starters are of a special faceplate pattern of heavy construction, with renewable contacts on all fingers and special carbon arcing rollers where necessary. The no volt coils are always connected independently of the machine field winding, and the overload relays are, therefore, arranged to break the no volt coil circuit. The standard pillar, as a result of this arrangement, can be used for series, shunt or compound wound motors without alteration. A slow-motion gear can be fitted to any starter as an extra. This extra feature is only necessary where a double pole switch and fuses are used, without further overload protection. It is of use with the contactor and starter combination, as, being of the ratchet step-by-step pattern, it provides a means of ensuring that the operator shall only stop directly over each contact.

Where contactor type circuit-breakers are fitted a push button emergency stop is provided to shut down the machine. This push button is in the operating coil circuit of the contactor switches, the main circuit being broken on the contactor switches. Additional push button switches for stopping the machine from a distance can be provided if required. The field regulators are arranged to give anything up to 1 : 4 speed range, and are always fitted with an electrical interlock which makes it impossible to start up the motor with a weakened field. The above device necessitates the field regulator being re-set after each start if the motor was running above normal speed when shut down.

In cases where this procedure is objected to for any reason, patent automatic field accelerating relay can be supplied at a small extra cost. This ensures that the motor always starts up under full field, but automatically brings the machine up to the speed at which it was running before the shut down, without any attention from the operator or alteration of the field regulator. This feature is particularly useful when it is desired to maintain the operating speed exactly.

The combination of starter and electrically interlocked contactor switches, while isolating the motors, always leaves a certain amount of the apparatus inside the control pillar alive. To meet this difficulty the combination includes a double-pole isolating switch, which makes everything inside the pillar "dead," with the exception of the line terminals and the line contacts of the isolating switch. These, however, are shrouded, and it is claimed that they cannot be touched either accidentally or otherwise. The doors are interlocked with the main switch, so that they cannot be opened except when the main switch is in the open-circuit position, and the latter cannot be moved while the doors are open.

Prices and dimensions of these pillars are given in control catalogue 91/2, and are made by the British Westinghouse Co., Trafford Park, Manchester.

MONOMETER TILTING FURNACE.

Oil and gas fuels for melting furnaces of the crucible type are considered with good reason as superior to coal or coke firing on account of the better control of the temperature, the semi-automatic method of firing and the elimination of dust and ashes. For these reasons developments in this class of furnace are of considerable interest. The Monometer Mfg. Co. (Ltd.), Whitehouse-street, Aston, Birmingham, have introduced many interesting and novel technical features into the manufacture of furnaces, and their latest developments in this direction are of interest to furnace users.

The crucible melting furnace of the tilting type illustrated are designed for oil firing, and form part of two batteries of 30, which, we understand, the firm is constructing for newly-erected works for melting copper, brass, nickel alloys, &c. The features of particular interest fall under three headings, (1) the combustion chamber, (2) the method of tilting the furnace, and (3) the constant vertical pouring point. It will be seen from the illustration that the combustion chamber is in the form of an annular chamber concentric with, but situated below the crucible, being connected to the melting chamber by inclined ducts of adequate area. The object of this combustion chamber is to delay the escape of the burnt gases and produce a simultaneous melting, and also to prevent the intense heat of combustion from concentrating at one point on the crucible, such concentration usually shortening the life of the crucible. The furnace takes standard crucibles without special spouts, and, we are informed, that the crucible life by the monometer system is materially enhanced. The body is $\frac{3}{8}$ in. thick of special quality iron of a patented composition and is extremely rigid.

The axis about which the furnace body is turned for the process of pouring is in substantial alignment with the pouring lip with the result that the deviation from a strictly vertical plane of the pouring lip is only about $\frac{1}{2}$ in., and is therefore negligible. Transverse trunnions of substantial dimensions are adapted to turn in bearings fixed to the main side frames of the furnace. It may be noted here that the construction and arrangement of the furnace renders the furnace self-contained and brick setting unnecessary. The oil burner directs the oil tangentially into the combustion chamber, and is attached to the furnace body so as to move therewith. The firing operation can thus be continued during pouring.

The tilting mechanism is of correct mechanical design, and comprises a transverse tilting shaft at the back of the furnace, a toothed wheel carried on the said shaft and a high-speed silent chain forming a connecting element of a flexible nature between the furnace body and the toothed wheel. On the bottom of the furnace body, which

FERRANTI LTD
Central House, Kingsway, London, W.C.
SWITCHGEAR. TRANSFORMERS. METERS.
ELECTRIC HEATING & COOKING APPARATUS.
Write for Binder "N."

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

QUEAD

ELECTRIC FIRES.



Q. 7.

THE Proprietors of **Quead** Fires beg to advise their numerous friends that owing to the great demand for their fires a New Company has been formed, and will be carried on under the title of

QUEAD, LTD.
(Late Ikin & Eads, Ltd.),
47/57, Marylebone Lane,
London, W.

1916/17 **QUEAD** MODELS CAN NOW BE INSPECTED AT THE COMPANY'S SHOWROOMS.

RING UP
MAYFAIR 3582.

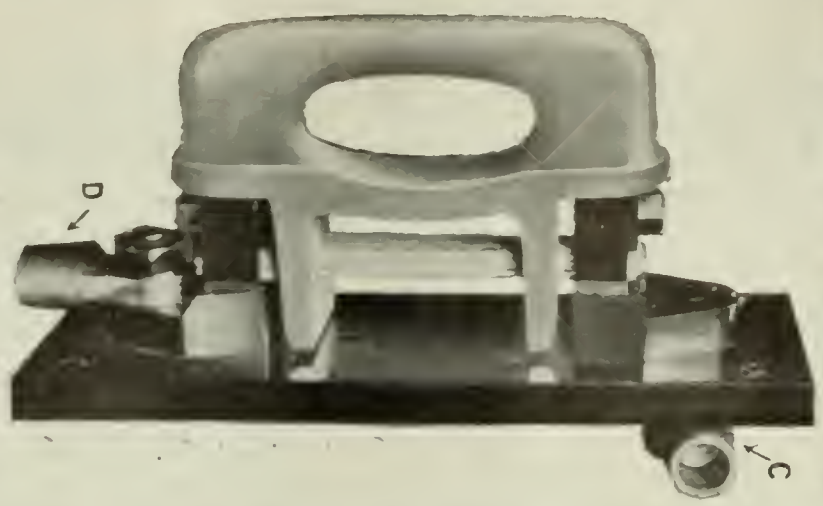
Order at Once for Early Delivery.

D. & S.
"HANDLE" FUSES.

50 amps. and upwards. 600 volts

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

incidentally is a substantial casting, is formed a quadrantal grooved runway intended to accommodate the silent chain. The tilting mechanism is completed by a worm and worm wheel, a pair of bevel wheels and an operative hand-wheel. By rotating the hand wheel, the tilting shaft is turned and the silent chain is wound on to the toothed wheel thereby exerting a force which through the chain elevates or tilts the body about the axis of the trunnions. The reduction gearing has been very carefully calculated, so that a minimum effort is required to turn the hand wheel, and at the same time the tilting movement is sufficiently rapid to meet all reasonable requirements. A point which may be noted is that the toothed wheel on the tilting shaft is of sufficient diameter to accommodate the silent chain when the furnace is fully tilted, so as to prevent the chain from hanging down; thus, there is no possibility of the chain slipping off the wheel. Another good point is that the tilting effort is exerted at the bottom and centrally of the furnace body instead of the body being subjected to a twisting strain. The preheater is arranged to prevent access of swarf to the combustion chamber, and a very valuable feature is the spigot arrangement which prevents escape of flame at the joint with the body.

For casting bar and strip brass, &c., the makers also supply a mould carrying turntable arranged in front of the furnace, and mounted on ball-bearings. The table has an integral spur-wheel operated by hand-wheel and pinion. The moulds are stood on the table for casting. We understand that the quickest possible casting speed is obtained by this system.

The whole of the features of this furnace are patented by Mr. I. H. Hall, the managing director of the company.

ROTOR STARTERS.

The type MF rotor starters are designed for use with alternating-current slip-ring induction motors. They operate in the rotor circuit only, and are not for use for speed control or where starting conditions are severe. The starters are capable of starting slip-ring motors against 150 per cent. of full load torque in not more than 15 seconds, once in 15 minutes. The contact arm is caused by a spring to return to the starting position if left at any intermediate point between the starting and running position. In the running position the handle is locked, but may be released by pressing a button in the knob. The chief features are complete enclosure of all parts, making accidental contact with live metal impossible; renewable resistance units and wearing parts; fireproof materials throughout. A separate line switch or circuit breaker is necessary to close and open the motor primary circuit, as the starter is connected in the motor secondary circuit only.



Type MF Starter, Front Cover Removed.

The foregoing starters are described in leaflet A56/31, which may be obtained from the British Westinghouse Electric and Mfg. Co. (Ltd.), Trafford Park, Manchester.

HIGH-ANGLE SEARCHLIGHTS.

We have been supplied with the adjoining illustration by the London Electric Firm, Croydon, who inform us that they are making a considerable number of these for fortress and ships' use. The movements of the projector can be controlled either by hand or electrically from a distance. The controller for the latter form of operation is quite portable, and can be moved about by one man:



General View of High-Angle Projector.

the controller also is dust- and watertight. It can be placed at any desired distance from the searchlight itself. The motion of the beam of light can be quick, as for searching for an object, or slow when it has been "spotted."

The searchlight lamp is, we understand, of an improved pattern, and the carbons may be worked either automatically or by hand-feed. Under either form of control the lamp burns quite steadily.

"THOR" High Grade Specialities

CASING and CAPPING
CONDUIT
CABLES
CABLE CONNECTORS
COMMUTATOR COMPOUND
WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.

WRITE FOR PRICES & DISCOUNTS.

HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, June 9, 1916.

THE ROUND TABLE.

By "KVA."

I have awarded "Ediswan" a hot-plate this week because it has great hopes of a good fan season. If the weather changes between the time of writing (Wednesday) and to-day I am afraid the point of the joke will have melted somewhat.

* * * *

According to the "Star":—

A woman, found sleeping in a hammock in Epping Forest, was charged with having "no visible means of support." It must have been a wireless hammock.

But why not one of Mr. Campbell Swinton's bedstead aerials?

* * * *

The "Machinery Market" has discovered a new dimension. Describing a new electric power plant at Cwm Dyli, near Penygwrd, in the Gwynant Valley, it states that "the pipe line which is in duplicate is built of rivetted mild steel pipes, 30 in. *interval* diameter." No doubt the editorial pause for breath after the unpronounceable names of the places referred to.

* * * *

The war is evidently producing electrical Pooh Bahs on many of the smaller supply systems. I notice that in a certain station one man acts as plant engineer (? gardener), meter reader, new business solicitor wireman and repair man for the entire undertaking. Doubtless he will shortly be asked to act as consulting engineer and switchboard attendant in his spare time.

* * * *

Mr. A. F. Berry's latest is an electric fire "with a flame in it." The first form of it to reach the market has been appropriately dubbed the "Tricity" baby, for even electric fires are born and not made. The girl in the picture is, perhaps,



"You're Ma 'Baby.'"

wondering where the flame comes from, the while it also reminds her of her young man at the front. I can't give Mr. Berry another Hot Plate, as he already has one, but he deserves one for producing a flame "that isn't there!"

From Glover's Calendar of the 13th inst.—Gertie (on shift): "Murphy, bring a floorcloth and a pail. The chief says the main is leaking!"



Festive Gent: "Orl right, Ole Feller (hic), I ain't a bally 'ostile Haircraft."

* * * *

I am relieved to find that the war is going to reduce the length of business letters. The following notice, received in a letter from a well-known firm of cable makers, is most welcome:

To meet the difficulty (due to the war) of greatly increased clerical work and decreased staff, we ask those with whom we correspond to kindly excuse our communications being of the briefest description.

Now I look forward to some gems of abbreviation: some which will bring letter writing to the level of the telegram composer's art. At any rate, there should soon be no more of "your esteemed communication of —— has safely reached us and is now before us. The matter will be given our earnest consideration in due course, &c."

* * * *

OUR HOT-PLATES.

No. 212 to—

The Edison & Swan Co. for its optimism in sending us a notice of its electric fir— FANS!! (U - - - - -gh!)

* * * *

THIRTY-SEVEN YEARS AGO.

[From The Electrician (Second Series), June 14, 1879.]

A Church at Wrexham Struck by Lightning.—A fearful thunderstorm broke over the town of Wrexham about half-past three on Sunday last, during which the spire of St. Martin's Church was struck by lightning. At the time of the catastrophe Mr. Aspinall was conducting a class in a room at the base of the spire. He was knocked down by the lightning, and his trousers split, but luckily escaped without any further injuries; but we regret to say that five of the scholars were burnt, three of them so severely that they were carried to the Infirmary at once, and one had his leg broken. There were a number of ladies conducting classes in another part of the church who were so alarmed that they fled through the rain, leaving hats, cloaks, bonnets and umbrellas behind them.

"DURADUCT."
The most durable flexible Woven Conduit made for protection of Electrical Conductors.
HIGHLY FLEXIBLE. LESS COSTLY THAN OTHER TYPES OF CONDUIT.
GREAT MECHANICAL STRENGTH AND INSULATING RESISTANCE.
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golslplat, Ox., London." 4746 Gerrard.

SIEMENS

ELECTRIC MOTORS



Part of small Motor Shop, Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood Bldgs.
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

ARTISTIC THEATRE LIGHTING.

How far the artistic treatment of theatre lighting has advanced may be gauged by comparing the accompanying photographs with one's recollections of the theatres of earlier times. They illustrate the main portions of the Criterion Theatre, Sydney. In the general

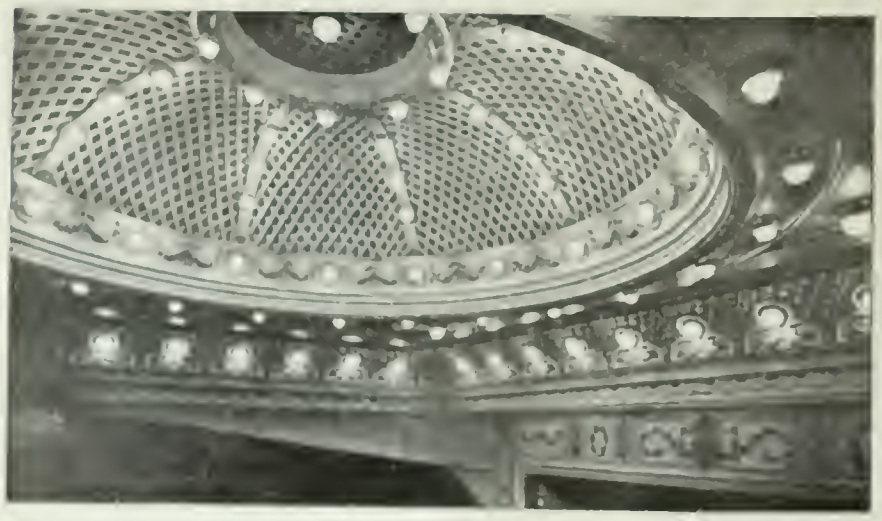


FIG. 1.—THE DOME.

lighting of the auditorium liberal use has been made of ceiling fittings, there being in all 174 of these, 110 8 in. Equiluxo hemispheres and 64 similar hemispheres 12 in. in diameter. The arrangement of these fittings contributes to the general design by throwing into relief the lines of the dome and at the same time gives a flood of well diffused light. Similar fittings are used for the illumination of the stalls, the lamps forming the centre decoration in the ceiling panels.

Partial use of ceiling fittings is also made in the illumination of the dress circle, but it is confined to the lower sections. Towards the back of the building, where the ceiling is lighter, semi-indirect lighting is adopted with effective result. The fittings are of oxidised silver, with Equiluxo bowls and Osram Atmos lamps. In the boxes fittings of a similar design, but with a smaller diameter, are installed.

In the vestibule the fittings are, as will be seen from the photograph, of a more elaborate character. The pendant shown has a large central light and joins subsidiary lights, each in Equiluxo urns



FIG. 2.—THE STALLS.

of Doric design. The metal work is in Grecian bronze and Osram Atmos lamps again are used. On the landing leading to the dress circle another ornate fitting is installed—a gilt colour brass pendant



FIG. 3.—DRESS CIRCLE.

with six lights around one central globe of "Superlux" glass. Ceiling fittings are again adopted at the side entrance and the top of the stairs. These fittings have a central 12 in. Equiluxo bowl and



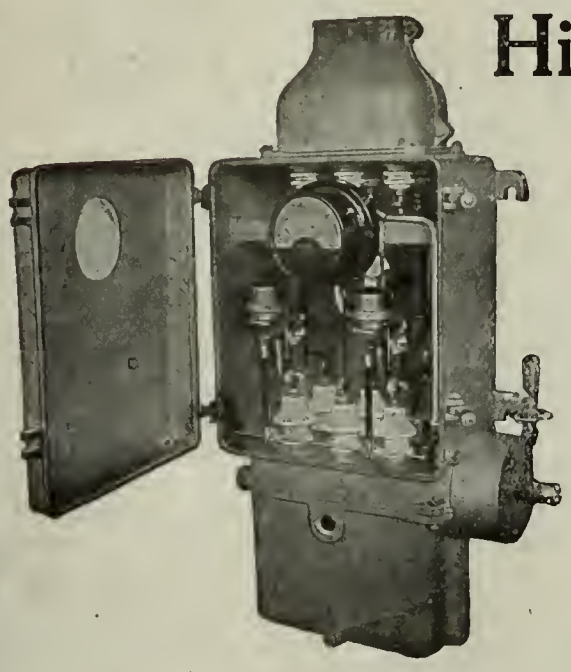
FIG. 4.—THE VESTIBULE.

three subsidiary pendants. They also are made of gilt colour brass. We are informed that local opinion on this installation is that it has made the theatre the best lighted in Australia. The whole

FURNACES for MELTING WHITE METALS, Etc.
Hall's Patents
AUTOMATIC HEAT CONTROL. MELT WITHOUT OXIDATION
PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Also Heat-Controlled Furnaces for Heating the Moulds.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham.

The Electric & General Works, Ltd.,

15, Victoria Street, London, S.W.



OPEN.

High Tension Switch Boxes

for 3,000 and 6,000 Volts.

TRIPLEPOLE AUTOMATIC OIL-SWITCH.
DOUBLE INTERLOCKED DOOR.
OVERLOAD & UNDERLOAD RELEASE.
AMMETER.
INVERSE TIME LIMIT ATTACHMENT.
FIRE-DAMP SAFETY DEVICE.



CLOSED.

Other Types for all purposes.

ELECTRICAL APPARATUS up to 80,000 Volts.

Telephone: 5223 VICTORIA. Telegrams: "GABIONAGE VIC. LONDON."

installation, fittings, glassware and lamps was carried out by the British General Electric Co. (Ltd.), which represents the General Electric Co. (Ltd.) in Australia. It may also be noted that all the fittings are selected from the company's stock, which includes such a wide variety of styles and sizes that practically every problem in decorative illumination can be suitably solved.

EDISWAN FANS.

Once again there is every indication of a good fan season, and those firms that are in a position to supply during the next few weeks will do well to circularise the local hospitals, doctors, nursing homes, authorities, &c. We have had a copy of the latest Ediswan fan list forwarded to us from which we illustrate a few of their leading lines. Figs. 1 and 2 show the Ediswan steamship and train fan (C.C.) in two different positions. The essential feature of this fan is its special combined supporting device and connection. One or more supports can be fitted in each cabin or saloon, so that the passenger can fix the fan to his own requirements, whilst by means of the swivel and trunnion movement the fan can be set to blow in any desired direction, from the roof, floor, or table.



FIG 1



FIG 2



FIG 3



FIG 4



FIG 5

Fig. 3 shows an Ediswan ceiling fan (C.C.) which is specially built for large halls, cinema theatres, clubs, institutions, &c. It is capable of energetically moving the air in a large radius without noise. An oil well fitted inside the body prevents oil from getting into the windings, and every part is substantially made from best material. Fig. 4 is the most popular model for convalescent homes, private houses, &c. Being convertible it can be used either as a bracket fan or on the table, floor, &c. It is one of the most silent fans on the market and is fitted with a regulator giving three speeds. Fig. 5 illustrates an "Ediswan" porthole fan (C.C.) This fan is specially built for factory ventilation and can be easily fitted to all existing buildings—the cast-iron ring may be fixed in a suitable aperture in the wall, window, or ceiling.

INSULATION BEADS

The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.

HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.

A GOOD EARTH



The Paragon Earth Cone has proved to be the most efficient and safest earth yet devised. It saves money to instal and saves worry afterwards. It is a hollow cone of pure copper perforated to give ample discharge points. It is filled with charcoal which attracts and holds the moisture. Wherever a reliable earth is required the Paragon Cone meets the case.

SCHOLEY & CO., Ltd.,

56, VICTORIA STREET, S.W.

Manufacturers of

PHOSPHOR BRONZE,

GUN METAL, MANGANESE BRONZE,

Brass & Copper

Tubes, Sheets,

Rods, Wire, and

CASTINGS.

PHOSPHOR TIN.

PHOSPHOR COPPER.

TRADE MARK.

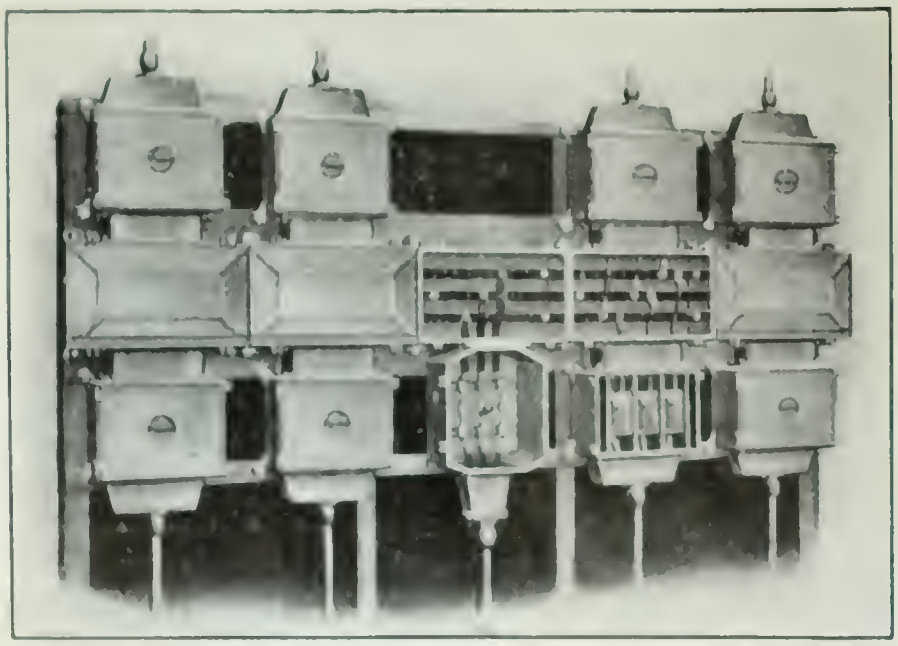


CHARLES CLIFFORD & SON, Ltd.

BIRMINGHAM.

AJAX GEAR AND FLUVENT FUSES.

The issue of a complete catalogue of their products by Parmiter, Hope & Sugden (Ltd.), Manchester, will, we feel sure, be welcome to consulting engineers, contractors and power installation men. The list in addition to containing full descriptions of "Ajax" ironclad



A Fluvent Ironclad Three-Phase Board

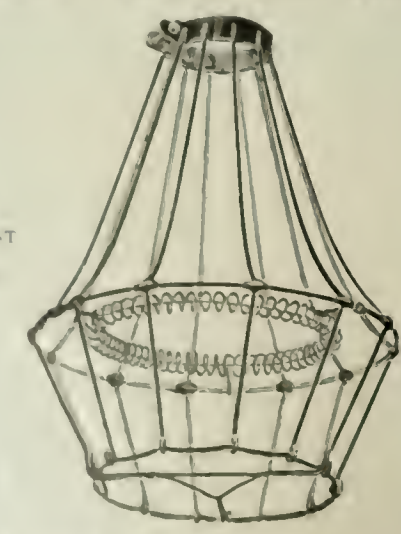
switchgear and the "Fluvent" fuse system, gives prices of each of the separate switches and fuses and of complete boards. The book is divided into two main parts which deal respectively with the foregoing apparatus. The "Fluvent" fuse system occupies 24 pages, and the chief merits of this ingenious fuse are pointed out. We have described the fuse on several occasions, but we may recall the fact that it differs from any existing type in that the fuse wire is placed diagonally in the fuse tube and not parallel with its axis, as is the case with other types. A remarkably short fuse wire is the result and also a very compact fuse holder. The reduction of the length of the fuse wire also greatly deduces the amount of heat generated by the fuse; another important point is that copper wire in air reaches a dull red heat at about 75 per cent. of its blowing current, but in the Fluvent fuse this temperature is only reached with 89 per cent. of the blowing current. Power engineers will realise the value of being enabled to wire up a number of fuses to run at currents quite near the fusing current without fear of premature blowing and without dangerous overheating. The "Fluvent" fuse can itself be used as a switch to break a circuit up to its maximum capacity, the arc being subdued or blotted out by the thickened extension of the porcelain handle, the cold china satisfactorily putting out the arc.

The contacts of the Fluvent fuse are placed at the side of the fuse bridge and not at the ends. The fixed spring clips are also placed parallel to one another on the terminal base, and when the fuse is in position it is claimed that a strong magnetic field is set up which assists in the blowing out of the arc when the fuse blows in the fuse handle.

These Fluvent fuses are now offered built up in ironclad form for two and three-phase circuits. A standardised arrangement of the terminals of the fuses and the cable entries has been effected, and any form of conductor can be brought in and neatly connected up through suitable glands or sealing troughs on the iron box. Recently the company has also incorporated their spring break switches in conjunction with these Fluvent fuses in one iron box. Similarly, they offer complete power centre distribution boards in which the bus bars, the fuses, the connecting links and the switches are all built up in ironclad form. This design of gear is exceptionally neat and compact, it complies with the Home Office regulations, and it provides a satisfactory and efficient means of grouping feeders and distributors at suitable points for supplying electrical energy to motor and lighting circuits in factories.

"L.P.S." ACCESSORIES.

The adjoining illustration shows a new design of lamp guard which the L.P.S. Electrical Co., 18, Adam-street, Strand, London, W.C.,



The Holdfast Lamp Guard

are putting on the market. The makers claim that the patented spring cushion absorbs shock and vibration and prevents breakage of the lamp at the neck. Between the cushion and the guard there

Life!
Look at my head — not a hair on it + still full of life!
Yours resiliently,
Pope's Elasta.



ELASTA BRITISH MADE WIRE

Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, N.W.

GREENLY

EDISWAN
EVERYTHING
ELECTRICAL

THE ALL-BRITISH
HOUSE FOR ACCESSORIES

ROYAL
"EDISWAN"
DRAWN WIRE LAMPS

CATALOGUES ON REQUEST
FROM THE
EDISON & SWAN
U·E·L CO., LTD.,
PONDERS END
MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06 - 27712/03 AND OTHERS

J. P. DEVINE CO., BUFFALO.

MANUFACTURERS OF

Vacuum Drying and Impregnating Plant.

(PASSBURG SYSTEM.)

The Devine Co. are well known in the United States and Canada as the leading manufacturers and experts in Vacuum Drying and Impregnating Plant and have over 1,500 such plants in successful operation.

AIR PUMPS, COMPRESSORS,
VULCANISERS,
CONDENSING PLANT.

Solvent Recovery and Derisinating Plant a Speciality.

Sole Representative:

JAMES LIVINGSTON, LTD.,

30, GT. ST. HELENS, LONDON, E.C.

Telegrams and Cables:
"CINERARY, LONDON."

Telephone:
LONDON WALL 3151.

IRONCASED SOCKETS & PLUGS

FOR HARD SERVICE.

Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.

Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,

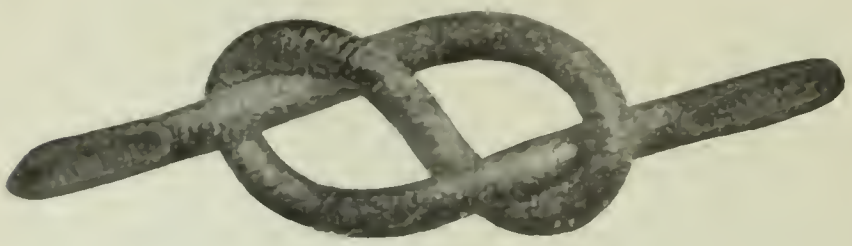
Ordsal Electrical Works,

SALFORD,

MANCHESTER.

...an inch clearance, which is sufficient to protect the lamp from external shocks. By means of the special trap lock the lamp is secured in position in the holder and cannot be removed by any unauthorised person. The lampguard is offered in a variety of sizes for the protection of the smallest and largest sizes of both carbon and metal filament lamps.

We also illustrate a short section of a type of flexible conduit which the same company is putting on the market. This is known as



SECTION OF "DURADUCT."

'Duraduct,' and comprises a type of woven fabric which is smooth inside and outside and which can be used for protecting all classes of interior insulated wire. This conduit is offered in sizes from ... in. diameter upwards, and we understand that early delivery can be given by the L.P.S. Electrical Co., who will furnish prices and further particulars on request.

B.T.-H. ISOLATING SWITCHES.

The type ... isolating switches dealt with in descriptive list No. 4,120 have been designed for use on high tension systems where it is necessary for purposes of inspection, cleaning or repair, to disconnect certain portions of the circuit from the mean supply.

These switches are intended for isolating purposes only and are, of course, not suitable for opening circuits through which current is passing.

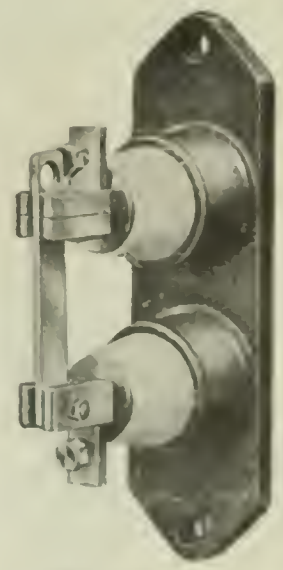
The switches are manufactured in the forms shown in the following table:

Volts	Form	Amps.	Description.
1,000	B2	50, 100, 200, 300, 400, 600	Single or double throw lever switch.
11,000	A	100, 200, 300, 400, 600, 1,200	Single or double throw lever switch.
6,000	C	200, 300, 400	Single throw rotary switch.
11,000	D	20	Single throw lever switch.

All switches, except Form D, are constructed throughout of wrought copper, except the blocks carrying the blades on Form C switches, which are substituted castings. The blades and contacts are carried on white porcelain insulators presenting a smooth surface, which is not liable to mechanical injury and which can be readily inspected and cleaned. On Form D switches the blade and clips are of br...

The Forms A and B switches are generally similar in design to ordinary lever switches, and are mounted on porcelain insulators. The insulators are arranged either for building into walls or passing through 2 in. barriers: they can also be mounted on cast-iron bases which are bolted to a wall or framework. Switches can also be supplied, if required, with insulators suitable for passing through 4½ in. or 9 in. walls. On single-throw switches, either of the switch contacts may be front or back connected. On double-throw switches the hinge contacts are always back connected.

The switches are designed so as to be operated by means of insulated hooks, which are furnished with specially treated wood insulating handles of various lengths. The clip contacts on the switch are flared so that the switch blade can easily be guided into them. The interlocking type of switch is suitable for isolating the equipment in an oil switch cell: as, by means of the rotating shaft, the isolating switch, oil switch and cell door can be readily interlocked. It is thus possible to embody the following features in the equipment of the switch cell: (1) The isolating switch cannot be opened unless the oil switch has first been opened. (2) The door of the cell cannot be opened unless the isolating switch is open. (3) The isolating switch cannot be closed until the cell door has been closed.



200 AMP. I.B.2 SWITCH ON C.I. BASE.

It is often necessary to mount isolating switches in positions where there may be a danger of the blades tending to open either by gravity or on account of the electro-magnetic effect due to large rushes of current. To obviate this the switches can be fitted with safety spring catches. These catches, however, are only required on systems where heavier currents are liable to flow.

Rotary isolating switches (Form C) are intended for use on three-phase systems, and are triple pole. They are manufactured in four forms, depending on the voltage for which they are suitable and on the distances by which the three phases are separated from one another. The blades for each phase are mounted on porcelain insulators on a common shaft, so that a quarter turn of the shaft operates all three blades together. The Form D provides an inexpensive means of isolating the leads to high tension potential transformers so that a fuse can be renewed without shutting down the circuit. The switch, which is of the lever type, is of simple construction, and the blade consists of a round brass rod hinged at one end, while at the other it is bent round to form a ring, so as to make it suitable for operating with an insulated hook as previously described. The switch is mounted on insulators, which can be built into walls or fixed on cast-iron bases, and the contacts are arranged for front connection only.

The dimensions of all these switches are given in the descriptive list mentioned, a copy of which may be obtained from the British Thomson-Houston Co., Rugby.

One, Two & Three Phase MOTORS.

LANGDON-DAVIES MOTOR CO.

Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

FERRANTI LTD

Central House, Kingsway, London, W.C.

SWITCHGEAR, TRANSFORMERS, METERS, ELECTRIC HEATING & COOKING APPARATUS.

Write for Binder "N."

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, June 16, 1916.

THE ROUND TABLE.

By "KVA."

"Municipal Engineering" seems somewhat indignant that the reports of gas and electricity committees fail to show a reduced consumption owing to the operation of the Summer Time Act. The burthen of our contemporary's complaint is that the Act was framed to effect a saving in these commodities, and it does not seem to have done it?

* * * *

Thus a gaseous contemporary—*i.e.*, a contemporary devoted to gas:—

The conditions promoting down-draught are somewhat obscure and complex; but they are frequently (though not universally) due to the relationship of the affected chimney to some external object which acts as a check to, or alters the course of, the current of the wind.

For instance, a passing aeroplane or the lodger going out in a tiff and banging the door.

* * * *

Although this is I.M.E.A. Convention week the first meeting is not held until Thursday, before which time the "Round Table" will have been "put to bed." I cannot say, therefore, who are, or who are not, attending. I hope Seaton will be there (if he is not called up; his eternal sparkle suggests youth) and say something about "disgruntled Diesels, the glamour of guarantees and the tendencies of turbines to turn again and rend you." I shall, however, be too late to warn him not to repeat his Coventry 1914 reference, now historic, to "Barney's Bull."

* * * *

THIS WEEK'S CHESTNUT.—Two R.E.'s, billeted behind the lines "somewhere in France," were recently served with ham and eggs by *la mère*. Unfortunately, the ham had seen better days, and it was necessary for the R.E.'s to bring the matter to the notice of the good lady responsible; but though the spirit was willing, the French was weak. Finally one of the boys "struck a bright." *La mère* was called in and the linguist of the party, holding the unsavoury dish under her nose, said in his best French: "*Je suis*!"

(Large Martell, please.—KVA.)

* * * *

I will forget for the moment how many years Mr. S. E. Fedden has been pushing the Sheffield municipal electricity department along the road of progress. Yet his City Council, with war parsimony only in view, *waste time* in discussing a niggardly honorarium of £100 to him for his efforts in extending the plant to cope with the colossal demand for "power." "Observer" in the "Sheffield Daily Telegraph" pays Mr. Fedden the highest possible compliment when he writes, "It may be that Mr. Fedden does not possess all the personal graces which enable some heads of departments to obtain whatever they desire." Thank Heaven, engineers are in no need of "personal graces," and Mr. Fedden must feel immense satisfaction in not being placed among "some heads of departments" who are content to remain charming, but obviously selfish, personalities and nothing more.

From a recent catalogue dealing with electric vehicles:—

No true lover of animals will be sorry to hear that the horse is being rapidly *suspended* as a motive power in haulage and delivery work.

Since when was the suspension of horses not a matter for lovers of animals to be sorry about?

* * * *

I believe the electric fire makers have squared the clerk of the weather. In spite of the gallant effort of "Ediswan" to introduce fans last week, the G.E.C. bring out a "Magnet" fire poster! If I were a contractor I would put a fire and a fan in the window and have them under the control of a thermostat,



"SOMEWHERE IN ENGLAND" IN THE MERRY MONTH OF JUNE!

either the one or the other being switched on according to the weather prevailing at the time. Local interest could be aroused by a sweepstake as to which would do the more work! To crown it all Drury Lane produces a "Razzle-Dazzle" Revue with a real ice skating rink!

* * * *

OUR HOT-PLATES.

No. 213 to

Mr. Gordon Bryant, electrical engineer, Great Yarmouth, for stating (when asked if he had slept in the borough since the last meeting) that he had done so *partly*.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), June 21, 1879.]

VOLUNTEER CAMPING AND THE ELECTRIC LIGHT.—The British Electric Light Company have arranged to light up the camp of the 3rd Northamptonshire Volunteers at the end of the present month.

THE SYDNEY EXHIBITION.—The works are being actively continued. At night the electric light is used. It is stated that the opening of the Exhibition is to be postponed from Sept. 1 to Oct. 1.

ELECTRIC LIGHTING IN ST. PETERSBURG.—The Municipal Council under the presidency of M. le Baron Koff, in its sitting of May 30, decided on erecting electric lights by the Jablockkoff process at several points in the city, particularly on the great bridge of Citernaya.

IGRANIC

Series Lock-out Automatic Starting Panels.

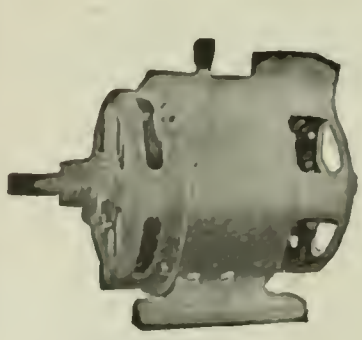
Fitted with patented two-coil magnetic lock-out switches ensuring quick action, posilive lock-out and positive closing and sealing. Will not stick or become sluggish.

Simple, robust and reliable in operation. Laminated brush contacts and copper to copper sparking tips. Patented plug for adjusting the current limit without using an ammeter.

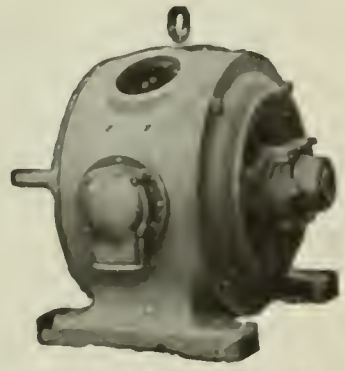
IGRANIC ELECTRIC Co. LTD 147, Queen Victoria Street, LONDON. Works: BEDFORD.

SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for
ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

"THOR" High Grade Specialities

CASING and CAPPING
CONDUIT
CABLES
CABLE CONNECTORS
COMMUTATOR COMPOUND
WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.
WRITE FOR PRICES & DISCOUNTS.
HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

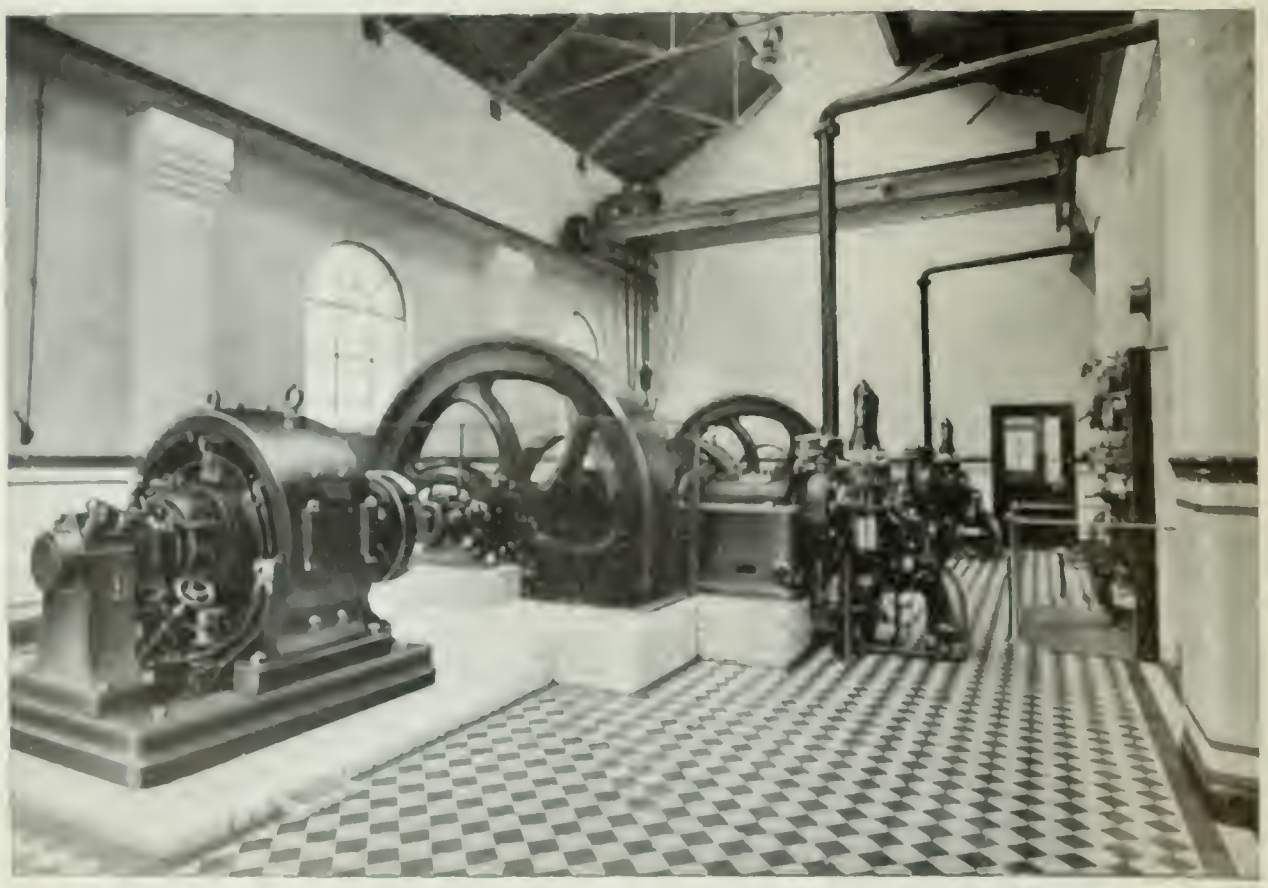
GAS AND OIL DYNAMOS.

We are reminded by the issue of a new set of catalogues of their gas and oil engines by Crossley Bros. (Ltd.) that there exists a wide field in which suction gas and oil and paraffin engines can be utilised both for the driving of dynamos for lighting and power purposes and for the direct operation of machinery. The Crossley internal-combustion engine needs no introduction at our hands, for, if nothing else, it was one of the earliest prime movers to be developed specially for dynamo driving, when belts were in vogue and such a thing as a direct-connected gas dynamo was considered impossible. The name Crossley has been associated with gas-engine building for over 40 years, so the preface to one of the catalogues reminds us, and during that time we have ourselves recorded their efforts in the production of these engines for the driving of dynamo electric machinery. Of later years refinements in metallurgy and improved workshop methods have contributed many notable improvements to the details of the Crossley gas and oil engine.

For the driving of dynamos, the company's improved throttle governing gear is worthy of note. The "hit or miss" governor is an obviously crude device for the purpose in view. With the throttle governor a positively graduated impulse can be assured for every working stroke, and silent running and freedom from irregular and violent shocks can be obtained. With this form of governor the compression pressure and the pressure of the ignited charge are reduced on lighting loads, a fact which the makers claim contributes to the greater life of the engine. In the catalogue three engine diagrams, taken at full, half and light loads, are reproduced to make this point clear.



A TYPICAL ANTHRACITE SUCTION GAS PLANT.

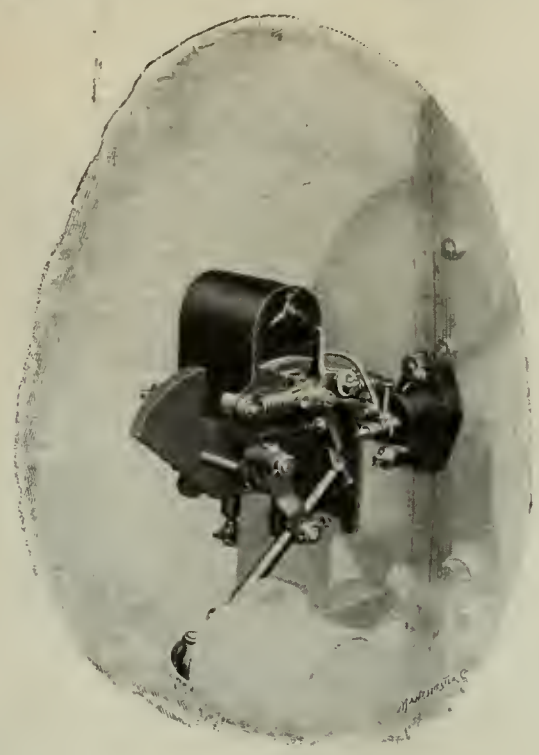


ENGINE ROOM SHOWING TWO LARGE CROSSLEY GAS DYNAMOS.

Compared with the "tube" ignition of a score of years ago, the magneto ignition gear of the modern Crossley is virtually a luxury. Both high and low-tension magnetos are fitted according to the size and type of the engine, or, alternatively, in accordance with the wishes of the customer. In both cases the magneto is actuated from suitable cam gear on the lay shaft. Provision is also made in both cases for advancing or retarding the spark. In the magneto the spark is produced in the cylinder head by make and break contacts, and the rocker spindle is designed for special lubrication, regardless of the heat given off at this part of the engine. The low-tension "sparking

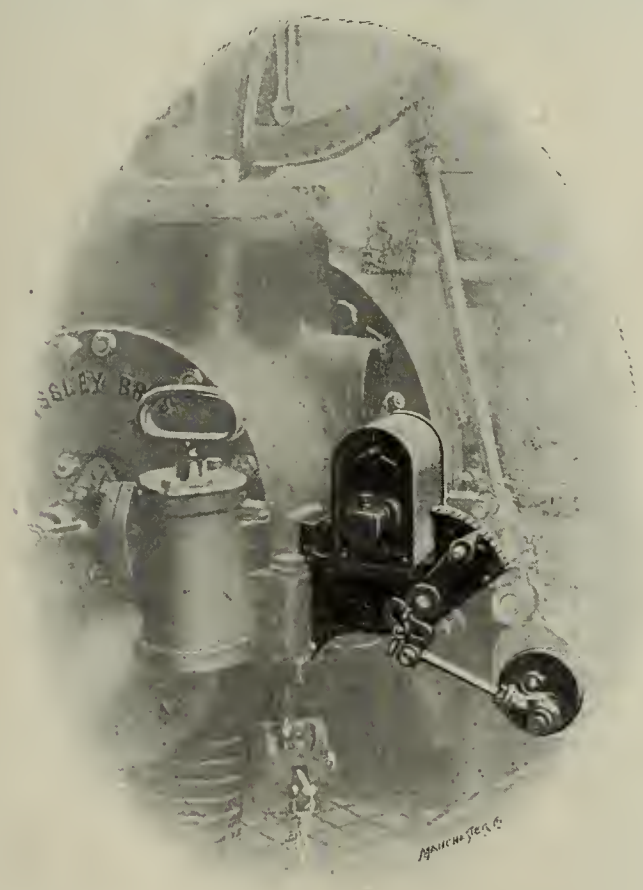
plug " is made up as a unit piece, and can be removed by the withdrawal of two nuts.

A considerable portion of the catalogues referred to is devoted to descriptions and illustrations of Crossley gas plants for anthracite, wood refuse and bituminous coal. All these types have been in



SIDE VIEW OF L.T. MAGNETO.

service for a number of years, and the added experience of practical operation has enabled the company to introduce numerous improvements. The poker, for instance, passes parallel to the brick work, so that the stoker knows when an obstruction is encountered that it is clinker, and not the brick work itself, as would happen with



END VIEW OF L.T. MAGNETO SHOWING SPARK ADJUSTMENT.

poker holes at an angle. Also the plates comprising the stepped grate are outside the angle of repose of the fuel, so that none of the fuel will of itself fall from the grate ; below the bottom plate the fuel rests on its own bed of ashes.

ELECTRIC HEATING AND COOKING IN GLASGOW.

A combination of factors has led during the past few years to the increasing adoption of electrical appliances for heating and cooking purposes. The introduction of a special rate for heating and cooking in 1910 got rid of the wiring difficulty, with its attendant inconvenience and expense to consumers. According to this rate all energy used for heating and cooking, beyond the amount normally taken for lighting purposes, is charged at $\frac{3}{4}$d. per unit, the whole

CONSIDER THIS ABOUT

SIMPLEX CONDUITS

They are made entirely by a British firm who possess the largest Works of any manufacturer of Conduit Wiring material.

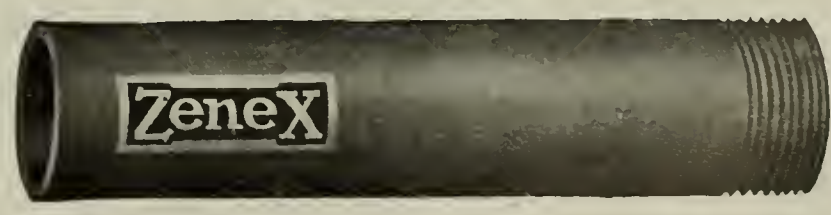
The only firm supplying from stock ZENEX finish Conduit.

Every possible type of fitting supplied for a complete wiring installation.

Skilled advice is always obtainable where laying down plant and Country house installations, etc.

The Simplex Conduit Wiring system makes a thoroughly sound engineering job, complying throughout with all mechanical and electrical requirements.

Booklet describing our new processes sent on request.

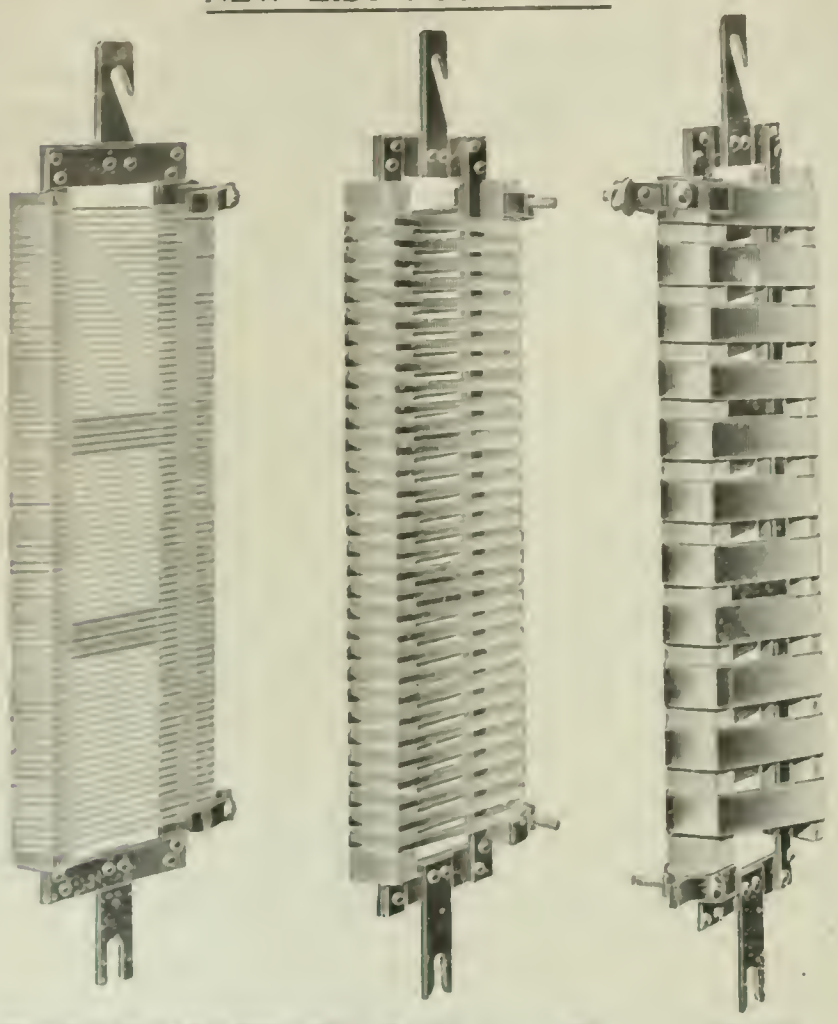


Simplex Conduits, Ltd.,
Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd., W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

RHEOSTATS

NEW LIST POST FREE.



ISENTHAL & CO.

DEPARTMENT 4

DENZIL WORKS, WILLESDEN, LONDON, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

consumption being recorded on the lighting meter. Precautions are, of course, taken to ensure that the wiring will carry the extra current for the heating apparatus.

Publicity work, propaganda and canvassing have been developed gradually. Smoke abatement exhibitions were held at intervals, and the latest electrical devices were displayed in the various short-time trade exhibitions, but the results, although fairly encouraging, seemed to indicate that something further was necessary to educate the mass of the public as to the possibilities of electricity for heating and cooking. Everything pointed to the need for a permanent showroom where a thoroughly representative and up-to-date selection of electrical heating and cooking appliances could always be accessible for the inspection of that section of the community to whom such apparatus is most likely to appeal. About a year ago the Glasgow Corporation electricity department, with the full knowledge and approval of the Scottish Electrical Contractors' Association, took a lease of commodious premises in Sauchiehall-street, the city's most popular thoroughfare, and these premises were carefully equipped and furnished as a showroom for the display of the latest electricity consuming devices. The delay in opening the showroom in Glasgow, while it postponed the large increase in the domestic load which would otherwise have taken place, has enabled the Glasgow showroom management to benefit by the experience of other towns where showrooms have been in existence for some time, and the result is that the Glasgow showroom is easily the largest of its kind in the kingdom. The gas department showroom, armed with a liberal hiring system, has familiarised the public with every kind of gas consuming device, but in the absence of properly organised means of demonstrating similar electrical apparatus electricity consumers continued to be sceptical of the advisability of using electricity for any domestic purpose other than lighting. In this respect the establishment of the showroom is meeting a very real want. Practical experience shows that electric heating and cooking appliances and electrically driven domestic labour saving devices only require to be adequately shown to be appreciated. The central showroom, under the ægis of the Corporation, is the easiest and most economical means for the display of a comprehensive range of apparatus, and so far as Glasgow is concerned this fact is being increasingly recognised by the electrical contractors of the city, who send their clients to the Corporation premises to the advantage alike of the supply authority and the contractor.



Exterior View.



The Front Show Room.

It was anticipated that the outbreak of war would have a deterrent effect on the further use of electrical apparatus, but the sequel has falsified these prophecies. In fact, the converse has been the case. In November of 1915 the threatened coal famine followed by the abnormal rise in the price of fuel, gave the showroom its

Why should the Manufacturer or trader who takes proper precautions and looks after the safety of his employees pay the same premium for his Employers' Liability Insurance as the man who takes no interest and adopts no safeguards ?



Before Renewing

your

EMPLOYERS' LIABILITY INSURANCE

Ascertain if you can effect a saving.

IF your business is well conducted,
IF you employ competent supervisors and foremen,
IF you have established proper means of protecting your Machinery, etc.,
IF your "past claims experience" has been light—

You can probably Save Money.

BECAUSE the British Dominions General Insurance Company gives individual attention to each risk, special regard being paid to any features which reduce the hazard involved.
Because though "on paper" the description of trade given on any two proposals may be the same, yet in actual fact the hazard to be covered in each case may be very different. The Company recognises this fact, and by carefully considering the conditions of each case on its own merits and by giving full credit to all favourable details, is able in many cases to make a substantial reduction in the premium.
Because the "Security" given by the Company cannot be challenged. Its reserves exceed £1,000,000.
Because the Company has a specially efficient "Claims Organisation," which not only saves the employer from all worry, trouble and anxiety in respect of claims, but which at the same time enables it to minimise the "claims cost" of the risk, putting the case on a most favourable footing, and thereby entitling it to "minimum rates" of premium.

Make a Test Enquiry: submit your case for Expert Examination and Advice. Write for Special Brochure Dep. EL. No. 81

THE BRITISH DOMINIONS
General Insurance Co., Ltd.,
British Dominions House, Royal Exchange Avenue, London, E.C.

RESERVES EXCEED £1,000,000. APPLICATION FOR AGENCIES INVITED.

AS/81

VULCANISED INDIA-RUBBER

CABLE

DELIVERIES FROM STOCK.

WM. GEIPEL & COY. HEAD OFFICE: ST. THOMAS STREET, LONDON, S.E.
CABLE WORKS: WEMBLEY, MIDDLESEX, LONDON.

opportunity. Not only were many electric fires placed from week to week, but steady sales have been effected for soldering irons, sterilisers, clothes washing machines, radiant heat baths, geyser water heaters, pitch boilers, hot air blowers, immersion heaters, coffee percolators, kettles, teapots, grill stoves, laundry irons, fans, radiators and ovens. Complaints from consumers either with regard to the failure of the apparatus or the amount of the electricity bills have been negligible, and easily handled. The behaviour of the electric fires has been particularly satisfactory. Element trouble is gradually being eliminated, and the conviction grows that electric heating has come to stay. Cost is not the prime consideration with many consumers, and to these the showroom makes a very ready appeal.

The ground floor of the showroom is laid out as a demonstrating hall, and here the possibilities of electric cooking are shown to large audiences of specially-invited ladies, the demonstrator holding the teacher's diploma of the West of Scotland School of Domestic Science. This is purely propaganda work, and although several large cookers have been installed in domestic premises and works, business in this branch will not be large until a hiring scheme has been put into operation. The contractors are coming to see that it will be an enlightened policy to second the efforts of the Corporation in this matter.

The first flat of the showroom is furnished as an electric house, and includes dining room, drawing, bedroom and bathroom.

When the load on the station grows by leaps and bounds due to the demand for power supplies to munition works the additions to the load resulting from the activities of the showroom are apt to be overlooked, but a reference to the published figures with regard to the growth of the heating and cooking load for domestic premises gives some idea of the work that is really being done. In 1910 the number of domestic consumers using electricity for purposes other than lighting was 583 and their total consumption per annum was 250,000 units. To-day the parallel figures are 3,000 consumers, with a total consumption of 1,500,000 units.

During the eight months the showroom has been open it has been the means of adding the equivalent of over 1,400 kw. of apparatus to the heating load. In addition to this a number of the contractors in the city, who hitherto have not stocked material, have begun to carry stocks and are doing an increasing business in heating and cooking appliances.

The establishment of munition works has given an excellent fillip to electric cooking. In factories making munitions steam continues to be used for boiling, but in certain cases where gas is not available roasting and grilling are carried out by electrical apparatus. In connection with the Princess Louise Hospital for limbless soldiers, a very complete installation of electric cooking apparatus is being put down, and this when completed will be one of the best installations of the kind in the country.



The Demonstration Hall.

THE TAYLOR STOKER.

Almost every industry is concerned with the savings that can be made in the operation of steam plant. There still remains a great deal to be done in order to secure that overall efficiency which is so essential to economical production in factory or workshop. In the boiler house the most serious losses are, as a rule, sustained. Engines, turbines and steam engine plant are generally nursed and watched with commendable care, but there is not often the same engineering skill applied to those obscure losses that arise between the coal pile and the stop valve. Thousands of tons of coal are wasted annually, and labour is used in the tending and maintenance of steam raising plant which could more profitably be employed in other directions. To-day, when our resources in material and labour need to be conserved with the greatest care, these facts become of national importance. When we shall so soon be called upon to re-establish ourselves in the world's market, every suggestion and every system that bears on the subject of economical production of finished material will need to be scrutinised with the most scrupulous care.

Hand firing is hardly justifiable under any conditions, and mechanical stokers—though they are multifarious—will seldom fail to justify their installation. The Taylor stoker has become world famous because it increases the capacity of the boiler; it burns fuel efficiently; it has low maintenance costs; it reduces operating cost.

The marked changes which the Taylor stoker has accomplished in combustion practice is, we understand, due to two fundamental features of operation. The first of these is underfeed, the second automatic cleaning. The mechanical and structural details on

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

ABOUT SECOND-HAND ELECTRIC MOTORS!

If your requirements cannot be filled by manufacturers quickly, why not consider a second-hand machine?

Is it on account of the danger of buying a "pig in a poke," or because you believe that second-hand motors are not reliable?

Your objections are justifiable—unless you buy from the firm who dismantle, overhaul, put in thorough working order, and submit every machine to a **full load test for a considerable period** before they deliver.

Under the above conditions, which are complied with by **THE VICTORIA ELECTRIC PLANT CO.,** it is not only quite safe to purchase second-hand motors, but **you save money** and obtain **immediate delivery.**

THE VICTORIA ELECTRIC PLANT CO. supply **Motors equal to new,** with a written guarantee, cheaply and expeditiously.

If you are in the market you can avoid the delay of weeks or months in waiting for new motors, by sending your enquiry to:

THE VICTORIA ELECTRIC PLANT CO.,

Spenser Street, Victoria Street, Westminster, S.W.

Telephone: Victoria 4026.

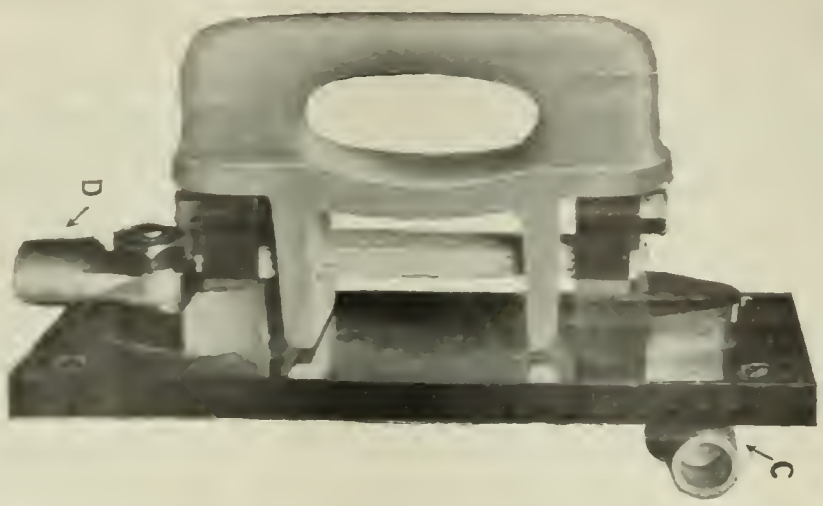
Suppliers to the War Office, Ministry of Munitions, &c., &c.

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

which these two operating features depend are seen in the accompanying illustrations.

The furnace bed is constructed of alternate coal retorts and tuyere or air boxes. At the end of each retort is a pair of rams operated by a crankshaft. Fuel is fed into the hoppers from above, flows downward, where it meets the impact of the upper ram, which pushes it outwards and upwards into the furnace, distributing it in the coking zone. The lower ram helps to move the fuel bed towards the rear of the furnace. The forced draught is supplied through the openings of the tuyeres. The fire burns downward and is continuously supplied with fresh fuel from the coking zone beneath and combustion maintained by the air permeating the combustion zone from below. The fuel bed is inclined and the ash rejected automatically by force of gravity.

There is a good heat distribution in the furnace, and this is obtained by a proper proportioning of draught and coal supply, so that no matter how rapidly the coal is fed in, there is always the proper amount of air to incandesce the freshly-fed fuel. Further, there is a constant and automatic cleaning of the fire by gravity. As a result, the Taylor stoker will drive boilers at high capacities, and will not waste fuel when giving an increase of 50 to 100 per cent. It is claimed that many boilers provided with Taylor stokers are to-day working at capacities for short periods up to 300 per cent. of the boiler-maker's rating without causing any injury whatever to the boiler.

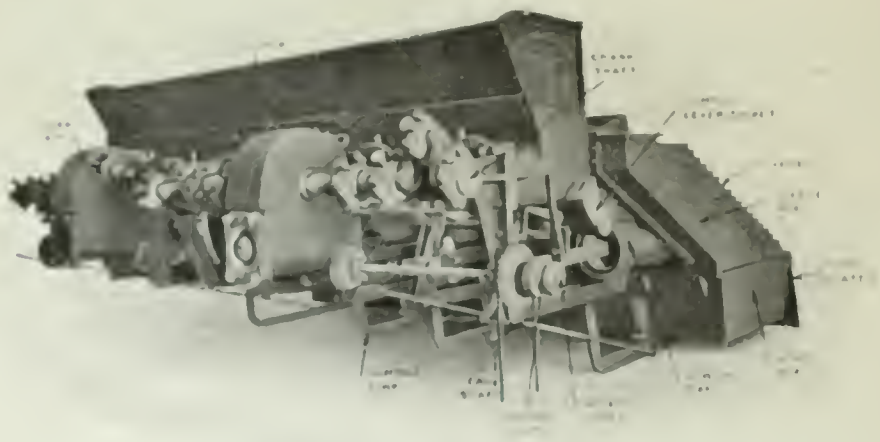
All the fuel is burned and all the heat is brought into effective contact with the boiler tubes. One electricity undertaking has stated that with the Taylor stoker it doubled its capacity without adding any further boilers, and at the same time lessened its coal bill by 10 per cent. per kilowatt hour.

The "Electrical World," in its issue of June 19, 1915, speaking of a large municipal plant, said: "The boiler units themselves are also especially interesting since they present a conservative example of the present trend towards very large boiler outputs. Each of the boilers is rated at 1,000 h.p., but in ordinary service can be operated at three times this rating. The boilers are equipped with Taylor stokers." The "Electrical Review and Western Electrician," of June 11, 1915, in describing the Interborough Rapid Transit plant at New York, says: "Taylor stokers are being installed in place of the old ones, it being calculated that while under the old engine conditions a maximum of 1,150 kw. per stoker was obtainable; under the new conditions 3,750 kw. will be satisfactorily carried."

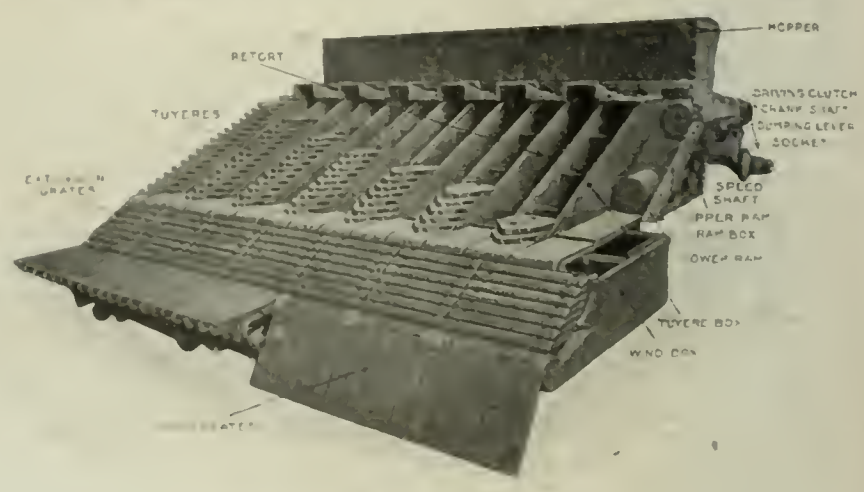
The Taylor design is simple and strong, both inside and outside the furnace. Inside the furnace—and this is a point of the greatest importance—there are no moving grates, plates, or automatic slice bars: in fact, no moving parts whatever. Gravity accomplishes the cleaning operation. The tuyeres are strong and simple, are always protected by the green coals shoved from beneath and cooled by the air pouring through them. The outside mechanism, crank shaft and rams, is strong, simple and in plain sight. The gears are interchangeable and run in an oil bath; speed shaft-gears are enclosed in a dust-tight compartment. A shearing pin between driving clutch and sprocket wheel protects the crank shaft, sprockets, &c., against breakage in the rare cases when a foreign substance in the coal jams one of the rams. The upkeep of the Taylor stoker, we gather, costs often less than 6d. per boiler horse-power per year. As no arch is required, the maintenance for brickwork is eliminated.

The labour cost is low, because the operations ordinarily performed by hand are, with the Taylor stoker, accomplished mechanically. As already stated, coal flows by gravity into the hoppers, from the hoppers into the retorts, from which the rams push it out into the furnace. These rams are operated by a crank shaft driven from an engine or electric motor. Air is supplied from a blower and forced up into the fuel bed through the tuyere openings. The plant can be arranged so that the engine which drives fan and crank shaft is controlled by the pressure in the main steam line: falling pressure automatically speeds up the blower and rams, thus accelerating the fire and restoring the pressure. The fuel-bed being inclined, the ash is drawn by gravity out of the combustion zone and deposits on the dump plates.

The foregoing details are taken from a booklet on the Taylor stoker issued by Scholey & Co., 56, Victoria-street, London, S.W., who are the agents on this side for the stoker.



FRONT VIEW OF TAYLOR STOKER.



FURNACE VIEW OF TAYLOR STOKER.

LEAD MELTING FURNACES

Hall's Patents

For Cable and Pipe Presses, Accumulator Grids, etc.,

WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.

ENORMOUS SAVING IN RESIDUE.

MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

FERRANTI LTD

Central House, Kingsway, London, W.C.

SWITCHGEAR, TRANSFORMERS, METERS, ELECTRIC HEATING & COOKING APPARATUS.

Write for Binder "N."

Printed and Published by the Proprietors, "THE ELECTRICIAN" PRINTING AND PUBLISHING CO., LTD., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, JUNE 23, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE I.M.E.A.—Mr. F. Ayton (hon. sec. Electric Vehicle Committee) steadfastly refusing to buy a copy of "The Electric Vehicle," which a fair maiden was offering for sale in the *foyer* of the Institution.

* * * *

BON MOT OF THE WEEK'S NEW BOOKS.—"British railway administration—God save the mark!—constitutes the most colossal and impudent swindle in human history; a swindle which has peers of the realm among its perpetrators, Cabinet Ministers for its tools and the entire British community for its dupes and victims."—Henry Murray, in "The Railway Swindle."*

* * * *

Many well-known faces were missing among the Convention crowd last week. Seaton and Grogan were inquired for several times, and their respective "lay sermons" and "extractives" would have contributed to the merriment of the unofficial as well as the official gatherings.

* * * *

Congratulations to Mr. F. M. Long upon his elevation to the I.M.E.A. peerage, the presidential chair for 1916-7. I hope the war will enable the clans to foregather in Norwich, the city of churches, canaries, Colmans (mustard), and the birthplace of Mr. Long's own famous system of charging.

* * * *

President Cramb looks more like the late Lord Kitchener than ever, though his voice breaks down the resemblance rather badly. That versatile municipalite, Alderman Smith, of Liverpool, who always makes himself heard, complained to me of the way "in which some of these engineers get up and then mumble in their beards, breasts or boots." Speakers (?) with a guilty conscience will please note this aldermanic admonition, and do better at the next Convention.

* * * *

I can vouch for there being no connection between the newspaper headlines last week :—

THREE CHAMPAGNE ATTACKS

and the I.M.E.A. Convention, because there were no (official) functions this year. Indeed, one Bailie has returned to his native "'burn" a sadder and wiser man, for he paid 1s. 8d. for a whisky and soda at a famous hostel not far from the Institution!

* * * *

At the small munitions works at which I now do three days a week a lot of gas is used on the soldering table and at the tool furnace. When the Gas Light & Coke Co.'s man came to read the meters the other day he lighted his way into the dark corner, where they tick off the cubic feet, with a mat— an ELECTRIC pocket flash lamp. Has this matter been brought to the attention of the British Commercial Gas Association, or would Mr. Wordingham regard this as intelligent co-operation between the gas and electric interests?

* London: Grant Richards, 2s. 6d.

MY AUTO 'TIS OF THEE.

My auto, 'tis of thee,
Short cut to poverty—
Of thee I chant.

I blew a pile of dough
On you two years ago,
And now you quite refuse to go,
Or won't or can't.

Through town and country-side,
You were my joy and pride;
A happy day.

I loved thy gaudy hue
Thy nice white tires so new,
But now you lose at least one screw,
Most every day.

To thee, old rattlebox,
Came many bumps and knocks;
For thee I grieve.

Badly thy top is torn,
Frayed are thy seats and worn;
The whooping cough affects thy horn,
I do believe.

Thy perfume swells the breeze,
And good folks choke and wheeze
While we pass by.

I paid for thee a price
T'would buy a mansion twice,
Now everybody's yelling "ice"—
I wonder why?

The motor has the grip,
Thy spark plugs have the pip,
And woe is thine.

I, too, have suffered chills,
Ague and kindred ills,
Endeavouring to pay my bills
Since thou wert mine.

Gone is my bank-roll now;
No more 'twould choke a cow,
As once before.

Yet if I had the mon,
So help me, brother John—
I'd buy another car I swan,
And speed some more.

* * * *

OUR HOT PLATES.

No. 214 to—

Mr. W. T. Kerr (Hereford), for his excellent and most timely Paper on "The Application of Electricity to Agriculture" before the I.M.E.A.

No. 215 to—

Councillor Longford, for his practical contribution "as an electrical farmer" to the discussion on Mr. W. T. Kerr's Paper, and for telling a story about "the curate and the eggs."

* * * *

THIRTY-SEVEN YEARS AGO.

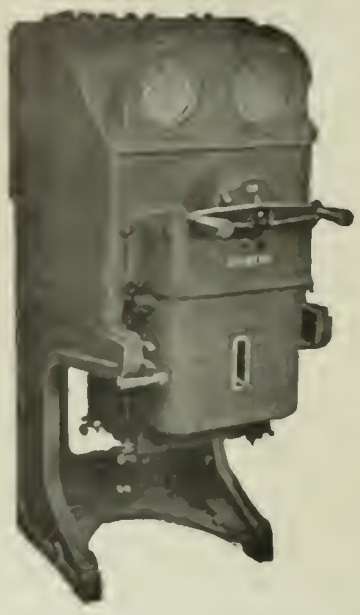
[From THE ELECTRICIAN (Second Series), June 28, 1879.]

THE BROOKS UNDERGROUND TELEGRAPH CABLE.—The system of Mr. Brooks differs from all others in the fact that the material employed for maintaining the insulation of the line is a liquid—paraffin oil—which is known to possess, for this purpose, qualities of the highest order; and in laying it the wires—30, 40 or 50, as may be required—covered with cotton binding, are placed in an iron pipe, conveniently located, and the pipe line filled with oil, allowed to run in until full, the maintenance of the supply being assured by providing an elevated vessel of the material at intervals, so that a constant pressure will be kept within the pipe. This is practically all there is about it, and its extreme simplicity appears to be not the least of its merits, as one of the great objections advanced by the advocates of the past system has been the great expense of laying and maintaining underground lines.

"DURADUCT."
The most durable flexible Woven Conduit made for protection of Electrical Conductors.
HIGHLY FLEXIBLE. LESS COSTLY THAN OTHER TYPES OF CONDUIT.
GREAT MECHANICAL STRENGTH AND INSULATING RESISTANCE.
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golslplat, Ox., London." 4746 Gerrard.

SIEMENS



IRONCLAD SWITCHGEAR FOR ALL PURPOSES

Control Pillars
Distribution Boards
Main Switchboards

Illustration shows our Standard Cast-iron Mining Pillar suitable for pressures up to 3,300 volts.

Write for particulars to —

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: CERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs
CLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

INSULATION BEADS

The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.

HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.

"UNIVERSAL" TABLE UTENSILS.

The mammoth posteard describing B. & K. "Universal" electric table accessories should be a great inducement to contractors, central station engineers and those electricity consumers who receive it independently to purchase one or other of the highly artistic and very useful designs of apparatus which are priced and illustrated. The publication is intended mostly for the consumer's eye, and doubtless is being distributed by the company among lay users of electrical energy. The apparatus illustrated is made up of an electric kettle, mission pattern samovar, the latter being fitted with a teaball attachment, an electric egg boiler, electric iron de luxe, curling iron, coffee percolator, toaster and four-heat grill. There is also an illustration of a coffee urn set known as the Colonial loving cup pattern. This is an attractive design which would make a very acceptable wedding present. A view of this is shown in Fig. 1.

The "Universal" curling iron, illustrated in Fig. 2, is another handy accessory which many ladies will welcome, more particularly as there is provided with it a detachable comb which heats up when slipped over the solid member of the iron and can be used for drying the hair.

In Fig. 3 we illustrate the "Universal" round radiant grill, which is offered as a useful accessory either for the breakfast table or the kitchen. It will be seen that this comprises a circular and fixed section which contains the heating element and three-pin terminal board. This is the electrical portion of the grill. Four degrees of heat are obtainable with the four loadings, 140 watts, 250 watts, 310 watts and 560 watts. The utensils, which form a separate part of the grill, comprise three circular pans, one shallow, one deep and one extra deep. The shallow pan can be used as a cover to either of the other two, or it may be employed directly over or under the heating element. It is claimed that a great variety of dishes can be prepared with this simple apparatus. There is a list of 25 of these given, but we may quote the following as appealing to English tastes: Griddle cakes, chops and steaks, fried or grilled bacon, ham and eggs, toasted cheese, omelettes, asparagus on toast, fried potatoes. Those of our readers who are not yet familiar with this grill should take an early opportunity of either writing to or paying a visit to the Brompton & Kensington Accessories Co., Earl's Court-road, London, S.W.



FIG. 1.—"UNIVERSAL" COFFEE SET—COLONIAL LOVING CUP PATTERN.

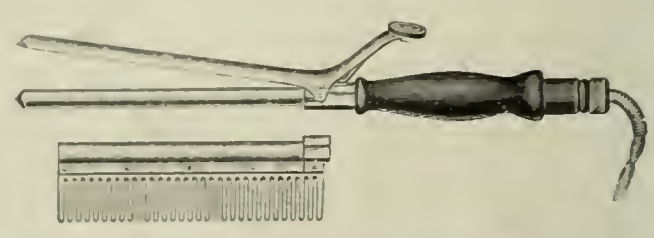


FIG. 2.—"UNIVERSAL" CURLING TONGS AND COMB.

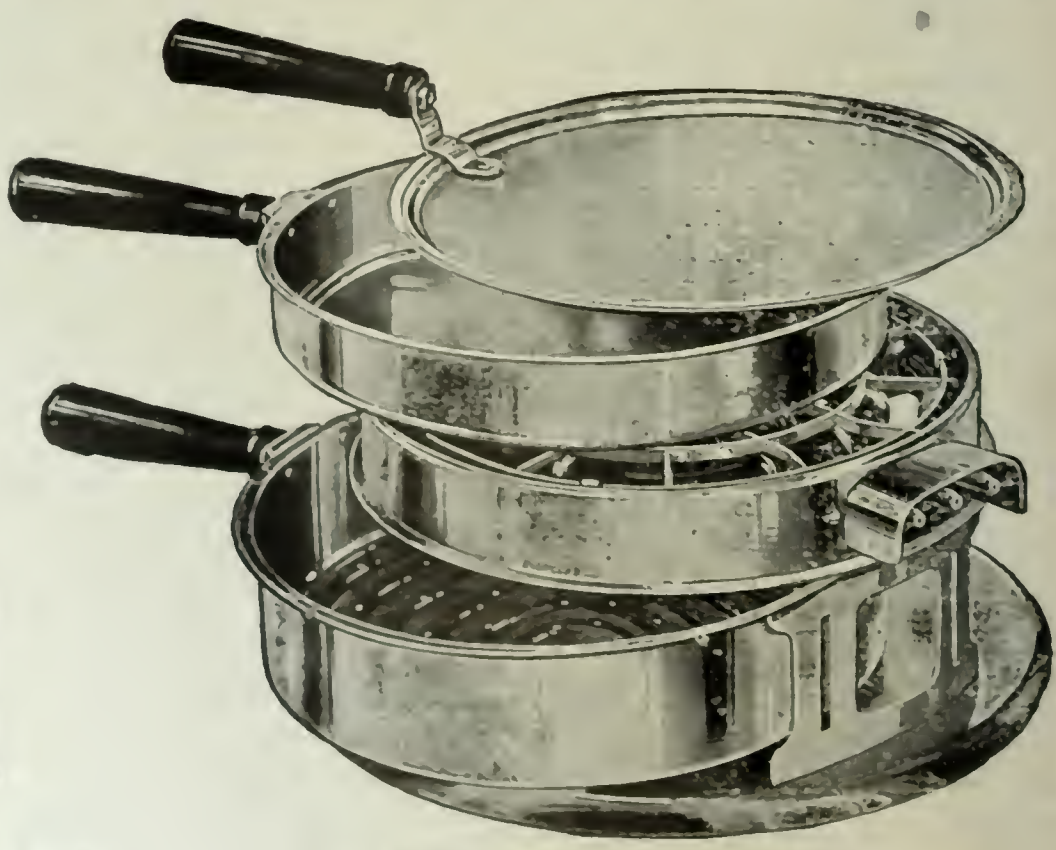


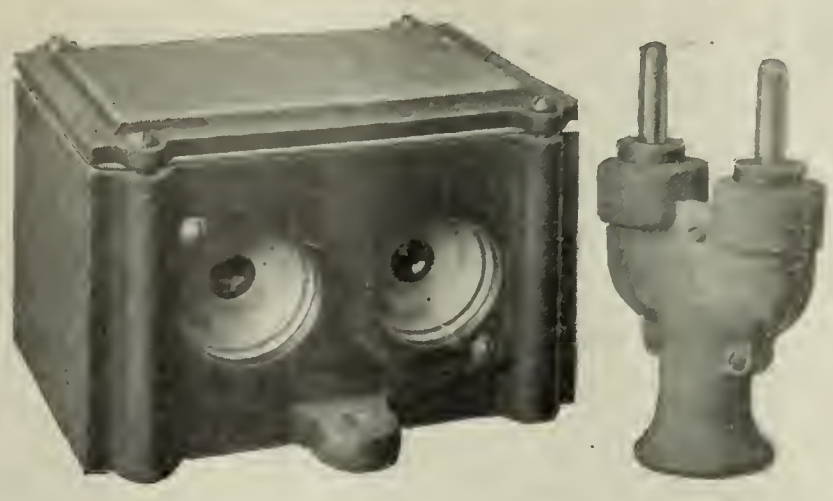
FIG. 3.—"UNIVERSAL" ROUND RADIANT GRILL.

IRONCASED SOCKETS & PLUGS

FOR HARD SERVICE.

Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.

Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,

Ordsal Electrical Works,

SALFORD,

MANCHESTER.

IRONCLAD SWITCH FUSES.

The totally enclosed ironclad switch fuses, type EK, form B, comply with the latest regulations issued by the Home Office. They are described and priced in list No. 4,310 just issued by the British Thomson-Houston Co. (Ltd.), Rugby. The switches are suitable



60 Ampere Switch Fuse (closed.)

for A.C. or D.C. circuits up to 700 volts, and are made double-pole and triple-pole in 20 ampere and 60-ampere sizes. The cases can be earthed with safety under all conditions. The switch fuse is totally enclosed in a cast-iron case with an external operating handle. The



20 Ampere Triple-pole Switch Fuse (open).

fuse clips and terminals are mounted on substantial porcelain bases which are fixed into the cast iron box, and insulating barriers are fitted into this box to prevent any possibility of arcing between poles or between the fuse clips and metal case. Movable parts are carried by the hinged cover, so that all parts are accessible when the case is open. Details of construction are clearly shown in the illustrations. A quick make-and-break action is ensured by means of a tension spring, but positive action in either direction is secured by means of a mechanical kick. The switch can only be left full on or off, and is locked in either position. The fuses can be removed, re-wired and



60 Ampere Switch Fuse, with Conduit Fittings.

replaced very quickly, but this can only be done when the circuit is broken and the cover open. Instructions for re-wiring are given on the inside of the cover. The cover cannot be opened until the circuit is broken; neither can it be closed with the fuses in the "on" position; consequently no parts of the fuse links and mechanism can be



60 Ampere Switch Fuse, with Connection Shields.

touched until they are isolated from live metal. Machined hinges are provided, and a good joint is secured by means of packing let into the cover. The case can be fitted with adapters for screwed conduit for incoming and outgoing cables, and these adapters can be supplied to suit conduit running vertically or horizontally.

When switch fuses are required for panel mounting they can be

One, Two & Three Phase MOTORS.

LANGDON-DAVIES MOTOR CO.

Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK.
SEA CLIFF
CHARLES CLIFFORD & SON, Ltd.
BIRMINGHAM.

To Inventors, Patentees and Others.

A controlled firm of engineers having an extensive plant of light machinery are able to manufacture one or two articles in addition to the work they are now doing for the Government.

They will be glad to consider undertaking the sole manufacture, and, if desired, the selling organisation, of one or two good specialities of use during and after the war.

Address: W.H.C., "Electrician" Offices, 1, 2 & 3, Salisbury Court, Fleet Street, London.

fitted with shields for protecting the connections from the fuse terminals to the back of the panel. Sealing chambers for armoured or unarmoured cables can be supplied if required. Wood bushes are fitted to the case where the leads pass direct from the terminals. Continuous-current switch fuses for capacities above 30 amperes 250 volts are fitted with magnetic blow-out attachments on the top contacts. The list is now being circulated, and a copy may be obtained from the company on application.

THE SECOND-HAND MOTOR.

Whatever was the commercial status of the second hand motor before the war, it has undoubtedly improved to a remarkable degree since. An unprecedented demand for electric motors, new or second-hand, has arisen since the organisation of the production of munitions, and naturally the second hand machine, where it can be obtained, has been in favour.

So far as the general number of second hand motors are concerned there has not been much reason for complaint as to their being sold under legitimate circumstances. Instances are, however, on record in which unscrupulous persons take advantage of the unwary and ignorant buyer and sell him a machine which fails to comply with even the legend on the name plate. The proverb for the buyer in case of this kind would seem to be, "Never judge a second hand motor by its name plate." If this is done there may be trouble. We recently had occasion to realise that this may be so after going over the premises of the Victoria Electric Plant Co., Spenser-street, Victoria-street, Westminster, London, S.W. This company has recently been formed to carry on business as dealers in electrical plant and machinery, chiefly second hand, and has set itself a high standard in the handling of motors, dynamos, starters, &c. Ample accommodation is provided on the premises for the stocking of motors of sizes ranging up to 50 h.p., and the firm make a feature of prompt delivery. Each machine which comes into the hands of the company is taken down and thoroughly cleaned. The bearings are adjusted, the commutator turned up if needed, the brush gear overhauled, the windings varnished, and all connections tightened up. After reassembly the motor is given a full load run for at least an hour, a Walker dynamometer of the latest pattern being used for this purpose. The legend on the name plate is in this way checked, and the machine afterwards offered to the customer at its true rating.

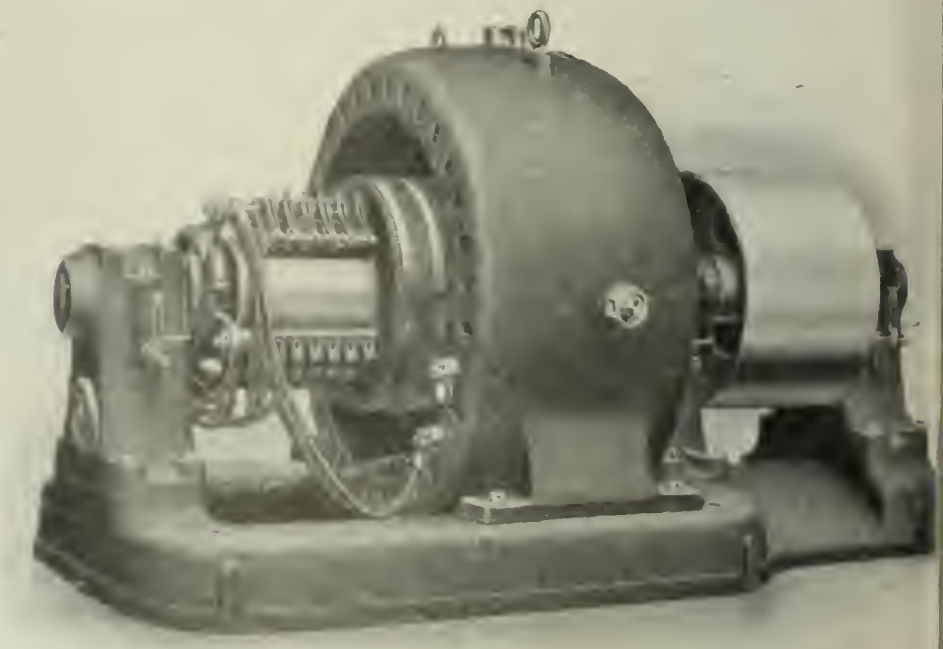
The company does not let the matter rest at this rejuvenating process, but gives the purchaser of any machine a written guarantee that it will furnish its rated output and run satisfactorily, providing always fair treatment.

We understand that during the past six months the Victoria Plant Co. has handled some 1,500 h.p. of motors of various sizes, and that among its customers it can claim the War Office, the Ministry of Munitions, numerous electricity supply authorities and many munition works. Those of our readers who are likely to be in the market for second-hand d.c. motors should give the company a look up. Messrs. Bloodworth & Brevig are the principals, and they will be found men who know the good and bad points of electric motors. They have both been for some years on the manufacturing and selling sides of the motor business, and in this respect differ from some of the dealers in this class of plant.

BROADBENT C.C. GENERATORS.

We have received a copy of catalogue No. 5 from T. W. Broadbent (Ltd.), Huddersfield, in which they describe their D type generators for continuous current.

These are well-built machines of the highest efficiency, and are cool and sparkless in operation. Unless otherwise ordered, every machine is connected so as to run in a clockwise direction, looking at the pulley end. The standard windings are 115, 230 or 460 volts;

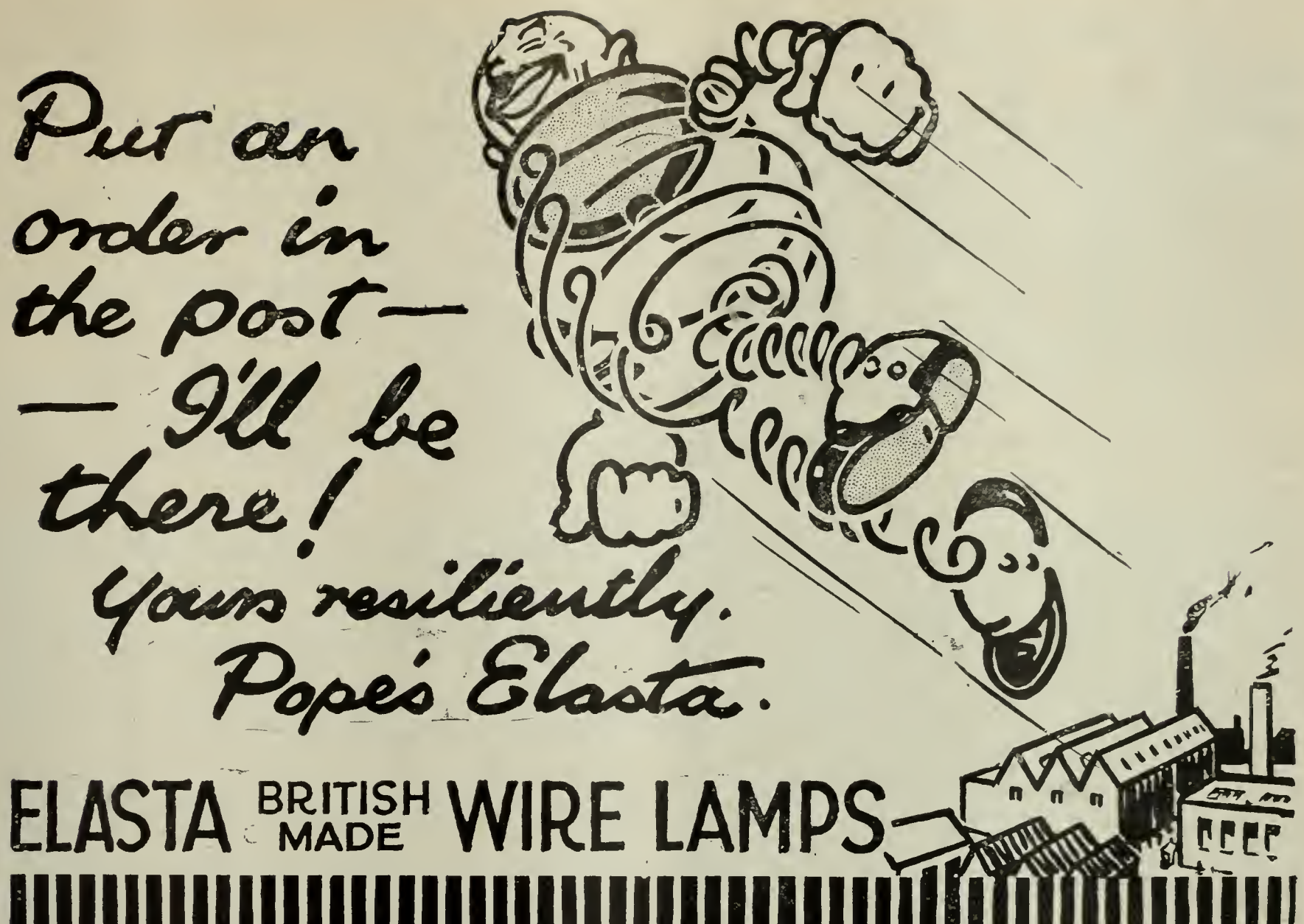


Broadbent D Type Generator.

the 460 volt generator is of a modified design, being fitted with commutating poles. The shaft is of best mild steel, accurately turned to gauge. The armature is of the toothed-drum type, and the D 18 and all larger size machines have ventilating ducts and spaces to ensure cool running. The coils are former wound, and thoroughly impregnated with insulating varnish. The commutator is of large diameter with ample wearing depth, and is tested, mechanically and

TINNING FURNACE
Gas or Petrol
For COATING WIRES with Tin, Lead, etc. For use as a BATH.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
The only Tinning Plant on the World's Market with Automatic Heat Control
Over 1,000 already in use.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

FERRANTI LTD
Central House, Kingsway, London, W.C.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.
Write for Binder "N."



Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W. GREENLY

electrically, before being connected to the armature. The field is steel-clad, and in the larger sizes is fitted with laminated pole-pieces. In the D 95 and D 160 sizes the magnet yoke is divided horizontally. The field winding may be either compound or shunt, as required, and the field coils are former wound. The commutating poles are proportioned so as to ensure sparkless running, even under severe working conditions. The cores and tips of the commutation poles are of soft steel or high permeability.

The bearings are of large diameter. and have an actual length of from $2\frac{1}{2}$ to 3 diameters. Automatic oiling rings are fitted to every bearing, and there are oil gauges and drain taps. For the larger sizes split bearings are used. The brush rocker is adjustable, and in the larger machines is provided with sensitive rack-and-pinion adjustment. Carbon brushes and brushholders of improved design are used throughout. Except in the five smallest sizes (which have bracket bearings), the machine is built on a substantial cast-iron bedplate.

Each machine before despatch is subjected to the usual load test; it is flashed with four times its working pressure, between the windings and carcase; and its insulation resistance is measured.

The generator will work at its specified output continuously, without undue heating and sparklessly; and for half-an-hour with an overload of 25 per cent. without injurious heating or sparking. It will work within the limit of temperature rise specified by the Engineering Standards Committee. The company offers to make good, free of charge, any defect due to material or faulty workmanship, should such arise in a machine within a period of 12 months from date of despatch, it being understood however that the cost of carriage to and from the works is to be borne by the client.

The catalogue referred to, which also gives prices and dimensions, may be obtained from the company on application.

"EDISWAN HOSGOOD UTENSILS."

An inexpensive line of stoneware utensils fitted with integral heating elements is being put on the market by the Edison & Swan Co. Stoneware jugs and casseroles were introduced by the American manufacturers some few years ago, but in their new leaflet (No. H.3143) the Edison & Swan Co. make a point of the fact that these very useful articles are now made in England.

One of the chief advantages of stoneware is the absence of risk from shock, which may be said always to be present with metal



Types of Stoneware Utensils.

utensils. The selection of designs put forward by the company is considerable, as a glance at the adjoining illustrations will show. The prices of the articles are quite moderate, ranging from a one-

H. WEIDMANN, Ltd., RAPPERSWIL, Switzerland.



WE ARE SPECIALISTS IN THE MANUFACTURE OF—

PRESSPAN (3)

(PRESSBOARD)

Best Quality. Proved by repeated tests.

Sheets in thickness from 0·1 upwards.
Endless Rolls and Strips from 0·1 to 1 mm. thickness.

Presspan Coils and Tubes for Transformers.
Presspan Armatures, Discs and Shaped Articles.

VARNISHED PRESSPAN. BLACK PRESSPAN.
OILED PRESSPAN. MICA-COVERED PRESSPAN, &c.

Silver Medal: Paris 1900. Grand Prix: Marseille 1908. Gold Medal: Berne 1914.

pint, one heat boiling jug at 6s. 6d., to a coloured casserole of 6 pints capacity and having two heats, at 21s. subject. The loading of the utensils ranges from 350 watts to 600 watts; in the two-heat vessels the half heat is anything from 150 to 300 watts, according to size.

The heating element is of the band type wrapped round the lower part of the vessel, and the ends are brought out to a bayonet cap connector which will take an ordinary lamp holder.

NEW T.L.A. DISCOUNT SCHEME.

Our readers will, we think, be interested to have details of the new T.L.A. lamp discount scheme which has just been inaugurated. New schemes are liable to failure because they are not thoroughly understood, and in order to avoid this, two booklets have been issued, one of which deals with the scheme from the point of view of the trade reseller and the other from the point of view of the trade user. These booklets are now being distributed to a number of our customers, and Messrs. Siemens Bros. Dynamo Works, who have sent us the details, will be pleased to supply copies to any of our readers who may be interested in the purchase of Wotan and other makes of T.L.A. lamps.

The scheme is based on the quantity of lamps purchased and delivered during 12 months, and the discounts are regulated in accordance with certain stipulated minimum quantities or equivalent net money values. The money values are introduced to cover half-watt type lamps which, as our readers will recall, are higher in initial cost than the ordinary lamps. The total annual turnover in all makes of T.L.A. lamps will, therefore, regulate the terms at which Wotan, half-watt type or Tantalum lamps or other T.L.A. makes can be supplied. The booklets referred to give an example of the method of procedure, and the following remarks on the method of procedure, extracted from the trade re-sellers booklet, will help to explain the scheme.

The following explanation will doubtless assist you to thoroughly understand how the system operates. On July 3 you purchase either from us, or any authorised T.L.A. factor, 50 Wotan lamps at a discount of 20 per cent. off current list prices. On July 20 you purchase 150 Wotan lamps. On August 5 100 Tantalum lamps, and on August 25 a further 200 Wotan lamps. You would then be entitled on September 1 (which is the first date for claiming rebate following your total purchase of 500 lamps) to advise the Secretary of the T.L.A., Bush-lane House, Bush lane, Cannon-street, E.C., that you had purchased 500 T.L.A. lamps. This is the first step at which you are entitled to increased discount. He would then send you a T.L.A. agreement, and on your signing same you would be entitled to purchase Wotan, or any other Association lamps, at 22 per cent., instead of 20 per cent., discount as previously, and in addition would receive from your supplier or suppliers a credit note for the difference between 20 per cent. and 22 per cent. on the original 500 lamps purchased. Your discount and corresponding rebates would then go on increasing during the period of your agreement strictly in accordance with your aggregate purchases by means of the above procedure. Should your order consist largely of Wotan half-watt type lamps (or other Association makes of half-watt type lamps), you would then, of course, avail yourself of the net value figure instead of the minimum quantity, and claim on money value in precisely the same way as set out for quantity of lamps.

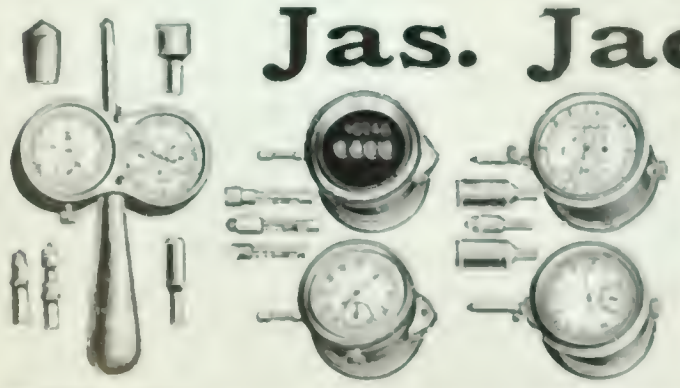
It will be observed that a new customer would commence to buy lamps at 20 per cent., but immediately his total purchases of T.L.A. lamps amount to 500 he would automatically become entitled to buy at 22 per cent. In order to avail himself of these terms he must notify the secretary of the T.L.A., and in addition he would receive from his supplier, or suppliers, a credit note for the difference between 20 per cent. and 22 per cent. on the original lamps purchased. As each succeeding step is reached the increased discount would be obtained by means of the same procedure.

There are, of course, a number of customers who were graded at a definite figure under the previous arrangement, and they will now receive the terms specified for a quantity of lamps based on their past purchases. This will bring them into the new scheme at approximately the discount to which they are entitled in accordance with their established turnover, and increased discount will be allowed should they improve on their previous figures.

The terms for the trade user have been somewhat revised, and if lamps are purchased in quantities of less than 50, a discount of 15 per cent. only is allowed. Providing the lamps are ordered in quantities of 50 and over for delivery at one time the standard schedule of discounts are applicable.

The scheme, therefore, has the merit of being equitable, and ensures to each trade buyer a discount directly in proportion to his turnover. As the discounts increase in a succession of easy steps the scheme should be an incentive to business extension. All invoices will be subject to one discount (*i.e.*, the one corresponding to the minimum quantity taken) plus the usual 2½ per cent. (cash) approved monthly account. This obviates the multiplicity of discounts, which are sometimes confusing, and often cause inconvenience and misunderstanding.

We offer our congratulations to Mr. S. H. Callow, manager, lamp department, Siemens Bros. Dynamo Works, who is, we understand, the originator of this interesting and valuable scheme.



Jas. Jaquet, Ltd., Basle
Switzerland.
Combined Revolution
Counters, with Chronograph.
Very Accurate Timekeepers.
CHRONOGRAPH AND STOP WATCHES.
Lists on Application.



Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London. Friday, June 30, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—"Glover's Almanac" celebrates its fifteenth birthday.

* * * *

Who dares speak of Imperial Liberty when one reads of "Wireless Chains?"

* * * *

I noticed among our press cuttings the other day one slip upon which our name was spelt "The Electrition." Perhaps the girl who wrote this was related to Mrs. Partington, who has already said that she knows that this is a war of "nutrition."

* * * *

"Cable, with stocking fitted, ready for drawing."

No, this is not taken from a summer sale advertisement; it is just a title to one of the many pictures in "Glover's Almanac."

* * * *

From the same source I also take the following:—

Works Manager: Want a job?
Lathe Hand: Thank ye kindly, sir.
Works Manager: Any particular line?
Lathe Hand (with "sarc."): Same as yourself, sir, screw cutter!

* * * *

A "gassy" contemporary writes thus: "Our old friend, Mr. H. H. Holmes, the energetic sales booster of the Marylebone electricity department, blossoms out in print again." I have heard that "the desert can blossom like the rose," but a booster if it's well made never blossoms; it does not even blush. Indeed, rather the "reverse," when it's "milking."

* * * *

The writer of Kitchen Rhymes in "Punch" evidently does not read the advertisements of the British Commercial Gas Association, for he (or is it a she?) writes as follows:—

FIRELESS COOKERY.

When I was young, in days long hence,
The heat of the kitchen was most intense,
But now, by the use of electric connections
Our cooks are able to keep their complexions.

"and"—as "Kukri" Grogan would have said, "also their extractives."

* * * *

During the I.M.E.A. Convention I understand that the discussion of a Paper on boiler-house lay-outs and stoker design was sufficient justification for the presence of so many engineers at the "Coal Hole!" (an adjacent hostel).

* * * *

The new T.L.A. (which, being interpreted, means Tungsten Lamp Association) scheme of discounts has brought into existence an Ediswan Ready Reckoner and a Britannia Discount Checker. Both of these are designed to save the poor lamp factor and contractor much cerebral activity in figuring out the price they ought to pay for their lamps if they are entitled to discounts A, B, C, D, &c. These labour savers should prove very useful in avoiding the "fifteen two, fifteen four, a pair six and one for his nob" methods which seem generally to prevail where T.L.A. lamps discounts lie in wait for the unwary and non-mathematical. I expect some other lamp maker will introduce a "hard drawn" slide rule for the same purpose guaranteed to withstand the strain even of a $47\frac{1}{2}$ per cent. discount.

The "Daily Chronicle," in its Office Window, says:—

Sometimes quite bright ideas reach us. Here is one from a correspondent anxious to do his bright bit:—The crystalline name "Anzac" is a monument more lasting than brass. Why not immortalise the prowess of those women who have kept the flag flying by becoming 'bus and tram conductors in similar fashion? Surely the Fates have forecast the following: L.C.C. (trams), the "Elsies"; M.E. (trams), the "Emmies"; L.C.E. (trams), the "Louies"; "General" ('buses), the "Jennies"; "Tillings" ('buses), the "Tillies."

To which I would add the "lady" munition workers, the "Millies," and the lady switchboard attendants, the "Fannies."

* * * *

The illustration shows a way they have with them in China, when laying electric supply cables. If it is inconvenient to go round a house in the path of the cable they go straight through it! Central station engineers please note. The photograph



was taken by Messrs. Henleys, whose cable was thus unceremoniously laid through this particular domicile, so they will perhaps supply details of the methods adopted to reconcile or coerce the inmates to have a real "live" cable as "one of the lodgers."

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), July 5, 1879.]

EFFECT OF PEROXIDE OF NITROGEN ON THE ELECTRIC SPARK.—It has been stated by M. Hempel that when a powerful electrical machine is in full activity, and giving strong sparks, the sparks can be made to cease and the machine to lose all tension if the red vapour of peroxide of nitrogen (N_2O_4) is allowed to escape into the space traversed by the sparks.

ELECTRIC LIGHT AT THE SALON.—The Salon closed at midnight on Monday. The electric light experiment, says *The Times*, attracted many visitors, but has not been an unmixed success. Portraits in general look well by it, but landscapes with grass or water have an unpleasing effect, and the large paintings, which are mostly failures, appear still more decided failures by artificial than by natural light.

ELECTRIC LIGHTING ON THE EMBANKMENT.—The Works Committee of the Metropolitan Board of Works have granted permission to the Société Générale d'Electricité to set up and work at their own charge a third pair of electro-dynamic machines in the engine house of the Victoria Embankment, with the object of further testing the power of the engine and the possibility of extending the distance to which the electric current can be conveyed for practical lighting.



SPECIAL RHEOSTATS FOR STARTING AND SPEED REGULATING.

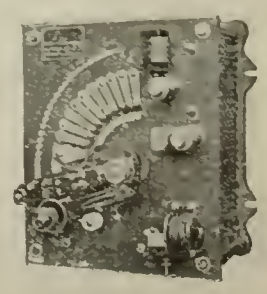
STANDARDISED BY

'IGRANIC'

ELECTRIC CO., Ltd.,
147, Queen Victoria Street, London.

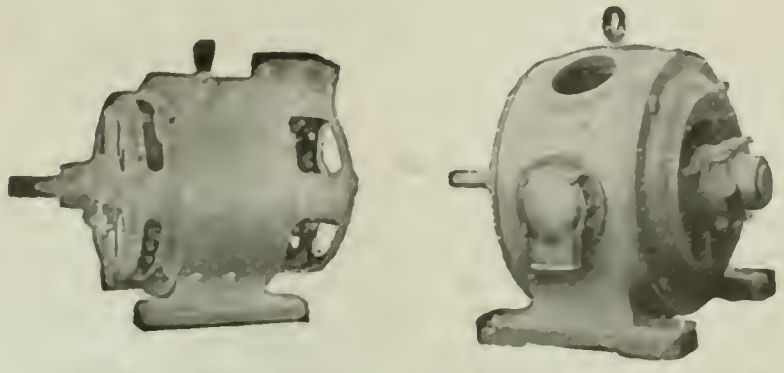
No. 27.—"Inching" Motor Starter for Printing Presses and Machine Tools. Heavily rated resistances, substantial segment contacts, carbon sparking rollers and Interlocked Circuit Breaker.

No. 38.—Starting Rheostat Interlocked with Shunt Field Regulator for variable speed motors. One handle both starts and regulates. Interlock prevents weak field when starting.



SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current. For Three-phase Current.

for
ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood Bldgs
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St.
GLASGOW—64, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

FURNACES for MELTING WHITE METALS, Etc.

Hall's Patents.

AUTOMATIC HEAT CONTROL. MELT WITHOUT OXIDATION.

PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Also Heat-Controlled Furnaces for Heating the Moulds.

MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham.

THE ELECTRIFICATION OF A MODERN FLOUR MILL.

An account of the electrification of a modern flour mill, previously driven by a single large steam engine, will be of interest to electric power engineers driving machinery, as well as to millers who contemplate a similar change in their methods of driving.

The original drive in this case was from a large horizontal engine on the ground floor of the main mill through one line of shafting on each of the four floors, the connection between them being by belts. The power was transmitted from the main shafting on the ground floor of the main mill through bevel gear to a horizontal shaft leading to the wing of the building containing the cleaning and conditioning machinery. Here the power was transmitted through bevel gear to a vertical shaft running upwards through the building and driving a counter shaft on each floor also through bevel gear. This arrangement, consisting of so many gears, gave rise to considerable friction, and it was decided, therefore, to separate the drive of the main mill from that of the cleaning and conditioning plant and install separate electric motors in each part.

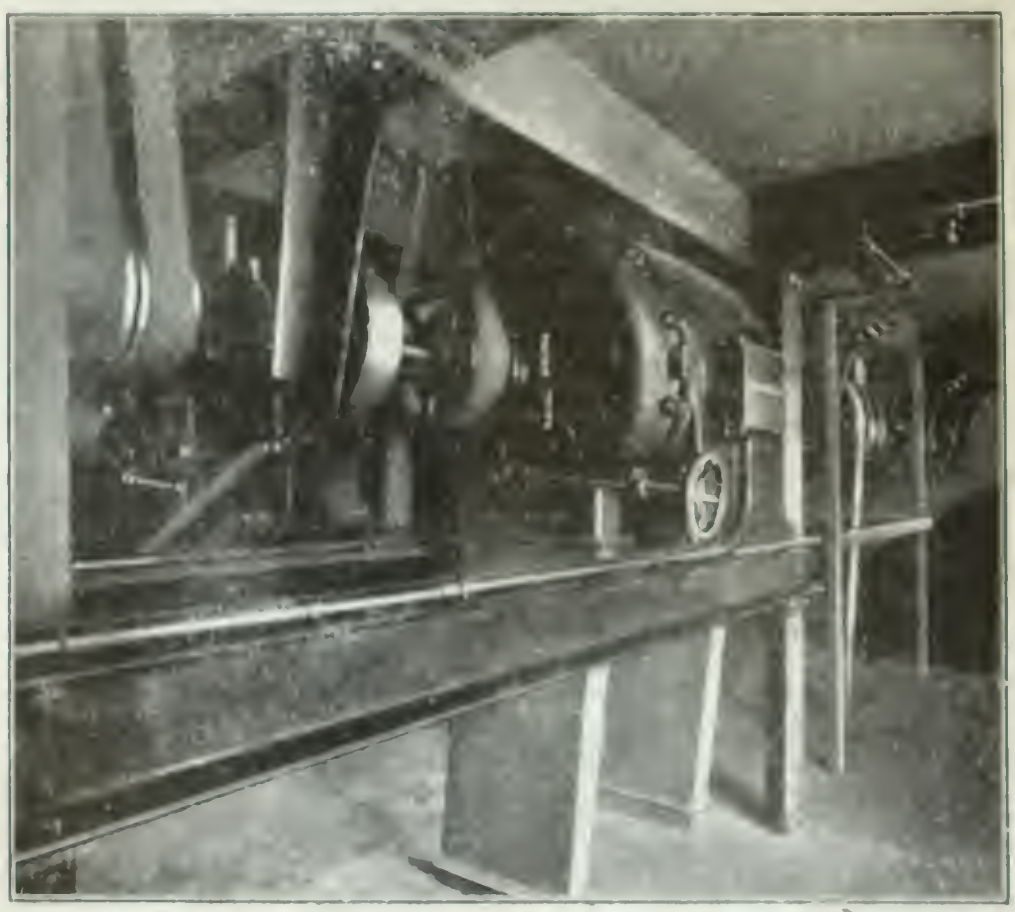


Fig. 1. One of the Four Westinghouse Electric Motors Coupled into the Line Shaft—Slip Ring Pipe Ventilated Type.

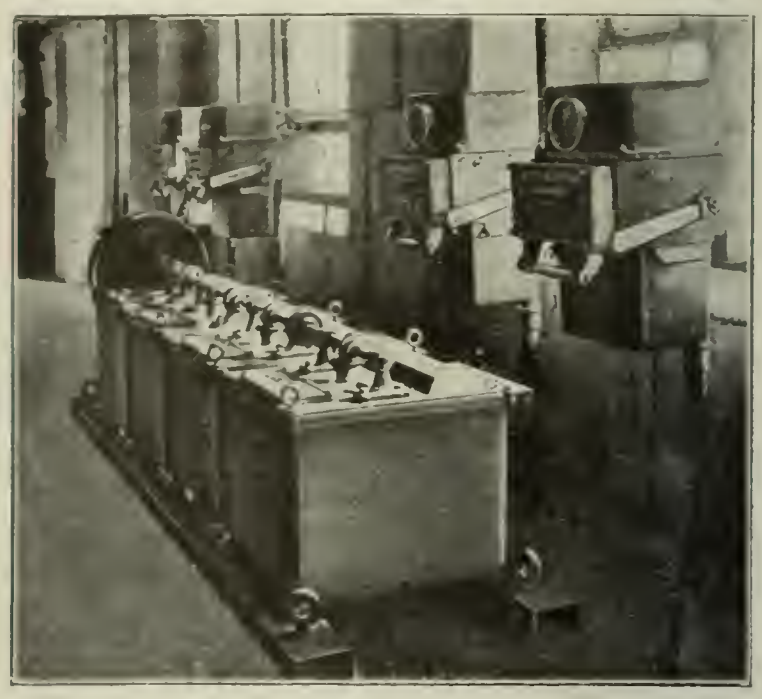


Fig. 2. Westinghouse OV Type Oil-immersed Starters starting four 110-b.h.p. Motors simultaneously.

The question then arose as to whether it was desirable to use one large motor for the main mill or a separate motor on each floor. In the matter of capital outlay the one large motor would be cheaper, but the four separate motors would be more economical in running costs, as much unnecessary friction in transmission belt would be eliminated: it was finally decided to adopt this scheme. The motor drives for the cleaning, conditioning and auxiliary plant were determined by the circumstances in each case.

The adoption of a three-phase alternating current in conjunction with slip-ring motors for all-round efficient and economical driving of flour mills was considered the best combination of power and the means of application possible for the particular purpose. In comparison with results eventually obtained, the first cost of a motor is scarcely worth the consideration generally given to it. What is essential is that it should be a first-class engineering job. The cost of maintenance is negligible, the only expense being lubrication: this cost is reduced to a minimum, as the bearings are most economical in the use of oil. These motors will run night and day for six days a week, in situations such as are described in this article, for months without any attention. On the other hand, a cheap motor, selected without discrimination will prove costly in regard to upkeep, besides being a perpetual nuisance to the persons having charge of it.

The mill here described contains a 35 to 40-sack (280 lb.) plant, and is fitted throughout with three-phase alternating-current slip-ring motors. The electrified mill has been in commission for 16 months, and the motors have been running day and night for six days a week during that period without a hitch. The main objects kept in view during the whole process of the change were to treat the mill as a complete unit, with arrangements for all sections to start up

simultaneously, and also to arrange for as few motors as possible, and still retain the advantages of convenient drives.

The motors are coupled to shafting by means of flexible couplings, thereby saving the loss in transmission which occurs when belts or gears are utilised. The main lines of shafting, four in number, are arranged in the usual manner customary in flour mills—namely, on the floor immediately under the rolls. The original speed of the shafts was 175 revs. per min., but this was found to be far too low for economical driving by motors, and it was decided to increase the speed to 375 revs. per min. This higher speed was adopted partly because the motors designed for that speed were the largest that could be got into the available space without undue cramping, and partly because of the much lower cost of the higher speed motors which give also an increased efficiency. The increased speed of the shafting necessitated a change in the pulleys driving the rolls, and this created an opportunity of increasing the speed of the break rolls by 15 per cent. and the reduction rolls by 25 per cent. The results fully justified this experiment, the feeds of rolls being spread more thinly and better work being done with less pressure applied to the rolls.

It was found impossible to connect the motors to the ends of shafting owing to lack of space, and consequent upon this a piece of each shaft was cut out at a convenient place near the centre. The motors were affixed at these points and connections to shafting were made by flexible couplings. One of the motors is shown in position in Fig. 1, being fixed to stout iron girders laid horizontally and bolted to vertical girders, thus forming a strong and rigid framework.

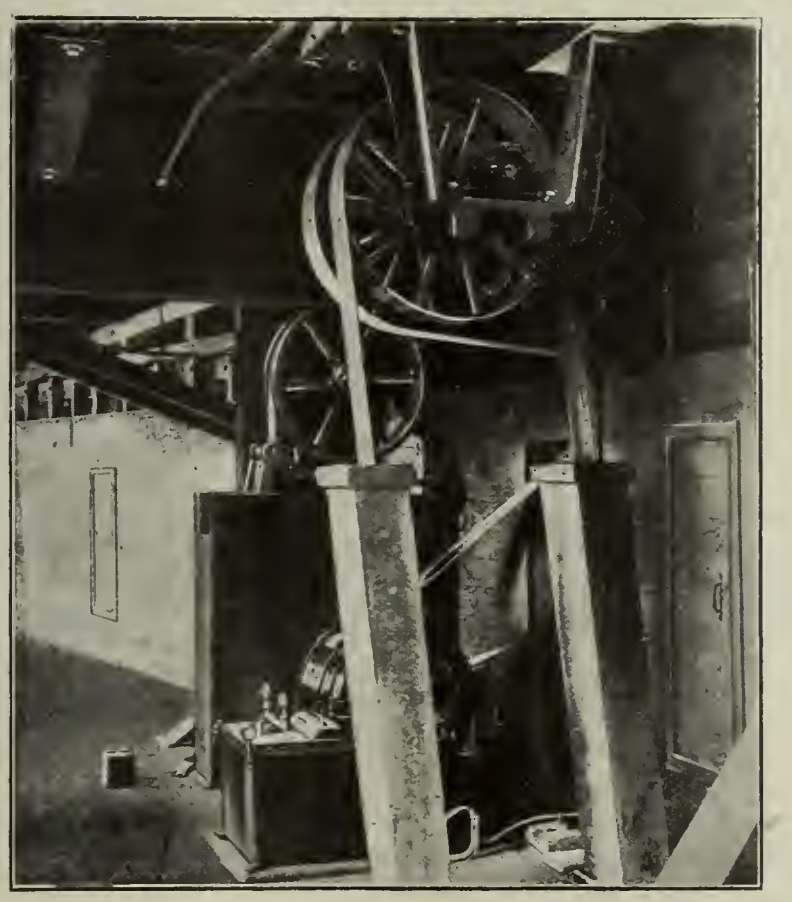
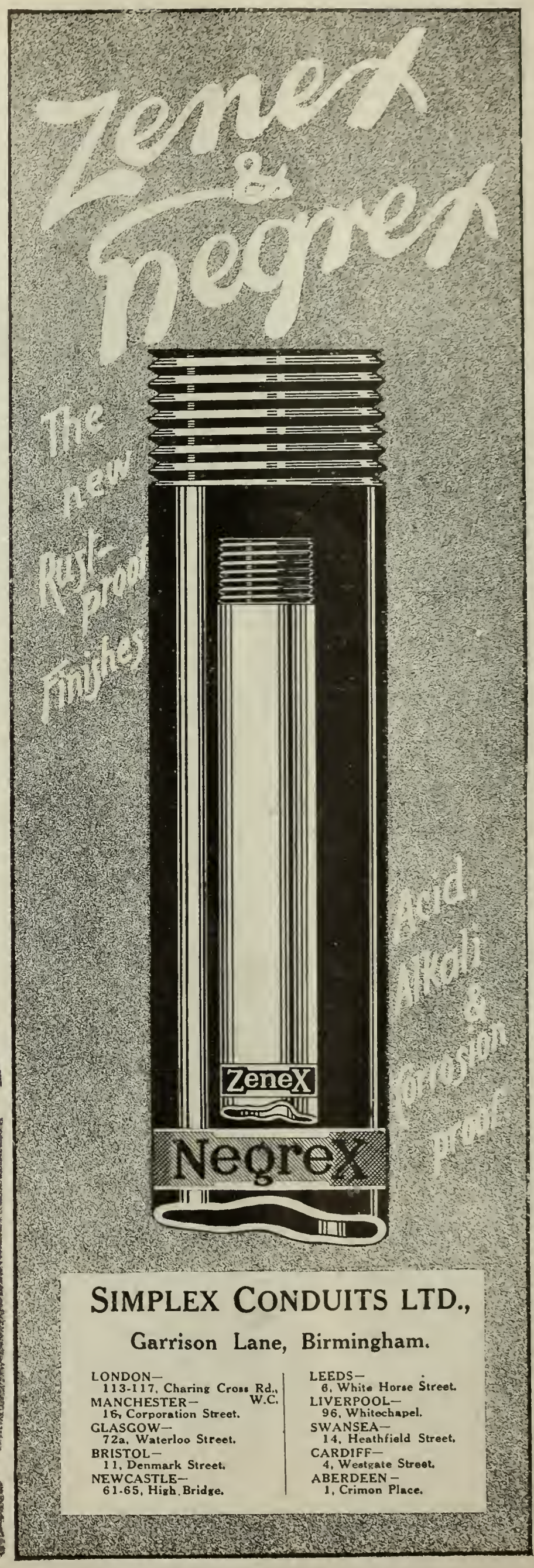


FIG. 3.—15-B.H.P. TOTALLY-ENCLOSED WESTINGHOUSE MOTOR DRIVING PACKING MACHINES AND FLOUR CYLINDERS.

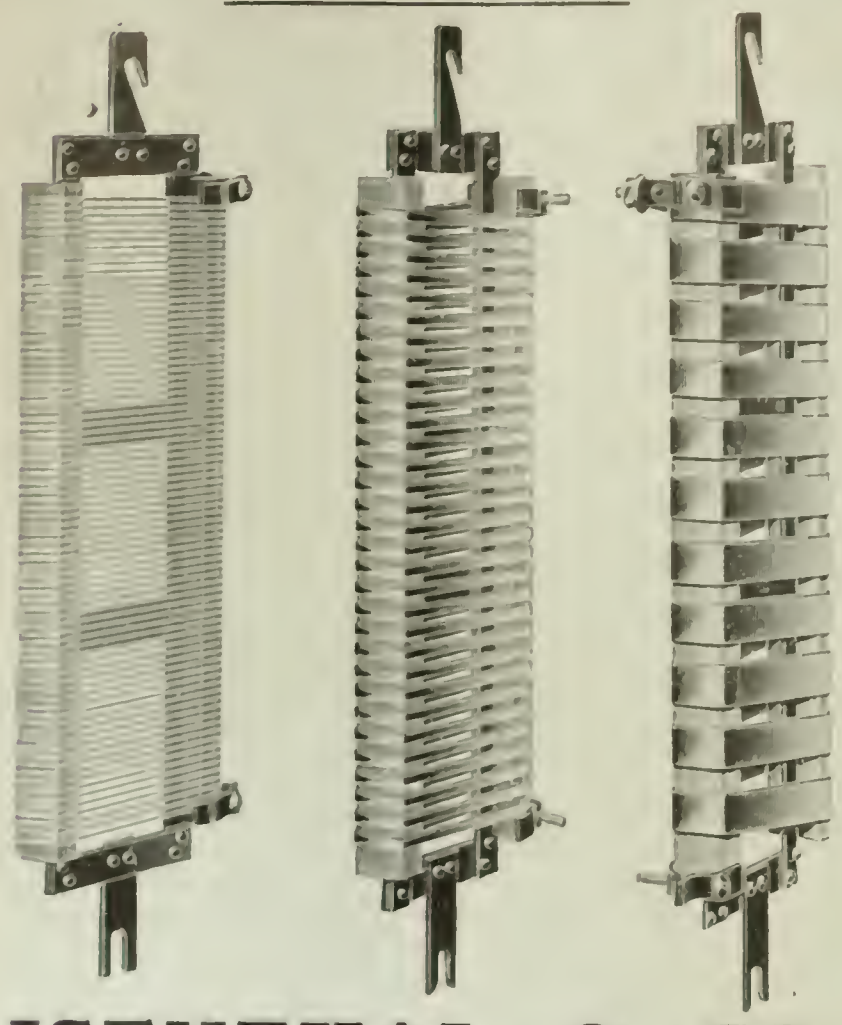
In order that the four motors should be started and stopped simultaneously, a special starting arrangement, shown in Fig. 2, was provided. The oil-immersed circuit-breakers, fixed to the bars closing the window embrasures, control the stator circuits of the motors. Each breaker is fitted with two overload releases, so that protection is given against breakdown in any of the three phases: these releases are fitted with time-limit attachments so that a momentary rush of current on starting does not cause the breaker to open. A no-voltage release is also fitted in each breaker, so that a failure of the supply causes it to open. This release can be brought into operation by means of emergency push buttons, which are fitted in convenient positions about the mill. It is only necessary to press one of these buttons to stop the machinery. The starters which control the rotor circuits of these motors are shown in Fig. 2 in front of the stator switches; they are geared together and operated from one handle, so that the starting resistances in each rotor circuit are cut out simultaneously, step by step, till all four motors are running at full speed. These rotor starters are electrically interlocked with the stator circuit-breakers in such a manner that the latter cannot be closed unless the former is in the "off" position. This prevents any attempt to start the motors with the whole or part of the rotor starting resistances cut out of circuit.

The speeds of scalpers, purifiers, centrifugals, &c., were not



RHEOSTATS

NEW LIST POST FREE.



ISENTHAL & CO.

(DEPARTMENT 4)

DENZIL WORKS, WILLESDEN, LONDON, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

altered, but in several minor instances a little speeding up was found to be an advantage. The wheat washing and conditioning plant is arranged to be driven by belt from a separate motor, and the wheat cleaning machinery from another similar motor, also by belt.



Fig. 4.—10 B.H.P. Enclosed ventilated Westinghouse Motor driving hoist in wheat house, elevators and band conveyor.

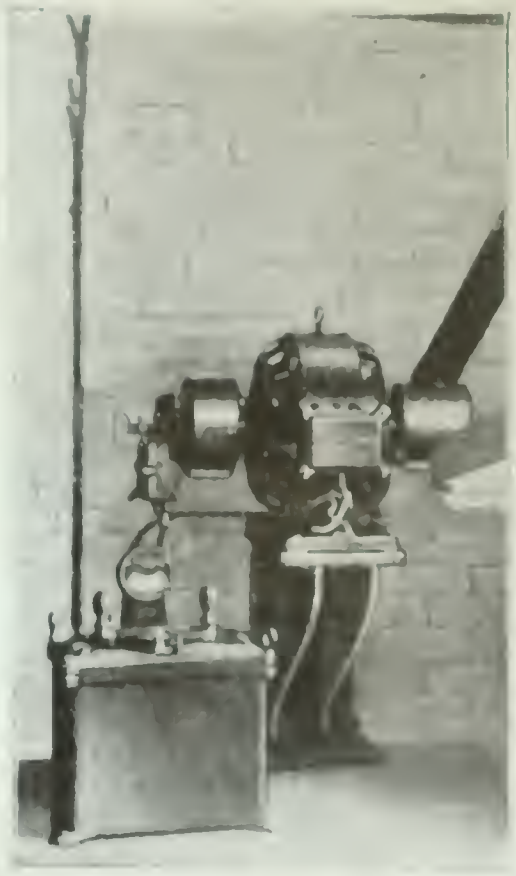


Fig. 5.—10 B.H.P. Enclosed ventilated Westinghouse Motor driving three elevators.

One of these motors is shown in position in Fig. 3. It is capable of giving 60 B.H.P., and has a speed of 750 revs. per min. The circuit-breaker for the stator is shown mounted on a column in front of the motor and the rotor starter on the floor just below. These are of the same pattern as the starters and circuit-breakers in connection with the main drive motors. The fact of being able to run these sections independently will commend itself to practical millers, as there are times when it is necessary to run part of the machinery only, in order to get wheat conditioned ahead of the mill.

The section of the plant containing the wheat cleaning and conditioning machinery, owing to most of the machines having to run at fairly high speeds, is admirably adapted for driving by electric motors with practically no alteration to existing shafting in many cases. This is in addition to the advantages of sectional control and regularity in speed, the latter being a most important factor where air currents are used to effect separations of screenings, &c., from the grain. Separate motors are also installed for driving the grain intake plants, sack hoists, and general warehouse work, each being stopped when not required (Figs. 4-5).

Electric motors drive at a much more uniform speed, and generally more regular results are obtained in an electrified flour mill than in a steam-driven mill: the increased cleanliness obtained, and also the improved and easy control of each section are also prominent features. The energy for this mill is derived from the supply company's transformer in a separate room, the secondary current from which is passed through a distribution board, where it is divided into two circuits, each feeding a different section of the mill.

The work was carried out under the supervision and to the specification of Messrs. Horace Boot & Partners, consulting engineers, of 7, Victoria-street, S.W., and Newcastle-on-Tyne; whilst the whole of the electrical equipment was installed by the British Westinghouse Electric & Mfg. Co. (Ltd.). (Abstracted from the "British Westinghouse Gazette.")

BELLING IMMERSION HEATERS.

These heaters, of which particulars are just to hand, are constructed in stout gauge sheet copper mounted on cast brass gland and frame. All outer surfaces of copper and brass parts are tinned, so that the heaters can be used with safety to heat water for general domestic purposes. Cast-iron grid plates are used to clamp the flat sides of the heater together and ensure good thermal contact. The heaters are wound with one resistance ribbon of large section, and the rating ensures every part running black for an indefinite period, the heater being, of course, properly immersed in fluid.

It is claimed that the ample dimensions of the heaters for their loading also make it unlikely that furring up of the water-container will seriously affect the operation of the heater. The immersion heaters can be fixed in any existing tank of the necessary size, and the efficiency must necessarily be as near 100 per cent. as it is possible to obtain. The terminals are mounted at the mouth of the gland for connecting external wiring. No perishable wires enter the heater, but are conveniently connected to terminals external to it. Substantial terminal boxes or covers are supplied at a small extra cost, and when these are fitted, the screwed tubing, flexible metallic tubing, cab tyre sheathed cable, &c., can be taken right into the terminal box, making a thoroughly sound job.

For large quantities of water, groups of Belling immersion heaters can be fitted into the bottom of a large tank, so that they stand vertically, or they can be put one above another through the sides of a large storage cylinder. By fitting a length of, say, ¾ in. water barrel to the gland of the heater, and on the same axis, a practical paddle is formed, which has a wide application for stirring and warming liquids of any kind. In this case the leading-in cable, preferably of the cab tyre sheathed quality, would be taken down the water barrel handle on to the heater terminals. When using immersion heaters for wax melting, pitch or tar, or other viscous substances, only half or two thirds of the usual maximum loading of the heater should be allowed for to ensure against over-heating and burning of the substance.

One back nut and iron washer to fit the gland are supplied with

FERRANTI LTD

HOLLINWOOD, Lancashire.

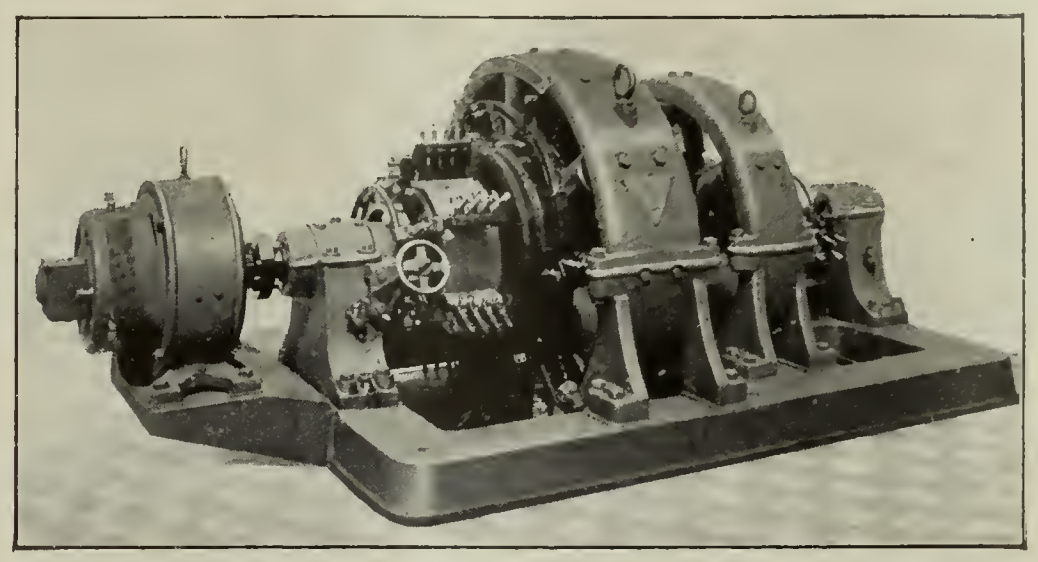
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

VICKERS LIMITED.

Motors and Generators of all types.

Rotary Converters.

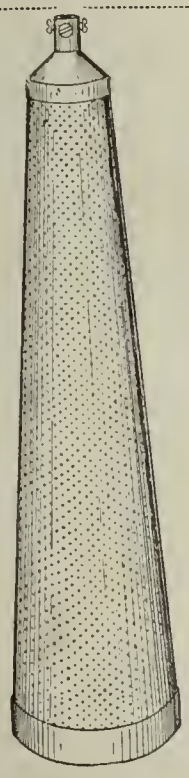
Complete equipment for the electrical lighting and driving of Machine Shops, Factories, Mills, etc



Patent Automatic Reversing Drive for Machine Tools.

250 K.V.A. Rotary Converter. 6 phase, 50 periods, 480/560 Volts. 1,000 r.p.m. Inverted type.

River Don Works, SHEFFIELD.



THE

PARAGON EARTH CONE

Simplifies the question of Reliable Earthing. It is a substantially constructed, hollow Cone, furnished complete with charcoal and braided copper cable of 61.968 C.M. cross section.

IN EVERY CASE WHERE GROUNDING IS ESSENTIAL THIS DEVICE IS PROVING SATISFACTORY

for ensuring underground cables against Electrolysis, for grounding telegraph systems, for providing suitable earthing at central power stations, sub-stations, and for electric tramways and railways.

Full particulars sent free on request.

SCHOLEY & CO., Ltd.,

56, VICTORIA STREET, S.W.

EDISWAN EVERYTHING ELECTRICAL

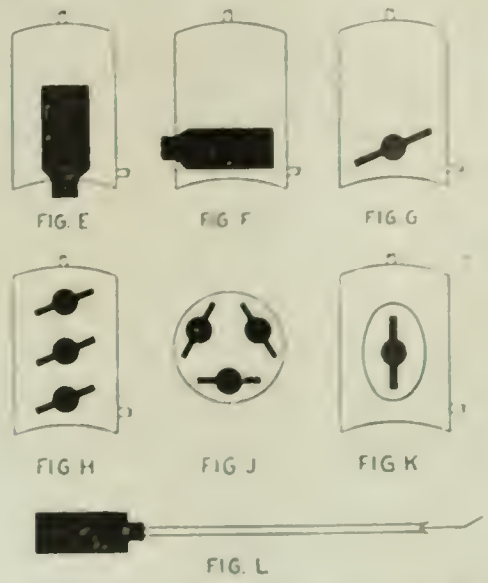
THE ALL-BRITISH HOUSE FOR ACCESSORIES

ROYAL "EDISWAN" DRAWN WIRE LAMPS

CATALOGUES ON REQUEST FROM THE EDISON & SWAN U·E·L CO., LTD., PONDERS END MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06 - 27712/05 AND OTHERS

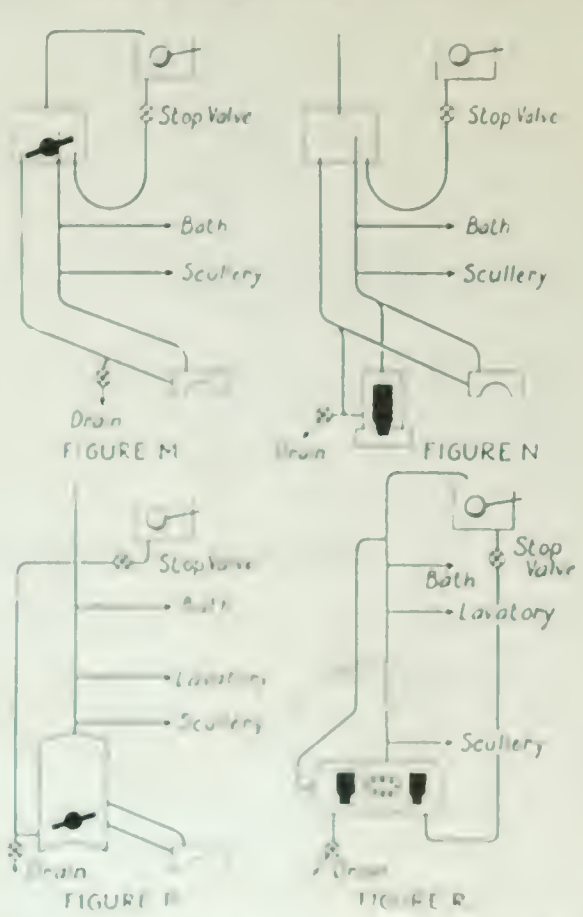
each heater. A water-tight joint is usually most conveniently made by use of a hemp grummet and red lead as practised by water fitters. When fitting the heater to a curved surface of small diameter such as the side of a small cylinder, it may be found necessary to knock up a shaped saddle out of a lead disc so as to take up the curvature. If such a saddle is used a hemp grummet should be placed between the immersion heater flange and the saddle, and a second grummet between the saddle and the tank, all on the inside. A further saddle on the outside of the tank may be necessary in some cases to give a



Some Arrangements of Belling Heaters in Boilers.

proper seating to the back nut and washer. When fitting immersion heaters to existing hand tanks, or arranging new tanks for them, it should be noted the size of the hand-hole opening is large enough to admit the heater. The immersion heater is put bodily into the tank and the gland passed out through the hole previously cut for it.

Some of the several ways in which Belling immersion heaters have been applied are shown in the diagrams appended, and the following hints in connection with water systems may be helpful to those engineers who are developing the use of this form of current-using device.



M N—Cold water feed and storage Tank cistern. P—Draw-off Pipe from F—Steam Pipe Circuit.

Some Diagram Arrangements of Boilers with Belling Water Heaters.

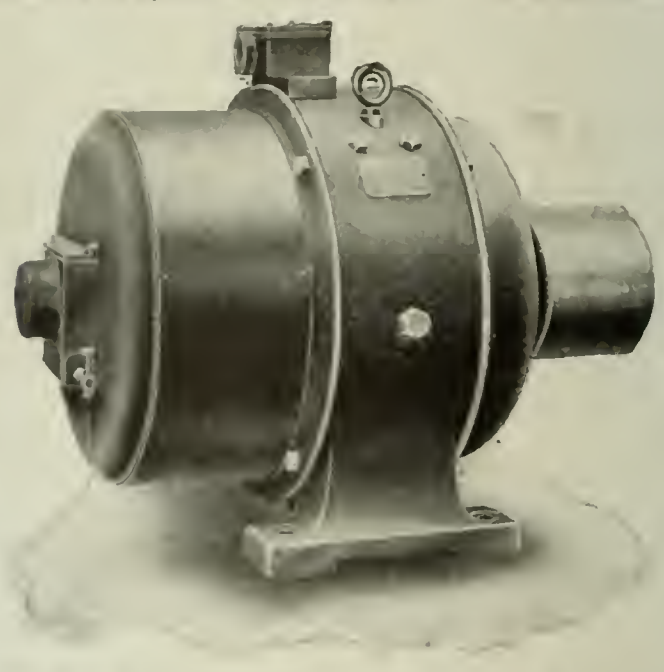
Every water system or tank must have a proper vent or expansion pipe. Only when this is impossible should a safety valve be relied upon (the valve referred to should be of the dead weight type). The vent pipe should be taken from the highest point of the hot water system up to a point above the cold water feed tank. The supply pipe, or cold water feed, must be of ample size to ensure the system being kept full of water, even when the lowest "draw off" is working full bore. In choosing a tank or cylinder, see that it is of sufficient strength to withstand the water pressure of the system. 2 ft. of water gives a pressure of about 1 lb. per square inch; 4 ft., 2 lb., and so on. It is generally best not to use cylinders of less than ⅛ plate, unless of very small capacity. Rectangular tanks should only be used for very low pressures. See that a drain cock is fitted to the system at a point where all, or nearly all, the water can be drawn off in case of repairs, &c. To ensure high efficiency, hot water tanks and piping should be lagged with non heat-conducting material. The heater is made in the following sizes:—

Size No.	Overall length	Overall width.	Overall diam.	Barrel size of gland 11tlds. per inch.	Maximum loading. 100 v. to 150 v.	200 v. to 220 v.	230 v. to 250 v.
1	20 in.	9 in.	7¾ in.	2½	5 kw.	5·5 kw.	6 kw.
2	20 in.	9 in.	7¾ in.	2	5 kw.	5·5 kw.	6 kw.
3	15 in.	9 in.	7¾ in.	2	3 kw.	3·5 kw.	4 kw.
4	14½ in.	6 in.	5 in.	1½	2·5 kw.	3 kw.	3 kw.
5	12 in.	4½ in.	3½ in.	1¼	2 kw.	2 kw.	2 kw.
6	10 in.	3 in.	2 in.	1	1 kw.	1 kw.	1 kw.

Prices can be obtained from Belling & Co., Derby-road, Edmonton.

PEEBLES "C" TYPE CONTINUOUS-CURRENT DYNAMOS AND MOTORS.

The Peebles continuous-current machines, as described and illustrated in pamphlet 4C, are, we need hardly say, the outcome of an experience extending over many years. They are fitted with commutating poles with but very few exceptions, and will, therefore, run sparklessly at all loads within their capacity with fixed brush position. One of the difficulties hitherto experienced in continuous-current machines was sparking at the commutator, due either to mechanical or electrical defects. The former defects were, however, avoided by careful mechanical design and reasonable care in operation: but the latter were not so easily got rid of, as the effect of the reaction set up by the armature current was to distort the main magnetic field, and thus alter the position in which the brushes had to be set to ensure sparkless commutation. These electrical defects



Peebles Standard Totally Enclosed Motor

were minimised with considerable success in earlier machines by the use of carbon brushes and a densely saturated magnetic field at the pole tips: but now the defects are obviated by the adoption of commutating poles, which, as is well known, neutralise the armature reaction and ensure ideal commutation at all loads. Commutating poles have the further advantage of greatly improving the efficiency of the machines and increasing their capacity to endure large overloads for short periods: also, when a large variation of speed is required, commutating poles are of special service.

The machines are of the self-contained form, having the bearings supported in substantial cast-iron end covers bolted to the field frame. The end covers of standard machines are arranged so that they can be turned through angles of 90 deg. or 180 deg., thus enabling the machines to be fixed to the wall or ceiling if required.

The frame is of cast steel of substantial design. Up to and including C9 the frame is cast in one piece, but in the larger sizes it is in two pieces, accurately machined and securely bolted together, the joint being along the horizontal diameter. All machines have four main poles, with the exception of three quite small sizes, which

FERRY | **FERROZOID**

CONSTANTAN | **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS, "FERRYDOM, LONDON."

BELLING

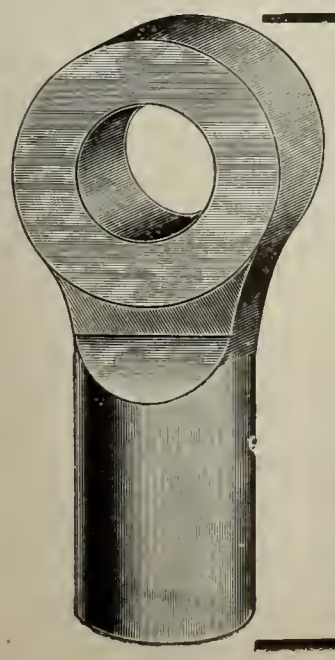
& CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialist, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,

STIRCHLEY, BIRMINGHAM.

Cast Cable Sockets.

Suite E74. Made in all Sizes.

Type A.—Straight.
,, B.—Offset.
,, C.—Right angle.

Illustrated Dimensioned Showcard for Drawing Office use supplied free on application.

Sole Agent for the Electrical Trade:—

LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

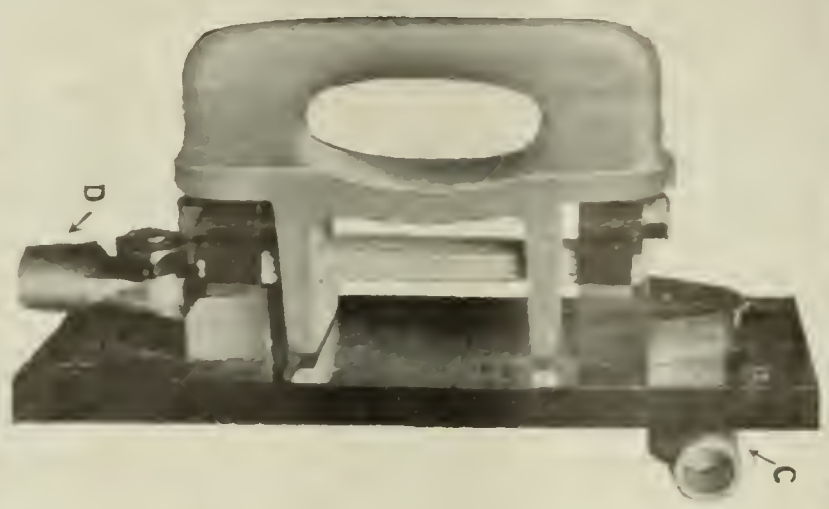
Established 1868.
Codes: 5th Edition A B C & Western Union.

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

have only two. In sizes C00 to C9 the poles are laminated throughout, accurately finished and securely bolted to the frame, which is machined to receive them. Machines sizes C10 to C14, however, have solid poles, cast as part of the frame, and laminated pole shoes.

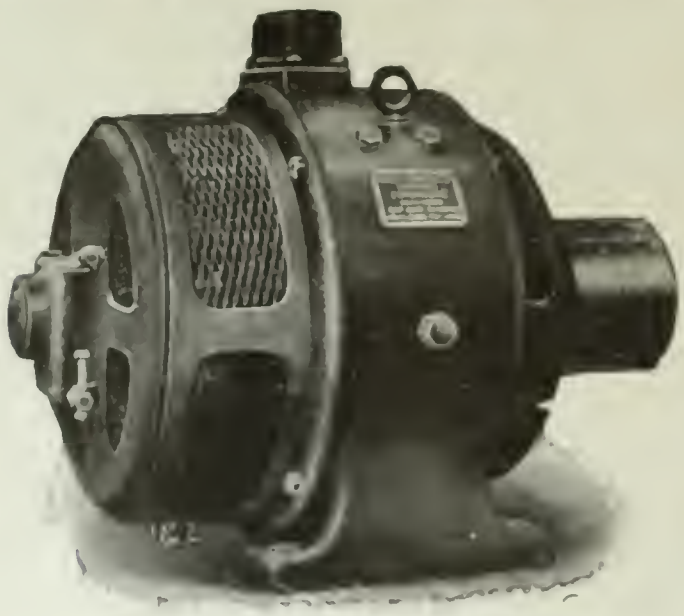
The field coils are former wound and carefully insulated from the poles. They are taped for mechanical protection, carefully dried under vacuum, thoroughly impregnated with special insulating varnish, then baked again in the drying oven before being placed in position on the poles. All standard machines are shunt wound. Series-wound machines can be supplied at the same price as shunt-wound machines, but a small additional price is charged for compound winding. A few turns of compound winding are necessary for variable speed motors with a wide range of speed, and prices for these will be quoted on application. The commutating poles are bolted to the magnet frame, and are of the best dynamo steel. The windings of insulated wire or strip, depending on the current, are connected in series with the armature, and carry the full armature current. In some of the smaller machines, and especially those designed to run on the lower voltages, the conditions are such that commutating poles are not required, and in these few cases they are omitted.

The commutator consists of high conductivity hard drawn copper segments of ample wearing depth, insulated from one another and from the commutator bush by mica. After assembly the whole is subjected to heavy radial pressure, and while under pressure the interior is turned and the bush fitted, the clamping ring is then removed and the exterior turned. The outcome of this construction is a strong commutator, in which dropped or raised bars are most unlikely, and which acquires an excellent skin after a short period of service. The armature is carefully balanced, and every precaution is taken to ensure smooth running without vibration. The shaft, of special mild steel, is designed to operate safely under the most severe working conditions. It is provided with thrower rings to prevent the lubricant from creeping to the windings, and is extended and keyseated in the standard manner to take pulley, pinion or half coupling.

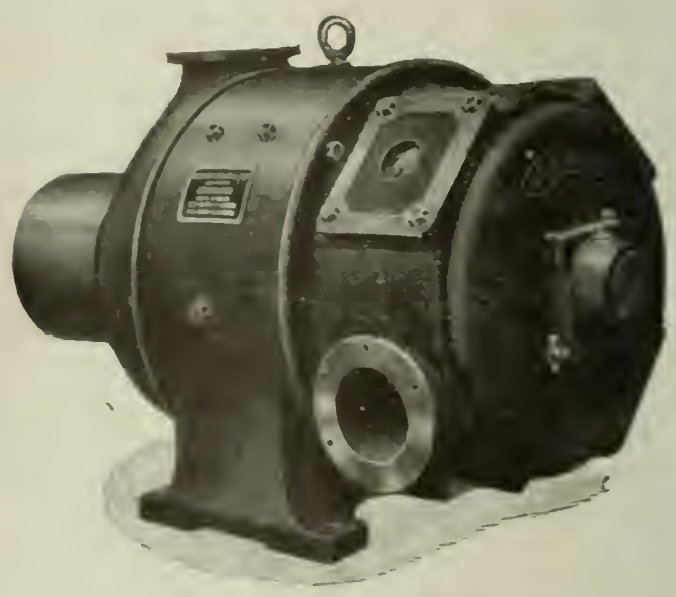
The brush gear, which is of substantial design, is a recent development in this important part of a continuous-current machine. The insulation is of mica, made specially thick and pressed on to the square end of the brush spindles, but protected from mechanical injury by stout gunmetal clamps. Each spindle is attached to the rocker by means of mica-insulated bolts in such a manner that it may be readily removed if required without in any way dismantling the machine. The brush-holders are of the box type, each made from a solid brass casting and having an adjustable spring, so that the pressure on any brush may be varied at will. The amount of pressure on the brushes is varied in sizes C7 to C14 inclusive by insulated thumb screws and worm-adjusting gear, while in the smaller sizes (C00 to C6) a loose insulated key is supplied for varying the brush pressure by means of a square-headed steel screw provided for the purpose on each holder. The brushes, which are of carbon, slide easily in the box portion of the holder, and copper flexibles are provided to make the necessary electrical connection.

Combinations of two or more self-contained continuous-current machines can be supplied as motor-generators, three-wire balancers or boosters. The different units forming these sets are direct coupled through flexible couplings and mounted on combination cast iron bedplates.

Further details and prices can be obtained on application to Bruce Peebles & Co. (Ltd.), Edinburgh.



Semi Enclosed Motor.



Pipe Ventilated Motor.

GUARANTEED SECOND HAND

MOTORS

THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.

"THOR" High Grade Specialities

CASING and CAPPING — CABLE CONNECTORS
CONDUIT — COMMUTATOR COMPOUND
CABLES — WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.

WRITE FOR PRICES & DISCOUNTS.

HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, July 7, 1916.

THE ROUND TABLE.

By "KVA."

My sympathies with Major W. A. Vignoles (Grimsby), who was wounded in the "great push," and is now in hospital in London. He is the first ELECTRICIAN "Hot Platist" to see active service; I wish him a speedy and comfortable recovery from his wounds.

* * * *

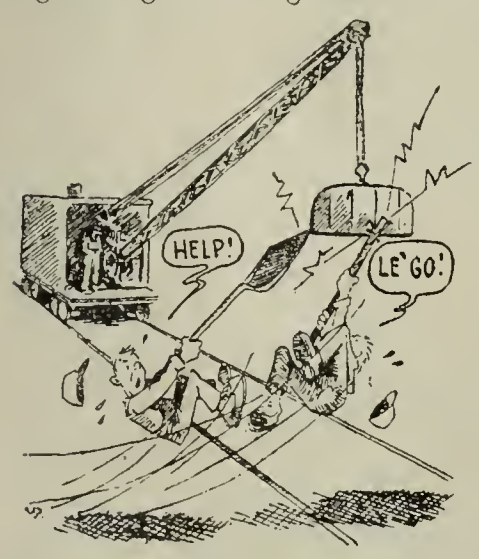
Baron d'Erlanger, speaking at a meeting of the Channel Tunnel Co., said, amongst other things, that he expected the scheme "to emerge from the realm of a cherished dream to that of a concrete reality." Begging the Baron's pardon, "a ferro-concrete reality," surely!

* * * *

In the "Buckinghamshire Advertiser" is a letter upholding the action of the electricity undertakings in increasing their charges for energy, due to Summer Time. The letter is signed "Y Grin," which concludes "there is nothing for it but to accept the situation quietly." A much better nom-de-plume would have been "Smile, D—— It, Smile."

* * * *

Some months ago I suggested that a monster Igranic lifting magnet might be designed to haul the gloves off the Mailed Fist, and thus stop the war. The "Milwaukee Journal" shows how timely a lifting magnet can be in settling disputes. A couple of navvies were about to "strafe" each other with punch bar and shovel respectively, when the works' crane with Igranic lifting magnet arrived and put an end to the dispute in the manner shown in the sketch. At the finish everybody laughed, including the would-be contestants. What else could they do?



* * * *

"The Times" Engineering Supplement surpasses itself in its description of Mr. A. F. Berry's new flaming fire. I think the writer must have had a Tricity shock, and have been so full of "extractives" that he could not help it. Thus (*my italics*):

The heating elements, which measure about 10 in. by 2 in., taking about 500 watts each, glow at a red heat, and in the fire they are set vertically in panels. Changes take place in the density and consequently also in the refractivity of the air, which entering at the bottom is gradually heated as it rises past up the element, and the differing refractivities of the different layers produce a shimmering effect, similar to that which may be seen along the steel rails of a railway line on a hot day. This taken with the direct effect of the rising air, where it is allowed to contact with the hot wire screen, permits the production of red or *smoky* flames at will and *gives body* or volume to the flames, which rival those of a coal fire at its hottest. Thus, so far from the fire presenting the monotonous appearances of, say, an electric lamp radiator, there is a continual play of flickering light and shade over the glowing wires, whence the *epithet* flaming.

I should have said, "Why the flaming epithet all this flaming epithet?"

The press cutting agencies have strict instructions to send along to us items of electrical interest, and these orders are obeyed to the letter. This week I came upon what I thought would be an interesting "item," it was entitled "A Bad Record." I had visions of some station giving bad results or a manufacturing firm in low water, or perhaps the failure of some well-known lamp. Nothing of the kind, for the first few lines undeceived me:—

"John Worral (41) electrical engineer, was indicted for stealing a rolled gold guard, sideboard cover and table cloth, the property of Henrietta Dixon."

The tale of J.W. and H.D. is then told in all its harrowing details, but I am afraid there is nothing of electrical interests save the statement that J.W. is an *electrical engineer!*

* * * *

SCENE—Anywhere. SCENERY—Anyhow.

(Enter crowd of Amperes.)

We are the Amps.,
We hurry through the lamps;
We crowd and crush, we shove and push,
We are the Amps.!
(Exit Amps., shoving and pushing.)

(Enter crowd of Volts.)

We are the Volts,
We launch the thunderbolts,
If we're let loose we play the deuce;
We are the Volts!
(Exit Volts, playing the deuce.)

(Enter a Thousand Watts.)

We are the Watts;
If you take us in large lots
We'll drive your mills (*you* pay the bills);
We are the Watts!
(Exit Watts, driving each other.)

(Enter a Megohm.)

We are the Ohms;
Where'er the current roams,
With foot and fist we still resist;
We are the Ohms!
(Exit Ohms, for once unresisting.)

(Enter a Platoon of Soldiers.)

We are the O.H.M.S.!!!
Those funny little gnomes
Who've just been here have no idea
Of what it means,—
To still resist,
'Midst shell and poison mist
Our Sovereign's foes! Their murderous blows,
Their base ill-will, we parry still.
We're none the less O.H.M.S.
To beat his foes; so now here goes
To give them Beans.
(Exit Platoon, beans and all.)

From "Glover's Almanac."

* * * *

The ideas of Councillors sitting upon Electricity Committees do not find their way into print as often as they should. There would then be some hope of making a text-book which would be useful to both present and prospective Councillors. Here, for instance, is a good example for the Oldham "Standard" under the title "Leakage of Electricity" (my italics):—

Councillor DIXON commented on *the size of the leakage of electricity*, the loss between the amount generated and the amount sold, and asked the Chairman of the Committee if it was not possible to reduce it somewhat. He knew that the doing so might be a little difficult. He thought something might be done in the way of *talking to the staff* and trying to get them to reduce the deficiency.

Councillor HARDMAN, replying, said Councillor Dixon had taken an active interest in the question of the loss during generating, and he thought it was essential that all the members should study these *imperceptible losses*. There was a matter of 1½ per cent. more than before, but it could be easily accounted for as the longer the mains the greater the *imperceptible losses*

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), July 12, 1879.]

GAS V. ELECTRICITY.—In an article on gas manufacture, the "Gas Trade Circular" admits that the electric light has given a grand impetus to the manufacture of gas throughout the kingdom. The present systems of electric lighting are not feared, but "it is the future of the electric light that has to be guarded against." Our contemporary, writing somewhat in favour of employés, points out that the directors of the various companies should appreciate and duly reward the scientific men and the inventors that are working to improve the manufacture of gas, and leading to still further economy. Hitherto talent has been at a discount, but as soon as existence is threatened talent is to be petted and promised rewards; at any rate, we have frequently found that the rewards end with promises, and the tangible results accruing to talent are, like will-o'-the-wisp, hardly ever to be caught. We heartily trust that directors of gas companies may even through fear be taught a lesson which will not be forgotten in a time of seeming security.

"DURADUCT."
The most durable flexible Woven Conduit made for protection of Electrical Conductors.
HIGHLY FLEXIBLE. LESS COSTLY THAN OTHER TYPES OF CONDUIT.
GREAT MECHANICAL STRENGTH AND INSULATING RESISTANCE.
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golslplat, Ox., London." 4746 Gerrard.

SIEMENS

ELECTRIC MOTORS



Part of small Motor Shop, Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St.
BRISTOL—30, Bridge Street.
CARDIFF—89, St. Mary Street.
GLASGOW—66, Waterloo Street.
MANCHESTER—196, Deansgate.
NEWCASTLE—64-68, Collingwood Bldgs
SHEFFIELD—22, High St.
SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

GARAGE LIGHTING WITH OSRAM "ATMOS" LAMPS.

The lighting of a large garage presents considerable difficulties owing to the lowness of the roof in relation to the wide area which has to be evenly illuminated without glare. Before the days of



GARAGE LIGHTED BY OSRAM "ATMOS" TYPE LAMPS IN G.E.C. LANTERNS.

half-watt lamps the garage illustrated in the accompanying photograph—the Albany-street premises of Messrs. Barningham (Ltd.)—was equipped with arc lamps. The change to Osram "Atmos" type lamps has, we understand, been accompanied by a marked improvement, not only in current consumption, but in the volume and distribution of the light.

The lamps, which are rated at 1,500 watts (approximately 3,000 c.p.), are installed in G.E.C. "Third Citizen" lanterns, made by the General Electric Company (Ltd.), of London and Witton, Birmingham, with their "Superlux" glass hemispheres. Superlux is an opalescent glass which gives an excellent diffusion with a comparatively small loss of light due to absorption. The lanterns used have been specially designed for half-watt type lamps. They are made of green vitreous enamelled iron, and are arranged with triple ventilation. Particular attention has been paid to the shape of the reflector, the curve of which has been so designed to give as uniform a distribution of light as possible. About 50 points were converted in the various showrooms, workshops and garages of the firm, with results which have proved uniformly excellent.

LEAD MELTING FURNACES

Hall's Patents
For Cable and Pipe Presses, Accumulator Grids, etc.,
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
ENORMOUS SAVING IN RESIDUE.
Easy Payments arranged in special cases.
MONOMETER, Ltd., 22, Whitehouse St., Aston, Birmingham

TUMBLER-SWITCH CONTROLS FOR SMALL CONTINUOUS-CURRENT MOTORS.

Fig. 1 shows one of the most recent of the numerous modifications of Messrs. A. P. Lundberg & Sons' well-known "Twinob" tumbler switch; a modification which suits it for the control of small continuous-current motors. The cover is removed to show the internal

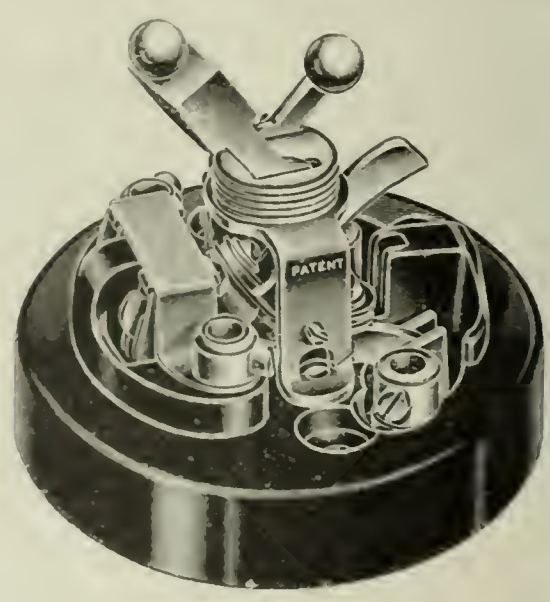


FIG. 1.

construction. It will be evident that the open box and knob on one lever ensure its being put on before the other, and also that both levers shall either be put off together or the "box lever" last.

The application of the switch to a small series motor is seen in the diagram in Fig. 2, where K is the lever which has to go on first. The

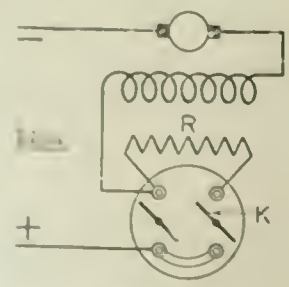


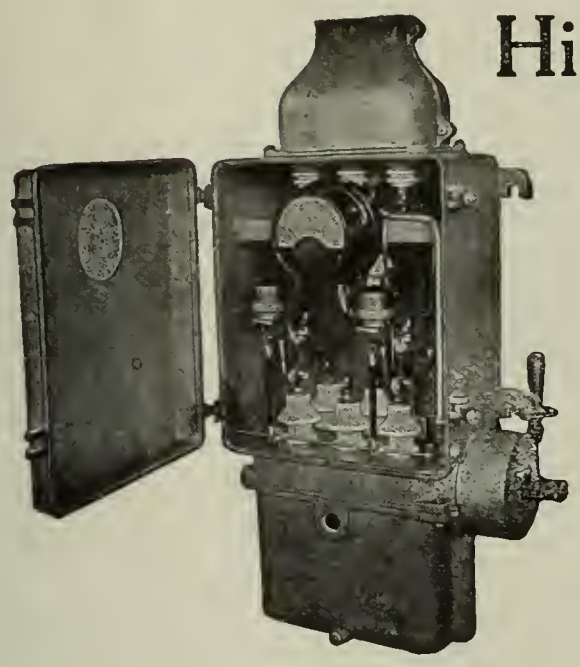
FIG. 2.

other lever is put on to bridge the resistance R when the motor has speeded up.

The same arrangement of resistance will suffice for a small shunt motor, the field being connected to the right-hand terminal and the

The Electric & General Works, Ltd.,

15, Victoria Street, London, S.W.



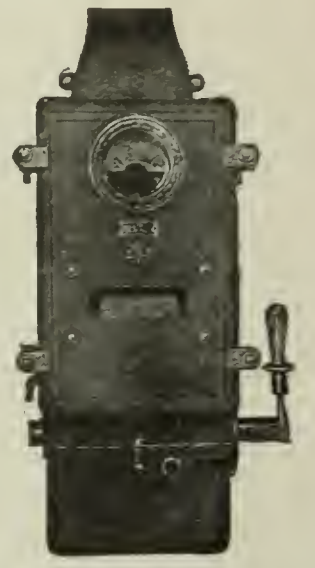
OPEN.

High Tension Switch Boxes

for 3,000 and 6,000 Volts.

TRIPLEPOLE AUTOMATIC OIL-SWITCH.
DOUBLE INTERLOCKED DOOR.
OVERLOAD & UNDERLOAD RELEASE.
AMMETER.
INVERSE TIME LIMIT ATTACHMENT.
FIRE-DAMP SAFETY DEVICE.

Other Types for all purposes.



CLOSED.

ELECTRICAL APPARATUS up to 80,000 Volts.

Telephone: 5223 VICTORIA. Telegrams: "GABIONAGE VIC. LONDON."

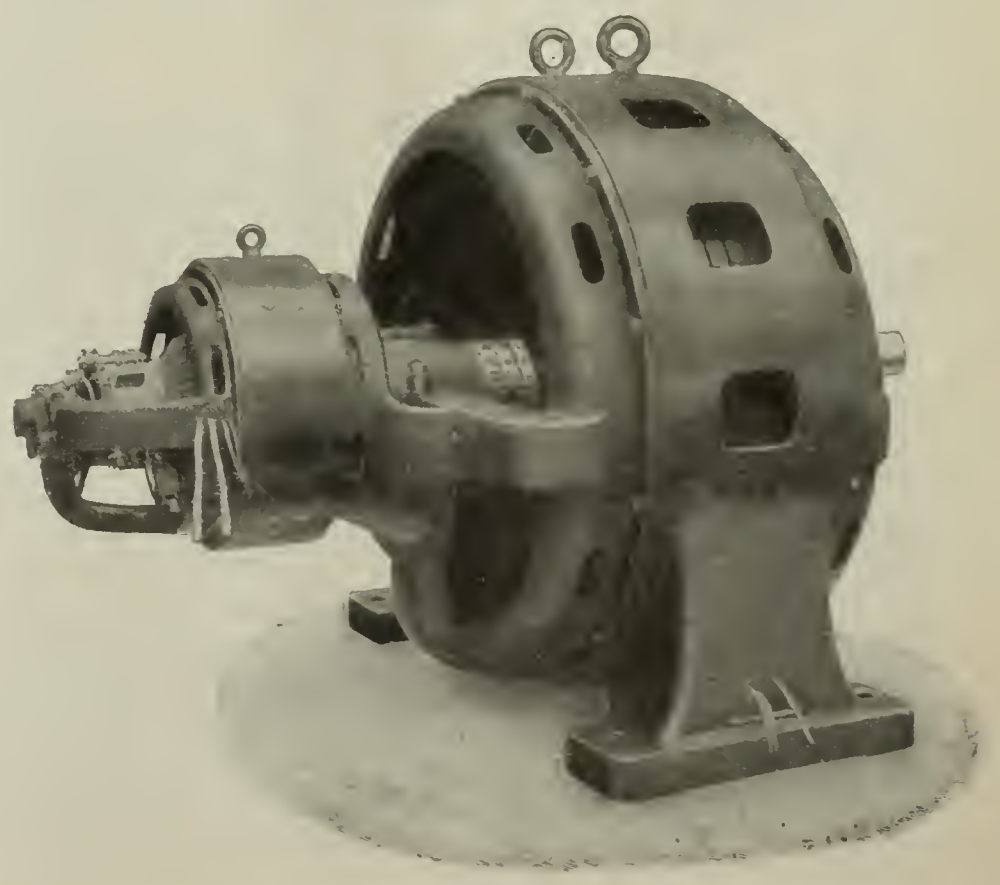
armature to the left-hand one. If in this case the resistance is dispensed with, the switch ensures the field being put on first.

Another type of switch will start, stop and reverse a small series motor; while yet another will control a shunt motor and put its field coils (if in two sections) in series for full speed and parallel for low speed.

Further particulars may be had on application to the makers at Pioneer Electrical Works, 477-489, Liverpool-road, London, N.

AUTOSYNCHRONOUS MOTORS.

The question of power factor correction has in recent years received considerable attention, and various methods have been devised for the purpose. The simplest of all methods, that is the use of synchronous motors, can only be applied under quite special circumstances owing to the difficulties in starting, even where the motor starts against light load. To overcome the difficulty the Allmanna Svenska Elektriska Aktiebolaget, Vesteras, Sweden, introduced about 12 years ago the autosynchronous motor invented by Mr. Danielson, who was at that time the chief electrical engineer of the company. This motor combines the favourable characteristics of the induction motor—viz., large starting torque and large overload capacity—with those of the synchronous motor. It consists of an induction motor with a specially wound slip-ring rotor, provided with a direct-coupled exciter. The motor starts as an ordinary induction motor, and when full speed has been reached, the exciter is connected to the slip-rings which gives to the rotor a definite polarity, transforming it into a synchronous machine. By regulating the field current, leading or lagging currents can be produced and the power-factor regulated within the limits which correspond to the rated output of the machine. The autosynchronous motor has, as compared with synchronous motors, a decided advantage, in so far that even if, due to sudden overloads or an abnormal drop in voltage, such as may occur, for instance, when a short circuit takes place, the



850 H.P. 900 R.P.M. AUTOSYNCHRONOUS MOTOR.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.
HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.

motor falls out of step, it will do so without causing any stoppage or disturbance to the supply. When out of synchronism the motor immediately recovers the characteristic of an ordinary induction motor with its heavy overload torque, and will remain running in this manner until the load falls to its normal value, when it will again run up to synchronism and automatically fall into step. Another advantage is that the autosynchronous motor does not depend upon its exciter in the same manner as an ordinary synchronous motor. It can at any time be used without the exciter as an ordinary induction motor. Such motors built by the above-mentioned company, who are represented in this country by the Swedish General Electric (Ltd.), Canada House, Kingsway, London, W.C., have found numerous applications, and have been supplied for outputs varying from 100 B.H.P. up to 1,500 B.H.P. The illustration shows an autosynchronous motor for an output of 850 B.H.P. at 900 revs. per min. Two of these were recently supplied for the waterworks of Edmonton Corporation, Canada. They were designed to work with a leading power-factor of 80 per cent. on a 2,200-volt 60 cycles supply. The efficiency is 93 per cent. at full-load, 92 per cent. at three-quarter load and 89 per cent. at half-load. The field current, and consequently the power-factor, is regulated by shifting the brushes on the commutator of the exciter.

Motors of this description are well suited for driving fans and air compressors in boiler houses and collieries. Although, in the case of air compressors the load fluctuates at frequent intervals from full-load to 10 or 15 per cent. of full load, the leading component of the current supplied by the motor still remains practically the same, so that the compensating effect on the supply is practically independent of these load variations.

Generally speaking, the autosynchronous motors can be used for any purpose where constant speed is required for constant or fluctuating loads, but the most favourable applications are those where the maximum overload does not greatly exceed the average load, and where the working hours of the motor coincide with the period of maximum load on the power station.

"MODERN ELECTRICAL PLANT."

The above is the title given to a new and attractive booklet just issued by the Electric Construction Co., London and Wolverhampton. It deals with the products of the company in dynamo electric machinery and switchgear, and its opening pages contain an account of the development of the company and the present works at Bushbury, near Wolverhampton. This description is of interest, and we quote it in extenso.



Part of the Winding Shop.

"The foundations of our present business were laid in 1880, when, in a factory situated in Commercial-road, Wolverhampton, our forerunners built some of the earliest dynamo-electric machines. The "Elwell-Parker" bipolar dynamo or motor—the standard direct-current machine up to the late nineties—though cumbersome and very expensive as compared with the productions of to-day, was a thoroughly practical machine. How practical it was may be gathered from the fact that even at the present day we are called upon to replace the original commutators of machines which, in many instances, have been in continuous operation for 20 to 25 years, and have incurred no maintenance charges beyond the occasional renewal of brushes and bearing bushes.

"The earlier alternating-current machines were used solely for lighting purposes; then came the induction motor, transforming alternating-current power into a commercial proposition, and we took up the manufacture of that type of machine under the Tesla patents.

"Although, as events have proved, the advent of the multipolar direct-current machine heralded an enormous advance in the economical application of electric power, it was not at first an unmixed blessing to manufacturer or consumer. In particular, the introduction of interpoles has overcome the commutation difficulty. The commutation of a modern interpole machine is sparkless from no load to at least 25 per cent. overload, and, in a variable-speed machine, throughout the speed range. So completely has the problem of sparking been solved that in small and intermediate sizes we do not fit brush rocking gear: it is possible to alter the brush position by slacking off the bolts and forcing round the brushgear ring, but this is only for the convenience of our testers, who, during the trial run, fix the correct brush position once and for all. In the larger sizes, on account of the weight of the brushgear, we fit handwheel rocking gear; but again the position does not need alteration after it has been determined during the trials.

"The history of switchgear is a romance in itself, the difference between the elementary types of early days and the present practice of oil switches, automatic circuit-breakers, all-metal construction, and so on, being even more marked than the difference in machine

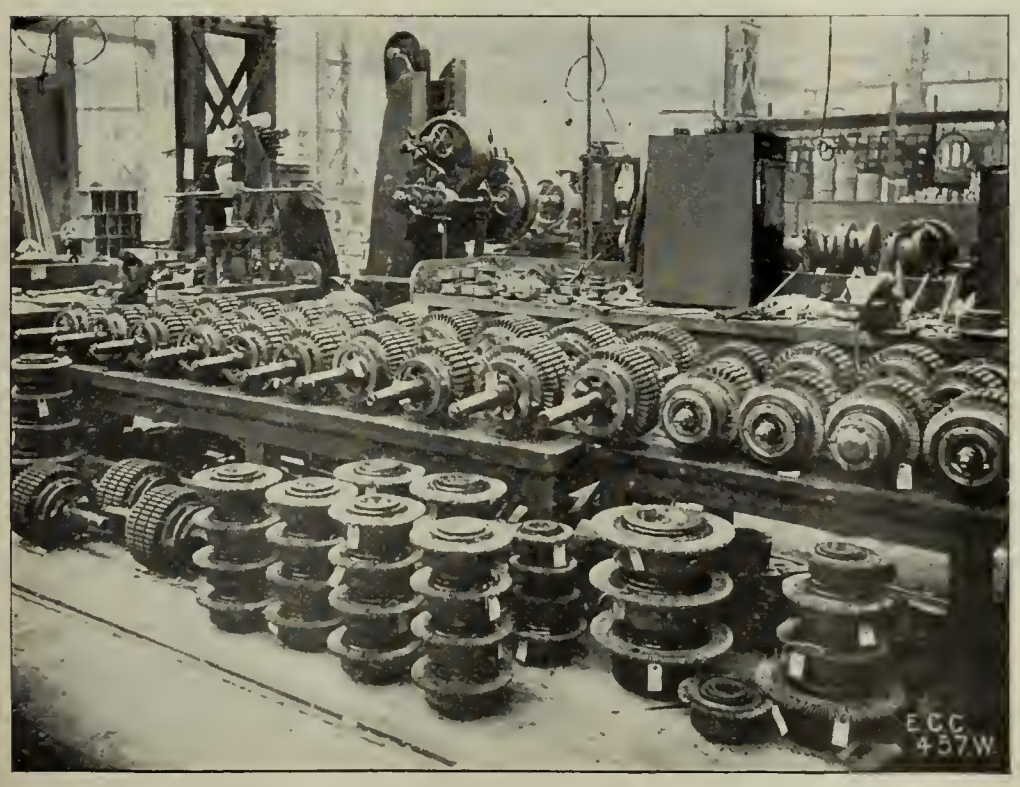


View in one of the Machine Bays.



Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W.

design. High-tension transmission, new applications of electric power, the growing stringency of Home Office regulations, have all demanded rapid yet practical development in switch and control gear design. That the demand has been met is self-evident. Switchgear is now fulfilling requirements undreamt of a few years ago; withal the modern tendency is towards simplicity of design, however complicated the function.



E.C.C. Works: Part of a Large Order for D.C. Machines.
The order was received March 9th; the illustration shows progress at 3 p.m., March 10th.

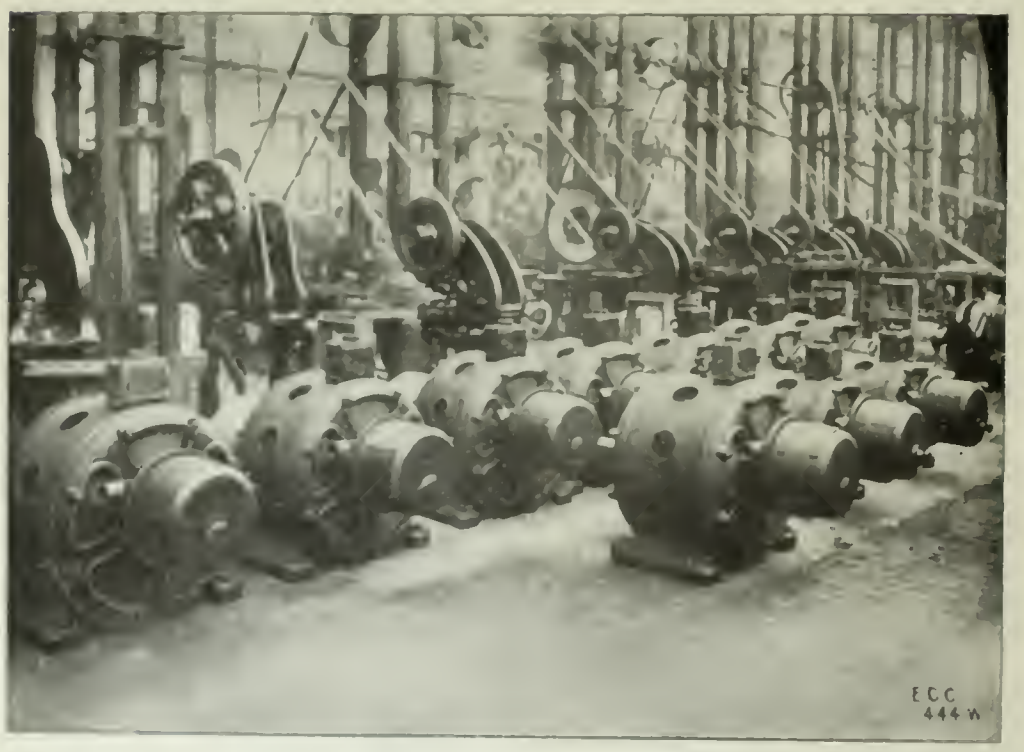
"In 1888 we built and moved into our present Bushbury works, which occupy a site of 23 acres, one-fourth being covered by building. The whole of the works is upon the ground floor, and the main factory consists of a single building, without interior walls, measuring 170 yds. by 90 yds. Here, under one roof, are grouped the press, core-building, commutator, insulation, winding, brushgear, machining, erecting, testing and despatch departments in connection with direct-current and alternating-current machines of all sizes; also the switchgear manufacturing, erecting and testing departments and the generating station. The shop in which heavy machine work and the erection of large motors and generators are carried out was formerly a separate building lying across the end of the main building but at some distance from it. The two buildings have recently been joined up and the intervening wall taken out, the result being an addition of some 2,200 sq. yds. to the total shop area, and increased ease of control and communication. Means of internal transport are provided by 14 electrically-operated overhead travelling cranes and by trolleys running on a network of rails."

"The machine tool equipment, which is quite up to date, comprises some hundreds of tools, including complete ranges of planers, vertical boring mills, high-speed drilling machines, lathes, automatics, grinding machines, presses, &c. No tool, whatever its age, is retained in the factory if it can be replaced by a better. The foundry, in a separate building of about 2,200 sq. yds. area, deals with castings from the smallest brass or copper switch parts to the largest iron castings required in the machine department. It is served by two overhead electric cranes. The factory also has its own pattern shop, carpenters' shop, smithy and fire station, while the comfort and recreation of the employés is provided for by mess rooms, works institute, tennis courts, bowling green and playing fields."

The illustrations in the booklet give some idea of the range of the company's manufactures. In preparing them they have, wherever possible, photographed the machines as actually installed, recognising that the reader will find such illustrations more interesting

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
CHARLES CLIFFORD & SON, LTD.,
BIRMINGHAM.
TRADE MARK.
SEA CLIFF

than those which merely show machines upon the shop erecting plates. In some instances he will have to accept the company's word as to what a motor is driving; nevertheless, they hope that

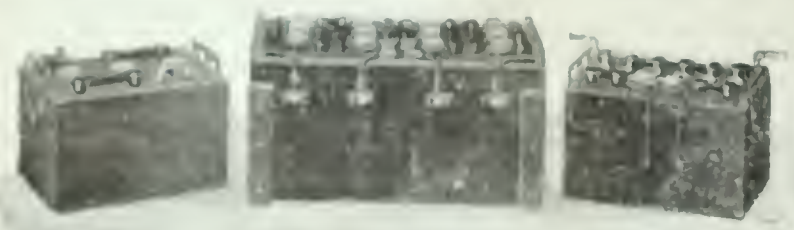


Face of an Order for Thirty five B.T.H. Three Phase Slip-ring Motors.

examination of even these illustrations will be profitable, as showing different methods of installation and the conditions under which standard machines are called upon to work."

BRITISH REPLACEMENT BATTERIES FOR AMERICAN CARS.

The great number of American cars now fitted with lighting sets and dynamo starters has given rise to a demand for British made batteries for these equipments. Messrs. C. A. Vandervell & Co. have



Y1 S Y17 S Y7 S
C.A.V. Replacement Batteries for American Cars.

sent us an advance copy of a list in which they describe and price the batteries which they offer for this purpose. To obtain a really reliable unit, a replica of the "Multex" plate is fitted, and the familiar 2 volt ebonite or hard rubber sealed-in units are employed. The units are mounted up in wooden containers treated to resist

Model.	Volts.	Amp. hrs.	Length.	Width.	Height.	Purpose.
			Ins.	Ins.	Ins.	
Y1.S ...	6	80	12	7¼	9½	Studebaker & Hupmobile.
Y3.S ...	6	80	11½	7½	9½	Bedford-Buick.
Y5.L ...	6	80	20½	4½	9½	Overland.
Y7.S ...	12–6	40	12¼	7⅛	9½	Maxwell & Mitchell.
Y9.S ...	12	40	12½	7½	9½	Ford & Genemotor set
Y11.S .	12	40	12¼	7⅛	9½	Briscoe & Scripps-Booth.
Y13.L .	12	40	20½	5	9½	Dodge Bros. car.
Y15.S .	18–6	35	15½	7⅛	11½	White-Coleman.
Y17.S .	24–12	30	20	10	10½	"USL" equipment

acid and fitted with flush-type carrying handles. Special adaptable cone fittings are fixed to the terminal pillars, which can be correctly positioned to suit the starter leads and taper contacts of each individual type of car.

The range of batteries has been standardised at favourable prices, and eliminates the difficulty of obtaining spares in this country.

The overall dimensions of the most popular 6-volt 80-amperes assembly are shown in the table, whilst full details are also given of the various cars for which the "American" replacement models are manufactured.

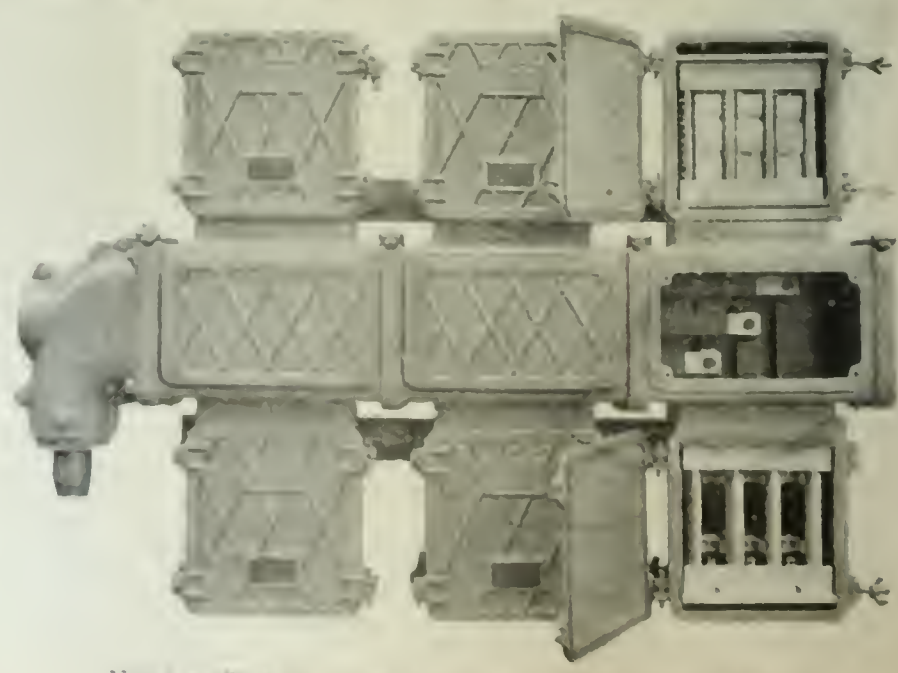
A copy of the leaflet will be forwarded on application to the company at Warple Way, Acton, London, W.

IRONCLAD DISTRIBUTION FUSE BOARD.

The growing use of ironclad switch and fuse gear for a.c. and d.c. circuits is indicative of the demand for sound engineering construction in electric switch control apparatus. The power circuits now employed in industrial undertakings are of a capacity that merits the wiring portion of the installation being carried out on quite substantial lines.

Much of the pioneer work in the iron enclosure of switches and fuses has been done in this country by A. Reyrolle & Co., Hebburn-on-Tyne, and many excellent examples of their designs are in service on circuits of every class. One of their most recent productions is shown in the adjoining illustration, which depicts an ironclad distribution fuse board arranged for building up on the unit principle. It is made up of three divisions, the iron portion of each being cast as one piece: the centre section is a 'bus bar chamber and the upper and lower sections are fuse chambers. In the illustration one of the units is shown open, and it clearly indicates how the 'bus bars are supported equi-distantly and the bar connections are taken from them, at the back, to each of the fuse sections, one above and one below. The 'bus bar sections are designed for bolting together to form any desired length of fuse board and the ends will accommodate either a blank cover or a cable entry box, through which the three-core cable can pass either from a vertical or a horizontal direction.

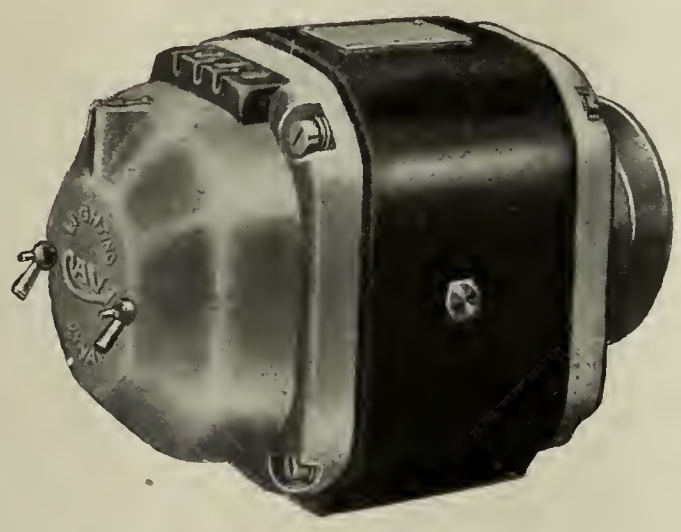
The fuses used are the company's standard porcelain ventilated handle type which are readily replaceable and can be re-fused with-



View of Three Units, Ironclad Distribution Board.

C.A.V. Dynamo Lighting for Automobiles

IN that all-important branch of the motor industry—the Electric Lighting of Motor Cars—this is the Dynamo which has replaced complicated apparatus, for it is the culmination of the engineer's true ideal—efficiency based on the bed-rock of simplicity



SIMPLE, SAFE AND CERTAIN

Since 1900 we have specialised in Car Lighting, and the introduction by us in 1904 of the first variable speed dynamo ever placed on the market has brought the C.A.V. self-contained Car Lighting System into world-wide popularity and use.

Driving behind C.A.V. Lamps makes travelling as safe and pleasant as by day. Write for literature.

C.A.Vandervell & Co.; LTD.,
Electrical Engineers, ACTON, LONDON, W



These **EDISWAN** *Letter Cards* *are* **FREE.**

Please write for a supply over-printed with ***your*** name and address to—

THE EDISON & SWAN UNITED ELECTRIC LIGHT CO., Ltd.,
PONDERS END, MIDDLESEX.
'Phone: 520 Enfield.

IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

out the need for special cartridges or refills. In every case the contacts and these fuses are self-aligning.

We understand that these boards are made up with standard castings for several sizes of circuits, particulars of which will be supplied by the company on request.

THE REFECTORY, GOLDERS GREEN.

Golders Green, the youngest and most enterprising of our London suburbs, provided as it is with so many means of social recreation and education, should now feel proud in the possession of a first-class restaurant on West-end lines. It claims to be the only electric restaurant in London open to the public and run on purely commercial lines as a restaurant only. Two other similar establishments exist, but they are owned by the makers of the cooking apparatus installed. There are, of course, a number of small public tea rooms in which electric cooking is in vogue, such as Harrod's and other West-end firms, but probably none of those depends for its existence entirely upon its being a commercial success.

The Golders Green enterprise is, we understand, due to a few public spirited local gentlemen who recognise the many advantages of electric cooking and decided to adopt it in preference to any other available method. The owners of the company are Electric Caterers (Ltd.), who are to be congratulated on the success of their enterprise, for we gather that it has now been in being for over four months. Judging by the daintiness and quality of the catering and the extremely moderate prices, the establishment compares quite favourably with any first-class West-end restaurant. It is to be hoped that the proprietors will not confine their operations to one district only.

Through the courtesy of Mr. B. C. Drummond, engineer and manager of the Hendon Electric Supply Co. (Ltd.), which supplies the energy, we were recently shown round these interesting premises. The building is chaste in design, commodious in accommodation, and planned in every detail in a manner which shows that the promoters know their business and the architect his craft.

The building has been appropriately termed the Refectory, and is in the main Finchley road, immediately opposite the exit of the Golders Green Tube Station. It forms a well-balanced and imposing piece of architecture in the Georgian style with a finely designed shop front in polished copper. The entrance to the dining room and lounge is through a foyer used for the sale of cakes, pastries and confections. The usual counters and shelving are replaced by refectory tables and dresser, where the products of the electric bakery are neatly displayed in pewter and other artistic dishes.

The tea room, which is entered directly through the foyer, is furnished with "Dryad" cane furniture and the floor is dark oak covered with Oriental rugs. The dining room on the lower ground floor is approached from the foyer by a short staircase and is of simple design and charmingly decorated in a colour scheme of grey with a black dado with picture rail and floral border. It is furnished in old English light oak, the floor being also covered with Oriental rugs. That good humour which is necessary to the enjoyment of a well served dinner is encouraged by the dispaly on the walls of reproductions of the drawings by Hassal, Lawson-Wood and Townsend, and the effect at night when the room is lit by electric table lamps with their pink shades is both pretty and cheering. Semi-indirect lighting with half-watt lamps is employed throughout, with handsome alabaster bowls for the public rooms. The fittings were supplied by the General Electric Co. (Ltd.)

Electric fans, both table and fixed, ensure a cool and sweet atmosphere, so essential to the comfort of a restaurant.

The kitchen, which is divided from the dining room by a servery, is equipped with the following electric cooking apparatus: Two No. 3 heavy hotel type Falkirk roasting ovens each loaded to 5 kw., the elements being arranged on both sides and wired for six-heat control. The ovens are double-sided, heavily lagged and are of glazed white enamel inside, thermometers are provided to assist heat regulation. The elements are all accessible without the need for dismantling the apparatus.

The efficiency of these ovens is shown by the following test: 250°F. in 15 minutes from dead cold, with consumption of 3 kw.; 320°F. in 20 minutes; 410 F. in 30 minutes; 550°F. in 45 minutes. Switched to half heat the temperature rose but not so rapidly, and at low heat with a consumption of 750 watts, a steady heat of 450°F. was recorded.

Two restaurant type Falkirk grills and toasters are provided, one loaded to 3 kw. and the other to 5 kw., each with three heat control; attached to each is an ingenious device for regulating the distance of the food from the heating elements. A combined carving table and hot cupboard of the "Falkirk" heavy restaurant type is placed in the centre of the kitchen, and loaded to 2 kw. for carving table and 3 kw. for hot cupboard, each having three heat regulation. Coffee urns and hot water urns, loaded to 2 kw. and 3 kw. are also provided. All apparatus is furnished with illuminated switch fuse board.

The pastry kitchen is situated on the first floor and the apparatus installed is as follows: Two "Falkirk" pastry ovens specially designed to meet the requirements of the restaurant in the way of the rapid baking of pastries and small cakes. The ovens are fitted with top, bottom and intermediate heating elements in place of the usual side heating, an arrangement which we were informed has proved most suitable for the small pastries which are turned out daily. Each deck has cast-iron sole plates ground and polished and fitted with enclosed elements rated at 1,500, 1,000 and 1,000 watts respectively, and the top deck has an additional heating element loaded to 1,000 watts. These ovens are wired for 12 heat regulation and are provided with thermometers. A griddle plate loaded to 3 kw. with three heat regulation is much used for baking Scotch scones, which are deservedly popular in the district. The building is heated throughout with "Falco" radiators.

The apparatus was supplied by the Falkirk Iron Co. (Ltd.), and the contractors for the electrical plant were Messrs. Crompton & Co. (Ltd.), Salisbury House, London Wall, E.C. We would express our thanks to Mr. Drummond for showing us round and take this opportunity of congratulating the proprietors of the Refectory upon their enterprise in establishing a real live, attractive electric restaurant in Northern London.

One, Two & Three Phase MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4024. Grams: Vicminster, Sowest, London.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, July 14, 1916.

THE ROUND TABLE.

By "KVA."

In answer to a correspondent, I am asked to state that Glover's cable stocking does not need a suspender.

* * * *

CAUSE: The ever-mounting price of petrol.

EFFECT: An article in "The Autocar," entitled "Electricity in Car Transmission."

* * * *

Really it is time we had electric vehicles on the streets if there is any truth in the following :—

Have horses a sense of humour? An incident that occurred recently in a New York street suggests that they have.

A hansom-cab horse standing near an empty motor-car began to lick the rubber bulb of the motor horn. Then he bit the rubber gently, with the result that the horn sounded. Passers-by stopped to laugh. Again and again the horse, with ears laid back, blew blasts on the horn, until a policeman interfered and spoiled the spor t. Spectators maintain that the horse laughed.

This is scoffing at the motor car with a vengeance.

* * * *

Pope's Elasta girls have been taking care of wounded Tommies lately; on the first occasion at Shepherd's Bush Empire, when 120 lads were the guests of the girls, and on the second occasion at Kew Gardens, where 60 of our heroes were given tea, cigarettes and a good time generally. Evidently the idea, like the lamp, is to be a lasting one, for I hear that a third collection among the Elastettes will provide funds for yet another outing for 60 wounded boys. Mr. Elasta, Pope's now famous mascot, is, of course, always there to act as chaperon.

* * * *

"Ediswan" have "shot off" the return match with the British Electric Transformer, and again have to acknowledge defeat, but by the narrow margin of only 10 points. After the eighth man of each team had fired, the B.E.T. were leading by only 2 points, but the latter "came again," and their last two

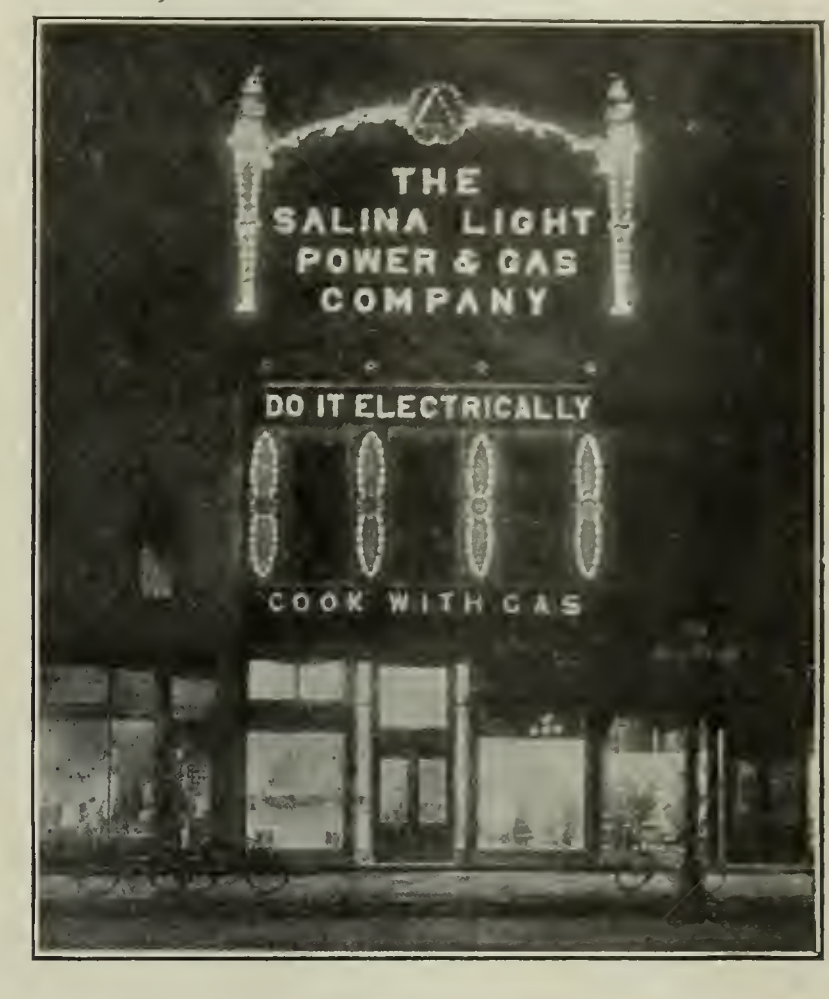


men put on 98 and 93. The victors were captained by Mr. A. C. Whish and the vanquished by Mr. Anderton. They occupy the centre of the front row of the picture of both teams, reproduced herewith. I suppose after this little *affaire des armes* the Ediswan team admit that their ponders end regarding their markmanship, and that they are fairly B.E.T.!

"The thick plottens" to start a rival institution to the Inst. E.E. When it's formed I suppose it will be called the Inst.Ha. Ha!

* * * *

I feel sure that Mr. Wordingham will be pleased with the adjoining photograph, which I have taken from an American contemporary. It is about the most effective form of co-



operation between the gas and electric interests that could well be imagined, though to "Do it electrically" and "Cook by gas" would seem to "Tricity" Berry, "Kukri" Grogan and "Red Hot" Bastian a contradiction in terms.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), July 19, 1879.]

LIGHTNING CONDUCTORS.—Mr. Richard Anderson, member of the Society of Telegraph Engineers, has nearly ready for publication a scientific and practical treatise on lightning conductors. The subject is an important one, and Mr. Anderson's experience in this department of applied science renders him a good authority in such matters. We await the publication with interest.

THUNDERSTORMS.—A heavy storm broke over Chester on Sunday afternoon and at night. Flashes of blue forked lightning came in rapid succession, followed by loud peals of thunder and torrents of rain. Great damage was done by the rain. When the storm was at its height the lightning struck a peach house attached to Hoole Hall, the residence of Mr. Arthur Potts, stunning Taylor, the gardener. At Liverpool the lightning struck and shattered a large cross on the schools connected with St. Francis Xavier's Roman Catholic Church. The *débris* fell into the school yard, but no one was hurt.



THE TWO MOST RELIABLE SELF-STARTERS

No. 29-1.—Self-acting Motor Starter for Direct-current, with interlocked solenoid operated finger contacts. Sure and simple in operation. Requires the least possible attention.

CONTROL IGRANIC ELECTRIC DEVICES

No. 30-1.—Self-acting Motor Starter with solenoid operated radial arm and interlocked circuit breaker fitted with magnetic blowout. Ruggedly strong. Built for heavy service.



IGRANIC ELECTRIC Co. LTD 147, Queen Victoria Street, LONDON.

SIEMENS



IRONCLAD SWITCHGEAR FOR ALL PURPOSES

Control Pillars
Distribution Boards
Main Switchboards

Illustration shows our Standard Cast-iron Mining Pillar suitable for pressures up to 3,300 volts.

Write for particulars to —

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. (Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

NEW "ARORA" COOKING APPARATUS.

Advance proofs have been sent to us by the Arora Co., Loughborough, England, of leaflets which deal respectively with their new electric grill and electric boiling plate. The first named, which is illustrated in Figs. 1 and 2, measures 8½ in. high outside, 6 in. inside, 11 in. wide outside, 9 in. inside and 10 in. deep outside and 7½ in. inside. The weight of the grill is 19 lbs. It is of solid construction and comprises three main parts: the supporting stand, which is of cast iron; the heating elements, which are carried in a cast iron frame; and the drip tin. The general construction is explained by the illustrations. The elements are of the sliding pattern, similar to those employed in the "Arora" fire, a description of which we published some months ago. The view in Fig. 2 clearly shows the design and arrangement of the two heating elements. The resistance material, which comprises a specially spiralled nichrome ribbon, is suitably supported on a fireclay base, in turn secured to the cast-iron body of the upper part of the grill. The loading of the element is 1,100 watts, and a bright red heat is obtained as soon as the current is turned on. It is stated that from 5 to 10 minutes only are required to cook cutlets, chops, steak, fish, &c., the time varying a little with the thickness of the food. The elements and their supporting frame form an independent unit, which also includes the main terminals. These latter are suitably protected by a cast-iron box, which is supplied with insulating bushes for the incoming leads. This grill is offered for all stock pressures from 100 to 250 volts. The list price is 25s.

Fig. 3 is a plan view of the new "Arora" three-section electric boiling plate. This has an opening 8 in. in diameter in a cast-iron plate which measures 14 in. by 12 in., and which rests on a supporting member 4 in. high. The weight of the complete boiling plate is 22 lb. A feature of the construction is the subdivision of the heating element into three entirely independent sector shaped units, which are supported on a retaining disc and held in place by two wing nuts.

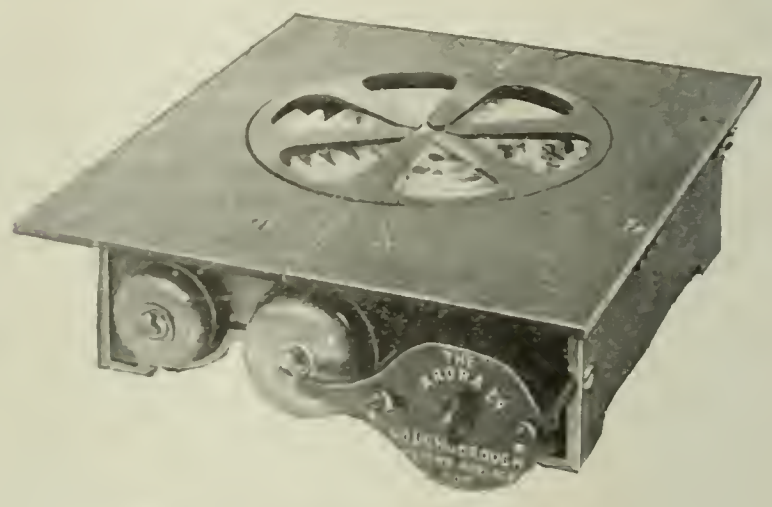


FIG. 3.—THE NEW ARORA HOT PLATE.

Any desired number of these three sections of the heating element can be turned on at one time. When the plate is turned on full the total consumption is 1,500 watts. By means of the control switches, one-third, two-thirds or full heat can be obtained. There is also a simmering heat, which is introduced by means of a third switch, which is under the control of what is known as the "simmering slide," a contrivance whereby the centre of the three switches cannot be turned on. This arrangement of switches provides for four heats, representing the various loadings 1,500, 1,000, 500 and 170 watts. It will be noticed that provision is made on the hot plate for sliding utensils partly on and partly off the central heater opening. The construction is exceptionally solid, and has been designed for kitchen and restaurant service. This hot plate is listed at 57s. 6d.



FIG. 1.—ARORA GRILL COMPLETE.

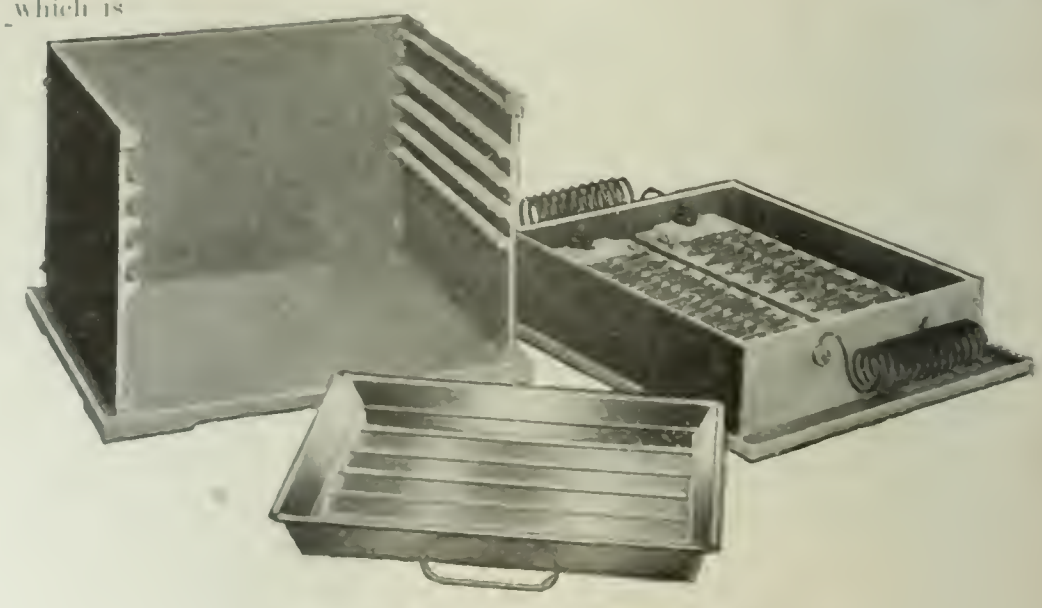


FIG. 2.—THE THREE UNITS OF THE ARORA GRILL.

TINNING FURNACE
(Hall's Patents)
For COATING WIRES with Tin, Lead, etc. For use as a BATH.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
The only Tinning Plant on the World's Market with Automatic Heat Control.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

J. P. DEVINE CO., BUFFALO.

MANUFACTURERS OF

Vacuum Drying and Impregnating Plant.

(PASSBURG SYSTEM.)

The Devine Co. are well known in the United States and Canada as the leading manufacturers and experts in Vacuum Drying and Impregnating Plant and have over 1,500 such plants in successful operation.

AIR PUMPS, COMPRESSORS,
VULCANISERS,
CONDENSING PLANT.

Solvent Recovery and Derisinating Plant a Speciality.

Sole Representative:

JAMES LIVINGSTON, LTD.,

30, GT. ST. HELENS, LONDON, E.C.

Telegrams and Cables: "CINERARY, LONDON."

Telephone: LONDON WALL 3151.

EDISWAN EVERYTHING ELECTRICAL

THE ALL-BRITISH HOUSE FOR ACCESSORIES

ROYAL "EDISWAN" DRAWN WIRE LAMPS

CATALOGUES ON REQUEST FROM THE
EDISON & SWAN U·E·L CO., LTD.,
PONDERS END
MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06 - 27712/03 AND OTHERS



PLEXSIM ELECTRIC HOT-PLATE.

A highly finished and robust boiling plate specially suitable for

Industrial Purposes.

MADE IN TWO SIZES.

No. C 1104 7 inch 750 watts.
,, C 1105 8 ,, 1,000 ,,

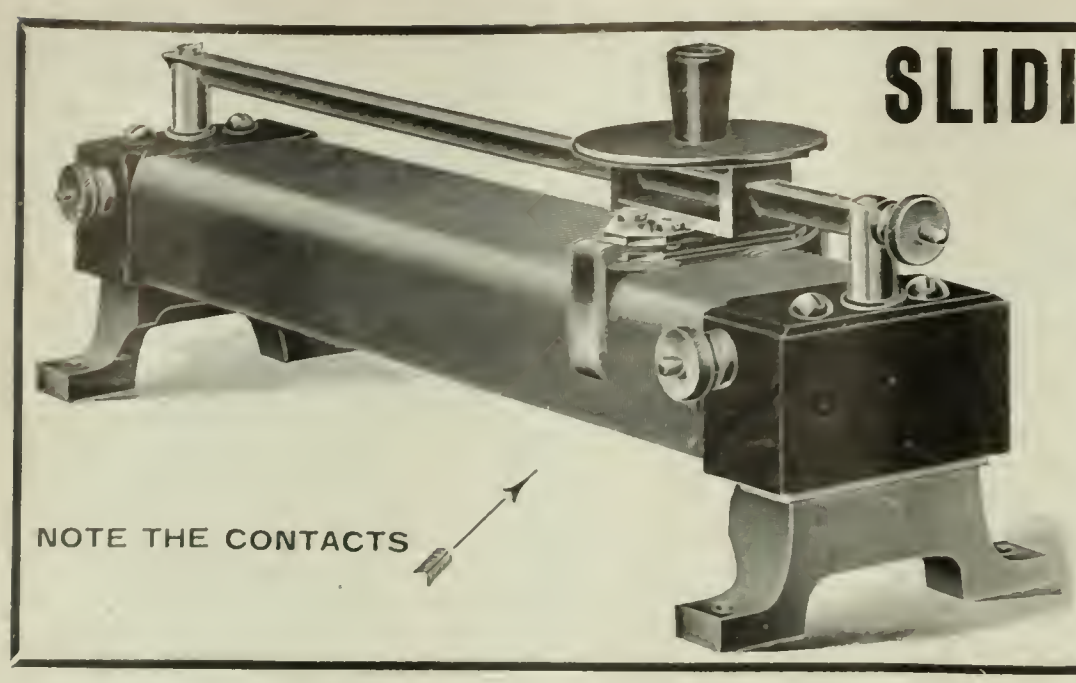
The most efficient and durable Hot-plate at present on the market.

"Plexsim goods make good."

SIMPLEX CONDUITS, LIMITED,

Garrison Lane, Birmingham.

LONDON: 113-117, CHARING CROSS ROAD, W.C
MANCHESTER: 16, CORPORATION STREET.
GLASGOW: 72a, WATERLOO STREET.
BRISTOL: 11, DENMARK STREET.
NEWCASTLE: 61-65, HIGH BRIDGE.
LEEDS: 6, WHITE HORSE STREET.
LIVERPOOL: 96, WHITECHAPEL.
SWANSEA: 14, HEATHFIELD STREET.
CARDIFF: 4, WESTGATE STREET.
ABERDEEN: 1, CRIMON PLACE.



SLIDING RESISTANCES
FOR
LAMP TESTING
METER TESTING
LABORATORY WORK, Etc.
BRITISH-MADE THROUGHOUT.
New List on request.
Nature says: "The list is one of the most complete we have seen."
ISENTHAL & CO.,
(DEPARTMENT 4)
DENZIL WORKS, WILLESDEN, LONDON, N.W.
Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

ELDER'S CABLE HANGERS AND CLIPS.

Lead-covered cables for telephonic and other purposes suspended overhead from a catenary suspension wire have hitherto had a comparatively short life, owing to the cracking and breaking of the lead sheath. To such an extent has this been the case that we understand some users of aerial cables have given up the use of lead-covered conductors. There is every evidence to show that the damage is due to the suspenders allowing the lead-covered cable to swing freely in the wind, independently of the catenary wire, thus causing ripples to run along the lead covered cables, and also owing to some of the suspenders gripping the lead of the cable, whereas others do not.

With regard to the latter point, the disadvantage is twofold. Firstly, the suspenders that grip the lead act as sails to a wind blowing along the line, with consequent buckling at changes of direction, as well as stretching and breaking of the lead sheath at other points. Secondly, those suspenders that do not grip the lead become blown along by the wind and bunched together at irregular intervals, thus causing long lengths of cable to become unsupported with consequent undue sagging of the lead covered cable, and the development of cracks.

Suspenders are usually spaced along the cable at distances varying from 18 in. to 6 ft. apart. The length of the suspender has not generally been considered of importance, and the distance between the catenary wire and the aerial cable has varied from 3 ft. to 6 ft., or even more. As a result of careful investigations after serious damage to lead-covered cables suspended in the usual manner, we are informed that it was found that the following points require careful attention:—

1. The suspenders should be spaced about 1 ft. apart and not more than 18 in.

2. The distance between the suspension wire and the lead-covered cable should be as short as possible, and not exceed 2½ in.

3. The suspenders should be designed so that each bears its proper share of the weight of the lead-covered cable, *i.e.*, they should be of equal lengths when fixed.

4. Means should be provided to prevent displacement of the suspenders along the cables in high winds, and also to prevent longitudinal movement of the lead-covered cable in the direction of the line, and particularly on hillsides and at other differences of level.

When the suspenders are too long they allow the lead-covered cable to swing freely, independently of the suspension wire, whereas short suspenders compel the lead-covered cable and the suspension wire to swing together.

The Elder method of suspending aerial cables has been developed by British Insulated & Helsby Cables to fulfil the requirements stated above. The suspenders are in the form of a simple loop, as this enables each suspender to be fixed without any risk of stretching it. This loop is kept as short as possible, and the suspenders should be spaced preferably 1 ft. apart. The suspenders are secured to the suspension wire by means of a patent clip, which grips the wire by spring pressure, and renders any displacement of the suspenders along the suspension wire quite impossible, once fixed.

This prevents the displacement of suspenders by the wind, each suspender retaining its proper position along the cable even in the highest winds. Furthermore, the suspenders being unable to move, the "sail" action already referred to, which causes a longitudinal drag of the lead-covered cables, is overcome.

The suspenders being in the form of a loop, do not grip the cable, and in order to prevent any creeping of the lead-covered cable within the suspenders, especially on slopes, flat spring clips are fixed at several points in each span to prevent any longitudinal movement of the lead covered cable, and to prevent buckling or stretching of the

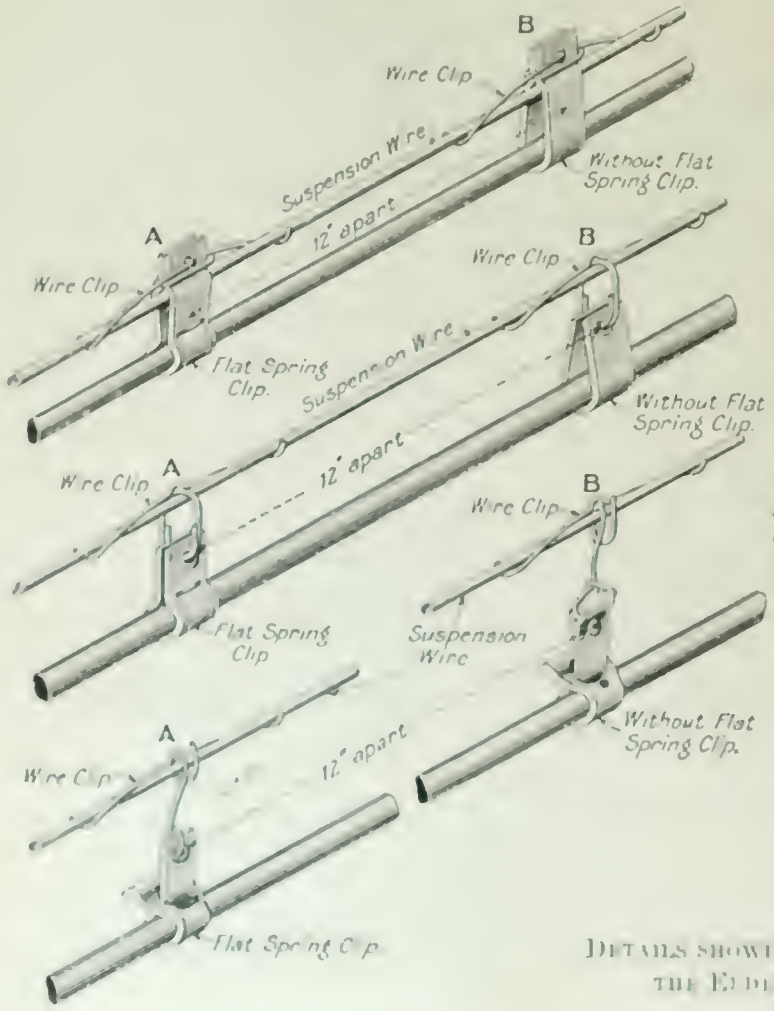


Fig.1.
Leather suspender showing patent wire clip on suspension wire and flat spring clip on cable.

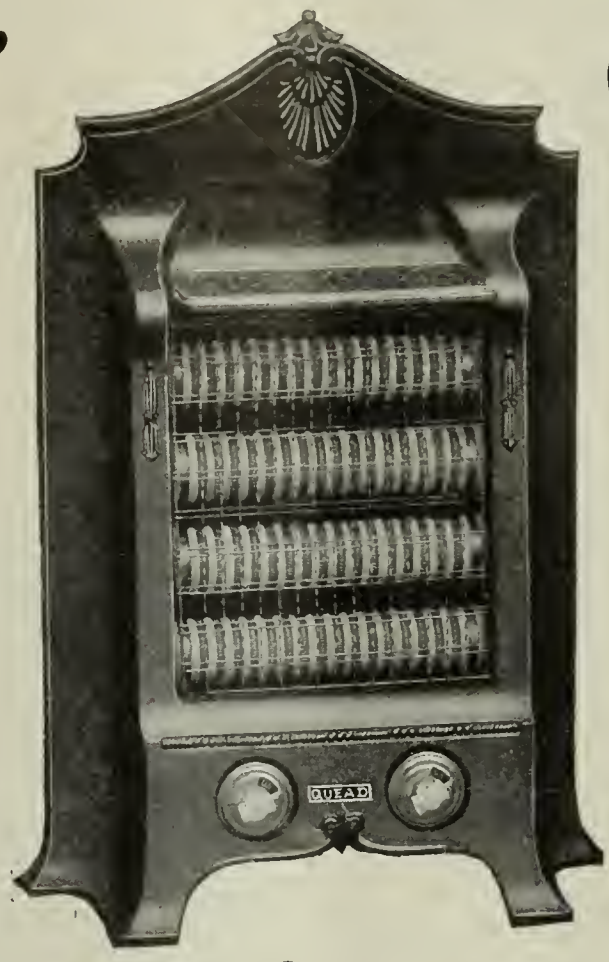
Fig.2.
Leather suspender with ring hook, showing patent wire clip on suspension wire and flat spring clip on cable. PS This arrangement is recommended for cables about ¾ in diameter as it is more adaptable for sliding along the suspension wire.

Fig.3.
Old types of leather suspenders and hooks, showing adaptability of the patent wire clips and flat spring clips

DETAILS SHOWING APPLICATIONS OF THE ELDER SUSPENDER.

"THOR" High Grade Specialities
CASING and CAPPING CONDUIT
CABLES
CABLE CONNECTORS
COMMUTATOR COMPOUND
WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.
WRITE FOR PRICES & DISCOUNTS.
HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

THE "ROYAL" QUEAD.



Q. 13.

Sole Manufacturers

..QUEAD LTD..
47 to 57 Marylebone Lne
London, W.

Telephone: Mayfair 3582.

Special Features

Sound Construction
. . Red Heat . .
Artistic Finish.

Ask for 1916-1917 List.

lead sheath. While the foregoing applies particularly to the suspension of lead-covered cables, the trouble from displacement of suspenders by wind is one that is experienced on all suspended cables, whether lead covered or not. To overcome this trouble a special form of patent clip has been designed which can be fixed over the hooks of the various types of suspenders in common use, and which may be adopted on existing work at small expense.

With the suspender and patent wire clip the usual wire hook is dispensed with, the leather suspender being clipped direct to the suspension wire by means of the patent clip. These suspenders are intended for use only in cases where the suspension wire can be reached from the ground at any point.

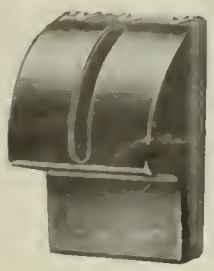
The suspension wire is first stretched in position and sagged up approximately correct. It is then lowered in lengths of several spans at a time so as to hang within a few feet of the ground. The lead-covered cable, which has been run out on the ground along the route, is then lifted up in sections to meet the suspension wire and the loop suspenders and clips put on. The latter clips are not, however, sprung on to the wire at this juncture, but are merely passed through the eyelets. The suspension wire and lead-covered cable are then lifted up together from each pole, the whole process being repeated at intervals along the line until the drum length of lead-covered cable is thus roughly suspended. When the cable and suspension wire have been raised into position, the sagging is completed, the suspenders are regulated for spacing, and the wire clips are finally clipped on to the suspension wire from a ladder.

In some cases it is not possible to reach the suspension wire from the ground after erection, and it would, therefore, not be possible to get at the suspension wire to spring the clips on to it. In such cases it is usual to erect the lead-covered cable by drawing it along the suspension wire on its suspenders, the latter sliding along the wire and being put on one at a time from a ladder at a pole as the cable passes by. In such cases flat spring clips are used to clip the suspenders on to the lead-covered cable, and so prevent them being displaced along the cable as they are drawn along, or by the wind. In addition, as many as possible of the suspenders which can be



A Typical Span, showing Lower Cable supported by Elder Suspenders.

H. Weidmann, Ltd., Rapperswil, Switzerland.



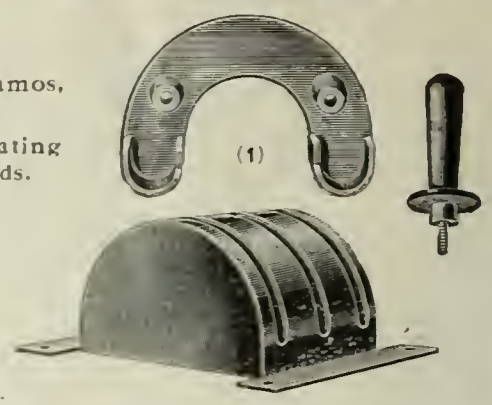
MAKERS OF PRESSPAN AND INSULATING MATERIAL.

Pressboard (Presspan) in Sheets, Rolls and Tapes, Oiled Presspan, Black Presspan, Presspan Tubes and Stampings.

Amianite (Vulcanised Asbestos) Coil Frames, Spools for Apparatus, Dynamos, Motors and Transformers. Insulating Blocks, Tubes, Plates, Boxes, &c.

Bakelite & Cornite (high tension material) Handles of Switchgear and Heating Apparatus, Controller Insulation, Moulded Pieces, Terminal Covers of all kinds.

Asbestos-Cement in Plates, Arc Shields for Controllers, &c.





Mica and Substitutes, Insulating Pearls, Transformer Spools.
Japanese Felt and Paper in rolls and tapes.
Oil-Varnished Linen, Diagonal Tapes, Oil-Varnished Silk & Paper.
Artificial Leather Discs for Friction Drive.
Insulators for Electric Furnaces, Tramways, &c.

reached from the pole at each side are fitted with the wire clips, clipped on to the suspension wire.

Existing work which has not proved entirely satisfactory can be readily altered in accordance with this improved suspension. If the existing suspenders are short enough, so as not to give more than 2½ in. between the cable and suspension wire, all that is required is to space them about 1 ft. apart and fix a spring wire clip over the hooks. Many existing suspenders are too long, however, but are long enough to allow of being cut shorter, punched with eyelet holes and fitted with wire clips to form Fig. 1a suspenders. In each case, flat spring clips should be fixed at intervals of about 30 ft.

The construction detailed above is the result of several years' investigation on the overhead systems of the North East Coast Power Companies, who are among the largest users of aerial cables in this country, in connection with pilot cables for the Merz-Price protective gear, and also for telephone cables on their overhead extra high-tension transmission lines, for each of which purposes paper insulated lead-covered cable is essential, on account of the low inductive capacity of such cables.

Since this method of suspension was adopted, about two years ago, a considerable mileage of lead-covered cable has been suspended in this manner with complete freedom from trouble. The cables mentioned have weathered some of the most severe storms, including that of Easter Monday, 1912, when houses in the district were unroofed, and also a severe snowstorm on Jan. 17, 1913, when sleet collected on the wires and cables to a diameter of from 4 in. to 5 in.: nevertheless, not a single crack has been found in the lead sheath of the cables.

THE TURBO-GENERATION OF CONTINUOUS CURRENT.

In large undertakings using continuous current the power is usually generated by turbo-alternators and transmitted at high pressure to sub-stations, where it is converted to continuous current either by rotary converters or motor-generators; but where the undertaking is small, and the distance over which the power is to be transmitted is not great, this method is not economically practicable. Continuous-current turbo-generators of various outputs up to about 2,000 kw. have been designed and are running successfully; but these machines are not altogether satisfactory from the point of view of the designer and electrical manufacturer. The high efficiency of the steam turbine, however, cannot be overlooked, and in large units the turbine must be utilised if low power costs are to be attained.

But in a continuous-current turbo-generator the designers of both ends have to compromise in order to make a satisfactory machine. The steam-turbine designer has to reduce the speed of the turbine

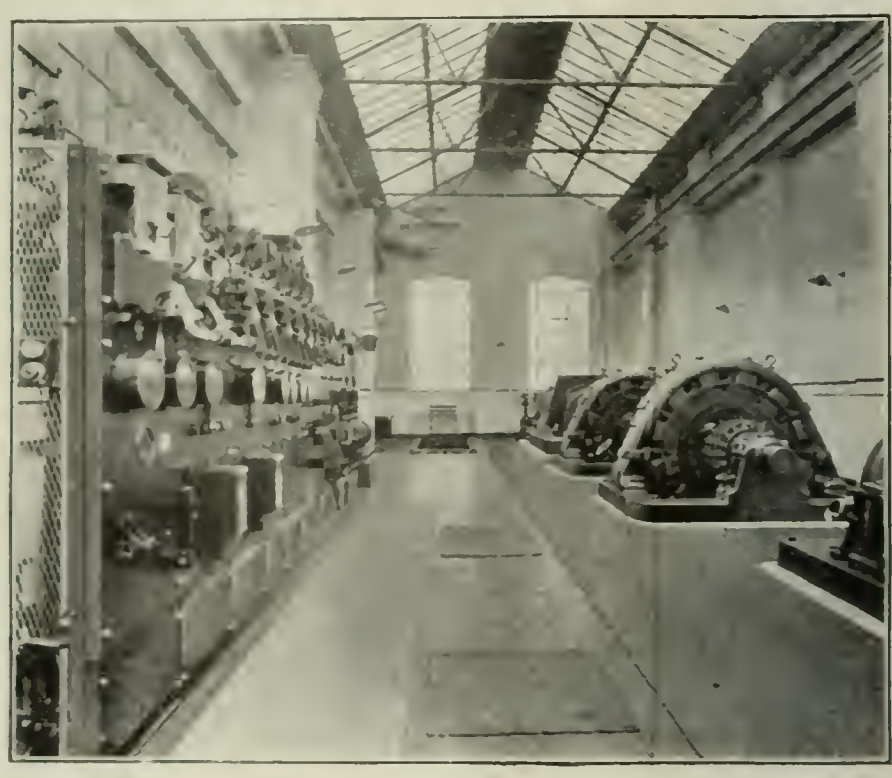


Fig. 1.—1,500 kw. "Witton" Turbo-alternator driven by a Fraser & Chalmers Turbine and Operating in Conjunction with "Witton" Rotary Converters for generating Continuous Current.

at the expense of efficiency, while the generator designer runs his machine at a higher speed than is desirable for satisfactory commutator construction. But in the ideal solution the turbine should

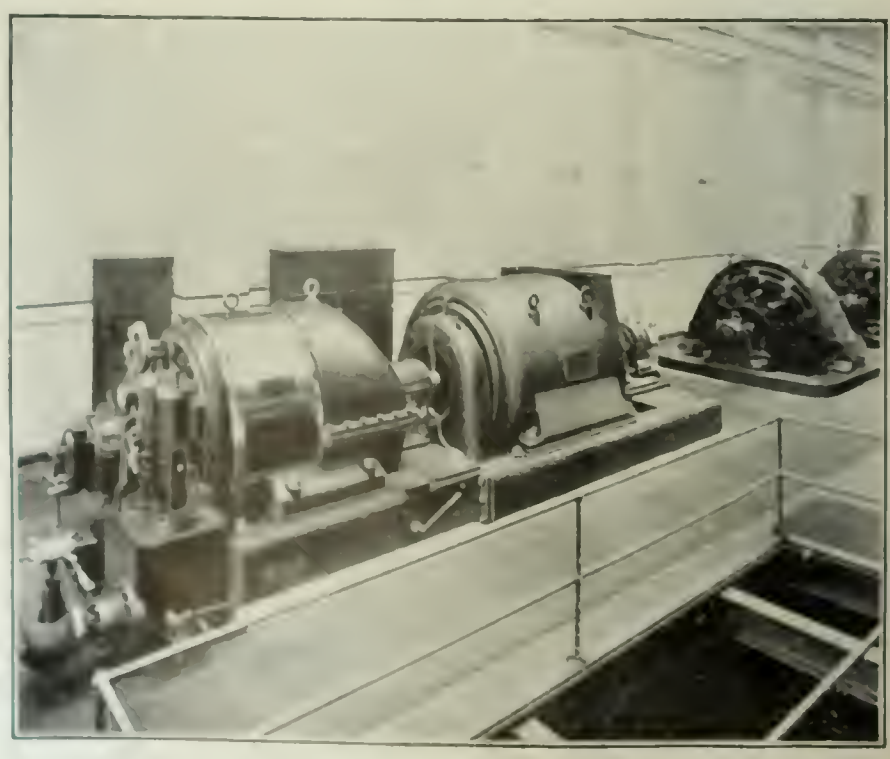


Fig. 2.—1,500 kw. "Witton" Turbo-alternator and Continuous current Side of the "Witton" Rotary Converters.



E. SHOWELL & SONS, Ltd.,
STIRCHLEY, BIRMINGHAM.

Drawn Shell Work
IN BRASS, COPPER, and STEEL.
Any size
up to 8" diam. × 4" deep.

Sole Agents for the Electrical Trade—
LIONEL ROBINSON, 3, Staple Inn, London, W.C.
Telephone: Holborn 6323

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYOOM, LONDON."

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868.
Codes: 5th Edition A B C & Western Union.

An Invitation

If you have any clutch or brake troubles, write us. We have a staff of experts who are daily engaged in the solving of such problems, and we have just installed a new testing plant—the only one of its kind in the world. We are only too pleased to place these at your disposal free of charge. This is part of the service that has helped to make **"Ferodo"** fabrics the most efficient and the proved best.

FERODO

CLUTCH AND BRAKE LININGS.

Contractors to the War Office and Admiralty. London General Omnibus Co. and Underground Electric Railways of London and Paris. *List X from*

The Herbert Frood Company, Ltd.

Works: CHAPEL-EN-LE-FRITH.

'Phones: 19 and 20 Chapel. Wires: "Friction, Chapel."

LONDON: 39, Upper Rathbone Place, W.
BIRMINGHAM: 202, Corporation Street.

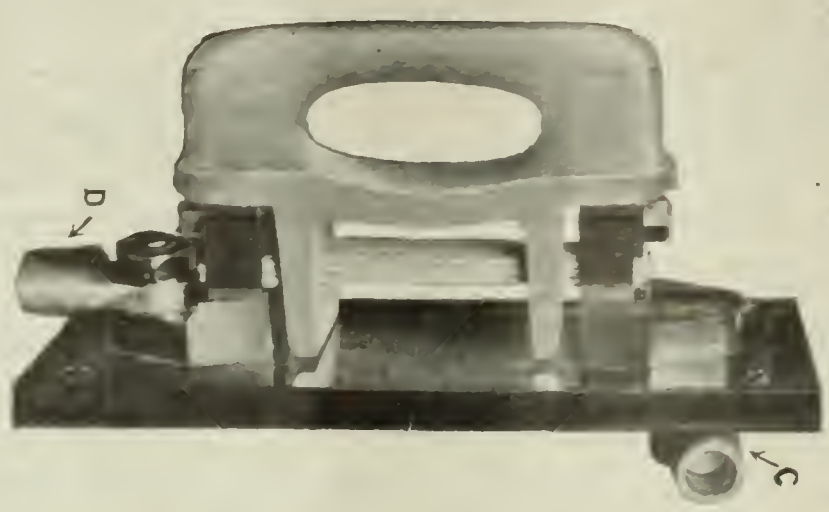
A1.

D. & S.
"HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

run at the high speed necessary to secure the best efficiency, while the commutator should be worked at a sufficiently low peripheral speed to prevent commutator troubles.

Recently two solutions of the problem have been resorted to—

(*a*) The installation of slow-speed generators driven by turbines through gearing.

(*b*) The installation of turbo-alternators driving rotary converters coupled direct electrically.

The General Electric Co. (Ltd.) has on hand a number of schemes on both principles, the selection of one or other solution depending upon individual circumstances. Both enable a works or small electric supply undertaking with a continuous-current system to

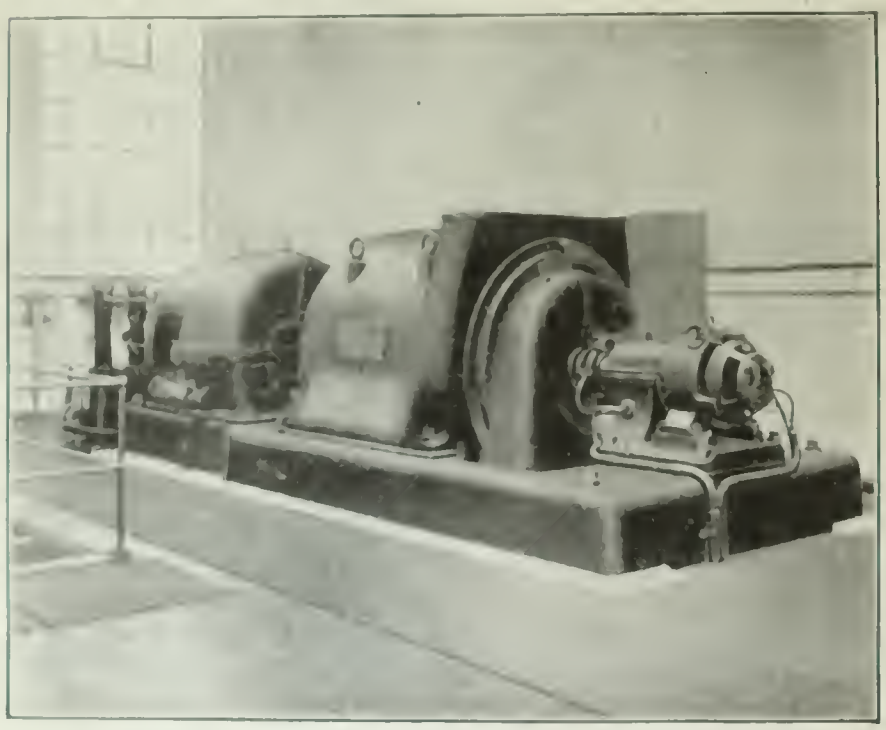


Fig. 3.—1,500 kw. "Witton" Turbo-alternator.

avail itself of the high efficiency of the turbine without resorting to any system of generation not known to be thoroughly satisfactory.

An example of the second solution is afforded at the works of Messrs. Fraser & Chalmers (Ltd.), of Erith, where an installation was laid down at very short notice. In this installation the proposals of the General Electric Co. (Ltd.), comprising turbo-alternators and rotary converters, were accepted as being both reliable and economical. The installation consist of a 1,500 kw. generating unit, composed of a Fraser & Chalmers turbine running at 3,000 revs. per min., and driving a "Witton" six phase turbo-alternator, generating three phase power at 325/370 volts 50 cycles. This unit is coupled electrically to two 750 kw. "Witton" rotary converters, running at a speed of 500 revs. per min., and generating continuous current at 440 volts, which is supplied to the "Witton" switchboard shown on the left hand side of Fig. 1.

The two rotary converters operate in parallel from one winding of the turbo-alternator, and, as is well known, unless precautions be taken trouble is met through the two rotary converters being connected in parallel on both the alternating-current and the continuous-current sides. In the early days of rotary converter operation it was found impracticable to run two rotary converters off the same transformer, due to the fact that there exists between each phase 'bus bar and the continuous-current 'bus bars a number of parallel paths of low resistance. The resistance of these paths is made up of the resistance of the connections, the converter armature, brushes and brush contacts. Although the total is low, the brush contact resistance constitutes a large portion of the whole, and, in addition, is a variable quantity. Moreover, the current distributes itself according to the resistance of each circuit.

A cross current flows in, say, the positive connection of two converters, subtracting itself from the current flowing down one lead and adding itself to the current flowing down the other. The result is that bad parallel running ensues. Where transformers are used they may be provided with two or more separate windings, each winding supplying one rotary converter. The same solution may be adopted in the case of generators, but it is not always desired to split up the generator winding into two or more parts. The two windings have been eliminated in a method (patent No. 11,905/13) introduced by the General Electric Co. (Ltd.). The present installation operates on this principle. Differentially-wound balancing transformers are installed in the low-pressure alternating-current leads of the rotary converter. They consist of two oppositely wound windings on the same cores. The alternating current supplying one phase of one converter is passed through one coil of the transformer, while that of the same phase for the other converter is passed through the second coil. Consequently, when the currents are equal, their effects cancel out, but should one converter attempt to take more than its share of the load the excess current magnetises the core and induces an E.M.F. in the other winding, which assists the current flowing therein and tends to cause it to increase until the two currents flowing are again equal. In this way the loads taken by the rotary converters are equalised, and the unbalancing of current brought about by the circumstances related is entirely obviated.

Any number of rotary converters can be coupled to the generator and run in parallel on this principle, and, if necessary, it is possible to take part of the generator output in the form of alternating current for transforming up and distribution at a suitable pressure to outlying districts. In the present installation, as in others on this principle installed by the General Electric Co. (Ltd.), the rotary converters are started up with the turbo-alternator and run up to speed with the machine. No synchronising is therefore required.

The arrangement offers a completely satisfactory solution to the problem of generating continuous current at a low power cost by means of turbines.

The complete electrical installation was supplied by the General Electric Co. (Ltd.), of London and Witton, Birmingham.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 422[illegible] Grams: Vicminster, Sowest, London.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, July 21, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—The Dominion of Canada Government is asked to prohibit the sale of 160,000 *units of horse power* to the United States.

* * * *

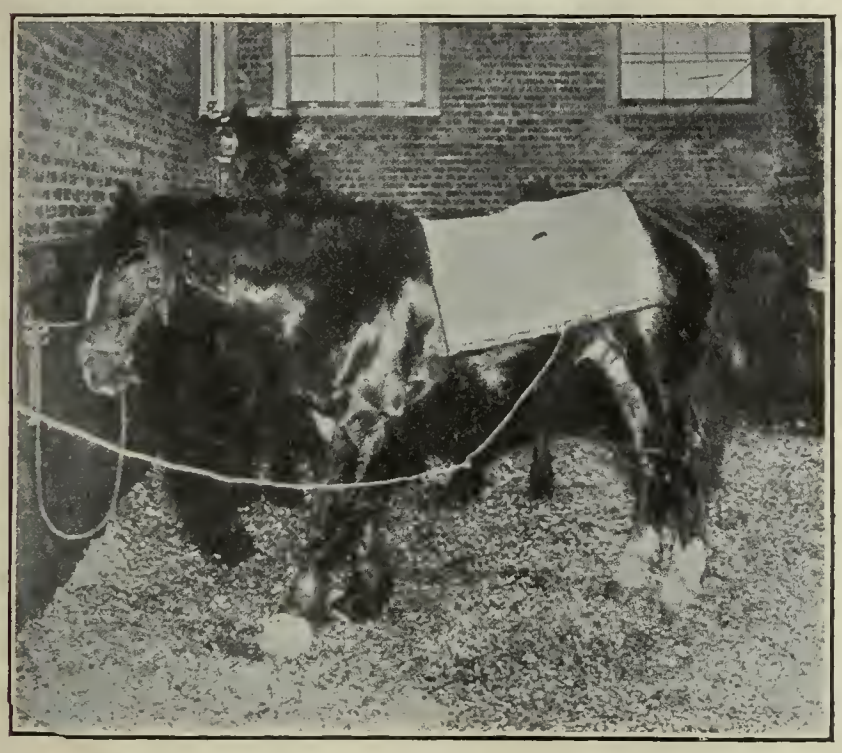
This is a period of micrometers, gauges (some people will spell it guages), limits and thousandths, so there is no excuse for any foreman mistaking that the man who asks to go for a "mic" is really going for a "mike"!

* * * *

During the discussion of Mr. Terry's Paper on "Electric Vehicles," at the Institute of Cleansing Superintendents at Cardiff, one of the speakers said that the batteries in his vehicle were not nickel iron or lead; they were Ironclad Exide!

* * * *

THIS WEEK'S CHESTNUT.—A director of an electrical manufacturing concern sat at breakfast at the S—— Hotel, London, and an obvious American sat opposite to him; he passed the morning paper over to the Yankee and asked him if he would like to read the war news headlines. After glancing over these, the American handed back the paper, remarking, "*Some* fight." "Yes," said the Englishman, "and *some* don't!"



The moral of the adjoining illustration is, "If you cannot buy an electric vehicle, you might at least buy a warming pad for your horse when he is poorly."

* * * *

The "Electrical Contractor" is famous for its proof errors, as I have so often pointed out. Its very latest is too good to pass unnoticed. Mr. Ellerd Styles descants on the new Inst.E.E. rules, and refers to "tough rubber compound protection" (otherwise C.T.S. or S.R.C.), and says that the rules required that this covering shall not be *less than* 50 *miles* thick! This may be one of Mr. Styles' subtle styles of giving his opinion without reserve of this style of conductor covering, or perhaps he thinks that cable factories are in need of "some" enlargement.

I understand that in the best munition circles a vernier is known as a "very near!" (Alright, I'm touching wood!)

* * * *

I am not sure whether I ought to be called a munition worker or a splinter dodger. 'Smarvellous the way brass and steel splinters "hae wi em." The life of some of them is short and sweet(?). They take a wild plunge into the soft part of one's thumb and then stick out about $\frac{1}{4}$ in., as much as to say, "Here I am; you can feel *and* see me." A jump, a big D—— and a twitch between thumb and fingernail is all the attention you give this variety. I am now well used to them.

* * * *

But I do not like invisible splinters in my canvas gloves or my socks. I find that the sharp, jerky style of Bart Kennedy is about the best to use while the splinter remains hidden in the glove (to stab when a handful of shells cannot be dropped down a flight of iron stairs), or is occupying some dug out in the No Man's Land of one's heel, that inaccessible region beyond the range of the most intense "adjectival" preparation.

* * * *

I have gone through one campaign to dislodge the illusive spline from the aforesaid region in my left heel, and found Bart Kennedy's style invaluable, chiefly because I was rolled up so much like a ball that nothing but short, snappy sentences could be got out. Now what I should like is some style and form of words in which to address myself to the next $\frac{1}{8}$ in. of brass splinter when I have it laid "dead" on a stretcher of white blotting paper. After three-quarters of an hour probing with a pair of nice nickel-plated tweezers, ending in the removal of the offender, all I said to it was, 'You—, You—, YOU——." Then my breath failed me!

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), July 26, 1879.]

THE TELEPHONE AS A LIGHTNING INDICATOR.—Mr. George M. Hopkins, of Brooklyn, N.Y., during a recent thunderstorm, connected the gas and water pipes of his dwelling with an ordinary Bell telephone, and discovered that the electrical discharges were plainly indicated, either by a sharp crack or by a succession of taps. This occurred when the discharge was so distant that the thunder was inaudible. The sound also seemed to be perceived by the ear before the lightning could be seen. There was a marked difference in the character of the discharges, some that appeared single to the eye were really multiple. Often the discharges would consist of a series, beginning and ending with discharges larger than the rest, thus: — — — — — — — — — —, sometimes it would be thus: —— — — — —, sometimes the reverse, and often a single crack. The gas and water pipes were used, being the most convenient and at the same time the safest conductors for the purpose. Special apparatus might be devised, having a good ground, and a series of points for gathering the electricity from the air, but in using apparatus of this kind there is always more or less danger.

ELDER'S CABLE HANGERS AND CLIPS.

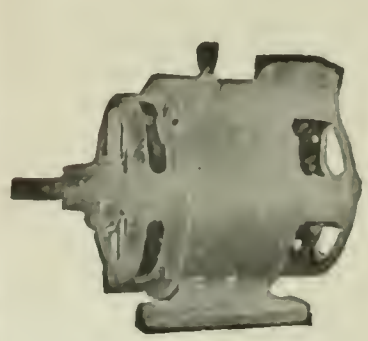
A Correction.—In our last issue we published an illustrated article on these clips, and included a photographic illustration showing a span in a three-phase line and below, on the same poles, a lead-covered cable was shown supported by suspenders. We incorrectly described these as Elder suspenders, whereas the view was taken to depict the old form of suspender and the way in which these tend to work into groups under the action of the wind. In the article we explained the principle of the Elder suspender at some length, and pointed out that one of its chief features is the obviating of this unsatisfactory and dangerous grouping. Doubtless those of our readers who were interested in the article would be a little surprised at the title of the illustration. We take this opportunity of expressing our regret for this error to the British Insulated & Helsby Cables (Ltd.), who are makers and suppliers of the Elder suspender.

L. P. S.
CLIPS, TIPS & TERMINALS
of all descriptions.
Write for Booklet, with Illustrations, of 75 types to:—
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

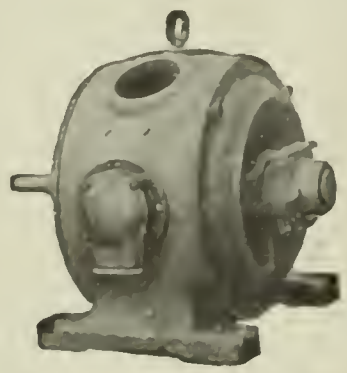
SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Golslilplat, Ox., London." 4746 Gerrard.

SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for
ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. | Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

B.T.-H. HAND-OPERATED STARTING COMPENSATORS.

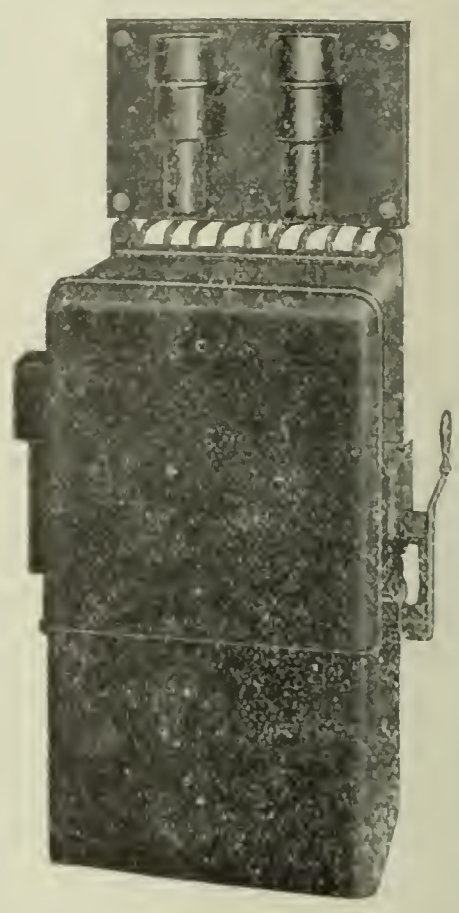
The starting current at full voltage of squirrel-cage induction motors up to about 10 H.P. varies from four to five times the normal full-load current, and in larger machines from about five to seven times the full load current. The corresponding starting torque for motors up to 10 H.P. varies from 1·25 to 2·45 times the rated full-load torque, and for machines larger than 10 H.P. between 0·75 and full-load torque. When a squirrel cage motor is connected directly to the line, the starting current is excessive, while the torque is, perhaps, unnecessarily high. In the case of large motors the heavy rush of current which occurs at switching on is liable to disturb the supply voltage.

It is a convenience to use a device which will reduce the starting current at the same rate as the torque, and for this purpose the British Thomson-Houston Co. supply a compensator or auto-transformer. This consists essentially of a transformer for lowering the pressure across the motor terminals during the period of starting. With this device, both the starting current taken from the mains and the starting torque of the motor are reduced as the square of the reduction in voltage.

The starting compensator differs from the ordinary type of transformer in having the secondary winding arranged as a portion of the primary, thus reducing its size and cost as well as increasing its efficiency.

Take as an example a 50 H.P. 400-volt three phase motor, of which the full load current = 61 amperes. The starting current at full voltage = 61 × 5·5* = 335 amperes. The impedance (between motor terminals) = 400/335 = 1·14 ohms. A 40 per cent. tap on the compensator gives a voltage on the motor of 160 volts. The starting current of the motor will be = 160/1·14 = 140 amperes, and the current in the line at starting = 160/400 × 140 = 56 amperes. The effect of the compensator is to reduce the voltage at the motor terminals from 400 to 160 volts, with the result that, although the motor takes a starting current from the compensator of 140 amperes, the current taken from the supply mains amounts to only 56 amperes, or 16 per cent. of what it would be without the compensator.

The type NR starting compensators, dealt with in List No. 5,250, are suitable for starting two or three phase 25, 33⅓, 40, 50 or 60 cycle squirrel-cage induction motors up to 750 H.P. on voltages ranging from 95 to 3,300 volts. They are supplied in the two following types: Wall suspension type, as illustrated, and the floor type. The former type includes compensators of small and moderate horse-power, while the latter type is composed of the larger size of compensators. The compensators consist of a strong iron box containing the compensator winding and an oil-immersed switch. The switch operating handle is situated on the outside of the case to the right, and a low-voltage release is similarly situated on the left.



WALL-TYPE COMPENSATOR WITH LOW-VOLTAGE RELEASE AND OVERLOAD RELAY.

The switch operating handle can be moved into three positions with the following results: "Off" position.—The compensator and motor winding are disconnected from the supply. "Starting" position.—The switch connects the whole of the compensator winding across the supply and a portion of the winding to the motor terminals. "Running" position.—The switch cuts out the compensator winding and connects the motor direct to the supply through the overload relays.

The operating handle is fitted with an automatic latch, which

* This figure is obtained from a table of mean starting currents and torques given with the list.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 409 Grams: Victminster, Sowest, London.

FURNACES for MELTING WHITE METALS, Etc.
Hall's Patents.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Monometer Heat-Controlled Furnaces for Heating the Moulds.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.



He's Put out!

But what matters, he's 93,000,000 miles away!

Yours resiliently, Pope's Elasta.

ELASTA BRITISH MADE WIRE LAMPS

Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W.

GREENLY

THE "ROYAL" QUEAD.



Q. 13.
3 and 4 kw.

Sole Manufacturers

..QUEAD LTD..
47 to 57 Marylebone Lne
London, W.

Telephone: Mayfair 3582.

Special Features

Sound Construction
. . Red Heat . .
Artistic Finish.

Ask for 1916-1917 List.

LEWIS'S SCIENTIFIC CIRCULATING LIBRARY.
ELECTRICAL, MECHANICAL & GENERAL ENGINEERING TEXT BOOKS & TECHNICAL WORKS.
New Works and New Editions can be had from the Library immediately on Publication. Telephone: MUSEUM 1072.
SUBSCRIPTION, Town or Country, from ONE GUINEA. READING ROOM open Daily to SUBSCRIBERS.
H. K. LEWIS & Co. Ltd., 136, GOWER STREET, and 24, GOWER PLACE, LONDON, W.C.

ensures the former being moved from the "off" to the "starting" position, and prevents it being moved directly from the "off" to the "running" position. A strong spring also prevents it being left in the "starting" position. The switch can be changed from the "starting" to the "running" position only by means of a rapid movement of the handle, thus preventing any decrease in the speed of the motor, and consequent increase in current, when effecting this change. A low-voltage release ensures the switch returning to the "off" position when the voltage fails or drops considerably.

The compensators are designed for bringing the motor up to approximately full speed within one minute after the switch has been thrown into the starting position. After starting a motor they should be allowed to cool for a minimum period of 15 minutes before being used again. The compensator windings and oil switch are enclosed in a substantial iron case. Removable covers are provided for inspection of the interior or for changing the connections to the compensator taps. The compensator coils, after winding, are vacuum treated and impregnated with compound under high pressure. This ensures a thoroughly moisture-proof construction, and also gives additional mechanical stability.

The switch is of the oil-immersed type, and is provided with heavy rubbing contacts entirely immersed in oil. All the current-carrying parts can be readily and cheaply renewed if necessary. The wall suspension type compensator has the switch arranged in the lower part of the case, the oil tank of which can easily be lowered for the inspection or renewal of the oil or the contacts without taking the compensator down from the wall or removing any of the cables. In the case of the floor-type compensator, the switch is situated in the upper part of the case, and, as it can be removed complete, is also accessible. With the largest compensators the current exceeds the limit of the capacity of the self-contained type of switch, and in these cases the compensator is provided with a separate control panel.

A copy of the descriptive list referred to can be obtained from the B.T. H Co., Rugby.

THIS SEASON'S "QUEAD" FIRES.

The attention of the trade is being called by Quead Limited in a recent catalogue to their new season's fires. We may remind our readers of the chief features of these interesting fires.

The "Quead" heat unit consists of a number of fireclay pieces of a chemically inert composition which obviates the possibility of trouble with the resistance wire at red heat, and which are grouped on a steel rod around a spiral of resistance wire, so that the latter is sunk into the surface of the fireclay but is still visible. When the current is turned on the spiral becomes red hot, and this in turn heats the fireclay; the result is a glowing mass, cheerful in appearance and intense in its radiant effect.

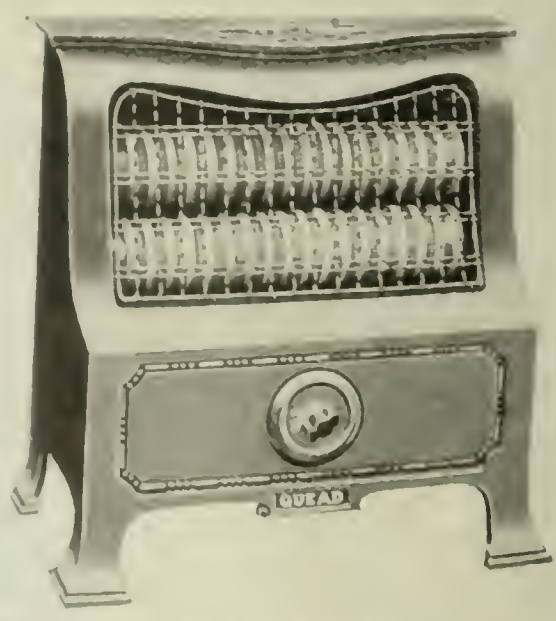
The method of sinking the wires into the surface of the fireclay has the effect of quickly making the latter red hot, but it also protects the wire from damage. The result is that the "Quead" is a robust unit which can be roughly handled, removed, replaced or packed for transit without fear of damage. Its simplicity is another point worthy of notice. It can be assembled from its component parts in a few minutes by a novice.

The "Quead" patent elements are guaranteed for a period of three years from date of sale to work satisfactorily when used under proper conditions—i.e., correct voltage and in "Quead" apparatus. Should any breakdown occur within this period, elements are repaired or replaced free of charge, provided the faulty element is returned, carriage paid, for examination. This guarantee is limited to "Quead" apparatus, and obviously does not cover any consequent loss caused by such breakdown. The elements are standardised at 1 kw. hourly consumption, and all the fires described in the list referred to are fitted with this standard element. The element measures 10 in. long and 2 in. diameter.



THE REGENT 3 KW. FIRE.

All new season "Quead" fires are fitted with a standard detachable interior. The whole electrical portion, in one piece, can, therefore, be removed by any unskilled person. These complete interiors, being standardised for each pattern, are interchangeable



THE QUORN FIRE.

with a minimum of trouble and cost. The makers recommend that fires of ample capacity be installed, in order that a good reserve is available for emergencies. It is found from experience more economical to heat a room quickly with a higher consumption of current

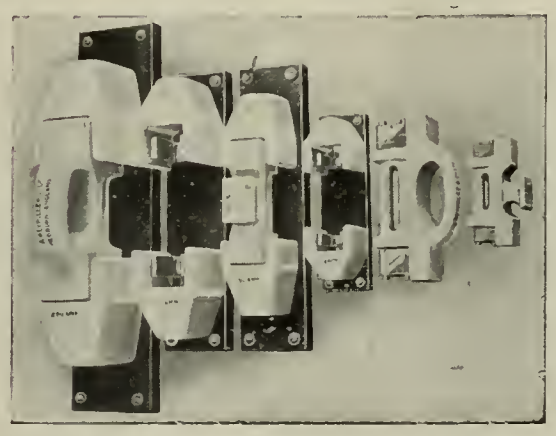
One, Two & Three Phase MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.
HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.

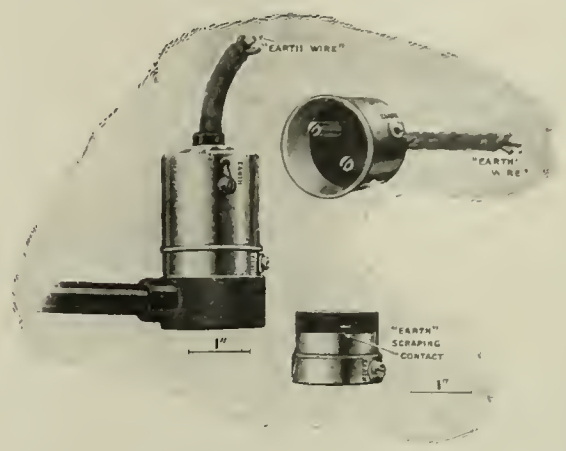
REYROLLE'S

Six Special Lines.

FUSES.



PLUGS AND SOCKETS.



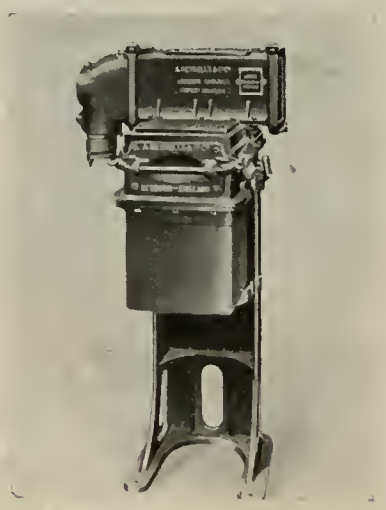
ARMOURED SWITCHGEAR.



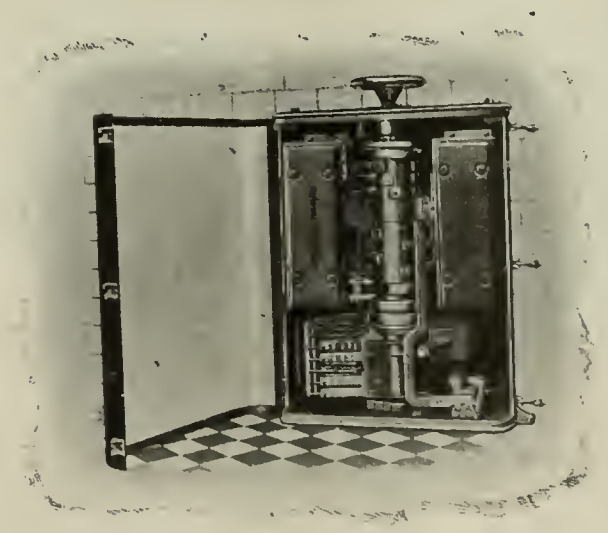
PROTECTIVE SYSTEMS.

Protective devices for A.C. Systems to isolate faulty sections instantaneously without interference with healthy sections. Also Relays for time limit current transformers, etc.

MINING EQUIPMENT.



MOTOR STARTERS.



A. REYROLLE & CO., LTD.

HEBBURN-ON-TYNE.

On War Office, Admiralty, and India Office Lists.

IRONCASED SOCKETS & PLUGS

FOR HARD SERVICE.

Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.

Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,

Ordsal Electrical Works,

SALFORD,

MANCHESTER.

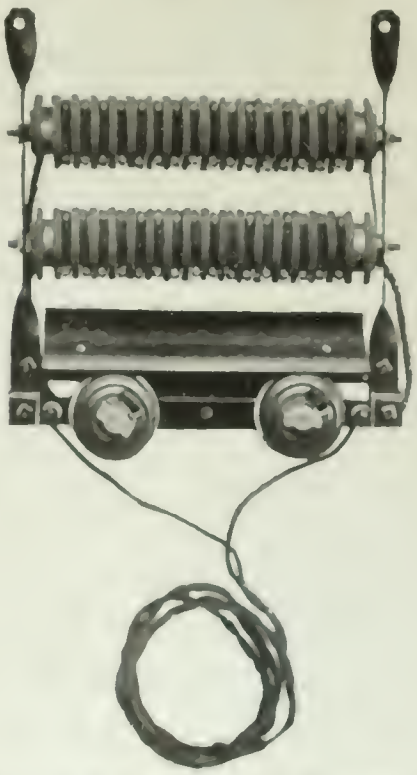
than to heat the same room slowly with a small consumption. If 1,500 to 2,000 watt heating capacity be installed for each 1,000 cubic ft. required to be heated, the reserve is equal to any possible emergency.

The "Quead" fire is offered in a variety of sizes from 4 kw. down to 1 kw. rating. The "Royal Quead," which is designed for 3 kw. or 4 kw., measures 18 in. by 26 in. high by 6½ in. deep, the weight being 27½ lb. The elements are housed in an attractive cast-iron frame, which can be supplied in a variety of finishes, from satin black to white vitreous enamel. The rotary snap switches are now recessed into the frame below the heating panel, and they give three degrees of heat on each pair of heating elements.

The "Regent" is another attractive design for 2 kw. or 3 kw. It measures 11½ in. wide, 16 in. high and 5 in. deep, the weight being 16 lb. The frame is provided with a flat top, upon which food and liquids can be kept hot or even boiling. In the 2 kw. size the two rotary switches give two heats and in the 3 kw. size three heats.

In the "Quorn" fire 1 kw. or 2 kw. capacity is available, the frame being of light cast iron. This fire measures 12½ in. wide, 12½ in. high by 6½ in. deep, and the weight is 14½ lb. This fire is recommended for the heating of small rooms, offices, bath rooms, &c. The makers of "Quead" fires recommend 1 kw. capacity for each 800 cubic ft. of space to be heated.

The catalogue may be obtained from Quead Limited, 47, Marylebone-lane, London, W.



Standard "Quead" Element Mounting, complete with Switches, Mains Terminals and Flexible Cord.

BLUE PRINT WASHING, DRYING AND IRONING MACHINE.

Operating successfully with either continuous rolls or separately cut prints, the machine illustrated makes further progress towards efficiency and economy. It is particularly useful where there is a constant and immediate demand for a number of prints. The successful operation, the speed of washing, drying and ironing, and the quality of the work are due to the following: The surface water is removed mechanically before attempting to dry the print; a strictly uniform amount of moisture is in the print when it goes to the hot drum; the print is held securely against the hot drum while it is being dried.

The principal features of this machine are: (1) A tank in which the prints are washed; (2) a wringer which removes the surface water; (3) a hot drum for drying and ironing; (4) an automatic winding up device for the long prints as they come from the drier.

A number of prints may be left in the tank as long as desired; long rolls are washed in passage through the tank. On leaving the tank the paper enters a wringer which consists of a steel shaft covered with felt bearing against a brass roller. This wringer removes the water from the print, which latter adheres to the brass roller. A set of stripping fingers removes the print from the brass roller and lays it on travelling belts, which convey it to the heated drum; during three-quarters of a revolution the paper is held firmly against the drum and dried and ironed. It is then stripped from the drum and deposited in a receiving trough at the end of the machine, or in the case of a continuous print is rolled up automatically. The machine is driven by a motor through a variable speed gear consisting of a belt running on two cones, driving the machine through a worm gear. The speed is instantly changed by moving a lever, and the machine may be reversed by operating a switch. A pedal throws the wringer out of gear, which may then be turned either way by hand in case a print should require to be adjusted. All rollers in the machine carrying any appreciable load are mounted on ball bearings. The machine will deal with prints up to 60 in. wide.



Print Washing, Ironing and Drying Machine.

The machine is described and illustrated in a new catalogue just issued by the Westinghouse Cooper-Hewitt Co., York-road, King's Cross, London, N. In the same catalogue particulars are given of two types of blue printing machines fitted with mercury vapour lamps as the source of light by which the printing is done.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, July 28, 1916.

THE ROUND TABLE.

By "KVA."

In the Round Table column of THE ELECTRICIAN of March 24th reference was made to a change of name from Grünbaum to Leyton. The paragraph, which was contributed by one of our provincial correspondents, implied that the person who had changed his name was a German.

Dr. Leyton, M.D., D.Sc. (of Portland-place, London, W.), who is a British subject and has had a distinguished medical career, objects to this paragraph, as it might, apparently, be taken to apply to him. We desire to assure Dr. Leyton that we unreservedly accept his statement that he is a British-born subject, and we regret that an announcement in our columns, which was not intended to refer to him, could be capable of such a construction.

* * * *

The "Daily Telegraph" says: "Certain firms and individuals can afford to buy and use 'steamers' and 'electrics,' but the majority of owners want a cheap substitute for petrol." Well, what's the matter with "*the* juice"?

* * * *

"E. C. L.," as so many of his friends knew him, has "gone west." We cannot yet realise it, but the truth can no longer be doubted. Laughton was an ardent Batti-Wallah—the log of the barge "Alde" stands to verify that—and a white man right through. He just would not accept a commission—he loved the boys in the ranks too much for that—and, unlike many company sergeant majors, he was universally liked. He has paid the price, but those of us who had seen him back on



COMPANY SERGEANT-MAJOR LAUGHTON.
[Killed in Action, July, 1916.]

leave—broad, tall, muscular and with the "devil in his eye"—feel assured that, if it was at close quarters, he sold his life dearly. I grieve to have to record his untimely death, for there was only one "E. C. L.," and we who were his friends know that it will be many a long day before we meet his counterpart.

[The official notice of his death in action appears on another page.]

The statement in a recently issued catalogue of magnetic clutches "that a mechanical clutch which is influenced by centrifugal force is always a *drawback*" sounds rather contradictory. Drawback is just what the centrifugal force won't let the clutch do.

* * * *

Under the title "The Electrician's Great Chance," the "Westminster Gazette" says:—

That tide in the affairs of men which it is part of the philosophy of our life and well being to believe in has come for the electrician.

We had thought the same, but this flattering reference to ourselves is encouragement indeed.

* * * *

Mr. Abraham, manager electricity and tramway department, Aberdare, says, in writing to the "Municipal Journal": "I know an Edison vehicle *with properly charged batteries* will get up any steep hill." "Edison"—Watson will, I am sure, agree with this instructive statement. The gradients in Aberdare are 1 in 16 and 1 in 18, and will probably be known among "electrics" as the "heights of Abraham."

* * * *

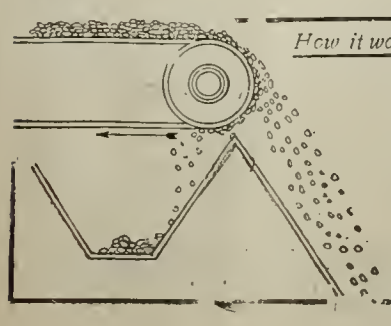
The women are becoming "volt-boys"! Look at this charming study of a "switchess" in one of the sub-stations of the Shropshire & Staffordshire Electric Power Co.! She looks as if she means to parallel the incoming machine no matter



[*Photo Miss Smith. B'ham.*

THE "SWITCHESS" ON DUTY.

what happens, even if she pushes the board over in the attempt. Get a charming girl on a switchboard and you will never find the instrument cases dull or the watt-hour meter glasses unpolished. The mirror effect is too "adjacent" to be resisted by any girl who uses a powder puff, and what "switchess" does not? I hope they keep the nosegays given them by admiring "shift-men," stokers and drivers out of the relays and plug-sockets!



'IGRANIC'

MAGNETIC SEPARATOR PULLEYS

form an economical method of picking out magnetic material—stray iron and steel—from non-magnetic material in bulk. They operate continuously without attention, and are extremely efficient in handling ores, grain, cement, rags and like materials. Write for Pamphlet No. 1600.

IGRANIC ELECTRIC Co LTD 147, QUEEN VICTORIA STREET. LONDON. Works: BEDFORD.

A Paper Manufacturer writes: "This pulley works most satisfactorily and takes out anything from a tack to a monkey wrench."

SIEMENS

ELECTRIC MOTORS



Part of small Motor Shop, Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

ELECTRIC SUPPLY AT HOLMFIRTH.

The electricity works of the Holmfirth Urban District Council were officially opened on Saturday, July 15. The generating equipment was inspected by the members of the Electricity Committee, who must have felt pleased that their prolonged efforts to introduce a system of electric lighting into the town have been brought to a successful issue. The question of lighting the town and district by electricity was considered publicly as far back as September, 1911, when a meeting of ratepayers was convened by the Council, and a resolution to apply for a provisional order was enthusiastically carried. A subsequent plebiscite of the ratepayers resulted in a two to one vote in favour of electricity. When the provisional order was obtained in August, 1912, negotiations were opened with the Yorkshire Electric Power Co. with a view to obtaining a supply of electricity in bulk. Local opposition to the scheme asserted itself, however, and as it seemed probable that the power company could not give the proposed supply for some few years, the original scheme was dropped.

The Council then decided to establish an electricity works in the town and an Electricity Committee was formed, having as chairman Mr. E. Overend, who had always been an enthusiastic advocate of electric lighting. Tenders for the entire generating equipment and complete installation were called for, to the specification of Mr. A. B. Mountain, until quite recently borough electrical engineer, Huddersfield; and in October, 1913, the contract was awarded to Messrs. T. W. Broadbent (Ltd.), Victoria Electrical Works, Huddersfield. The Council, therefore, allotted the work before the recent heavy increase in the costs of all engineering materials took effect, although as a matter of fact, the formal contract was not prepared until March, 1915.

The electricity works, which are conveniently situated near the centre of the town, are large and well lighted, and provision has been made for probable extensions in the future. Continuous current generators driven by gas engines supplied with producer gas, and working in conjunction with a small battery, are employed. The gas-producing plant has been placed in a shed which adjoins the generating station and forms a part of it, and is partly open to the outside air on one side to provide suitable ventilation. The plant consists of two open-hearth suction producers, of Crossley Bros.' latest design, and having several novel features. One useful and important feature is the arrangement of pipe connections, by which either engine can be run from either plant merely by closing and opening isolation valves. The gas generator is a cylindrical vessel, lined with firebricks, the fuel being supported on a stepped grate, so that the fuel bed is in full view of the operator.

By an ingenious arrangement of water syphon the amount of steam generated is automatically governed by the load on the engine. The water necessary to generate the steam passes through several gilled tubes in series, where it receives an increment of heat from each tube, and finally overflows into a "flash" tube where it is flashed into steam. On its way to the scrubber for cooling and cleaning, the hot gas is made to pass through two cascades of water which form the overflow from the scrubber; by this means the heavier impurities are removed before the gas reaches the coke in the scrubber.

The gas engines also by Crossley Bros. are of the horizontal type, developing 190 P.H.P. and 95 B.H.P. respectively, and both running at 190 revs. per min. They represent throughout the latest development in modern gas engine practice. The larger one is a double cylinder engine: the cylinders are all of the same size, which obviates the need for holding a large stock of spare parts.

The governing of the engine is effected by means of "variable admission" governing gear, with which the main inlet valve becomes a throttle. This has proved an ideal one for controlling internal combustion engines, because impulses are not only given to the engine at each working stroke, but are certain at any position of the governor. The governor is of a heavy, powerful type, and all working parts are enclosed in a stationary oil-tight casting.

The generators are belt-driven from the engine flywheels, the larger of the two machines having an output of 100 kw. when running at a speed of 625 revs. per min.: the output of the other unit is 60 kw. when running at a speed of 640 revs. per min. Both generators are of an improved design, having auxiliary poles, and the working pressure at the terminals is 460 volts. There are three massive bearings to each generator, and they are of the automatic ring oiling type. Carbon brush-holders of improved design are used, and we understand that when under test from no-load up to full-load and over, the brushes were in a fixed position, and remained sparkless. We understand that the temperature rises of the windings, taken at the end of the full-load test run were, with both machines, below the limits laid down by the Engineering Standards Committee.

The three-wire system of distribution is employed, with a declared pressure of 440 volts across the outers, and the neutral earthed. A rotary balancer is employed to maintain the electrical equilibrium between the two sides of the system. There is a small battery, which is large enough to deal with the night load, thus permitting the generators and balancer to be stopped. The battery, which is by the Chloride Electrical Storage Co. (Ltd.), consists of 250 H.L.G. 3,5 type cells of the Plantide accumulator in glass boxes, the plates being suspended from the sides of the boxes. Sufficient margin has been allowed in the dimensions to meet with the possible requirements of additional capacity at some future date. The battery is capable of discharging at the rate of 104 amperes for one hour, 34 amperes for five hours, or 20 amperes for 10 hours, and is fitted throughout with wood separators. The positive plates are of the pure cast-lead ordinary Plante type, the negatives being of "box" construction. The frames of the latter are made in two halves, being rivetted together after insertion of the active material. For charging the battery, a three-wire motor driven booster is employed.

The switchboard consists of eight panels of enamelled slate, securely mounted on a substantial angle iron framework. The switchboard is approximately 13 ft. 6 in. wide by 6 ft. high. There are three generator panels (one of them being blank at present), one battery panel, one balancer panel, one booster panel, four feeder panels, and two street lighting panels. The distribution has been carried out by means of overhead mains. These are borne on steel poles in the centre of the town, and on wooden poles in the outskirts. The arrangement of poles, struts, stays and brackets has been carried out in a specially secure manner suited to the peculiarities of Holmfirth, where acute angles and steep hills present problems requiring more than an ordinary amount of thought and attention. The poles serve also as standards for the street lighting fittings and lamps, the street lamps being controlled by automatic time switches, which are affixed to the poles where required.

House services are tapped off the overhead wires, and the tappings are taken into the consumers' houses (usually in the upper storey) through porcelain leading-in tubes. The charges for current are 6d. per unit for lighting, and 2d. per unit for motive power, heating or cooking, and they are not unreasonable in view of the present high prices of fuel, &c.

Already there is a fair demand for current for lighting purposes; and if the demand grows as it is expected to, the undertaking should,

ZeneX
&
NegreX



The Protective Coverings of Simplex Conduits and Fittings are perfect.

The threads of Simplex Conduits are cut after the tubes are enamelled.

They screw into fittings easily and make a perfect electrical and mechanical connection at every joint.

SIMPLEX CONDUITS Ld.
Garrison Lane, BIRMINGHAM.

LONDON—
113-117, Charing Cross Rd., W.C
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868.
Codes: 5th Edition A B C & Western Union.

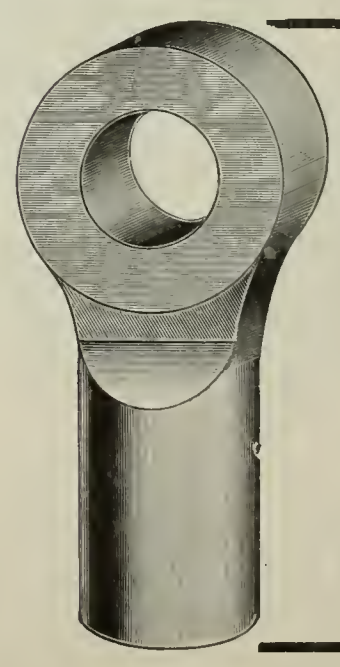
BELLING
& CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialist, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,
STIRCHLEY, BIRMINGHAM.

Cast Cable Sockets.

Suite E74. Made in all Sizes.

Type A.—Straight.
,, B.—Offset.
,, C.—Right angle.

Illustrated Dimensioned Showcard for Drawing Office use supplied free on application.

Sole Agent for the Electrical Trade:—

LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.

REGULATING RESISTANCES



ISENTHAL & CO.

Department 4

Denzil Works,

Willesden, London, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

NEW LIST ON REQUEST.

NATURE says:

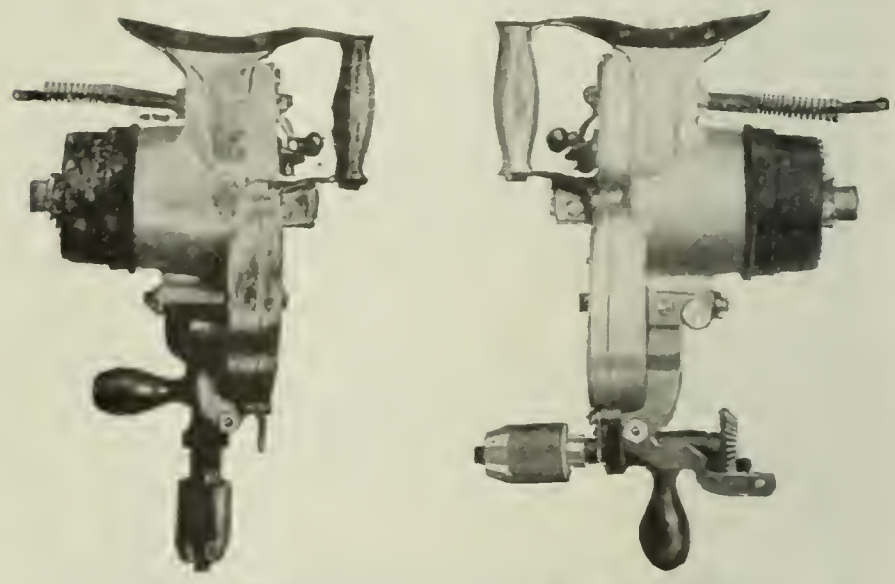
"The list is one of the most complete we have seen."

under the management of Mr. A. C. Bott, the engineer to the Council, prove a practical success. The capital charges are not excessive, and it is likely that the ratepayers will in time be rewarded for their enterprise.

We are indebted to Messrs. T. W. Broadbent (Ltd.), Victoria Electrical Works, Huddersfield, for the foregoing particulars, they being, as we have already said, the main contractors for the installation, as well as the builders of the dynamos, balancer and booster, and the makers of the main switchboard.

"SUN" FANS AND PORTABLE TOOLS.

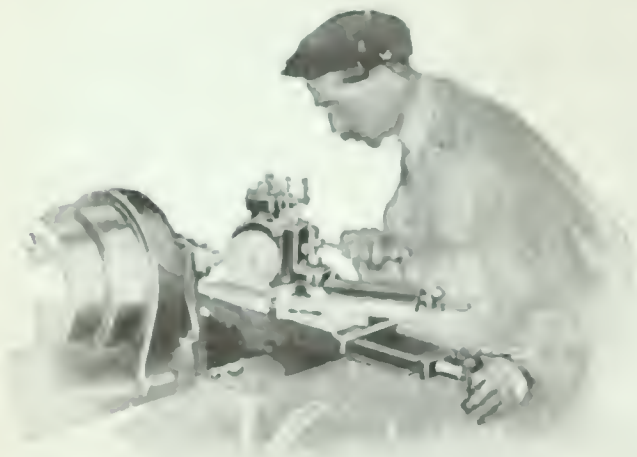
The latest lists issued by the Sun Electrical Co. deal respectively with fans (list No. 276) and portable electric tools (list No. 275). The fan list gives illustrations and prices of desk, table, wall, ceiling, oscillating, swivel, trunnion, ventilating and exhausting fans, both for alternating-current and direct-current circuits. The smallest size is fitted with 9½ in. diameter blades and takes 20 watts on continuous current. The same size fan takes 35 watts on alternating current. These details refer to small table or desk fans with fixed motor on vertical pedestal. The smallest size swivel and trunnion fan is designed for 12 in. blades, the energy consumption being 45 watts continuous current and 50 watts alternating current. The oscillating fan, which also has a swivel and trunnion base, is made in two sizes both for continuous and alternating current, namely, 12 in. and 16 in. blades. The swivel and trunnion and oscillating fans are fitted with three-speed regulator mounted in the base of the pedestal. The motor and frame are finished in black enamel with gold lines, and the blades, guard and fittings are of polished brass. The ventilating fans can be supplied with ordinary blades in two sizes, 12 in. and 16 in., for both continuous and alternating current. These are designed for fixing at a circular opening, the motor body being attached to a ring which fits the ventilating hole and acts as a support to the entire fan. These fans are also offered with box blades for exhausting or delivering large volumes of air. The ceiling fans, of which a number of sizes are offered, can be supplied with



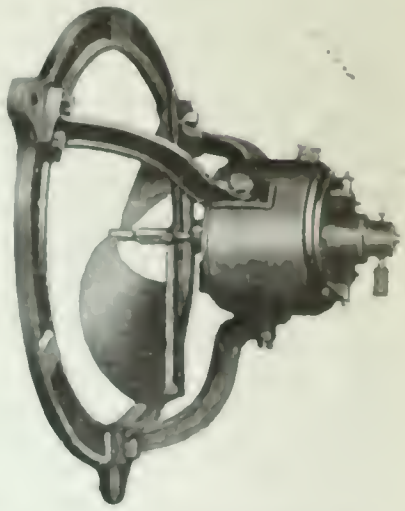
Two Views of Semi-portable Electric Drill.

either long or short stems. A special squat pattern is also listed for ship's cabins and low ceilings. This is obtainable in four sizes, 24 in., 32 in., 36 in., and 44 in.

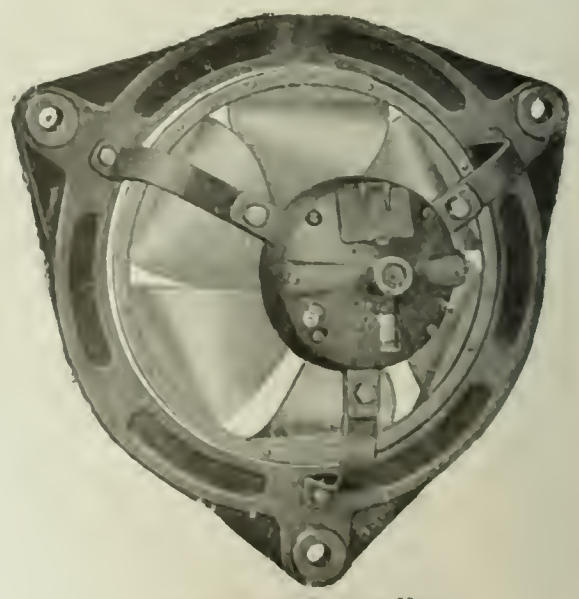
The list dealing with portable tools will be of considerable interest at the present time, now that so much prevision work upon metal is being done. The "Sun" portable electric grinder is fitted with a ½ h.p. motor running at 10,000 revs. per min., a speed which gives a correct peripheral velocity to the emery wheel. The motor of this is a series wound machine to work on either alternating-current or direct-current circuits. The machine measures 10½ in. long overall and weighs 5¼ lb. The fixing arm measures 1 in. by $\frac{7}{16}$ in. and is designed to clip round the body of the motor. The shaft is extended well out on one side of the machine, so that internal grinding can be carried out. The "Sun" electric tool post grinder is another useful little machine which is supplied as a complete lathe accessory. It has 3 in. of travel of lever feed, 1⅜ in. of vertical feed, and the distance between the body and the emery wheel is 2⅞ in. In its extreme position the length of the grinder is 11 in. and the height in the extreme position is 9 in. The weight of the machine is 23¼ lb. The motor is designed to take a 4 in. emery wheel, and its speed running idle is 3,800 to 4,000 revs. per min. When a special head is fitted this speed is increased to approximately 8,000 revs. per min. We



"Sun" Grinder in use on Lathe Centre.



"Sun" Fan with Bladed Propeller.



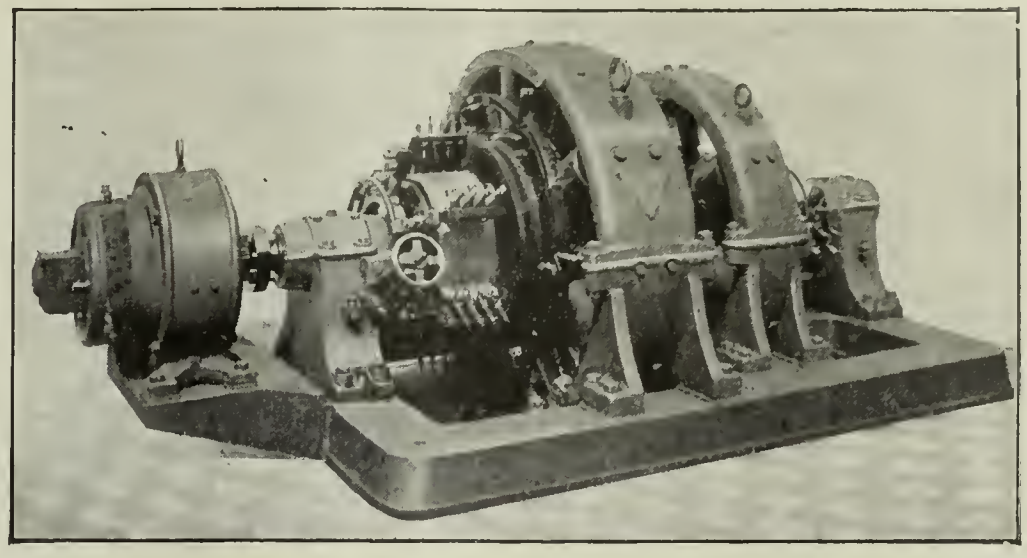
"Sun" Box Blade Fan.

VICKERS LIMITED.

Motors and Generators of all types.

Rotary Converters.

Complete equipment for the electrical lighting and driving of Machine Shops, Factories, Mills, etc

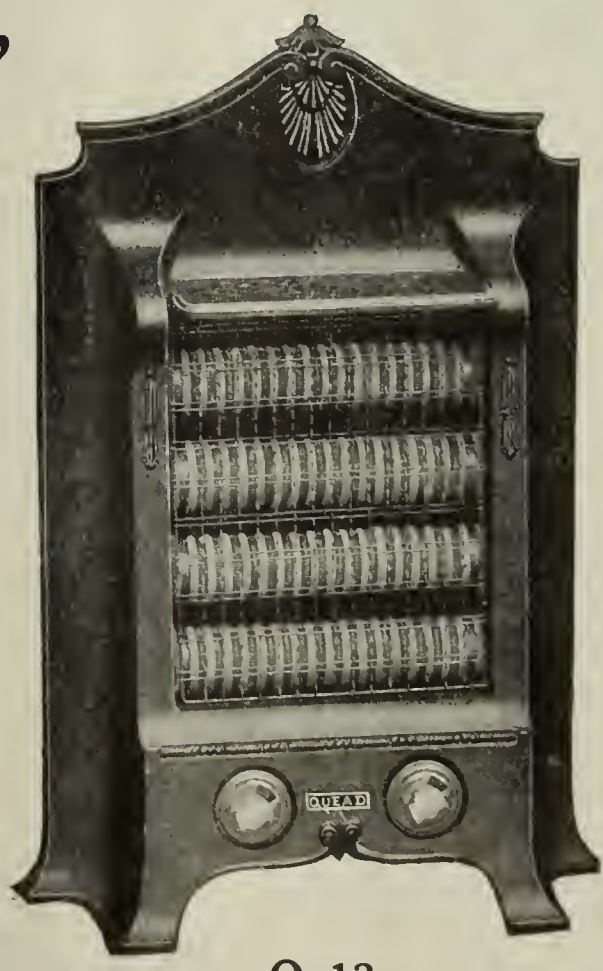


Patent Automatic Reversing Drive for Machine Tools.

250 K.V.A. Rotary Converter. 6 phase, 50 periods, 480/560 Volts. 1,000 r.p.m. Inverted type.

River Don Works, SHEFFIELD.

THE "ROYAL" QUEAD.



Q. 13.
3 and 4 kw.

Sole Manufacturers

..QUEAD LTD..
47 to 57 Marylebone Lne
London, W.

Telephone: Mayfair 3582.

Special Features

Sound Construction
. . Red Heat . .
Artistic Finish.

Ask for 1916-1917 List.

"THOR" High Grade Specialities
CASING and CAPPING CONDUIT CABLES
CABLE CONNECTORS COMMUTATOR COMPOUND WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.
WRITE FOR PRICES & DISCOUNTS.
HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

LEAD MELTING FURNACES
(Hall's Patents)
For Cable and Pipe Presses, Accumulator Grids, etc.,
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
ENORMOUS SAVING IN RESIDUE.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

understand that this machine is carried in stock for voltages from 100 to 240. The lever feed provides for 3 in. longitudinal movement and is quick and delicate in action. For grinding long work (above 3 in.) between centres, a clamping device for locking the lever feed is provided, so that the full travel of the lathe slide rest can be used. The base of the grinder is flat, and when bolted to the slide rest all parts can be freely operated. The vertical feed enables the operator to adjust the emery wheel to the work centre easily and quickly.

The off-set head is adjustable, enabling the emery wheel to be set close in to the work or in an outer position. When the wheel is set in the outer position, it extends beyond the motor body and is thereby adapted to straight work on centres. The head is fitted to either of the extreme positions by removing the screw from the slot in the head and inserting it in the opposite side of the head. The wheel can then be set in the position best suited to the work and locked. For light internal grinding a special head can be supplied. This is interchangeable with the standard head and runs the emery wheel at double the speed. This extra equipment materially increases the usefulness of the tool. The higher speed is specially useful for internal grinding.

The Sun portable electric drill runs equally well on direct-current or alternating-current circuits. It has a drilling capacity up to $\frac{3}{8}$ in. and a tapping capacity up to $\frac{1}{16}$ in. In designing this tool, we gather that every detail of the motor has been carefully considered so as to ensure reliable and satisfactory working. Large brushes, plenty of ventilation, easy and reliable oiling, and various other details ensure freedom from breakdown. Aluminium is used where possible, making the tool light to handle. The switch is placed just below the handle, where it is always within easy reach. The one switch lever starts, stops and reverses the motor. Adequate ventilation is provided, and the ventilation holes are so placed that no chips can fall into them, no matter in what position the drill is used. When the drill is in position the weight is balanced between the handles, and the operator's view of the drill point is unobstructed. This makes the drill easy to hold, gives a correct sense of direction to the operator and ensures accurate work.

The motor is so designed that the speed regulates automatically with any size drill up to $\frac{1}{2}$ in., or tap up to $\frac{3}{16}$ in. A $\frac{1}{8}$ in. drill will run at a speed of from 300 to 400 revs. per min. with a pressure back on it of from 130 lb. to 150 lb. A $\frac{1}{16}$ in. drill with a pressure of from 100 lb. to 120 lb. will run 500 revs. per min., and so on. The smaller the drill the less pressure it requires, and consequently the greater the speed at which it will run. The maximum speed of the drill spindle is from 1,000 to 1,100 revs. per min. The emery wheel fitment requires a few seconds adjustment only, and enables drills to be ground on the tool—a most useful feature on outside work.

Both the lots referred to above can be obtained from Sun Electrical Co., Charing Cross-road, London, W.C.

PECULIAR BEHAVIOUR OF A THREE-PHASE MOTOR.

An extraordinary story concerning the behaviour of a three-phase motor is told by a correspondent of the "Electrical World." During a heavy rain storm a 5 h.p. three phase 220 volt motor erected in a garage suddenly stopped and started again in the opposite direction and ran for a few seconds. It then stopped again, reversed and blew the fuses. On replacing the fuses and closing the switch the machine ran for several seconds in each direction and finally came to rest. The electrician who was called into remedy the trouble was told that the machine had reversed its direction of rotation on two other occasions, and that the direction in which the rotor ran seemed to depend on the way in which the switch was closed. When the machine started in the wrong direction the switch was opened, and then after the machine had come to rest it was closed again. A voltmeter connected across the switch blades corresponding to phases one and two indicated a pressure of 220 volts; across phases two and three there were also 220 volts, but across phases one and three the pressure varied from 0 to 440 volts, the voltmeter needle oscillating very much like that of a synchronising voltmeter. These readings indicated that something was wrong on the supply lines. Inspection showed that the motor was fed from two transformers, some distance apart, and that each transformer was connected in open delta. As the secondaries were properly connected it was suspected that the trouble was in the primaries, as the voltage of the secondary windings was normal. Further inspection disclosed a tie switch in between the primaries, and this switch was open. Consequently the transformers were on separate circuits, and were being fed from separate sub-stations. On closing the coupling switch, thus paralleling the sub-stations, the trouble vanished. Excessive load on one station, arising from the stormy weather, caused a reduction in the voltage of that station, and on one transformer, with the result that the motor acted as a balancer. As a final remedy the motor was fed from one transformer only.

ELECTRIC LIGHTING SET WITH OVERHEAD VALVES.

Owing to the regulations recommended by the International Convention on the Safety of Life at Sea, which included the compulsory installation of electric supplies high up above the water in passenger vessels, combined sets consisting of oil engines direct coupled to dynamos were becoming very common before the war.

According to the "Motor Ship," an interesting high-speed paraffin lighting set of this type, which has several unusual features, is manufactured by Mr. R. Brightwell, engineer, 107, Queen's-road, London, W., and marketed in 12 sizes, varying from $\frac{3}{4}$ B.H.P. to 28 B.H.P.

A supply of oil is carried in a tank attached to the engine, but this arrangement can be altered to suit individual requirements. Provision is made for heating the vaporiser when starting from cold by a lamp, but if so desired, petrol or some other light fuel may be used until the engine is warmed up. A governor controls the throttle and limits the revolutions to a speed of 950 revs. per min. An unusual feature for so small an engine consists of overhead valves operated through push rods and rocker arms from a short camshaft.

NEW PUMPING PLANT AT EXETER.

The Exeter Waterworks recently converted the old beam engine house into an electric pump house. The Mayor and Sheriff at the inaugural ceremony jointly set the electric pump working. The pump is a Rees Roturbo pressure chamber pump, capable of delivering 25,000 gallons per hour against a head of 325 ft. when running at 1,720 revs. per min. The suction and delivery pipes are 5 in. in diameter. The pump is driven by a British Thomson-Houston two-phase 400-volt slip-ring motor of 63 B.H.P. The actual power required to drive the pump is 57 B.H.P. The control gear consists of an oil immersed rotor starter, a wall-pattern triple-pole switch, fitted with a no volt release, and an ammeter. The plant was supplied by the Rees Roturbo Mfg. Co. (Ltd.), of Wolverhampton, who also superintended its erection. A suction well of the same size as the engine-room floor has been constructed to serve four pumps. The floor is of reinforced concrete. The whole of the work, including

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026 Grams: Vicminster, Sowest, London.

C.A.V ACCUMULATORS

Perfect in every Detail

STRENGTH :: EFFICIENCY :: RELIABILITY



Manufactured by the firm renowned throughout the world as the pioneers in the making of Car Lighting and Starting Batteries

"The first man to make an accumulator in this country that would really stand the racket of the early motors was C. A. Vandervell. He succeeded because he is one of those rare individuals who have an infinite capacity for taking pains."—Extract from THE MOTOR TRADER.

Motorists in general and American Car owners in particular are invited to write for particulars of the British Battery that will put an end to their Lighting and Starting Troubles.

C.A. Vandervell & Co; LTD.,
Electrical Engineers, ACTON, LONDON, W.

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

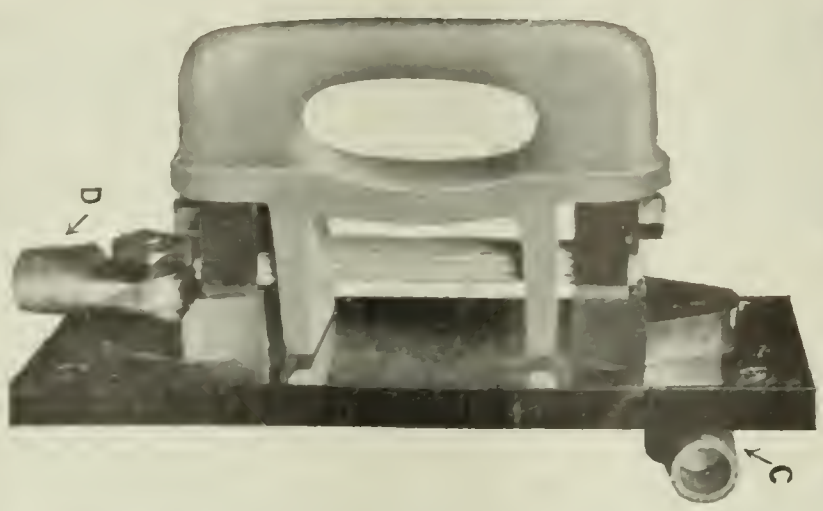
TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

erection of the plant, has been carried out by the waterworks staff under the superintendence of Mr. A. Kneed, the resident water engineer, and the direction of the City Engineer and Surveyor. The electric supply is taken from the Council's mains, which necessitated an extension of the high-pressure cable by about one mile. A transformer has been erected at the works for reducing the pressure to the necessary voltage. The laying of the cable and the erection of the transformer was carried out under the direction of Mr. Munro, borough electrical engineer, who agreed to supply the current at the works. This is part of the scheme for extending the waterworks which the city surveyor (Mr. Moulding) advised the committee to carry out in December, 1914. The installation of this new pump gives a fair margin of safety, and assures the city of a continuous and ample water supply under almost any circumstances.

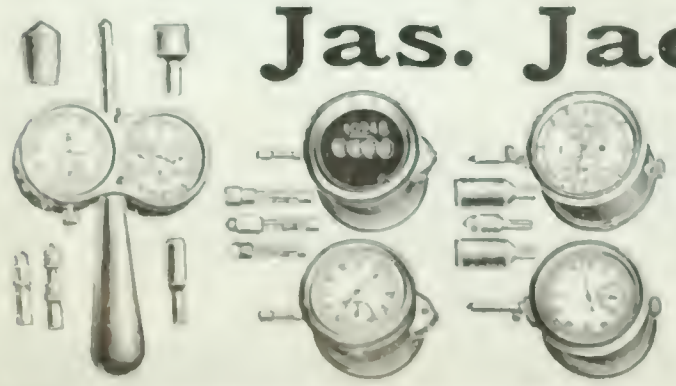
"EVOLUTION IN VENTILATION HYGIENICS."

The above is the title of an article which recently appeared in "The Syren and Shipping" Naval Architects' number, from the pen of Mr. James Keith, A.M.Inst.C.E., M.Inst.Mech.E., &c., of the James Keith & Blackman Co. (Ltd.), Farringdon-avenue, London, E.C. A reprint of this is being circulated by the company, and will be found of considerable interest, particularly to engineers who have generating plant, boiler rooms, switch houses, sub-stations and power basements to keep in a properly ventilated condition. The subject is treated initially from the scientific point of view, and is then developed with specific reference to the Keith fan driven either by electric motor or steam turbine. The text is illustrated with a number of line and half tone illustrations, which clearly indicate the principles of ventilation enunciated in specific cases. An interesting example is that of an underground engine room forming the isolated plant of the Singer Building, Broadway, New York, in which are installed three large open fans, each suspended from the ceiling and capable of propelling fresh air into the engine room under moderate water gauge to the extent of 120,000 cubic ft. per minute. These fans totally change the air contents of the engine room 60 times an hour. At the St. Denis, Paris, station a series of 10 Keith open fans 25 in. diameter 700 revs. per min. are installed along the whole length of the switchhouse ceiling, and deliver 90,000 cubic ft. of fresh air per minute, distributing it in the direction of the engine room from the switch house platform. In this case the whole of the cubical air contents of the switch house are changed 90 times per hour, the energy consumption being 14 kw.-hours. A number of interesting diagrams show how the ship's engine room can be ventilated by a number of large open type Keith fans. Another interesting pattern of Keith ventilator is one in which a small silent running motor operates a Keith fan, draws the air in from the base of the outfit, and delivers it into the room through a comparatively large area of fine wire gauze in such thin streams that ventilation is obtained without draught discomforts. Such a fan running at 1,200 revs. per min. will give over 6,500 cubic ft. of fresh "live" air every hour, the energy consumption being 24 watt-hours. Some interesting remarks are made on the subject of so-called natural ventilation and negative ventilation. Forced draught for war vessels is dealt with under a separate heading, the 30 in. fans in this case being driven by steam turbines at from 1,500 to 1,600 revs. per min., and delivering up to 25,000 cubic ft. of air per minute against a static water gauge in the stoke hole of 6 in. pressure.

The sections on warming and ventilation by conduction and convection, and the ventilation of offices and large buildings, are of great interest, and should be read by those who have in hand the designing and lay-out of offices, factories, public buildings, halls, &c. We understand that the pamphlet referred to is available for distribution, and copies can be obtained from the company on application

"THE NEW MAID."

She was always a problem before the war, and an unsolved one at that. No one quite knew how to take her, and certainly very few knew how to keep her. Since August 4, 1914, she has been very little new and less housemaid, and in a domestic sense it seems that she is not likely to be new again. Half the work she used to do is now done by the housewife, and the other half may safely be entrusted to the electric housemaid—namely, the suction cleaner—if folk who use electric light can be persuaded to buy and use it. The Electric Suction Cleaner Co., 56, Victoria-street, S.W., have this fact in mind in sending out their little book entitled "The New Maid," with illustrations from the inimitable pen of Hilda Cowham. The booklet contains a war-time story of a newly-married couple, whose income became halved at the outbreak of war, and whose servants "went away" to make munitions. The situation is saved by "Mrs. Newley-Wed," who gets a small boy in three mornings a week to clean windows, steps, &c., and also she buys "Clarissa," the pet name which she gives to the Premier electric cleaner, to do the rest of the work. The story is well told, and the Cowham illustrations help to make it more pleasing. The booklet should be useful to contractors and station engineers who realise the need for efficient help in the house at this time, and who must know many of their electricity consumers who would find a Premier suction cleaner a profitable investment, not merely in war time, but at all times.



Jas. Jaquet, Ltd., Basle

Switzerland.

Combined Revolution Counters, with Chronograph.





Very Accurate Timekeepers.

CHRONOGRAPH AND STOP WATCHES.

Lists on Application.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of LONDON, Friday, August 4, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—One of our gaseous contemporaries goes bald-headed for a much advertised *gas-cooker*.

* * * *

In the course of a discussion on street lighting at Rathmines during which the total darkening of the town was considered, Mr. M'Bride said : "It was a reasonable compromise to revert to every second lamp." But surely this was nothing unusual late at night, even before the war !

* * * *

Bath City Council recently discussed the electricity department, and one of the speakers said that the street lighting would never go back to the same *pitch* ; to which another speaker replied that it would "when the Diesel engine was at work." Is this a kind way of referring to a prospective "gummed up" piston ?

* * * *

A welcome change which may be noted by the B.C.G.A. (my italics) :—

"The Clerk (Dawlish) produced a letter from the Electric Light Company enclosing a schedule showing the respective costs of street lighting by gas and electricity, the former of which they found was *considerably in excess of the latter*. The Council gave consent to the request of the Electric Light Company to increase their charge."

* * * *

"West Ham" Beauchamp has always been well to the fore with "electrics," and he has a fine district in which to push the commercial variety. He has sent me a copy of a circular letter with which he is conducting an anti-petrol campaign among vehicle users in West Ham, pointing out how they can conserve the valuable imported petrol for military purposes, by using battery vehicles. His example is worthy the emulation of other central station men in industrial areas.

* * * *

A certain Dr. Vincent has, according to the lay Press, revived men by electrical means, "who would have remained invalids all their days." In one case a witness stated that Dr. Vincent subjected him to a current that would have run a tramway. The effect was so powerful that for two days he walked incessantly, being unable to stop or to sleep. Here is an idea to "improve the mileage" of main's foremen, jointers, meter readers, and all outside men of electricity departments !

* * * *

The big push is not the only indication that peace may not be very far off. There are other signs of an early return to the *status quo ante bellum ;* for instance, as a correspondent points out to me, a fire which occurred this week in the London Docks is unblushingly attributed by the lay papers to the "fusing of the electric wires." Somewhere else I have noticed a reference to a pre-war fiction that gas is five times cheaper than electricity. Truly, peace is at hand !

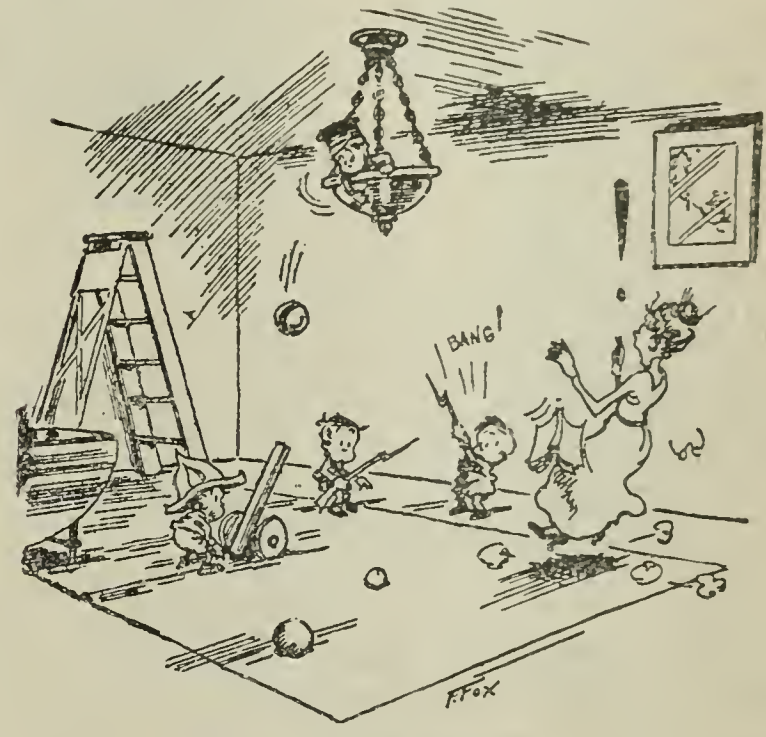
* * * *

At Oldham there are some two thousand two-rate meters which are, of course, each fitted with a clock. At the last meeting of the Electricity Committee it transpired that these had not been altered to "summer time," consequently the consumers were paying an hour at the higher rate everyday, 4½d. instead of 2d. The Committee could not set back so many clocks, it said, and those who had a grudge against "summer time" could have a meter for the "flat" rate. Councillor Dixon, who raised the question, thought it might be a joke, but in any event it seems to have fallen very "flat" !

The motoring editor in one of the London evening papers waxes prophetic ; perhaps he has had a shock from the ignition batteries of his petrol car and feels spiteful against petrol vehicles. He actually says : "It would not greatly surprise me to hear some day that the London General Omnibus Co. had decided to replace all their vehicles *with electrics*." Even this does not satisfy him, for in his outburst of spleen (he must have had a shock) he goes on : "The petrol situation can only be relieved in two ways, by enforcing the use of paraffin in commercial and public service vehicles or *by the adoption of electricity*." And for years this dear man has boomed what the Yankees call gasoline.

* * * *

This sketch, taken from the "X-Ray Reflector Journal," is a cheery example of American humour. The daring aviator who has just launched his last bomb, is using the "Eye Rest" bowl as



an aeroplane. The picture is redolent of what we may expect in the nursery in a few years' time. Electrical contractors please note to make all nursery bowl fittings strong enough to permit of this class of aerial warfare upon realistic lines.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), Aug. 9, 1879.]

ELECTRICITY IN NAVAL AFFAIRS.—It is now proposed (says "The Times") that the officers undergoing a course of torpedo instruction on board the "Vernon," at Portsmouth, shall also be required to familiarise themselves with the practical application of electricity to the art of war. The teaching element has not as yet been perfected, but proper instructions will, no doubt, be provided in course of time. Steam was got up in the "Dreadnought" on two occasions, and the first lesson in the production and management of the electric light were imparted. The turret ship is provided with a couple of lamps placed at each end of the flying deck, the current being generated by one of Wilde's electro-magnetic machines, the motive power from which is supplied by a strap from the forward ventilating engine. The illumination is produced by a couple of vertical carbon points, which are worked by hand. There is no subdivision of the current, so that only one light can be used at a time. Until lately, however, the after light could only be obtained by disconnecting the forward one, and forming a new and separate connection with commutator between decks. The method not only entailed great loss of time, but was attended with great difficulty. Now, however, an important improvement has been introduced, by means of which it is only necessary to shut off the forward connection, and the after light may be used at once. Some experiments have also been made with the Gramme machine on board the "Bloodhound."


L. P. S.
CLIPS, TIPS & TERMINALS
of all descriptions.
Write for Booklet, with Illustrations, of 75 types to:—
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Goldiplat, Ox., London." 4746 Gerrard.

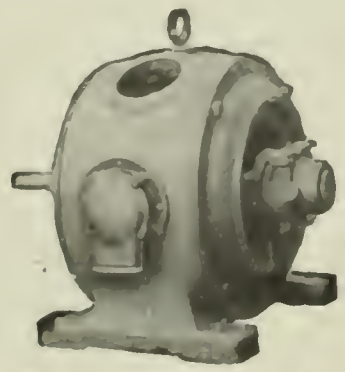
SIEMENS

STANDARD

ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED

HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.

Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."

Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.

Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."

HOME BRANCH ADDRESSES!

BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.

BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood

CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs

GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.

Branches in Principal Towns Abroad.

MAGNETIC COUPLINGS, CLUTCHES AND BRAKES.

Magnetic clutches and couplings have a wide field of usefulness, which includes all those cases for which mechanical devices have been or could be properly employed, and for such cases magnetic clutches and couplings offer immense advantages.

One feature is that magnetic clutches and couplings can be controlled from remote positions. Another is the smoothness of engagement due to the fact that the action is independent of centrifugal force. A mechanical clutch influenced by centrifugal force is always a drawback, for it tends either to make the clutch engage sharply or else to prevent it from engaging, in which event a considerable force must be applied to the operating lever in order to throw the clutch into complete engagement. "Igranic" magnetic clutches, described in Leaflet No. 1,621, do not, we understand, suffer from either of these disadvantages. To make the clutch engage the current is switched on, and as centrifugal force neither hinders nor assists, the result is a smooth engagement. The following particulars of the uses of "Igranic" clutches and couplings are taken from the same pamphlet.

Magnetic clutches have been widely employed in rubber mills, which require robust, dependable clutches, susceptible of remote control. Recently about 140 small "Igranic" magnetic clutches were supplied for use in connection with match making machinery, and remote control was a desideratum. In another case 75 magnetic clutches were supplied to an explosives factory in connection with nitrating machines. These rotary machines have a stirring mechanism to cause complete saturation of the cotton or cellulose with nitric acid. It is important that they should be accelerated slowly, or the friction caused by slippage of the stirring mechanism on the contents of the vat may create enough heat to cause an explosion. By the use of magnetic clutches, in combination with a two speed gear train, this danger was entirely obviated, and partly owing to the facility of remote control it was found that the device was handled by the operators with great convenience and consequently with considerable speed.

In the case of small reversing mechanisms driven off a line shaft, "Igranic" magnetic clutches have, we gather, worked to advantage. For example, in the manufacture of tin and lead foils, some 80 or 90 clutches are used for the starting, stopping and reversing of the rolls in which the foil is produced. "Igranic" clutches are usefully employed in power plants in which generators are to be driven either by steam or water power, and the latter is available during certain seasons of the year, but the former must be substituted during other seasons. The change over, from one prime mover to the other, can be accomplished from the switchboard; consequently, with a minimum loss of time. The users state that the maintenance costs of "Igranic" clutches are materially lower than the maintenance costs of the mechanical clutches formerly used. A number of "Igranic" magnetic clutches are used with automatic tyre building machines, because on these machines it is desired to accomplish a series of operations automatically, and magnetic clutches are best adapted for this purpose. Makers of clay working machinery have also found "Igranic" magnetic clutches very useful. The magnetic clutch would seem to find its widest field in those lines of service where a reliable clutch is required for the transmission of considerable power at low speed, and particularly in installations where it is desirable that the space taken by the clutch should be the absolute minimum.

The rapid stopping of heavy inertia machinery is often necessary to avoid accidents and injury to workpeople. It is not unusual to employ an "Igranic" magnetic clutch or coupling between the machine and the motor, together with a magnetically operated brake. These two are combined in the "Igranic" coupling brake, and controlled by one switch, so that the act of exciting the clutch releases the brake and the switching off of the clutch causes the brake to be applied, thereby stopping the machine in the shortest possible time.

The type A magnetic coupling consists of two members; the field or driving member, which carries the magnetising winding, and the armature or driven member. These are carried on the outer circumferences of a pair of annular spring steel plates which are attached at the inner circumference, the one to the driving hub and the other to the driven hub. Normally, the two members are held out of contact, but when the current is supplied to the winding of the field member, they are magnetically drawn together, the spring steel plates allowing the necessary movement to take place. The power is then transmitted entirely by the frictional engagement between the two members. Type A couplings are not suitable for accelerating a stationary load as the engagement is quite sudden. They should not

Ratings of Type A Couplings.

Size, in.	Maximum torque, lb. at 1 ft. radius.	Safe H.P. at 100 R.P.M.	* Max. R.P.M.	†Current consumption, watts.
12	191	2·4	1,680	75
14	305	3·9	1,440	85
16	455	5·7	1,260	75
18	645	8·2	1,120	85
20	886	11·2	1,010	113
22	1,175	14·9	915	142
24	1,530	19·4	840	170
26	1,950	24·6	775	170
28	2,440	30·8	720	213
30	3,000	37·0	670	280
32	2,640	46·0	630	234
34	4,370	55·4	590	320
36	5,180	65·5	560	320
38	6,100	77·2	530	300
40	7,100	89·9	505	290
42	8,200	104	480	380
44	9,440	119	460	360
46	10,800	137	440	345
48	12,300	156	420	450
50	13,900	176	400	430
54	17,500	222	370	415
60	24,000	304	336	503
64	29,100	368	315	480
68	35,000	443	296	730
72	41,500	525	280	705

*Maximum speed given should not be exceeded unless the speed is specified when ordering.

† Direct current must be provided.

BURNER & HEAT CONTROL

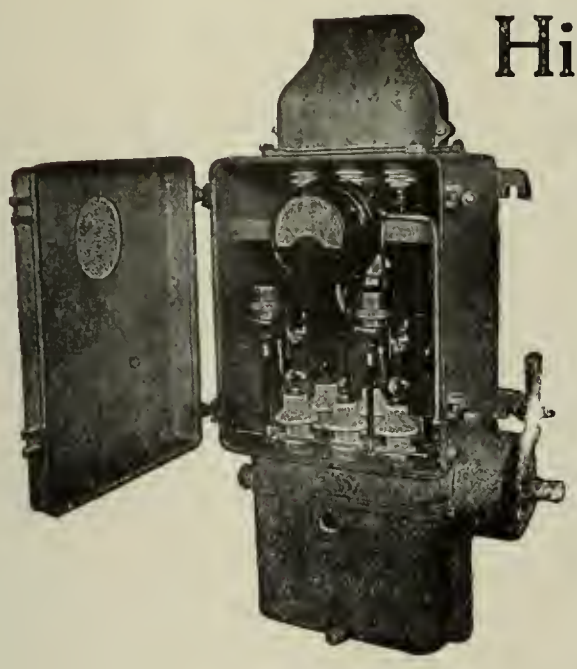
Equipment for Lead Presses

(HALL'S PATENTS).

MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

The Electric & General Works, Ltd.,

15, Victoria Street, London, S.W.

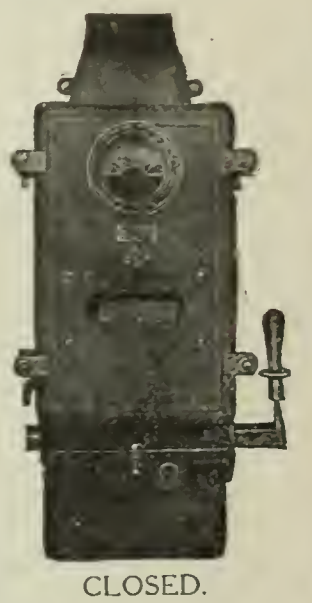


OPEN.

High Tension Switch Boxes

for 3,000 and 6,000 Volts.

TRIPLEPOLE AUTOMATIC OIL-SWITCH.
DOUBLE INTERLOCKED DOOR.
OVERLOAD & UNDERLOAD RELEASE.
AMMETER.
INVERSE TIME LIMIT ATTACHMENT.
FIRE-DAMP SAFETY DEVICE.



CLOSED.

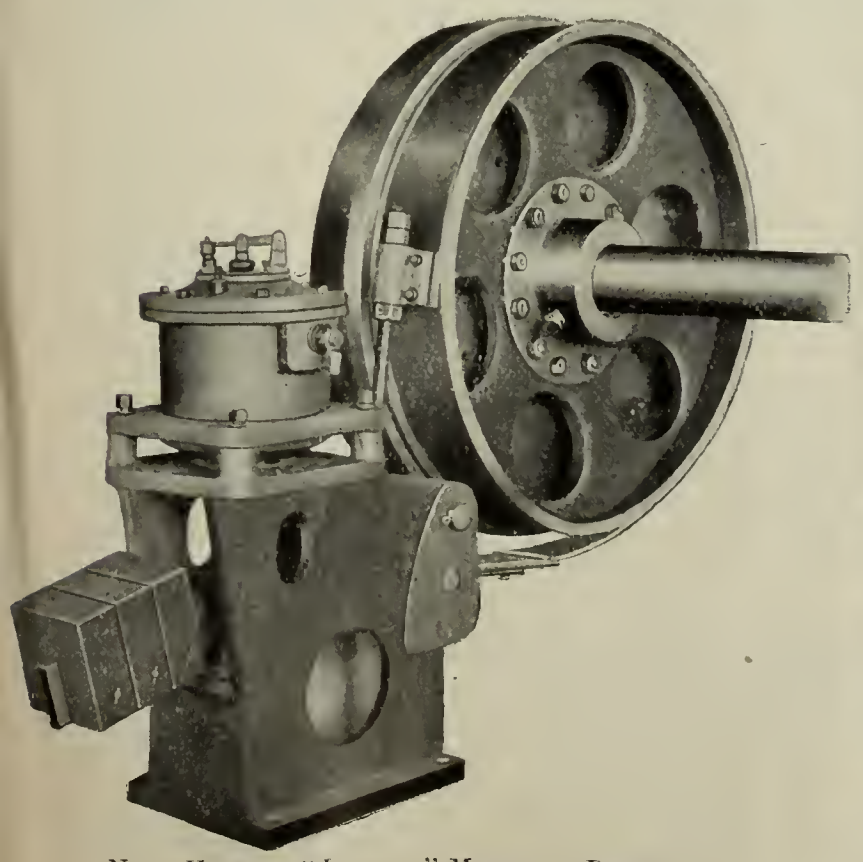
Other Types for all purposes.

ELECTRICAL APPARATUS up to 80,000 Volts.

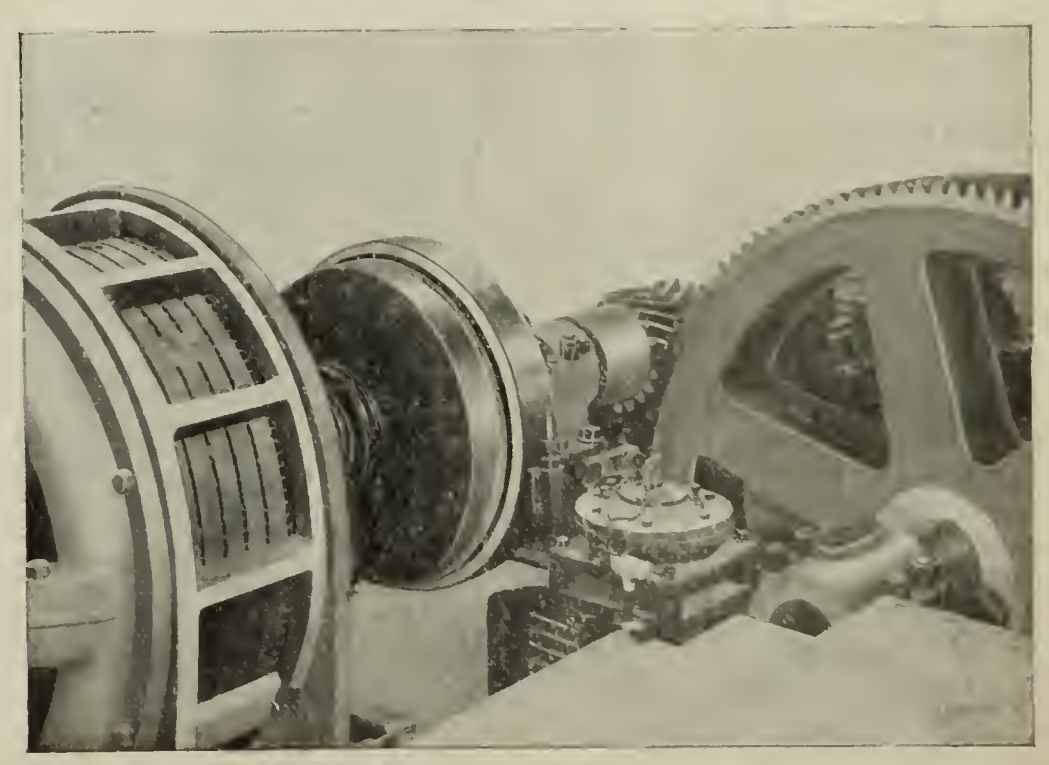
Telephone: 5223 VICTORIA. **Telegrams: "GABIONAGE VIC. LONDON."**

be employed for any class of service for which jaw couplings would not be satisfactory for load acceleration.

Type A couplings can be supplied in combination with magnetically released band brakes and in this construction the hub carrying the armature member of the coupling also carries the brake wheel, which is encircled by a band lined with woven asbestos and brass wire. This friction band is released by a solenoid connected in paralle with the winding of the coupling, and is applied by a weight on the end of the brake lever. When the magnetising winding of the coupling is de-energised by the tripping of one of the safety switches, that of the brake solenoid is also de-energised and the brake applied. The driving power is cut off and the brake instantly applied so that



Near View of "Igranic" Magnetic Brake.



An "Igranic" Magnetic Clutch in Service.

EDISWAN
EVERYTHING
ELECTRICAL

THE ALL-BRITISH
HOUSE FOR ACCESSORIES

ROYAL
"EDISWAN"
DRAWN WIRE LAMPS

CATALOGUES ON REQUEST
FROM THE
EDISON & SWAN
U·E·L CO., LTD.,
PONDERS END
MIDDX.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21515/06, 27772/03 AND OTHERS

the equipment is brought to rest in a period of time which will prevent injury to workmen.

The type H-30 magnetic clutch embodies the essential features of the type A coupling, but in addition is provided with a separate lined friction face external to the poles of the field member, which is arranged to prevent the pole faces from coming into contact with the armature. The lining is similar to that employed for the brake bands already referred to. It possesses a high coefficient of friction, and the low pressure at which it is worked makes it durable when subject to slipping during starting. This type of clutch can be used for accelerating at frequent intervals, and the engagement is as gradual as that secured with any form of mechanically operated clutch.

Ratings of Type H-30 Clutches.

Size, in.	Maximum torque, lb. at 1 ft. radius.	Safe H.P. at 100 R.P.M.	* Max. R.P.M.	†Current consumption, watts.
7	34	0·4	2,500	75
10	89	1·1	2,000	90
12	164	2	1,680	104
14	245	3·0	1,440	168
16	366	4·5	1,260	177
18	520	6·5	1,120	204
20	714	9	1,000	220
22	951	12	920	261
24	1,243	15·5	840	274
26	1,568	20	780	334
28	1,960	25	725	354
30	2,410	31	675	369
32	2,920	37	645	461
36	4,160	50	600	461
40	5,710	72	580	470
44	7,600	97	490	485
48	9,860	124	450	521

* Maximum speed given should not be exceeded unless the speed is specified when ordering.

† Direct current must be provided.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

The details of construction of the type H-60 magnetic clutch are the same as those of the type H-30, except for the pressure per square inch under which the friction faces are operated, this being roughly twice that to which it is subjected in the type H-30, thereby enabling an H-60 clutch to transmit a larger horse-power than an H-30 clutch of the same dimensions. In consequence the type H-60 clutch is not recommended for service where the load is to be accelerated at frequent intervals, while the type H-30 clutch is offered for such service.

Ratings of Type H-60 Clutches.

Size, in.	Maximum torque, lb. at 1 ft. radius.	Safe H.P. at 100 R.P.M.	* Max. R.P.M.	†Current consumption, watts.
20	1,428	18	1,000	230
22	1,902	24	920	274
24	2,466	31	840	288
26	3,136	39	780	350
28	3,920	49	725	372
30	4,823	61	675	388
32	5,840	74	635	485
36	8,320	105	560	485
40	10,420	132	500	495
44	15,200	192	460	510
48	19,720	250	520	550
54	28,100	355	375	610
60	38,600	485	340	660
66	51,400	650	300	730

* Maximum speed given should not be exceeded unless the speed is specified when ordering.

† Direct current must be provided.

The clutches and brakes described above must be operated by direct current. Where alternating current only is used, direct current may often be taken from the direct-current exciters, but if this is impracticable a small motor-generator set can be installed. The power required for the couplings and clutches is given in the tables herewith. The standard clutches and brakes are wound for 110 or 220 volts direct current. When ordered for 500 volts 220 volts windings are employed and operated in series with a fixed resistance.

INTERESTING MANUFACTURING OPERATIONS.

The production of a number of electrical accessories has now to be undertaken upon so extensive a scale that the manufacturing operations which would be performed by hand for a comparatively small output, are more economically entrusted to machinery, now that the output extends to hundreds of thousands. The electric fan and the electric flat-iron are examples of this class of product into the manufacture of which the machine tool has been successfully introduced, and particularly in the United States. In a recent issue of "Machinery" an illustrated article appeared, in which the details of the production of the wire guard for a General Electric (Schenectady) fan were clearly shown, and also the milling tools used for the continuous facing up of the bases for electric irons.

Fig. 1 shows the wire guard of the G.E.C. fan, and it will be noticed that it comprises a central monogram which is in cup form, eight arms, and front and rear rims. Two arms are made up of one piece of wire, and the complete guard is therefore fashioned out of six separate lengths of wire. This wire is first cut into suitable lengths, which, in the case of the arms, are long enough to include all bends. A preliminary operation is the placing of the length of wire in a

(*Continued on page* 137.)

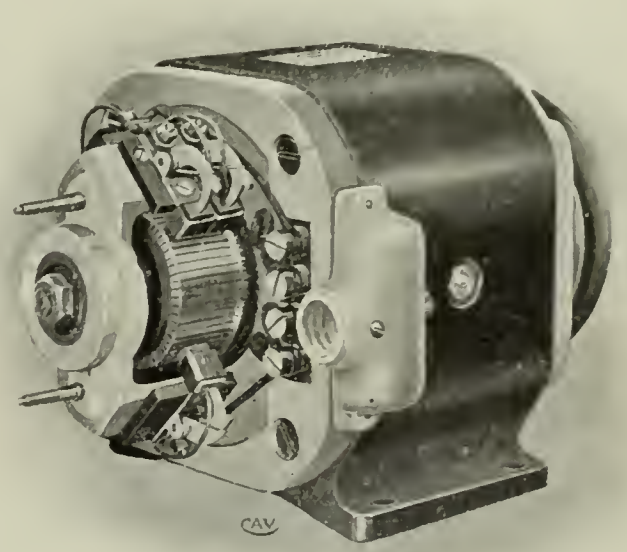
INSULATION BEADS
The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.
HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.

ORGANISING BRITISH INDUSTRIES.

THE WORKS OF C. A. VANDERVELL & CO.

This war of men, materials, methods, micrometers and munitions is not yet over, and it may be premature to suggest what shall or shall not be done to re-establish in British hands those branches of industry and trade which a lack of Government appreciation and a consequent slackening of manufacturing effort, allowed to drift into the grasp of now enemy firms. The policy which is to govern trade within the British Empire, trade among the Allies and trade with so-called neutral countries, is at the present moment, like the British army was at Mons, dans l'air. Our ears are tickled with reports of "Paris Conferences," "Trade Understandings," "the Exclusion of the Hun from the Markets of the World," "the Commercial Ostracising of Germany," and a number of other threats which should in their very utterance cripple any subtle attempts of the enemy to overwhelm us with their war-hoarded products when peace is finally declared. But the signs and portents point to a Government wrestling with the improvised defence of a peace-loving empire, the hurried haranguing of manufacturers into the conversion of their factories to the auto-tooling of munitions, and the continuous keeping up of shell supplies regardless of what the works may have been doing in the way of pre-war production.

What is more natural than that the manufacturer should ask what the business side of the Government proposes to do for him when munitions output is no longer the sine qua non of his daily round? We believe this question is on the lip of every British manufacturer at the present moment. We were not in the least surprised to be asked this very question by Mr. C. A. Vandervell, the head of an electrical works at Acton, which has grown out of all recognition during the last five years. The initials "C.A.V." are something of a talisman among motorists, but they are not without meaning to a large number of electrical men who are "not in the motoring line," and we feel they will need little or no introduction at our hands. Messrs. C. A. Vandervell & Co. have built up a purely specialist business since the petrol motor car industry came into being, which has proved of enormous benefit to the industry, and, further, have demonstrated that British enterprise is neither dead nor decadent in the matters of industrial organisation and enterprise. We have no need to remind our readers that the establishment of any new specialist industry in this country, under trading conditions which admit to the home market all and sundry among the nations, is no mean achievement. Scores of firms boast big businesses which are based solely upon non-manufacturing interests, all too frequently trading with producers well outside the limits of this Empire of ours.



A Typical "C.A.V." Product: Type H Car Dynamo with End Cover Removed.

We gathered from a recent conversation with Mr. C. A. Vandervell that the war should correct much of that class of trading which resolves itself into the mere handling of goods in the scientific production of which we, as a nation, have not the smallest concern. His remark was, of course, based upon the assumption that the Government is intending genuinely to encourage manufacturers to produce upon a scale which will



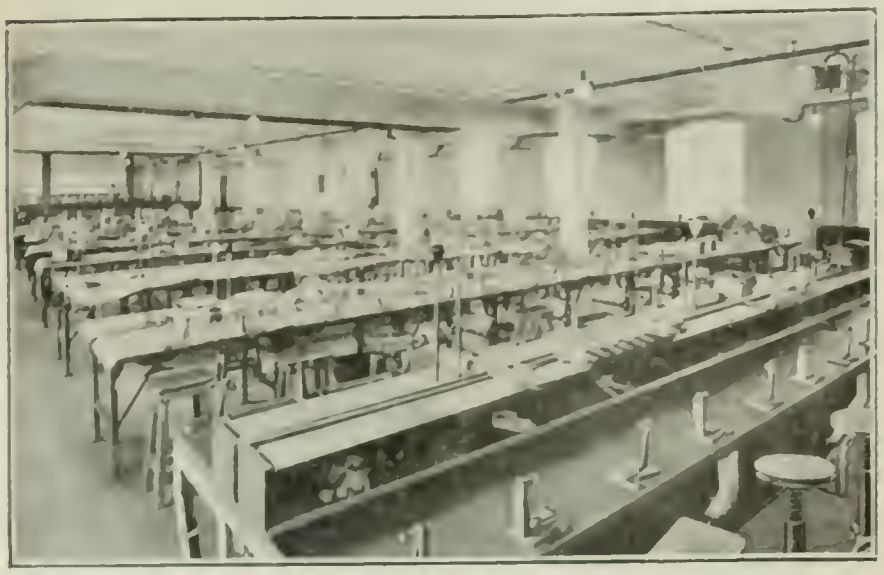
Front View of the Extensions to the Acton Vale Works of C. A. Vandervell & Co.

keep enemy competition in its proper place at the conclusion of hostilities.

No surprise need be expressed at this outspoken attitude of the head of a manufacturing business which has grown from modest proportions within a comparatively few years until it now employs about 3,000 hands, and can boast of an area of approximately 600,000 sq. ft. of workshops. If any good is to come to Britain out of this war it has got to come to her manufacturing interests. We have heard enough of the cry that the British manufacturer is this or that many years behind the Continental or American variety of producer, and that he has no natural ability for quantity production or organised industrialism. The effort which we are making in the wholesale and unprecedented grinding out of munitions—an effort improvised within a few months—is the answer to those who still wish to claim that we are a nation of shopkeepers!

Our visit to the Acton Vale Works of C. A. Vandervell & Co. provided us with a convincing collection of material upon which to base our firm belief in the future of the specialist British manufacturer. What Mr. Vandervell has done at Acton can be done elsewhere. He himself has an abundance of faith in the ability of the British builder to beat the Hun and any of his neutral (?) satellites at their own game. The Acton Vale factories are organised for world market production, and in that respect they yield nothing to the equipment of German or American works. What Bosch and Ruthhardt did for the magneto on the other side of the Rhine Vandervell has already done on this side of the Thames, and why should it not continue to be so? We saw enough in going through the magneto, battery and car dynamo shops at Acton Vale to confirm what we have always believed, that the British manufacturer takes to organisation, standardisation and quantity production as naturally as a duck takes to water, to employ a case-hardened colloquialism. The "C.A.V." business in these products has been built up in the face of not only the competition of home producers, but also of unrestricted American and German imports. The severity of the latter, known to those who are "in the trade," is in itself an index of the success which has attended the efforts of Mr. Vandervell, his energetic staff and his army of workmen.

On this occasion we do not propose to do more than indicate by photographic means the extent of the many airy and well-equipped shops at Acton Vale. Details of their products in the way of magnetos of all classes, car dynamo lighting and lighting and starting sets, battery outfits for all lighting purposes, motor car or otherwise, and the accessories connected therewith would occupy more space than we have at disposal, and would defeat our object in that they might prove tedious to the reader. We were especially impressed in our tour of the works under the guidance of Mr. Arthur Goodwin, the manager



Armature Winding Department, Acton Vale.



Another View in the Armature Winding Department, Acton Vale.



A Corner of the "C.A.V." Birmingham Works, where Car Projectors are Made.

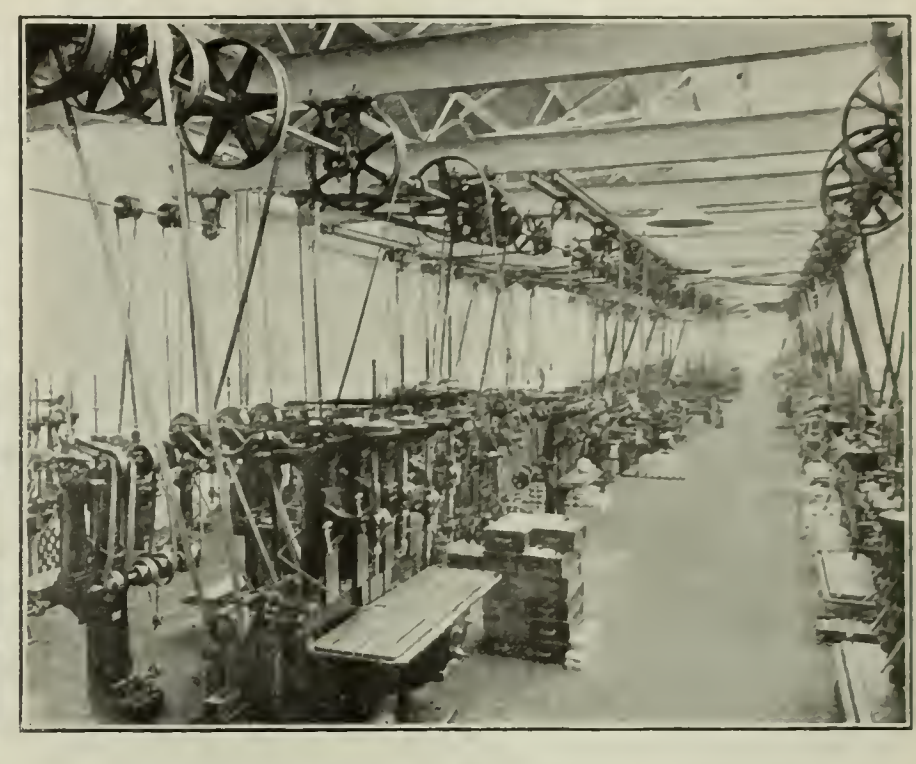


Car Dynamo Assembling Department, Acton Vale.

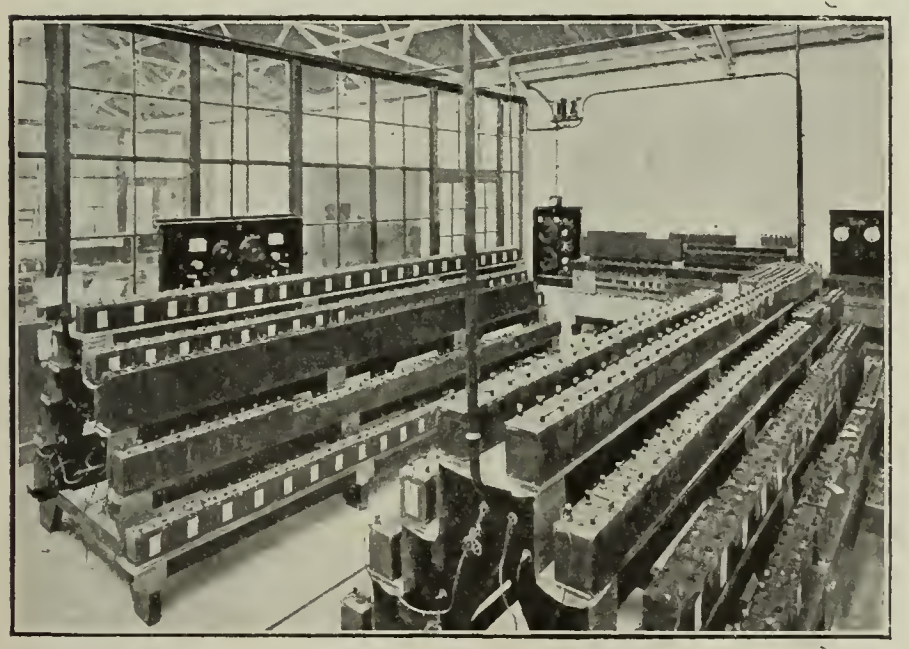
AT VANDERVELL'S, AT ACTON.



An Avenue of Machine Tools, Acton Vale.



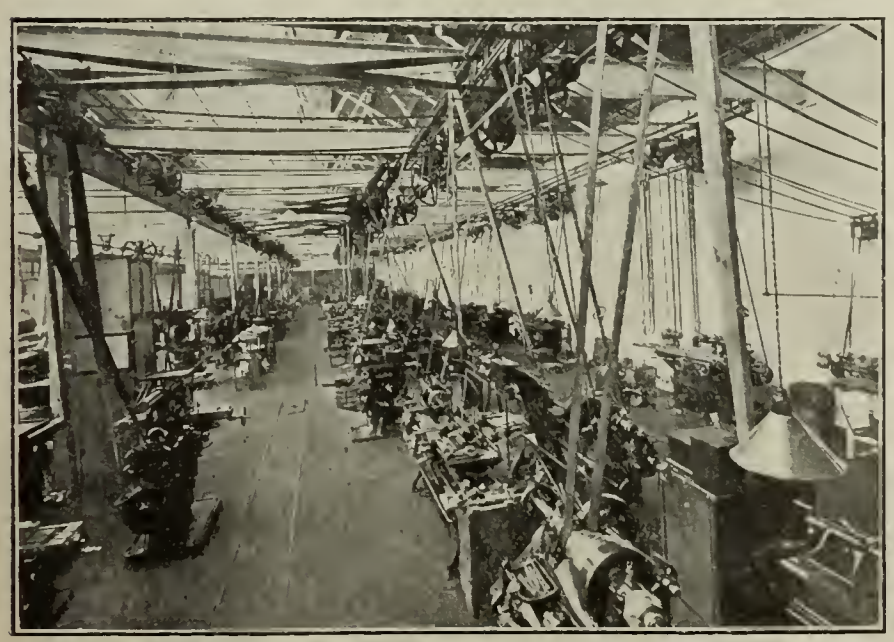
A "Battery" of Vertical Multiple Drills, Acton Vale.



Battery Forming and Charging Department, Acton Vale.



Lead Burning Shop, Battery Department, Acton Vale.



A View in One of the Machine Shops, Acton Vale.



The Battery Box Department, Acton Vale.

of the company now for some 10 years, with the plan upon which they have been laid down, and the appreciation of the management of the need for science and organisation in the conduct of the place. In the research department the quality and suitability of the materials employed for magneto and small dynamo manufacture come in for the closest scrutiny.



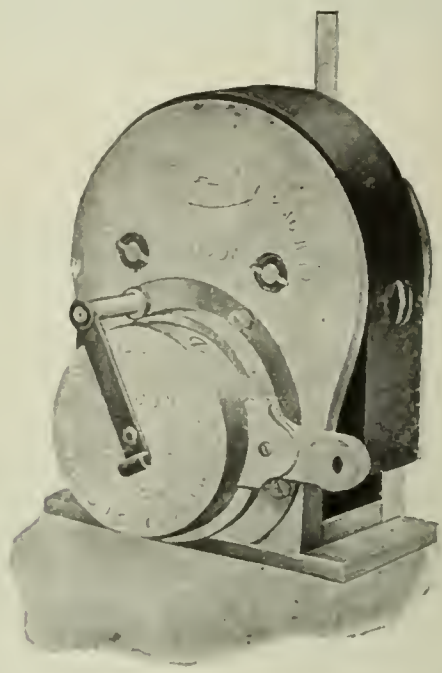
A Village Street "Somewhere in Bucks" Photographed by the Headlights of a Car Fitted with "C.A.V." Equipment.

Although the bulk of the purely raw materials is, quite naturally, the product of outside specialist firms, the element of chance is not allowed to enter into their composition. The work of research also goes hand in hand with the experience gained in the operating field with the products of the company. Faults, inherent or transient, are traced and as much as possible corrected by modification in design or an adjustment of some process of manufacture.



The Dash of a Rolls Royce Car Fitted with "C.A.V." Dynamo Starter.

In the machine shops also we were shown how method and management make for accuracy in the production of details and interchangeability of standardised parts. Not only machine tools and close inspection of each finished part, but also a careful training of the workman have contributed to these desirable ends in the production of such highly specialised goods as are turned out in their hundreds of thousands at Acton Vale. A perusal of the company's comprehensive booklet, "Public Service and Commercial Vehicle Lighting" (15,000 such vehicles have been "C.A.V.'d" in five years), will give the reader some insight into the amount of detail which is involved in but one of the specialised products of the works. Taken in conjunction with another publication which deals with "C.A.V." dynamo lighting and starting systems for pleasure cars, one has in the two booklets all the evidence to prove the triumph of electricity as an accessory in motor vehicle service. Although acetylene has been ousted as a motor car illuminant only within some five years, the motor vehicle user to-day wonders how he managed, even so short a time ago, without his "C.A.V." starting and lighting equipment. An instructive item on this point is the extent of the shops at Acton which are devoted solely to the fitting of private and commercial cars with these central stations in miniature. At the time of our visit this department was filled with every kind of motor vehicle But despite rapid development the company has been able to standardise, and especially so with control boards, junction boxes, armoured "cabling" for the interconnections, battery groups, adapters, &c. "Contrariwise"



One of Numerous "C.A.V." Magnetos Made at Acton Vale.

standardisation has not been another word for stagnation: the department responsible for the research and experiment with dynamo starters, lighting dynamos and magnetos is always busy, and some of the things we were permitted to see there indicated that progress can still be made.

A word may be said as to the welfare work of the company. On a plot of land near the works, and facing a new road, a spacious and well-lighted restaurant has been built to accommodate the male and female employees who come from a distance and want "somewhere to go" for meals. There are two large halls, either one of which would do justice to a good-sized parish, one for the men and the other for the girls, and between them are well-fitted kitchens with an abundant supply of hot water. These will shortly be opened and will be much appreciated.

This is not all. In spite of the fact that the works have been enormously enlarged of late years, the company has land immediately available on which many more shops are being built, and which, when in operation, will more than treble the output of the works. This fact is an indication in itself that Mr. Vandervell and his immediate advisers are not merely hopeful of the future of British supremacy in their particular products, but have taken the necessary steps actually to produce, while the war is still on, upon a scale which will absolutely ensure success when peace comes. W.E.W.



Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W. *Greenly*

INTERESTING MANUFACTURING OPERATIONS.

(*Continued from page* 132.)

central position in a fixture in which the wire is secured against creeping during the bending operation. At opposite ends of this fixture there are two fulcrum pins round which the bends are made with the aid of a hand key having a central hole to engage the fulcrum pin, and a projecting stud which reaches far enough over the wire to control the bending when the key is turned. One turn of the key completes the upper bend where the wire engages with the front rim, and a half turn forms each of the end bends where the wire engages with the back rim and the monogram cup respectively. In Figs. 2 and 3 are shown the punch and die for assembling the wire arms and the centre plate, and the tool for applying the monogram cup to the centre guard respectively. The operations in the bending of the arms are performed in separate dies. In the case of Fig. 2 the die closes the lugs in the centre plate over the four double arm wires. To facilitate the placing of the work in position, the die is mounted on a slide on the bedplate. The centre plate is first located, and then the four wires are placed in position, the outer ends of the arms being supported by guides round the edge of the work holder. A single stroke punch turns over the 12 lugs, and closes them on the

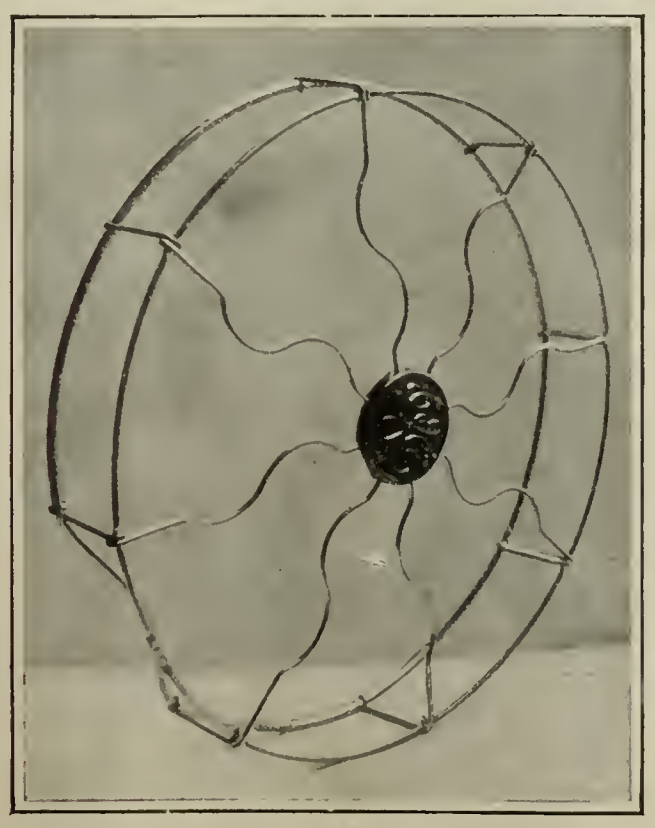


Fig. 1.—View of Complete Fan Guard.

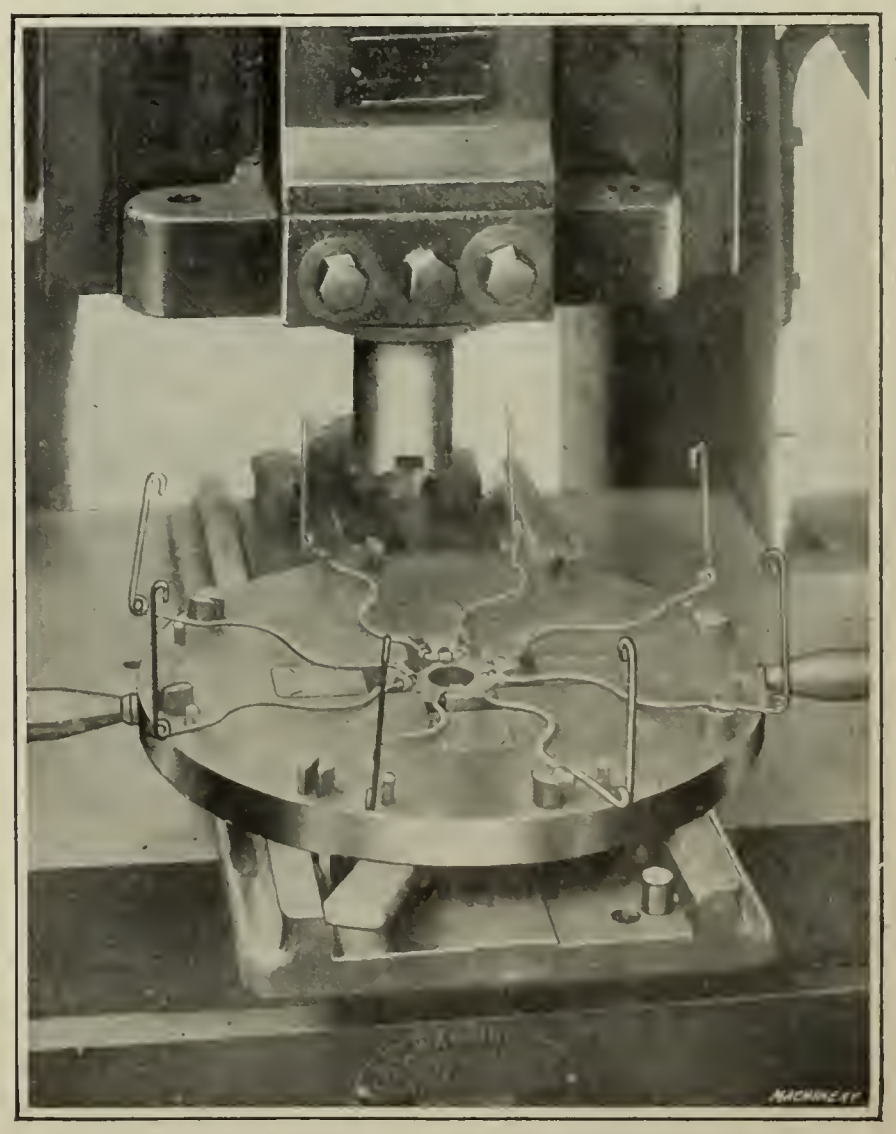
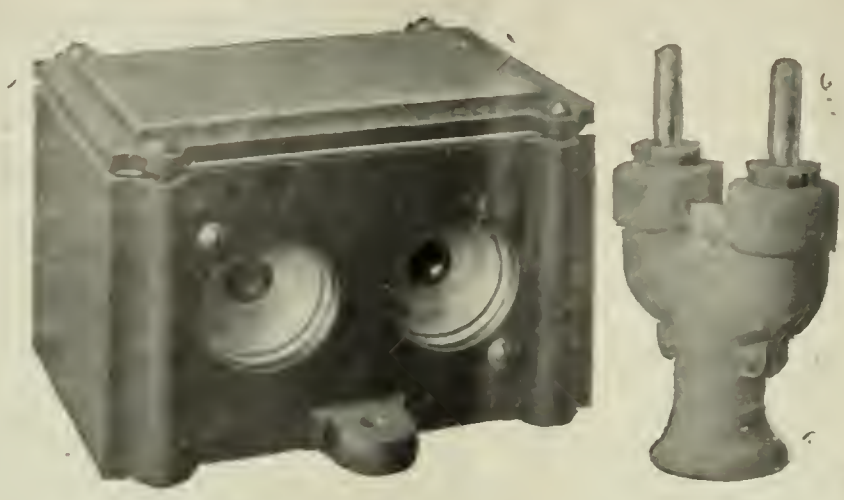


Fig. 2.—Assembling Arms and Centre Plate.

IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

arm wires. The work is ejected from the die by the movement of the lever at the front.

The wires forming the two rims are cut off and formed by rolling, and the ends are coupled up with a short length of brass tube which is craped into place. Previous to the closing of the ends of the front rim the arm loops must be threaded on by hand. The application of the monogram cap to the centre of the fan guard is accomplished in the milling machine. There are eight slots in the monogram rim, which allow it to pass over the wires from the front, and after dropping in the thin backing plate the edges of the monogram are spun over by a tool in the drilling machine.

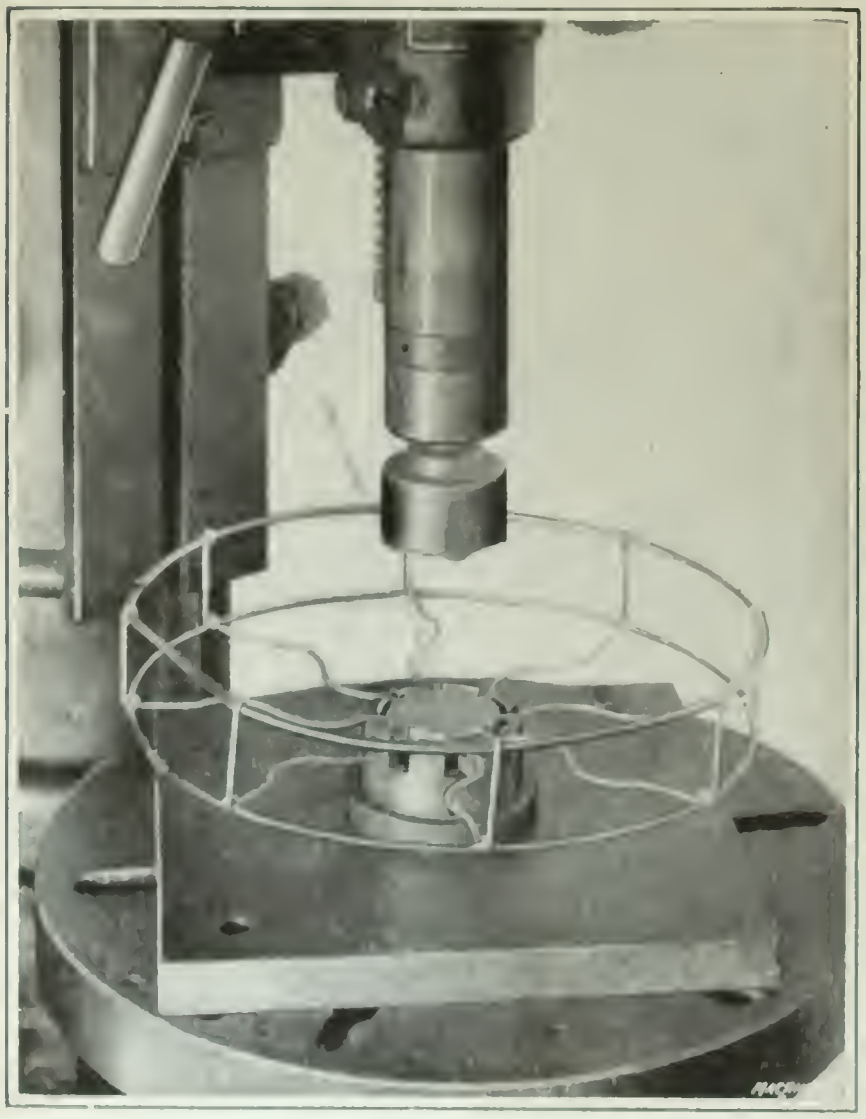


Fig. 3.—Applying Monogram to Centre of Guard.

In the manufacture of electric flat irons at the Pittsfield plant, there are several machining operations of special interest, because of the high rate of production. The tops of flat iron bases are finished by milling on a vertical milling machine, as illustrated in Fig. 4. On the table of the machine is a continuously rotating fixture that holds 14 castings. Each of the seven handwheels operates a wedge that enters between two castings and forces them forward against positive stops on the fixture. The milling is done by a large flat face mill that removes $\frac{1}{16}$ in. of metal from the face of each casting. Although the fixture rotates continuously, it gives the operator time to remove and insert new castings without stopping the rotation of the table. This method of milling takes care of the facing of the top sides of these castings at the rate of 200 per hour. The facing of flat iron clamps is another operation that is done in a somewhat unusual manner. It is performed on a dry grinding machine. This machine is similar to a large disc grinder in principle, but employs solid blocks of emery

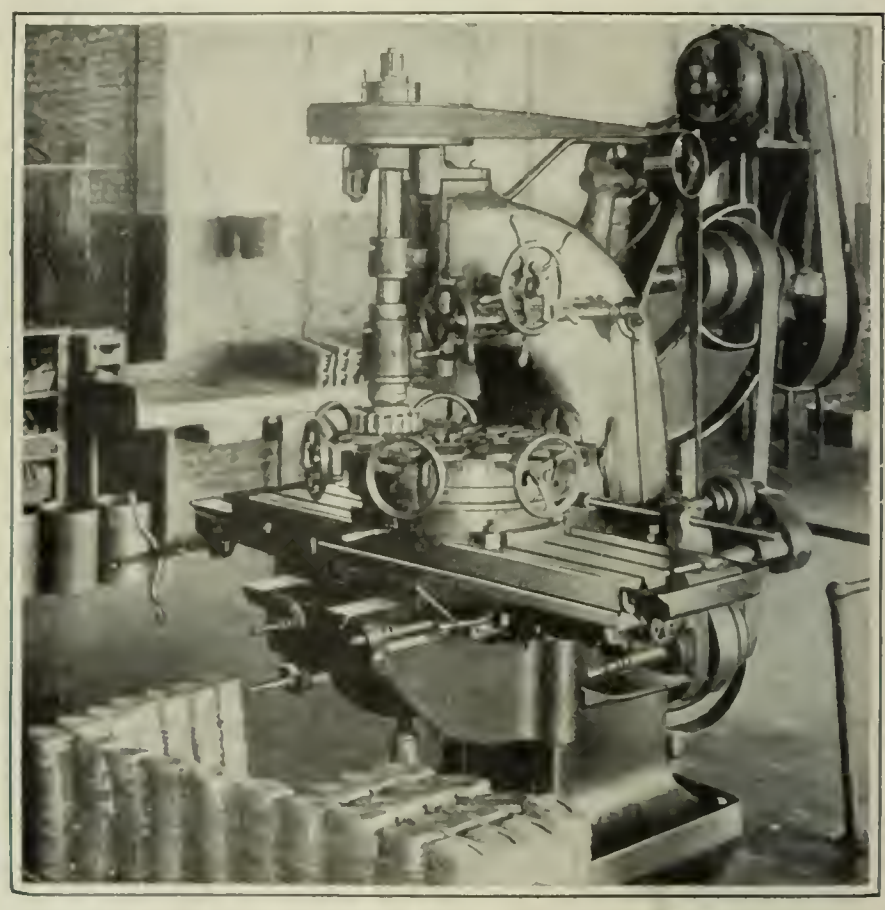


Fig. 4.—Continuous Milling Flat-iron Bases.

for the abrasive. These blocks are closely fitted round a 6 ft. diameter disc, and both sides of the disc are similarly fitted. The irons are held in magnetic chucks that are mounted on the work tables. Levers are used for pressing the work against the grinding

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK. SEA CLIFF
CHARLES CLIFFORD & SON, LTD.,
BIRMINGHAM.

Our Manufactures include:

Cables for Lighting, Power,
Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

FACULTY is described as "The skill derived from practice."

That belongs to US, for we are the largest manufacturers of Electric Cables and Copper Wires in Gt. Britain.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

Works: PRESCOT and HELSBY.

Branch Offices in:—LONDON, MANCHESTER, GLASGOW, BIRMINGHAM, NEWCASTLE, CARDIFF, DUBLIN, LEEDS & BELFAST.

OVERSEAS BRANCHES:

AUSTRALASIA: The Wool Exchange, King Street, Melbourne.
EASTERN INDIA: 11, Clive Street, Calcutta.
SOUTH AFRICA: Telegraph Manufacturing Co. (Colonial), Ltd.,
P.O. Box 2827 Johannesburg.

H. Weidmann, Ltd., Rapperswil, Switzerland.

WE ARE SPECIALISTS IN THE MANUFACTURE OF—



PRESSPAN (3)

(Pressboard)

Best Quality. Proved by repeated tests.

Sheets in thickness from 0·1 upwards.
Endless Rolls and Strips from 0·1 to 1 mm. thickness.

Presspan Coils and Tubes for Transformers.
Presspan Armatures, Discs and Shaped Articles.

VARNISHED PRESSPAN. BLACK PRESSPAN.
OILED PRESSPAN. MICA-COVERED PRESSPAN, &c.

Grand Prix: Marseilles 1908. Gold Medal: Berne 1914. Silver Medal: Paris 1900.

disc. The work-holding tables are automatically oscillated while the disc is in rotation. The amount of metal removed is just sufficient to clean up the casting, and 200 finished pieces per hour is the production of each operator. One of the advantages of this machine is its high cutting capacity, which is due to the large diameter of the disc.

Still another facing method that is used on flat iron castings is the operation of grinding on a surface grinder. This is shown in Fig. 5, which represents the machine at work; the water guards have been removed for the sake of clearness. From 10 to 16 flat irons are placed upon the magnetic chuck and about $\frac{1}{32}$ in. of metal is ground from the face of the castings, leaving the bottom perfectly smooth and true. One operator will face off 800 castings in 10 hours.

We are indebted to the Editor of "Machinery" for his kindness in lending us the blocks in the above article.

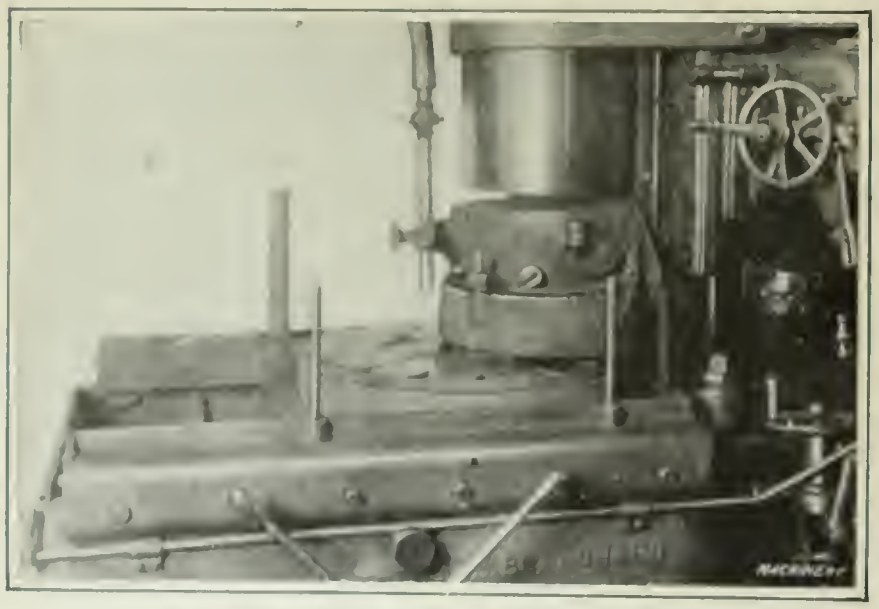


Fig. 5.—Surface Grinding Flat-iron Bases.

"RE-SET" SIGNS.

This interesting sign is one upon which the desired lettering can be reset or changed as frequently as desired, and this changing can be undertaken by a junior within a few minutes. Its applications are, of course, too numerous to mention, as a sign of this description can be put to good service by every class of tradesman with a shop window or showroom. It will doubtless be taken considerable advantage of by central station engineers and electrical contractors, who are out to appeal directly to the general public. By the introduction of an electric lamp the head line can be brought into prominence, and at the same time effectively illuminate the advertising matter.

The signs are supplied in either hard wood or metal frames, the letters being of black steel with the characters lithographed in white. Each sign is supplied with a sufficient number of letters and figures according to size of the frame. The letters and numerals are made in three styles, $\frac{1}{2}$ in., $1\frac{1}{2}$ in. and 2 in. in height, and these can be used on any sized signboard. The $1\frac{1}{2}$ in. letters are supplied unless otherwise stated.



View of "Re-Set" Sign showing Compartment containing Lighting Unit and Flasher.

The glass panel can be any colour and have any desired lettering.

An electric flasher is fitted on to each sign, which assists in making the apparatus equally attractive by night as by day. Bayonet cap adaptors are provided at the end of the flexible cord unless Edison screws are particularly called for. The sign, as illustrated, measures 18 in. high, 14 in. wide and $3\frac{1}{2}$ in. deep, a very suitable size for everyday purposes. Larger ones can be made up to order.

Particulars and prices of this sign can be obtained from Berry, Skinner & Co., 86, Newman street, Oxford-street, London, W.

One, Two & Three Phase MOTORS.

LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, August 11, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—The following from the "Bristol Times":—

We are asked to make the announcement to the public that all gas lamps will remain extinguished from last Saturday night until the night of August 19th, the electric light only being lit.

* * * *

The "Wall Street Journal" says:—

"General Electric plant at Schenectady has completed for the United States Navy the most powerful searchlight in the world with a 5 ft. mirror, the beams of which are visible at more than 200 miles. Additional searchlights are in course of construction."

How much more than 200 miles?

* * * *

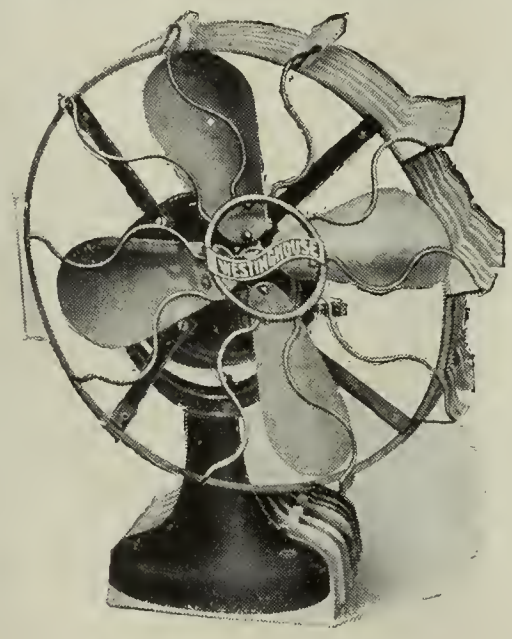
Mr. A. W. Berresford, of the Cutler-Hammer Mfg. Co., says in an interview to the "Electrical World" (my italics):—

"One effect of the war has been to bring England and her colonies into close touch. The natural result of such a condition would be preferential trade between England and her colonies, and a disposition on the part of the colonies to purchase from the Mother Country whatever she can supply. *This must have its effect on our Canadian relations.*"

Waal, Mr Neutral Berresford, what else did you expect?

* * * *

A distinct novelty in fan catalogues is just off the "Westinghouse Press." The picture shows that the pages are stamped out the shape of a Westinghouse fan, and by slightly opening the pages the list will stand up. If there is anything in auto-suggestion, this catalogue carried in the pocket ought to keep



one cool. Perhaps Mr. Gibson, who presides so genially and successfully over the Westinghouse supplies department at Long Millgate, Manchester (*see* p. 146), will try the suggestion on some particularly embonpoint electrical contractor and report results.

* * * *

Municipal electrical engineers are not allowed to make speeches at annual meetings of shareholders, otherwise I should be able to report a suitable reply to the following effusion of the chairman of the Bristol Gas Light and Coke Company:—

Gas has long been threatened by electricity, but gas engineers are not easily beaten. They manage to counter the efforts of their rivals by cheaper productions, and to hold their own notwithstanding the increasing cost of coal.

What do you think, Mr. Holmes?

Sometimes hydro-electric plants are shut down for lack of water, but the reverse was recently the case on the Southern Atlantic Coast of U.S.A. when a hurricane, with cloud bursts, lasting three days shut down about 200,000 kw. of plant. According to the reports, some score of stations electrically interconnected, including one group of five plants "in series" on the Catawba River, were ringing each other up to take on the load which the rising waters would soon compel them to drop. One station lost its dam so it could not hold its load. Altogether the affair would seem to have been in the language of the trenches, a complete "washout."

* * * *



THIS *must* BE THE LADDER HE SENT ME FOR.
[By kind permission of "Glover's Almanac."

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), Aug. 16, 1879.]

PHYSIOLOGICAL EFFECTS ACCOMPANYING METEOROLOGICAL PHENOMENA.—"Le Journal d'Hygiène" publishes a lengthy article, in which the sufferings of certain persons on the approach of rain are attributed to the electrical changes taking place in the atmosphere. The case is cited of a retired captain whose leg had been amputated, and who patiently noted the periods of the recurrences of pains due to the irritability of the severed nerves, and the coincidences between these periods and the atmospheric disturbances registered by the central meteorological office of the United States. He ascertained from his observations that his sufferings were greater when rain was about to fall than when it was actually falling; and he claimed that he could thus predict and give the time of the occurrence of rain even when the shower did not occur within a distance of some kilometres from his residence. M. de Fonvielle gives another case, that of a female who in her youth had been struck by lightning, and had since suffered from an incurable contraction of the muscles of the neck. Every time rain is about to fall she experiences sharp pains in this region, which become alleviated only when the rain has fallen. It is suggested that, in view of the great sensitiveness of the animal organism as an electroscope, the sensations of such persons should be carefully compared with observations made on the variations and current phenomena of atmospheric electricity.

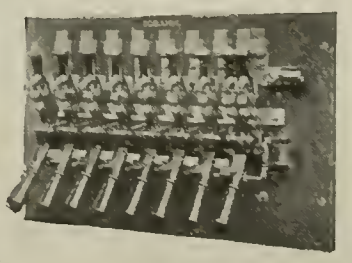
Liberally rated resistance will carry 150 per cent. of full load current during starting. Rated for one minute starting. Carbon roller contacts eliminate arcing. Laminated brush bridges from segment contacts to massive hub plate.



FOR HEAVY DUTY & FREQUENT SERVICE

CONTROL IGRANIC ELECTRIC DEVICES

IGRANIC ELECTRIC Co LTD 147, Queen Victoria St., London. Wks.: Bedford.



Toggle joint levers make positive contact with easy closing. Interlock introduces hand over hand operation, which prevents too rapid starting. Liberally rated resistance, heavy laminated contacts and massive bushes ensure cool and satisfactory working.

SIEMENS



IRONCLAD SWITCHGEAR FOR ALL PURPOSES

Control Pillars
Distribution Boards
Main Switchboards

Illustration shows our Standard Cast-iron Mining Pillar suitable for pressures up to 3,300 volts.

Write for particulars to —

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

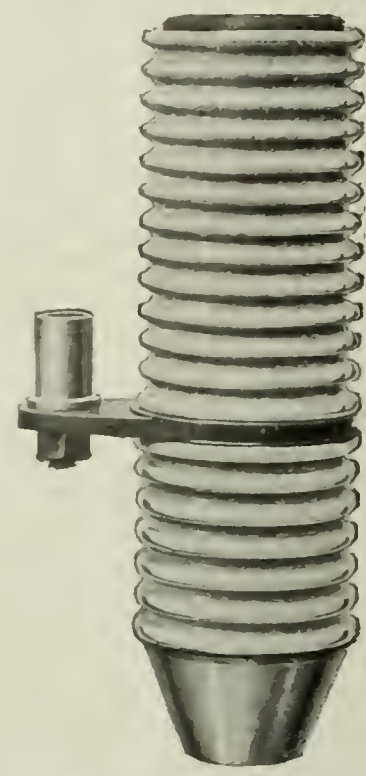
NEW "J. & P." LISTS.

Messrs. Johnson & Phillips have sent us advance copies of three of their latest lists: J.B. 1, Sealing Ends; J.B. 2, Colliery Boxes; J.B. 3, Inverted Pole type Trifurcating Box. The sealing ends are supplied for single, concentric or triple concentric cables. They are substantially made, and are fitted with British white glazed corrugated porcelains. Plumbing glands are provided in every instance for the incoming cable, and in the list drawings are given showing alternative arrangements of the tails for either rubber-covered or bare strand conductors; these may be taken off either the single cable or the inner conductor of concentric cables. Ample clearances between the conductors are allowed for, and the connectors are of heavy construction and mechanically sound. The sealing ends for use without rubber tails are listed in the single screwed cap type, the single screwed sleeve type, single bus bar type and the special fibre tube type. Six different sizes of each type are listed, the sizes of the cable ranging from "up to 0·05" sq. in. to "0·75 to 1" sq. in. cross-section. For the small size sealing end 2 oz. of compound is necessary, and for the large size 1¼ lb. The sealing ends for use with rubber tails are listed as single with sleeve connector type, concentric type, triple concentric type, lamp-post sealing and dividing box.

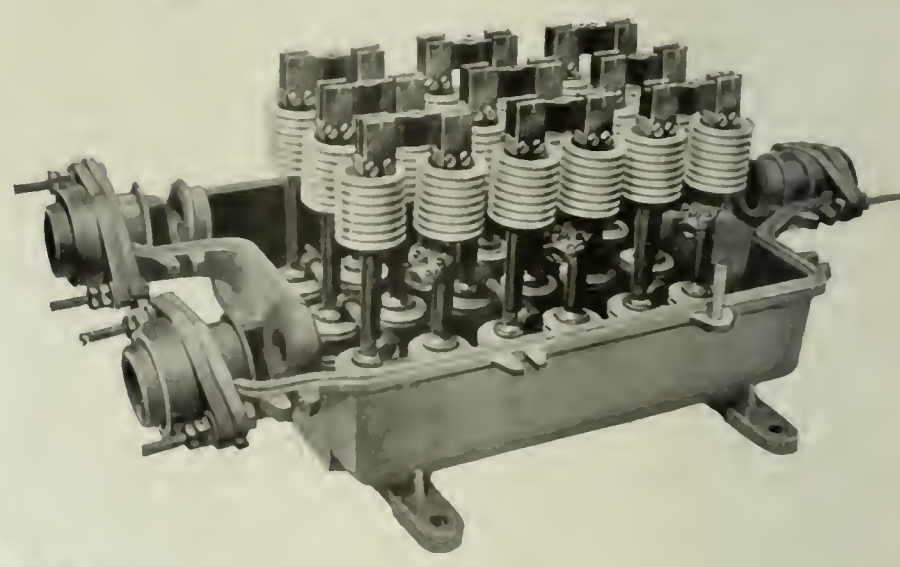


The latter is suitable for street lighting purposes, and is only made in one size. In the case of the first three, six sizes are offered, as in the previously-named types.

The colliery boxes are listed in seven different types: (1) Standard straight through non-disconnecting box; (2) standard three-way non-disconnecting box; (3) standard four-way non-disconnecting box; (4) straight through disconnecting box; (5) three-way disconnecting box; (6) three-way looping-in disconnecting box; (7) four-way disconnecting box. These boxes are all of substantial design, and have been developed as the result of considerable experience of colliery practice. The list clearly shows in diagram form the arrangement of the connectors and the method of dividing each of the conductors so as to accommodate them equi-distantly within the compass of the box. We illustrate the three-way disconnecting box suitable for three core cables up to 0·3 sq. in. cross-section. Porcelain and mica insulation is employed, the interior fittings being mounted on a steel frame. Creepage is obviated by the use of a porcelain shroud which covers the live metal at the compound level. Where the joints between the various sections of the box are above compound level they are machined on, where they are below compound level they are packed. The armouring of the cable is secured to the box by cast iron cone clamps; but electrical continuity between the armouring of all the cables is secured by brass clamps which are all connected by hard copper strand. The types of boxes illustrated conform to the Home Office regulations for the use of electricity in mines. We understand that the list contains only the



VIEW OF SEALING END FOR SINGLE CABLE.



COLLIERY THREE-WAY DISCONNECTING BOX SHOWN OPEN AND CLOSED.

ZeneX
&
NegreX



The Protective Coverings of Simplex Conduits and Fittings are perfect.

The threads of Simplex Conduits are cut after the tubes are enamelled.

They screw into fittings easily and make a perfect electrical and mechanical connection at every joint.

SIMPLEX CONDUITS Ld.

Garrison Lane, BIRMINGHAM.

LONDON—
113-117, Charing Cross Rd., W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868.
Codes: 5th Edition A B C & Western Union.

BELLING

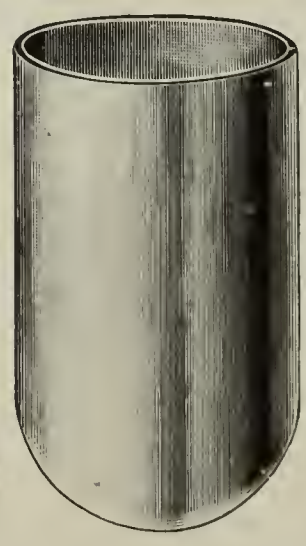
& CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialists, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,

STIRCHLEY, BIRMINGHAM.

Drawn Shell Work

IN BRASS, COPPER, and STEEL.

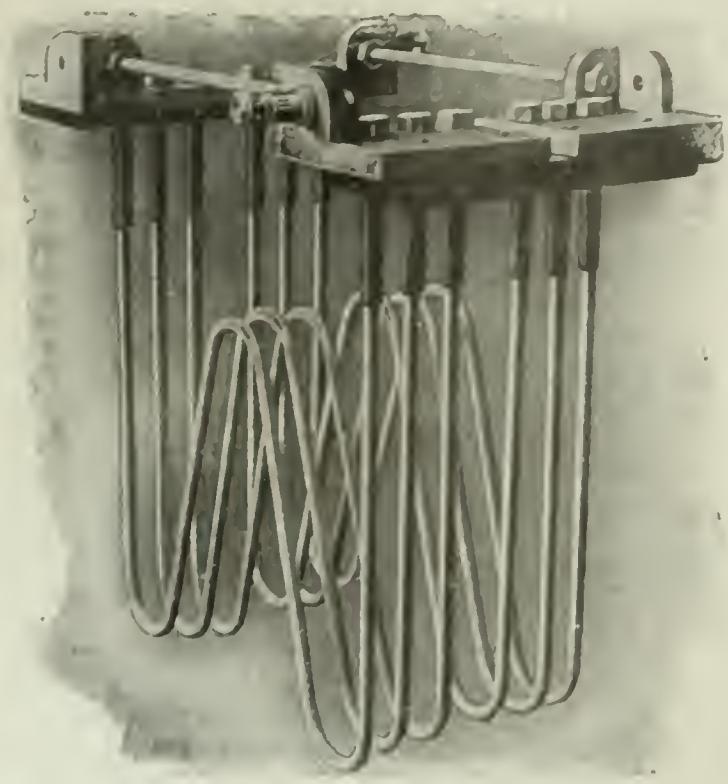
Any size
up to 8″ diam. × 4″ deep.

Sole Agent for the Electrical Trade:—

LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.

ELECTROLYTIC RECTIFIERS



Write for List "G."

ISENTHAL & CO.

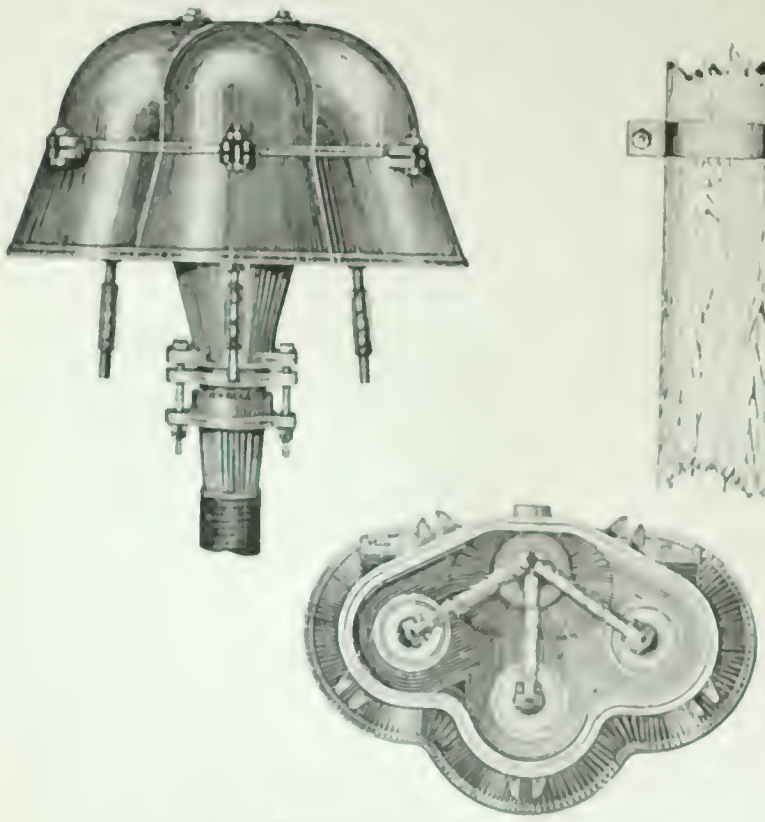
(DEPARTMENT 4)

Denzil Works, Willesden, London, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

company's standard range of boxes, and that a large number of patterns are available and can be quoted for against special requirements.

The pole trifurcating box list deals with seven different types of this form of box. There is a low tension single sealing box, low-



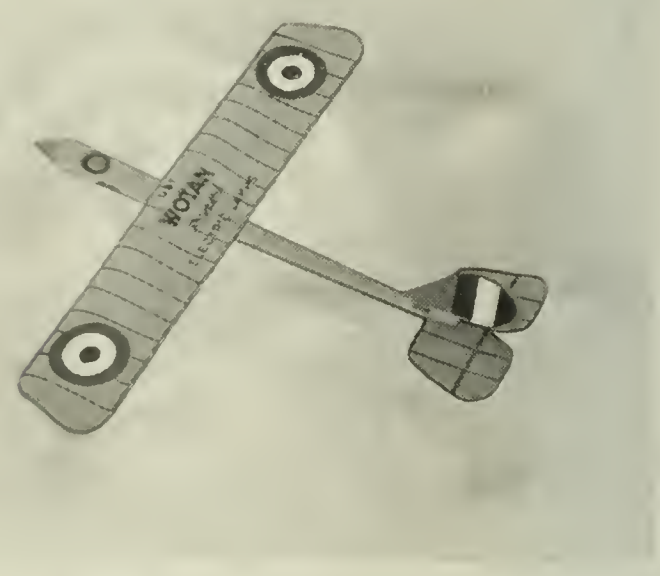
Three Views of Pole Trifurcating Box.

tension twin dividing box, low tension concentric dividing box, triple concentric dividing box, low tension three-core dividing box, low tension four-core dividing box, and high tension three-core dividing box. It will be seen from the illustration that the incoming conductors are brought up to a cone-shaped gland on the underside of the box, and that the armoured cable is secured to this gland by means of heavy clamps. Provision is similarly made for wiping glands, and armoured clamps can be supplied when specified. The tails are brought out under hoods which entirely isolate the conductors from dripping moisture or driving rain.

Copies of the lists referred to are available from the offices of the company at Charlton, London, S.E.

WOTAN MONOPLANE MODELS.

An ingenious advertising device, known as the Wotan Monoplane Model, is now being issued to the electrical trade. It consists of a sheet of paper of a special quality on which the component parts of a monoplane model are printed in colours. The various parts must be cut out as directed, and when bent and stuck together can be



The Wotan Monoplane Glider in Full Flight.

easily assembled. The size of the completed model is 10½ in. across the wing tip, and the length from nose to tail is just over 9 in. The illustration is an actual photograph of the made up model in flight. It is accurately balanced, and when launched in the manner of an ordinary glider is capable of performing many of the evolutions of a power-driven aeroplane. By adjustment of the tail it is possible to make the model loop-the-loop, or complete a spiral descent. The instructions give the various adjustments required for the different manœuvres. For instance, if the tail is set horizontally the model will fly a good distance in a straight line before coming to earth. If the tail is slightly turned down the model travels downwards at a direct angle. If the tail is turned upwards the model lifts in flight.

Especially at the present time, the great interest taken in aviation should stimulate a lively demand for this novelty, which will be supplied free to users of Wotan lamps. The making-up of the model is not an arduous occupation, and can easily be accomplished during the course of any free evening.

An open space is, of course, the best place in which to make flights, as even in the largest room there must be a certain amount of obstruction. The various members of the trade who are interested in the sale of Wotan lamps should take an early opportunity of communicating with Messrs. Siemens Brothers Dynamo Works, Ltd., Upper Thames-street, London, E.C., asking for a supply of these sheets for distribution amongst their customers. We also understand that a number of complete made-up models are available for trade display, so that the actual model can be exhibited in any contractor's window. It is, of course, understood that these advertisements are supplied free and must therefore not be sold.

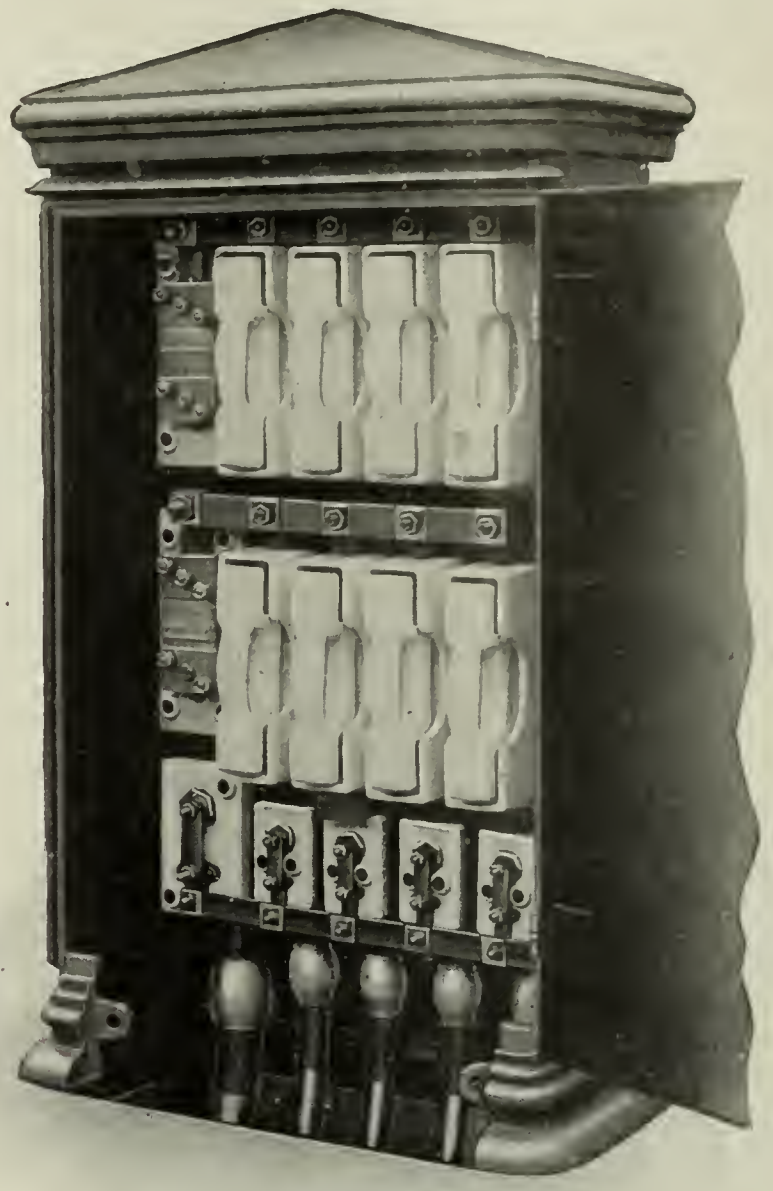
We extract the following notes from the printed sheet of instructions:—

Before launching see that the model presents a symmetrical appearance as viewed from the front. This is very important in regard to the wings, and if the machine shows a tendency to bank on one wing tip, the error can be rectified by turning up the tail elevator on whichever side the model lifts. If through any error of con-

Our Manufactures include:

Cables for Lighting, Power,
Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

Prescot Pillars



L.T. Pillar fitted with Prescot Insulated Units.

(Pat. No. 15706/12.)

Prescot Insulated Units will place your Pillars on a level with your power station, for safety and finish, at a minimum of cost.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

Works: PRESCOT and HELSBY.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

struction the model persists in turning over to one side, then bend down the wing-tip on whichever side the model turns and bend up the other wing-tip. Normally the tail plane should be parallel to the main plane and not tilted either to one side or the other.

When launching the completed model, hold it by the body just behind the wings, and throw horizontally with a pushing motion. If the model dives nose downwards turn up the elevators until the best adjustment is found. If the model shows a tendency to rear up and stand on its tail, turn the elevators down. If the model is tilted sideways when launching it will describe a spiral. To loop-the-loop, turn up the elevators (the best position can easily be found by experimenting), and throw the model sharply downwards towards a point on the ground about 10 ft. in front of you. Care should be taken not to pinch the model when it is thrown, or there is a likelihood of breaking the body.

"WESTINGHOUSE SUPPLIES."

Although the supply department of the British Westinghouse Electric & Mfg. Co. (Ltd.) has only been established in Long Millgate, Manchester, for some three years, it is generally well known, and is likely to become a "landmark" by reason of the large public clock



EXTERIOR VIEW OF THE WESTINGHOUSE MANCHESTER SHOW ROOMS.

which has recently been erected over the entrance to the premises. This clock is of handsome appearance, and consists of a copper housing supported on wrought iron supports, with the name Westinghouse saw-pierced over the top of the dials at each side, the dial and backing to the saw piercing being of white opal. The clock will be illuminated as soon as the lighting restrictions are removed, and will be seen from both ends of Long Millgate. This clock is one of four which are synchronised with and receive half minute impulses from a master or controller clock situated in the showroom. This master clock, in its turn, will shortly receive the 10 a.m. time signal direct by wire from Greenwich Observatory. The system has been supplied and fixed by Messrs. Synchronome (Ltd.), a firm which needs no introduction to our readers. By reason of its precision this clock will doubtless in a short time come to be recognised by the public as an institution upon which reliance can be placed, and the value of a name which is practically a household word in connection with efficient electrical apparatus will be correspondingly enhanced.

The illustration also shows another attractive feature of the shop window at Long Millgate—namely, an outline advertisement cut out from a "Cat" fan poster and stuck on the inside of the glass forming a striking advertisement. The window is set out with Westinghouse fans of different types and sizes and with a novelty list and window card combined, making a good window display. The latter is a special catalogue designed and devised by the department, and takes the form of a Westinghouse fan stamped out to correct shape, and printed in three colours to represent a fan; by means of a strut attached to the bottom of front cover and fitting into a slot in the back cover, this will stand on its own base. This forms an attractive and novel advertisement for electrical contractors and station engineers to whom it has been distributed. The whole scheme shows considerable originality, and this forceful advertising is typical of the firm of which the department is a part—and a rapidly growing part.

CONDUCTING A HOUSE-WIRING CAMPAIGN.

There is probably no central-station man who does not recognise the desirability of making the load on existing lines as large as possible. In general, there are only two ways in which this can be done, the first being to increase the load of the present customers, and, second, to increase the number of customers along the lines. This second avenue of new business activity involves in nearly all cases the wiring of the premises that are to be connected, and in order to stimulate such wiring a large number of house-wiring campaigns have been carried on by the more aggressive central-station companies in recent years. As a rule, however, such campaigns have been more or less spasmodic, and their results, while usually satisfactory, have been far from what they should have been.

It is interesting to note, therefore, a house-wiring campaign which involves a distinct departure from former methods in a number of respects. Reference is made to the special campaign being conducted throughout the present year by the Rockford Electric Co. of Rockford, Ill. Probably the most striking feature of this campaign is its persistence. Instead of being conducted for a period of several weeks or a month, it has already been in effect for the past six months, and will be continued until next January at least. To this feature alone probably is due a large measure of success attained, because every renewed effort to call attention to the value and benefits of electric service and to the reasonable cost at which it may be secured makes a deeper impression upon those who at first are interested in merely a casual way. By such renewal of a special effort to interest prospects the advantage is also secured that attention is aroused at one time or another when the prospect finds himself in financial condition to sign a contract, whereas on the first one or two appeals he may not be in this condition. Another feature of the Rockford campaign is the spirited advertising and publicity work which is being carried out, both through the newspapers, through special circulars and by personal appeals of the company's salesmen and also of old customers.

Another striking feature is the emphasis laid on the value of electrical appliances. Usually house-wiring campaigns call special attention to the value of electric lighting, and this, while one of the most important features connected with electric service in residence districts, does not realise the maximum possibilities of such service. By laying stress on the value of electrical household utensils of all kinds in reducing the drudgery of the housewife and in increasing the comforts of the home, the double advantage is secured of in-

"THOR" High Grade Specialities
CASING and CAPPING CONDUIT CABLES
CABLE CONNECTORS COMMUTATOR COMPOUND WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.
WRITE FOR PRICES & DISCOUNTS.
HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

TINNING FURNACE
(Hall's Patents)
For COATING WIRES with Tin, Lead, etc. For use as a BATH.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
The only Tinning Plant on the World's Market with Automatic Heat Control.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

FERRY | **FERROZOID**

CONSTANTAN | **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

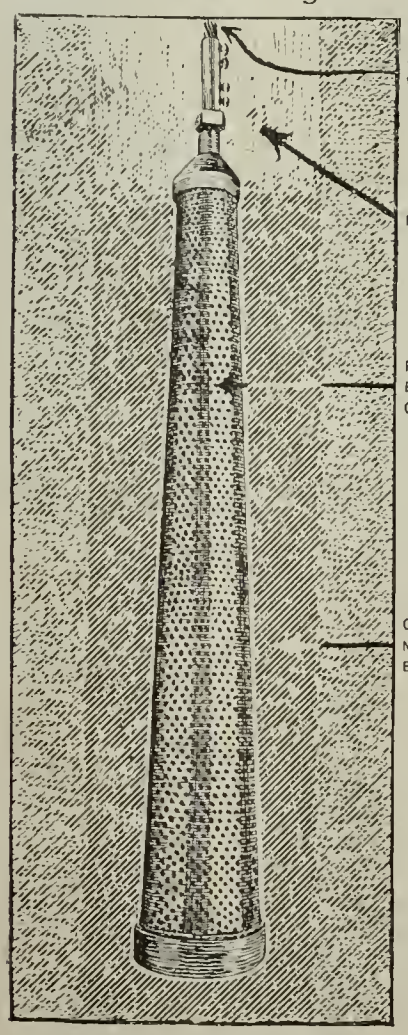
AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

An Improved Method of Earthing

whereby a **certain** and **permanent** earth is assured is represented in Scholey's Paragon Earth Cone as illustrated hereunder. Engineers should obtain full particulars.



The
PARAGON
Earth Cone

is made of pure copper, suitably perforated and filled with charcoal.

The earth around cannot dry up and shrink away from the cone.

It absorbs moisture and keeps the earth round the cone always moist, thus making a perfect earth.

It is extremely easy and inexpensive to instal. A large excavation is not required. Just bore a hole with a post augur and drop it in.

Solves the question of reliable earthing and possesses many advantages over earth plates.

SCHOLEY & CO., Ltd.,
56, VICTORIA STREET, LONDON, S.W.

J. P. DEVINE CO., BUFFALO.

MANUFACTURERS OF

Vacuum Drying and Impregnating Plant.

(PASSBURG SYSTEM.)

The Devine Co. are well known in the United States and Canada as the leading manufacturers and experts in Vacuum Drying and Impregnating Plant and have over 1,500 such plants in successful operation.

AIR PUMPS, COMPRESSORS,
VULCANISERS,
CONDENSING PLANT.

Solvent Recovery and Derisinating Plant a Speciality.

Sole Representative:

JAMES LIVINGSTON, LTD.,
30, GT. ST. HELENS, LONDON, E.C.

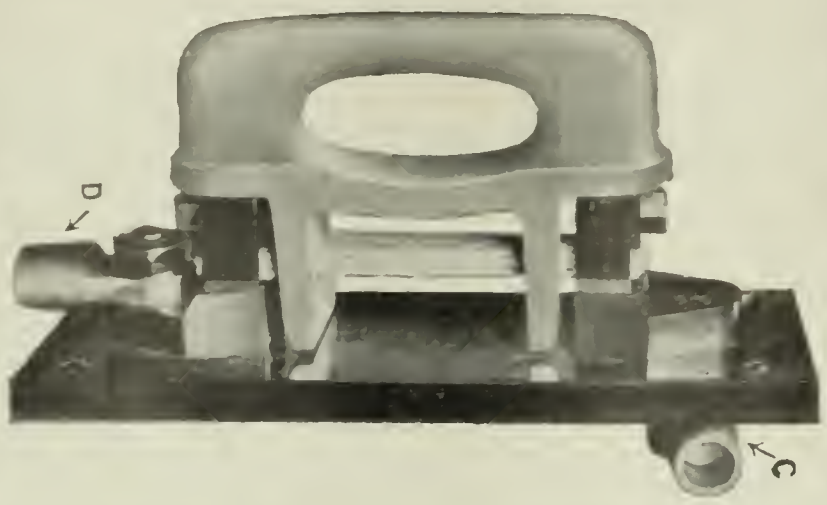
Telegrams and Cables: "CINERARY, LONDON."
Telephone: LONDON WALL 3151.

D. & S.
"HANDLE" FUSES.

50 amps. and upwards. 600 volts

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

teresting the women particularly and at the same time securing a much more respectable load from the customers connected. Still another aspect of the Rockford campaign is the splendid co-operative spirit in which it is being carried out. The central station is working in full harmony with leading contractors of the city, and has even secured the active co-operation of its old customers. By the simple expedient of giving prizes in the form of appliances the interest of old customers in this campaign is aroused, and they are induced to work among their neighbours in the most effective way possible, since a good word from a present user of electric service goes farther with a prospect than a great deal of the special effort made by those immediately interested. Combining such a large number of valuable and yet commonsense features, it is no wonder that the campaign has been an exceptionally successful one. A study of it by other central stations should, therefore, prove to be very profitable.—*Electrical Review and Western Electrician.*

CHARGING ELECTRICS AT RUGBY.

Messrs. the British Thomson-Houston Co. (Ltd.), and also Messrs. Willans & Robinson (Ltd.), have kindly promised to provide charging facilities for any electric vehicles passing through Rugby upon the following conditions:—

1. During holiday periods no arrangements can be made for the charging of outside vehicles.

2. A charge of 2d. per unit will be made for all electrical energy supplied for this purpose between 7.30 a.m. on Monday and 12 noon on Saturday.

3. At week ends an additional charge of 2s. per hour will be made for charging vehicles between 12 noon on Saturday and 7.30 a.m. on Monday.

4. It is understood that neither of the firms will accept any responsibility for loss or inconvenience that may be caused by their inability or failure to charge any vehicle or vehicles.

It is advisable that any firm sending vehicles through Rugby and requiring a charge at that place should communicate in advance with either firm in order that the necessary arrangements may be made. The Electric Vehicle Committee are indebted to Messrs. the British Thomson Houston Co. (Ltd.) and to Messrs. Willans & Robinson (Ltd.) for kindly making these arrangements.

ELECTRICALLY-OPERATED FLOW METER.

A new design of flow meter for water, air, steam and gas has recently been introduced by the Republic Flow Meters Co., 565, Washington Boulevard, Chicago. According to "Engineering News" it comprises a pitot tube and a differential pressure gauge, both of special construction. The pitot tube comprises two tubes going entirely across the flow pipe, the static and dynamic-pressure openings being two lines of small holes at the midpoints of equal annular areas, by which, it is reported, a true average velocity pressure is obtained directly. The lines of holes are 180 deg. apart. The differential pressure gauge is a casting with two reservoirs, one above the other and connected by a vertical shaft. This arrangement takes the place of the usual U-tube. In the lower reservoir is mercury. Above this is water, and on top of all is oil. In the reservoir well is a steel tube supporting a series of resistance spools and dependent contact rods. There is a constant-voltage (40 volts) alternating-current circuit flowing from a special transformer through the resistance and mercury to the pipe connections, and thence to indicating and recording instruments. As velocity and impact pressure rises, mercury is forced from the lower reservoir up the contact-rod well, short-circuiting more and more of the resistance, and displacing oil (which in the tube well rests on the mercury). The resistance units are so designed that the current is kept proportioned to the square root of height of mercury column, and so to the pipe velocity.

SOME USES FOR FERODO.

An interesting feature about Ferodo fabrics is their adaptability. Although designed originally for lining clutches and brakes, their high coefficient of friction results in their being used in many ways. The latest instance comes from a firm who are extensively engaged on munitions. They are using Ferodo fibre in a circular vice for holding the shells whilst screwing in the noses. They write that it gives good results as it does not mark the work, and has great gripping power. The manufacturers of Ferodo fabrics, the Herbert Frood Co. (Ltd.), Chapel-en-le-Frith, are, we understand, at all times ready to give advice in regard to the use of their fabrics, and will welcome inquiries.

JAPANESE CENTRAL STATIONS.

A statistical report of electrical plants in Japan at the end of 1914 has been issued. The report shows a total of 1,940 stations generating electrical energy, of which 390 are central stations, 24 railway plants, 47 combined railway and central-station plants, 1,366 isolated plants, and the remainder official plants; 695 of the plants generate energy by water-power, 788 by steam and 457 by gas. The total capacity in 1914 amounted to 608,554 kw., of which 341,809 kw. was in central-station plants. The next largest was that of isolated plants, with a capacity of 140,022 kw. The capacity in water-power generating equipment is 366,243 kw., in steam equipment 217,967 kw., and in gas equipment 24,344 kw.

Out of a total of 22,669·6 miles of transmission lines, 21,908·8 miles was aerial line and 750·8 miles underground line. The number of lighting customers was 2,966,085, of which number 2,903,208 were supplied at a flat rate, 35,723 at a metered rate and 27,155 by a combination flat and metered rate. Most of the incandescent lamps used in 1914 were of the carbon type. Of the total of 6,992,885 actually lighted, 4,150,847 were carbon filament lamps and the remainder metal filament lamps. But 1,555 arc lamps were in service. The connected loads of the lamps amounted to 177,940 kw.

Power customers totalled 32,033, of which 22,565 were supplied on a flat rate and the remainder on a metered rate. The total horse-power connected in motors amounted to 148,702 h.p. Other electric appliances, having an aggregate power of 133,051 kw., were connected to the lines of the different companies. The large number of customers supplied on flat rate is noteworthy.

Paid up capital amounted to $230,177,620, the nominal capital being $289,080,240. Debentures and loans amounted to $49,348,707 and reserve amounted to $7,400,604. Revenue from electric lighting amounted to $18,630,850, and from power consumption the income was $6,990,681.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, August 18, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK—Why, the Wotan monoplane, of course! Have you flown one yet?

* * * *

Now that Canada has prohibited the export of hydro-electrical energy, the question before Congress is—"Shall Niagara be diverted?"

* * * *

A certain widely-read halfpenny morning daily has been conducting an interesting correspondence on "The Waste of Coal." Has it forgotten that it has itself been responsible for a considerable leakage of gas for many years?

* * * *

The "Sheffield Telegraph" tells us that

> alternating electric currents have now come to stay, but they had a very severe struggle against continuous currents.

Yes, and still have in those beastly rotary converters, doncherknow, especially during the hunting season!

* * * *

An individual recently applied for exemption on the ground that he was an electric welder. The Tribunal asked what previous experience he had had of this work, and the reply was that he had been a barber! This must explain the little fused knobs at the ends of one's hair after the singeing operation!

* * * *

I really think that some of my friends who have made quite big bets on peace before January 1, 1917, have a fair chance of winning, for Sir L. Chiozza Money has written an article in the "Daily Mail" suggesting that the adoption of a national scheme of electric power production will pay for the war at a stroke!

* * * *

A bishop "way out west" is reported to have been electrocuted while fishing. He seems to have been making a cast when his line came in contact with an adjoining 44,000-volt transmission circuit. While deploring so sad an event, it certainly suggests that his lordship had been reading one of the Society for Electrical Development's posters: "Do it electrically."

* * * *

Some men returned from the front seem to recover hearing and sight when their teeth are extracted or they slip up on the pavement; at home there is a noteworthy increase in the number of people who are struck dumb with the price of commodities and the size of electricity and gas bills. And there seems no hope of recovery!

* * * *

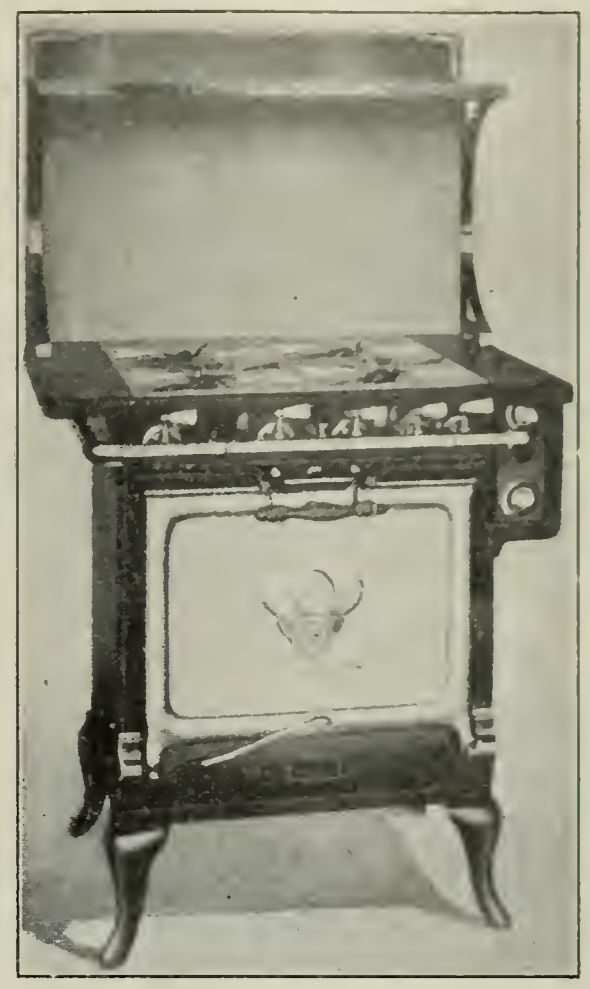
The trials of the signal service at the front are poignantly illustrated by Capt. Bruce Bairnsfather in one of his inimitable sketches in this week's "Bystander." The joke attached will be appreciated by all signalling men and electrical engineers of the Electroharmonic and Batti Wallah ilk.

THOSE SIGNALS.

The Vigilant One: "I say, old chap, what does two green lights and one red one mean?"

Recumbent Gladiator (just back from leave): "Two crême de mênthes and a cherry brandy!"

I am running a considerable risk in publishing this little picture, but I am going to take it. Be it known that until the electric boiling plate—the electric "gas ring" it was once flippantly called—is perfected, the combination range will be



THE GAS-ELECTRIC RANGE AT LAST.

the order of the day. The stove illustrated is a Yankee production, because "over there" co-operation such as would rejoice even Mr. Wordingham's heart, is now regularly indulged in.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), Aug. 23, 1879.]

THE ELECTRIC LIGHT AT BLACKPOOL.—The Corporation of Blackpool have decided to light up the Promenade with six of Siemens' electric lights, representing 6,000 c.p., at a cost of £2,500. The light will be in operation in a few weeks' time, and will be used every season for about 20 weeks. On the Thames Embankment the electric light exhibited only represents 300 c.p., so that there will be no comparison between the display there and at Blackpool. The Corporation proposes to spread the cost of the light over 10 years.

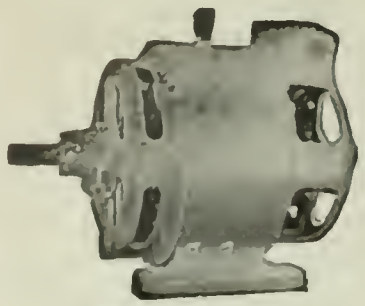
THE GAS LIGHT & COKE CO.—The fear from competition with the electric light expressed at some of the meetings of the gas companies not so very long ago seems to have subsided, and yet we should be inclined to say the competition will be a reality. At the last meeting of the Gas Light & Coke Co., the following paragraph was read in the report: "The directors have before expressed an opinion with regard to the effect likely to be produced upon their undertaking by the electric light. That opinion remains unchanged, but in the interval which has elapsed since it was communicated to the proprietors, the subject of lighting by electricity has been investigated by a Select Committee of the House of Commons, the results of whose deliberations, having been reported to the House and made public, it is now unnecessary to refer to more fully."

L. P. S.
CLIPS, TIPS & TERMINALS
of all descriptions.
Write for Booklet, with Illustrations, of 75 types to:—
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

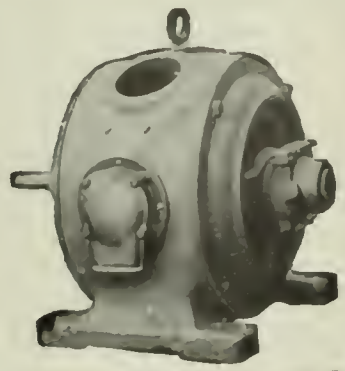
SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Goldplat, Ox., London." 4746 Gerrard.

SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: 'SIEMOTOR, CENT., LONDON."

HOME BRANCH ADDRESSES!

BIRMINGHAM—Central Ho., New St.
BRISTOL—30, Bridge Street.
CARDIFF—89, St. Mary Street.
GLASGOW—66, Waterloo Street.
MANCHESTER—196, Deansgate.
NEWCASTLE—64-68, Collingwood
SHEFFIELD—22, High St. [Bldgs
SOUTHAMPTON—46, High Street.

Branches in Principal Towns Abroad.

THE BRASS TACK BRIGADE MEETS BROWN.

BY FRANK B. RAE, JR.

[*The following breezy story taken with acknowledgments from "Electrical Merchandising," N.Y., is reproduced as a thoroughly typical example of American methods applied to central station commercial work. There can be no disagreement with the moral of the story, which is as applicable to our own general sales methods as those of the Yankees, no matter what the branch of trade, commerce or industry may be. As a "nation of shopkeepers" of "some" experience, we incline to quarrel with the 100 per cent. efficiency idea. Even Yankees with all their hustle, snap and ginger and "pep," cannot keep working at that rate. However, as a holiday "yarn" it will no doubt be appreciated by those who are taking no holidays, at least not officially.*]

"Come around to the meeting in the morning—eight-thirty."

Davis, of the Combination Gas & Electric Company, extended the invitation as though he meant it, but I stalled.

"I'll do my sleeping in bed, if it's the same to you, old man. I know all about these meetings—roll call, and then some drivelling whiner that you're about to 'can,' gets up and tells what a dreadful time he had failing to sell a flatiron, and then some fellow who you know was playing pool all the afternoon reports 33 calls, and then you give the bunch helen repeat and everybody goes away sore. Not for me. I'll come down to the office after the sad rites are over."

"You'll come down to the meeting and get a shock," said Davis, decisively.

"What's the big idea?—going to pull a hoochi-koochi dance, or have somebody take rabbits out of a hat, or something like that? I can't think of anything else being done at a central station salesman's meeting that would be particularly shocking. For me, they're most boresome and futile proceedings. Better let me out."

"You come," Davis was serious. "These meetings of ours are not the usual bunk. When this company's pack of order-hounds gets together, they meet for a purpose. They call themselves the Brass Tack Brigade, and, take it from me, they certainly do get down to brass tacks. Better join us."

* * * *

"Fellows, we'll come to order." It was a pretty good-looking crowd—this Brass Tack Brigade. Two or three were obvious cubs, a couple were greybeards, and the rest—perhaps 15—were average salesmen. To tell this story well, I suppose I should describe all of them as tall and handsome and clean limbed—whatever that may mean—like a gathering of Robert Chambers' heroes, but, as a matter of truth, I must state that the Combination Gas & Electric Company's commercial department was made up of fellows very much like you and me. About the only distinguishing feature of the crowd was a general air of assurance. They knew they were making good, and they showed it.

"Pretty fair crew of appliance pushers," I whispered to Davis.

"Too confounded cocky," was his undertone response. "But we'll cure all that in a few minutes. You watch."

As the roll was called, each man rose and reported on his work of the previous day—so many calls, so many actual interviews, so many sales. Adams, whose name headed the list, started by reporting two vacuum sweepers and a house wiring contract. Colgate, the next man, had sold an equipment of flatirons to a laundry, a milk warmer to a man who had become a father not six hours before, and a sign to a corner druggist.

"It's going to be a record day," whispered a young chap sitting next to me, and as the reports rolled up the men began to applaud each sale, until even Davis showed signs of enthusiasm. It was fast developing into one of those mushy mutual admiration meetings, when I received the shock which had been promised.

"Fellows, that's a pretty good day's work." Davis hushed the laughter and put an end to the back-slapping by rising to his feet. "It's a pretty good day's work, but it's not a good *two days*' work. The good report you all turned in for yesterday, is not a licence for you to loaf to-day. I want you to hop to it just as if this were an ordinary report. But before you go I want you to listen five minutes to a chap who doesn't think much of you—a chap who came in this morning and complained that your laziness and inefficiency are costing him money. His name is Brown."

It was amusing to see their faces change, first from smiling complacency to seriousness, and then, as the stranger was presented, to actual belligerence. Lazy and inefficient! Did this guy think he could call them lazy and inefficient after hearing that sales report?

"I am Brown of the Sunkist Sweeper," began the stranger. He looked like a fellow whose name should be "Knockout" Brown. He was thick and hard looking, like a decent pugilist. The obvious animosity of the boys failed to disturb him.

"I sold an electric sweeper yesterday to a woman whose house was not wired for electricity. She paid cash for the sweeper. When I spoke to Mr. Davis about it, he looked up the prospect card on this woman and the report read, 'Says she can't afford electricity just yet.' But I sold her for cash a sweeper which is useless until one of you fellows hustles around and gets the wiring contract."

There was something like a gasp of astonishment, then a snicker ran through the room. The wonderful sales report of a few moments before was forgotten. The Brass Tack Brigade came down from its lofty height of self-complacency and began to study the husky stranger with interest. "This fellow," their manner seemed to say, "has something that we can use in our business." And they settled down to the job of absorbing Brown's words—of learning, if possible, the secret of his salesmanship.

"You fellows are a good crew," continued Brown. "You know it. But you are a crew of amateurs. You are a bunch of dilettanti. You *play* at salesmanship.

"Now, I am not here to bawl you out. Mr. Davis has asked me to tell you how I did it, and that is what I want to do. I'll begin at the beginning.

"A little while ago I was driving a delivery wagon at $8 a week. I was a fair-to-middling delivery wagon driver. One day—don't think I am pulling any sob sister stuff, for this is the story of a man who can go 10 fast rounds with any plug-ugly in the State—one day I happened quite by chance to read this ad.," and Brown fished out a frayed newspaper clipping:—

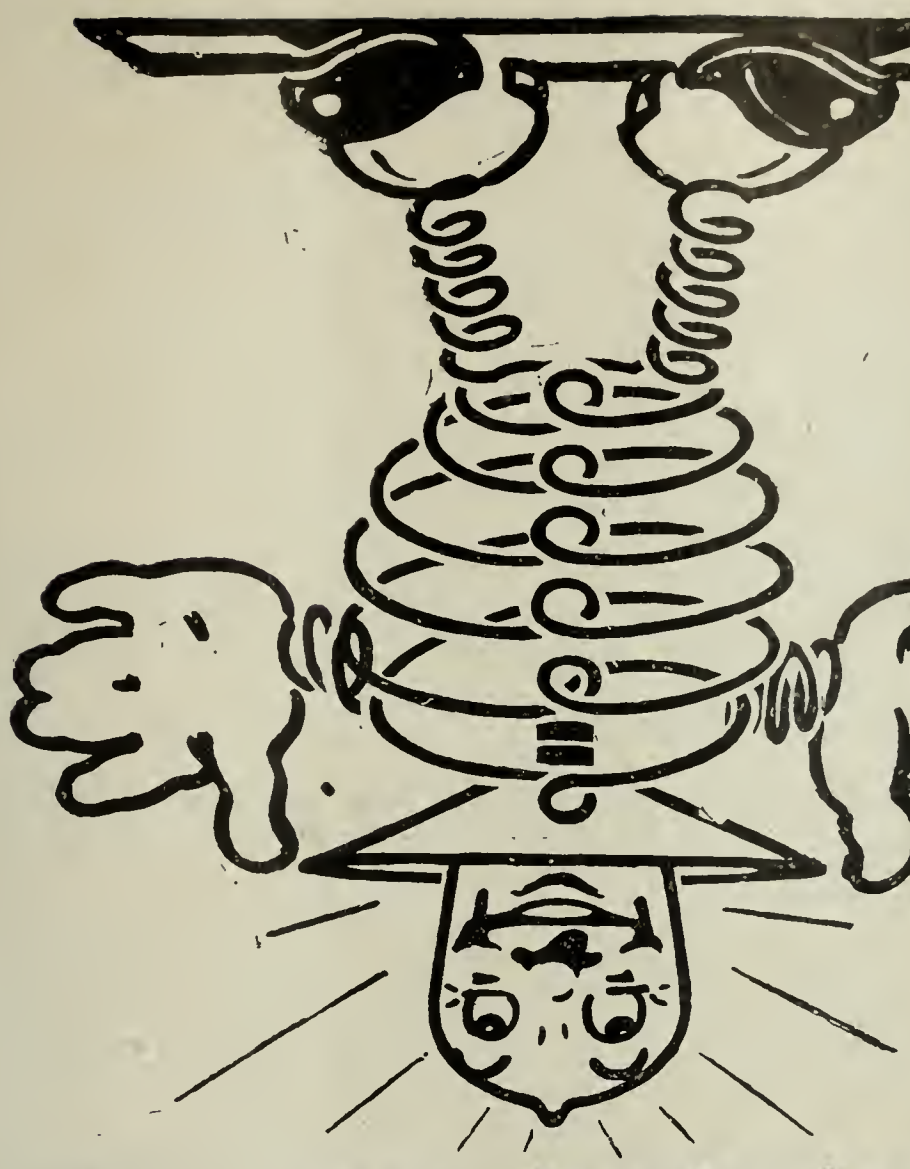
A CORPORATION WITH A HEART.

SALES DEPARTMENT.

In the beginning let it be understood that this is no philanthropic or charitable organisation, but a concern of national reputation, manufacturing a meritorious article of recognised merit, who employ large numbers of men and who are now making arrangements to increase their forces in the sales department.

We want men of undeveloped sales ability who have failed to make a success in the business world through the lack of opportunities or who realise they are failures due to their lack of aggressiveness.

Men of good appearance, members of good families, who are now determined to make good, who are willing to concentrate time and attention to attain a place in the sun. Men with latent ability who, under our supervision and encouragement can be



I never go black in the face—I'm used to working like this!

Yours resiliently,
Pope's Elasta.

BRITISH MADE

WIRE LAMPS

Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W. *Greenly*

First in the Field and Foremost ever since.



C.A.V. ACCUMULATORS

British Made Throughout

"THE first man to make an accumulator in this country that would really stand the racket of the early motors was C. A. Vandervell. He succeeded because he is one of those rare individuals who have an infinite capacity for taking pains."

—*Extract from THE MOTOR TRADER.*

FULLY GUARANTEED

Members of THE MOTOR TRADE ASSOCIATION

The Hall Mark for everything Electrical in connection with Motoring is C.A.V.

C. A. Vandervell & Co.; LTD.,
Electrical Engineers, ACTON, LONDON, W
BIRMINGHAM. MANCHESTER.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK.


CHARLES CLIFFORD & SON, LTD.,
BIRMINGHAM.

developed into representatives business men, commanding large returns.

This is the kind of human material we desire, and if you possess these qualifications and are sincere, write for interview.

Box 322-H., Tribune.

"That corporation-with-a-heart stuff got under my skin. I wrote a reply and in due course I met the man who put the ad. in the paper.

"'What you doing?' says he.

"'Driving a truck,' says I.

"'Is that all you're good for?'

"'I dunno,' says I. 'Maybe I could do something better. I never had much of a chance.'

"'Young man, you're a failure!'

"'Oh, well,' says I, 'if that's what you think'—and I started to go.

"'*Sit down*' he says, so explosive it was like pulling the floor from under me. I sat down—hard.

"Then this chap began to talk to me. He told me all my faults, to begin with. He told me I was drifting along, living only because I was too lazy to die. He told me that 90 per cent. of men just dawdle along, like I'd been doing, and that half the man-hours in the world are wasted. He made me see that my $8 a week represented about 10 per cent. of my ability, and that if I applied 100 per cent. I'd be making $80 a week instead of $8. That old duffer talked to me like a Dutch uncle and Billy Sunday and Jilliam Bennings Wryan all rolled into one. When he got through he had sold me one big idea—and that was that the sky is the limit for the man who will apply his brain and *will* to the business of making his every minute and his every ounce of energy count.

"To put it another way, he showed me that the reason men don't succeed is because they dawdle, they get discouraged and stop work, they waste time in gossip like old wives, they let their minds jump around loose and inconsequential like deranged jack-rabbits, they get stuck on themselves and excuse to-day's laziness by telling about last year's success, they punish their stomachs with pills or pie, they mistake booze and foolishness for honest good fellowship.

"And then, when he got all through, he gave me a job.

"Now, the joke of this proposition was that after I had agreed to go to work for him, I didn't know what the job was nor how much it paid. All I knew was that I had a different job, and that the evangelist I was going to work for had promised to show me how to apply my time and energy to that job. Which is exactly what happened. I learned to cut out human waste. Incidentally, I learned that application means money. No man can hustle intelligently without lining his pocket.

"Now, I can see you fellows sitting back and saying, 'Nice little Sunday school story, that, but you must have been a real salesman at bottom or you couldn't make good.'

"You're wrong. The man hired more than 100 salesmen while I was close to him, and very few of the men were salesmen when he took hold of them—though all of them were when he got through. One was a busted newspaper reporter who had been sleeping a week on a park bench. One was ex-secretary to the president of one of the largest railroads. One was a rah-rah boy whose people had decided to disown him for some escapade. There were farmers, bell hops, bookkeepers, truck drivers. Most of them were of the no'er-do-well type that changes its job every two or three months and spends its leisure hanging around pool rooms.

"No, sir! These men were not 'natural' salesmen. They were 'made' salesmen. They were the men who had to be taught the secret of the whole selling proposition. This chap who hired me started more than 100 of us on the road to success in salesmanship by advertising for failures. He got applications from failures. And he made *men* of those failures.

"I'm not a better salesman, but I make more sales than any of you fellows. Why? Because I'm a *professional* salesman. I'm not an amateur like you. My job is to sell—sell—sell! I sold a woman a cleaner before you sold her the service to operate it. I sold her because *selling her* was my business.

"Now, I'm not here as an apostle of salesmanship. I'm here to line my pocket. I'm here to sell you a recipe for money-making. And I expect to make money doing it. My proposition is that if you will find me prospective customers for Sunkist Sweepers I will show you how to double your sales. I will teach you the secret that I learned when I answered that ad.

"What is the answer?"

* * * *

In reply to such a proposition nine commercial managers out of 10 would have said something about "knowing how to run their own business," but Davis was cast in a larger mould. He rose, a little flushed.

"Fellows, I guess Friend Brown has made goats of all of us, but of all the goats I am the prize-winning, ring-tailed snorter. I got him into this meeting to show you fellows up a bit, and, by thumping thunder, he has showed me up. He tells us that it was his boss who made him a star salesman, and in the same breath he offers to take my job away from me by assuming to become your leader and teacher. Well, I'm going to make him make good.

"Three things are going to happen to-day," he went on. "In the first place, I am going out personally to get that wiring contract where Brown sold the cleaner, and I am going to give the commission to Brown with this department's grateful compliments. In the second place, every man in the department is going to dig up a prospect for Brown—every one of you must find a good, live prospect where Brown can sell a Sunkist Sweeper, and every one of you must go with him and learn his secret: this department needs a bunch of Browns. In the third place, I think we ought to elect Brown an associate member of the Brass Tack Brigade. That's all—meeting dismissed."

"One minute," called a voice from th crowd, and big Jim Lennox lumbered to his feet. "Perhaps it don't need to be said—perhaps we all have the hunch already—but I believe in getting right down to brass tacks. I think we ought to try out Mr. Brown's recipe *quick*. He says salesmanship is *concentration* and *determination*. All right. If that's so, then I promise right now to turn in a bigger report to-morrow than I did to-day. We're all proud of this morning's report: let's determine to-morrow to beat it, and let's concentrate on making good that promise."

"Thata boy, Jim!" came a voice. "We'll do it."

"Three cheers for Brass Tacks Brown," came the call.

The three yips had not ceased to reverberate when another voice cut in—

"Gee! it's 12 minutes after nine. I'll have to hop to it fast if I'm to beat yesterday's record—and it's *got to be did!*"

ELECTRIC LIGHT SWITCHING.—On another page will be found the results of the latest of Messrs. A. P. Lundberg & Son's switching competitions or examinations. This time it is called a supplementary examination, because it followed closely on the heels of one held in February, when record entries were obtained. It was, in fact, instituted mainly to allow those who had entered the previous competition to follow up their successes without delay. For these reasons the usual money prizes were not offered, but these will make their reappearance when the next regular competition comes along. It says much for the interest of the subject that so many should still be giving it attention in these times.

One, Two & Three Phase MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

Why not a space like this under reading matter? The cost is purely nominal. Let us quote you.

Our Manufactures include:

Cables for Lighting, Power, Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

BRAIDED AERIAL CABLES.

The weather proofing on these wires and cables is not used for insulation, but only for the purpose of protecting the conductor from mechanical injury and from corroding elements which may be present in the atmosphere.

The covering consists of either single (Simplex), double (Duplex) or triple (Triplex) braiding, thoroughly impregnated with preservative compound.

The conductor may be of hard drawn or annealed copper as required.

We manufacture these cables on a large scale.

SEE LIST P117 FOR SIZES AND LIST NUMBERS.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

Works: PRESCOT and HELSBY.

Branch Offices in: LONDON, MANCHESTER, GLASGOW, BIRMINGHAM, NEWCASTLE, CARDIFF, DUBLIN, LEEDS & BELFAST.

OVERSEAS BRANCHES:

AUSTRALASIA: The Wool Exchange, King Street, Melbourne.
EASTERN INDIA: 11, Clive Street, Calcutta.
SOUTH AFRICA: Telegraph Manufacturing Co. (Colonial), Ltd., P.O. Box 2827, Johannesburg.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

POWER "MUTUALITIES."

In Oregon, Ohio, an electric power company and a lumber or saw mill have been erected in close proximity to each other. The saw mill required a considerable amount of power to drive its wood-working machinery, and the power company needed fuel for steam-raising purposes. Accordingly a contract was drawn up whereby the requirements of each could be met on terms mutually satisfactory. The refuse from the saw mill is transmitted by means of a blower and conveyer to the boiler-house of the power station, but instead of selling this material at so much per ton, the power company agreed to pay the wood company $0·005, or about ½d. per kilowatt-hour at the switchboard on all the energy generated, while, per contra, the saw mill pays $0·009, or about $\frac{9}{10}$d. per kilowatt-hour for the first 1,000,000 kw.-hours of energy it consumes, and $0·008, or $\frac{8}{10}$d. per kilowatt-hour for all energy which it requires over and above this amount. A further clause in the contract specifies that the power company is to purchase sufficient fuel to generate a minimum of 3,000,000 kw. hours per annum for commercial purposes, in addition to the energy supplied to the mill. As a matter of fact it generates some 4,500,000 kw.-hours per annum for that purpose.

The arrangement works out satisfactorily to both parties, though the lumber company appears to have made a very good bargain. The total amount of energy generated is as follows: Supplied to the lumber mill on an average 8,500 kw. hours per day—say, 8,500 × 300 = 2,550,000 kw.-hours per year; energy generated for commercial purposes, in excess, 4,500,000 kw.-hours per year. Total current per year, 7,050,000 kw. hours per year. The amount paid by the power company to the saw mill for fuel at ½d. per kilowatt-hour = £7,343. As a set off to this the saw mill takes from the power company energy to the amount of 8,500 kw. hours per day, or 2,550,000 kw.-hours per year, as above stated, and for this it pays as follows: 1,000,000 kw.-hours at $0·009 = £1,875; 1,550,000 kw., hours at $0·008 = £2,583; total, £4,458. Subtracting this sum—which was paid by the saw mill to the power company, from £7,343 paid by the latter to the former for fuel, leaves a balance of £2,885 per annum in favour of the saw mill. In return for this amount the power company has the sale of, say, 4,500,000 kw.-hours to the public, and, presuming that the charge for this is $0·009, the sale will yield £8,437.

The fuel as delivered by the mills to the power station is in the form of shavings, sawdust and chips. The shavings are blown through a distributing system into cyclones or sawdust collectors, situated on the roofs of the fuel bins owned by the power company, and extending under the saw mill. The fuel bins hold a quantity large enough for a 10 days' run, so that a temporary shut down of the mill does not interfere with the generation of power. From the fuel bins the refuse is taken to the boiler-room by conveyers. The boiler furnaces are of the Dutch-oven pattern, with stationary plain girder grates, the wood being fed in from the top of the furnace and burned by natural draught. There are five boilers totalling 1,850 n.p.

It is stated that if the power company had to use coal as fuel the cost per kilowatt-hour at the switchboard would be between two and three times the present net cost with wood fuel, which works out at just under 0·118d. per kilowatt-hour.—"The Engineer."





TWO SPECIMENS OF SOME OF THE POSTERS WHICH THE SOCIETY FOR ELECTRICAL DEVELOPMENT, N.Y., ARE USING FOR ELECTRICAL WEEK THIS YEAR.

ARORA THREE-BAR FIRES.

In a recent issue we described several new season Arora electric cookers and fires. We now illustrate one of the large Arora electric fires fitted with three 750-watt elements. As with the two-bar fire,

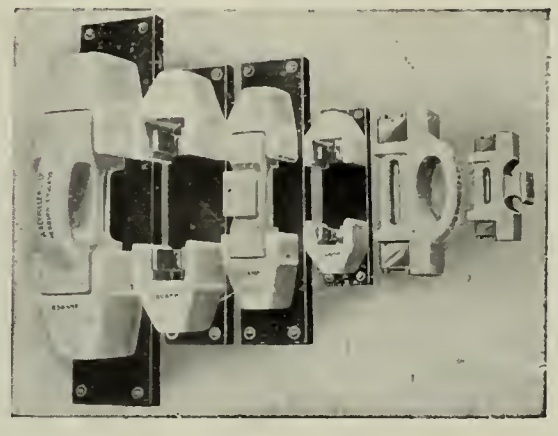
INSULATION BEADS
The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.
HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.

FURNACES for MELTING WHITE METALS, Etc.
Hall's Patents
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Monometer Heat-Controlled Furnaces for Heating the Moulds.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

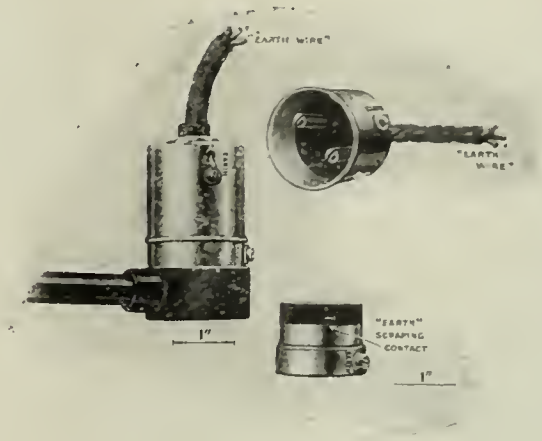
REYROLLE'S

Six Special Lines.

FUSES.



PLUGS AND SOCKETS.



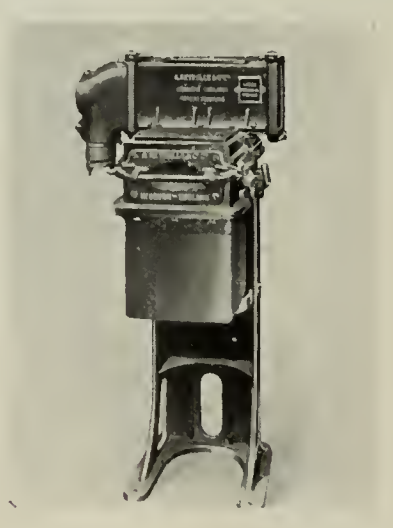
ARMOURED SWITCHGEAR.



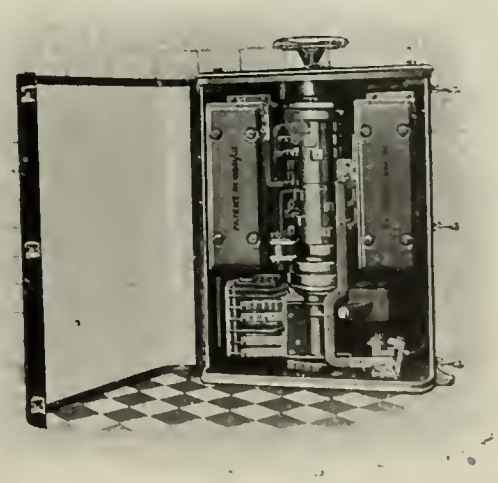
PROTECTIVE SYSTEMS.

Protective devices for A.C. Systems to isolate faulty sections instantaneously without interference with healthy sections. Also Relays for time limit, release current transformers, etc.

MINING EQUIPMENT.



MOTOR STARTERS.



A. REYROLLE & CO., LTD.

HEBBURN-ON-TYNE.

On War Office, Admiralty, and India Office Lists.

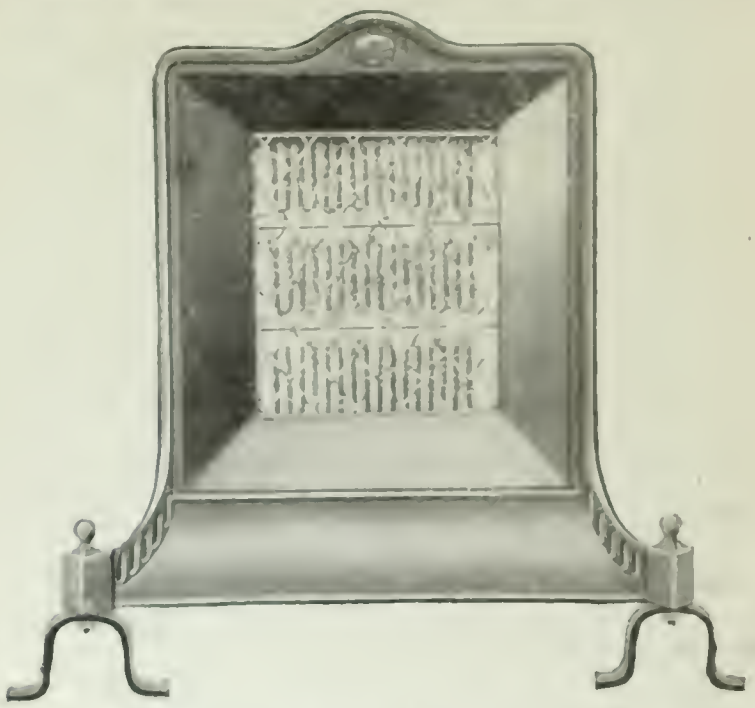
IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

the frame is of artistic design in cast iron, with ornamental "dog" feet and sloping front. The elements are of nickel chromium ribbon wound into a continuous spiral and laid in pairs (see illustration) in suitably shaped grooves in the face of a fireclay bar. These elements glow at a bright heat and produce a maximum of radiant effect. The bars are fixed horizontally in a cast iron box, which also carries the connections, switches and main terminals.

One of the bars is directly connected to the incoming flexible cord,



and is put in circuit when the plug is put into the wall socket. The other two bars are under the control of tumbler switches placed one on each side of the element box. The entire construction is mechanically strong, and the fire is "steady on its feet"—that is, it cannot easily be knocked over.

Arora fires are offered in a variety of finishes, according to taste and pocket. Prices and fuller details will be supplied by the Arora Co., Loughborough.

GERMAN AND AUSTRIAN ELECTRICAL INDUSTRIES.

According to the Swiss correspondent of "The Engineer," it is, of course, not easy to procure trustworthy information concerning conditions in the German and Austrian electrical industry. Such details as are suffered to be published are naturally only favourable, so that all may be made to appear in the rosiest possible light, and the bad effects of the war as carefully concealed as may be. The electrical industry in both the Central Empires belongs to the category of semi-war industries; that is, industries which minister to the needs of the army, although they are at the same time useful to the civilian populations. Consequently it is quite likely that electricians and technical experts, whose work is directly connected with the electrical industry, have not suffered from the war, and have no lack of employment of which to complain.

The Germans, for instance, announce that as far as the building of accumulators is concerned, much more work is being done than was the case at the corresponding period of last year, and that in order to supply the needs of the army it has been, and still is, frequently necessary to work overtime. More orders have been received this year for electrical measuring instruments than in 1915, and during this year either double shifts or else overtime have had to be worked. As might be expected, also, electrical medical appliances, which are mostly required for the army, are in great demand. In the production of low-tension current business is said to be brisker than in 1915, while the production of high-tension current is not diminishing: and as regards electrical installations, they are in some cases "in greater demand than last year"—a somewhat vague expression when last year's figures and those of the year before are not given.

The extent to which women are now employed in electrical industry in Germany is proved by the fact that in 21 sick fund societies all the members of which are connected with electrical work of one description or another, there were in May of last year 25,380 male and 34,997 female members, in which month the percentage of male members increased by 1·62 per cent., and that of female members by 5·48 per cent.

Concerning Austria information is invariably more difficult to obtain even than as regards Germany. The reports and balance-sheets of the Austrian branches of Siemens-Schuckert and of the Union Electricity Company have just appeared, however, and the former shows a dividend of 7 per cent., as compared with 5 per cent last year, and the latter 6 per cent., as compared with 4 in the previous year. The Siemens-Schuckert report lays great stress upon the heavy demands made by the war upon the electrical industry in general. Not only had all manner of electrical installations to be erected for the use of the army itself, but many others which only indirectly served military purposes. Furthermore, difficulties had to be encountered because of the calling up of so many skilled workers, who had to be replaced by untrained assistants, who apparently answered "as well as could be expected," although on this point no very explicit information is forthcoming. Another difficulty was the necessity for extreme economy in the use of all materials imported from abroad, so that "home-produced substitutes" had to be used as much as possible. Some of these substitutes have, say the reports, proved sufficiently good for their use to be continued after the war: but as to the others silence is observed. If the directors of Siemens Schuckert are to be believed, they have a number of orders, given in peace time, which they have never yet been able to execute for want of time. The Union Electricity Company states that it has been chiefly engaged in producing electrical machinery and apparatus, and that it has had more orders than it has been able to execute with its apparently limited supply of labour

LEWIS'S SCIENTIFIC CIRCULATING LIBRARY.
ELECTRICAL, MECHANICAL & GENERAL ENGINEERING TEXT BOOKS & TECHNICAL WORKS.
New Works and New Editions can be had from the Library immediately on Publication. Telephone: MUSEUM 1072.
SUBSCRIPTION, Town or Country, from ONE GUINEA. READING ROOM open Daily to SUBSCRIBERS.
H. K. LEWIS & Co. Ltd., 136, GOWER STREET, and 24, GOWER PLACE, LONDON, W.C.

Printed and Published by the Proprietors, "THE ELECTRICIAN" PRINTING AND PUBLISHING CO., LTD., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, AUGUST 25, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—The proposal of the "Commercial Motor" to run present petrol-driven vehicles with compressed gas. Thus :—

"There is fully as much prospect of success for the permanent use of compressed coal gas as there is for the permanent use of battery-equipped vehicles using electricity."

* * * *

"Electrically Driven Hoppers," says a headline ; doubtless these are descendants of the famous performing flea.

* * * *

Even our ponderous contemporary the "Daily Telegraph" can be guilty of unconscious humour, as the following paragraph reveals :—

"The electricity generating station of the Brighton Corporation, at Southwick, is to be the new home of the large *scale* experimental work of the Corrosion Research Committee."

Or is Mr. Christie responsible for this punning effort ?

* * * *

The following letter appeared in a recent issue of the "Yorkshire Herald" :—

ELECTRICAL ALARMS.—"If 'J. C.' and others who are troubled with the difficulty—alarm going off on slight reduction of gas pressure—will set his contacts by the daytime pressure, so that the points are a quarter of an inch apart, and add a few drops of water when required, his trouble from that source will cease."

This is, I imagine, just a subtle way of telling "J. C." "to take more water with it."

* * * *

Things are moving over here and no mistake ! Read this little extract from the "Gas World" :—

DR. CARPENTER SEES A VISION.

Probably the passage in Dr. Carpenter's address at the South Metropolitan Gas Co.'s meeting which will be regarded as of greatest general interest is that in which he draws the conclusion that the original opposition of electricity and gas supply, viewed as public supply services, should be more properly esteemed an apposition. The change of initial letter makes all the difference. Not long since we expressed the aspiration for something better in the way of electricity generation than the lamentably extravagant steam boiler and engine combination fired with raw coal. This line of development, of course, points directly to the only other known combination, of electric power station and gasworks ; which Dr. Carpenter had in contemplation. It might not be precisely the same pattern of gasworks now extant, nor would it be the same sort of electric power station : but something into which the element of a coke works might also enter is not beyond the range of a very practical imagination.

* * * *

"Charon was the conductor across the Styx," says a "B.I." advertisement. Now we know who is responsible for that "allotted span." O ! Shade of Virgil ! Thou hast established the antiquity of the electrical industry !

* * * *

According to the "Investors' Review," 200 American manufacturers, having a share capital of over one thousand millions, made 157½ millions during 12 months. "Some" profit ! (and some don't).

Owing to the scarcity of straw at home (the horses, men and officers want it at the front), Real Red Heat Bastian has been asked to quote for quartz tubes for the munition workers' lemon squash !

* * * *

The "Camberwell and Peckham Times" contains a short article on the "Heat Treatment of Steel by Electricity." As this is a London suburban journal we may take it as an example of bringing the benefits of electricity home to the public with a vengeance !

* * * *

"Women Using the Shovel," says a daily paper headline, anent the employment of female labour in Bo'ness for cable laying ; there is nothing new in this, however, for they have used the poker ever since marriage was an institution.



"S'TREUTH ! THAT HOLE'LL TAKE SOME PLUGGING."

[*From Glover's Almanac.*

* * * *

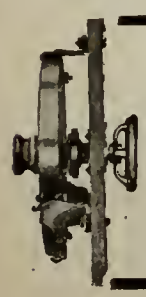
THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), Aug. 30, 1879.]

ELECTRICITY AS A MOTIVE POWER.—This subject, which is attracting a good deal of attention at present, has been treated by Dr. Paget Higgs in a small work published by Messrs. Spon, of Charing Cross, which we hope to notice at length in another issue.

SMART WORK.—An enterprising tobacco manufacturer of the north recently did a smart thing. He had the electric light put up in his factory, had it well puffed in the daily papers as likely to supersede gas, invited people to see it, and bought gas shares largely at a low price ! The electric light was not a success, but the gas shares were.

DEATH OF AN ACTOR BY LIGHTNING.—A painful scene recently occurred at the Altorf Theatre. As "Lucia" was being performed, a violent thunderstorm burst over the house. The tenor was singing the air in the malediction scene, when Edgardo fell forward, struck down by lightning. He was immediately raised from the ground, and, though then alive, was found to be paralysed in every limb. The performance, of course, was brought to an abrupt termination.



Have you got the 'IGRANIC' Shunt Regulator List?

It contains over 300 standard sizes. Large numbers are stocked for quick despatch. These regulators are easily convertible from front to rear of board type, and they are thoroughly insulated. Pamphlet 631 contains full particulars and prices.

IGRANIC ELECTRIC Co LTD 147, Queen Victoria Street, LONDON.



SIEMENS

ELECTRIC MOTORS



Part of small Motor Shop, Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. (Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

TO HELP SALES.

The salesman of much of the heavy plant and machinery which is regularly disposed of every year by electrical manufacturers cannot obviously "carry samples." He relies on catalogue illustrations, photographs of machines, or apparatus under construction, and views of installations, to interest the prospective customer. Often it is not convenient to show these, or they will not in themselves be attractive enough to hold the attention of the individual to whom they are presented. During the past year a number of American manufacturers have adopted "something different" along the lines of selling helps by making use of special binocular photographs. The purpose is threefold and makes use of small stereo photographs with a collapsible instrument something after the nature of the stereoscope, but occupying only pocket space. This salesman's equipment assists:—

1. By showing machinery accessories or complete installations in a way that only binocular photographs can do. The salesman finds it possible to give a prospective customer a more satisfying idea of his goods than can be done from catalogues or photographs with descriptions.

2. These pocket outfits usually contain a series of factory photographs, showing reasons why a certain piece of machinery or any other manufactured article is all that is claimed for it.

3. A salesman when dealing with difficult prospects often would be able to satisfy his customer, if it were only possible to take the prospect to the factory and show details of construction that cannot easily be explained. In many cases the deciding point is to satisfy the customer that the firm which the salesman represents is a substantial one properly equipped.

LEAD MELTING FURNACES

(Hall's Patents)
For Cable and Pipe Presses, Accumulator Grids, etc.,
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
ENORMOUS SAVING IN RESIDUE.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

These considerations have been prominent in developing the use of binocular photographs for selling purposes. A firm in Cleveland (Ohio), the Corte-Scope Company, has been responsible for most of this development. The illustrations herewith show the size of the complete equipment. The instrument itself is not larger than a sixpenny novel. The case in which the Corte-Scope is contained accommodates 50 to 75 thin photographs specially made for use with the Corte-Scope. The interest of the equipment has been established and is worth investigating by manufacturers who are looking for ideas for their sales promotion work.



THE CORTE-SCOPE FOLDED FOR THE POCKET.

The advantage of the Corte-Scopic photographs lies in their vividness, for such photographs when viewed through the binocular lenses of the Corte-Scope appear not like photographs, but in bas relief and full size. The most complicated piece of machinery stands out when viewed in this way with the same definiteness as though he were looking at the actual article.

Although the average buyer can easily interpret blue prints to his own satisfaction, the fact remains that he would be more deeply



THE CORTE-SCOPE OPENED, SHOWING STEREO-PHOTO READY TO VIEW AND WALLET CONTAINING OTHER PICTURES.

impressed if he were looking at the actual machine or installations. The memory effect also of this kind of representation is important. Most people remember visually. Therefore, the salesman who makes the deepest visual impression has gone farthest towards establishing himself in the mind of his customer. This difference between flat photographs and Corte-Scopic or three dimension photographs is so great that it is difficult to make satisfactory comparisons. People

FERRANTI LTD

HOLLINWOOD, Lancashire.

SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

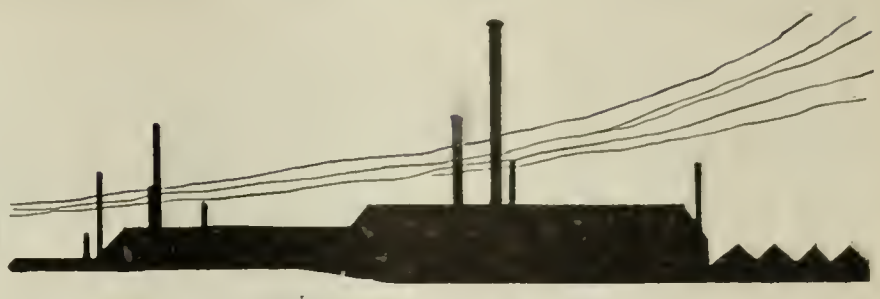
Established 1868.
Codes: 5th Edition A B C & Western Union.

EDISWAN EVERYTHING ELECTRICAL

THE LAMP FOR ALL-ROUND EFFICIENCY · STRENGTH · BRILLIANCY · ECONOMY · DURABILITY ·
ROYAL EDISWAN DRAWN WIRE LAMPS

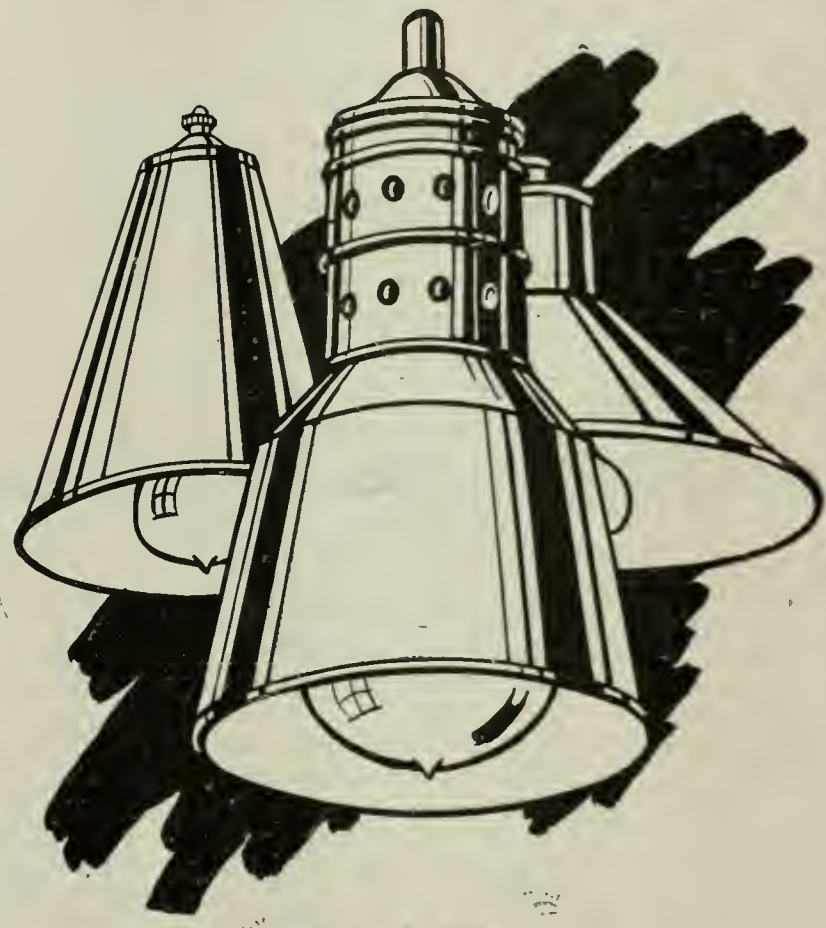
THE
EDISON SWAN
ELECTRIC CO., Ltd.,
PONDERS END,
MIDDLESEX.
'Phone 520 Enfield.

FULLY LICENSED UNDER BRITISH PATENTS Nos 21513/06 - 27712/05 AND OTHERS



SIMPLEX

ANTI-ZEPPELIN REFLECTORS



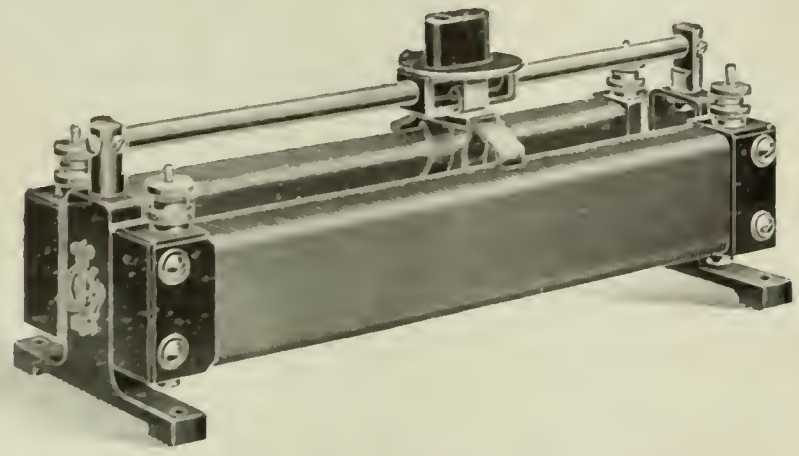
FOR FACTORY LIGHTING

we can deliver from stock

Simplex Conduits, Ltd.,
Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd, W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
1, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

RHEOSTATS



List (covering all types) on request.

ISENTHAL & Co.

(DEPARTMENT 4)

DENZIL WORKS, WILLESDEN,

LONDON, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

are so used to considering photographs as being correct that they cannot easily appreciate the failings of ordinary photographs; but when the same object is shown in the flat and also a three dimension photograph the difference is surprising indeed. The Corte-Scope also helps in the hands of a tactful salesman by its power to command the attention of a customer.

By the use of the Corte-Scope we understand that many firms are greatly reducing travellers' samples. Some have almost eliminated the use of large sample trunks, carrying only specimen pieces to show weight, quality, texture, &c. Firms previously carrying large portfolios of photographs reduce the bulk and cost to a minimum and secure infinitely better results by using the Corte-Scope. Things which cannot be photographed with the ordinary single lens camera without distortion or foreshortening are, we are informed, shown in accurate form and size by the Corte-Scope. The high lights so objectionable in ordinary photographs of glassware, furniture, switchboards, machinery, &c., are not avoided by the operator, but sought for because of the brilliance they give in the Corte-Scope.

The whole idea possesses not only the element of novelty, but also of improved efficiency in selling, and on this account it should appeal to many branches of the electrical business.

THE ELECTRIC IN THE DAILY PAPERS.

The interest created in the electric vehicle by the high prices of petrol and the scarcity of horses is causing considerable comment in our daily contemporaries. The motoring notes in the "Westminster Gazette" are presided over by "J. O.," who has recently said some nice things about the electric vehicle. He has evidently been discussing the matter personally with Mr. F. Ayton, hon. sec. Electric Vehicle Committee, and the ventilation of the subject should do a lot of good. The following article taken from our contemporary shows that the matter is being dealt with in a sane and business like way.

"The petrol machine has been the hare in the race for the conquest of the roads, and its pace has been so furious that but for striking a cul-de-sac we might have forgotten the existence of the tortoise that was slowly following it up. The progress of the battery vehicle has been painfully slow, admittedly, but none the less sure on that account, as we now see, and all that it is necessary for us to do now to bring it into line with the petrol-benzol-paraffin driven machine is to remove the misunderstanding concerning its economical employment. As to this, some points of Mr. Frank Ayton's letter were referred to recently, but as scepticism dies hard I cannot do better than further quote Mr. Ayton's views on the subject, because we have been discussing this matter privately as well as publicly. 'I am not surprised,' he says, 'at what you tell me regarding the views held by many of your engineering friends, even electrical men, as to the possibilities of the electric, for my own experience is identical in this matter. I am glad to say, however, that many of my engineering colleagues who once held these pessimistic views have since become converts, and I have no doubt that we shall convert them all before long.'

"Mr. Ayton attributes this scepticism in engineers to two causes. Firstly, he says, battery engineering is an art by itself, which comparatively few electrical engineers outside those engaged in such work have thoroughly gone into or studied carefully. The problems indicated are looked upon as somewhat abstruse, and only understandable by the trained electro-chemist. This, he urges, is a wrong view to take, because, given a good battery, designed upon proper lines, the problems underlying its working and maintenance and the obtaining of efficient and economical results are of the simplest description. It is only within the last few years that battery makers have discovered what are the fundamental and necessary requirements for a battery that is to be used on an electric vehicle. There are still several British makers who will have to alter their designs before they are really suitable for this purpose. The main defect in these batteries is that sufficient space is not provided between the lower edge of the plates and the bottom of the cell, or container, for the reception of the sludge. The one or two British makers who understand the requirements provide ample space, with the result that their lead-acid accumulators give very good service in vehicle work. The same thing can be said about the batteries turned out by the principal American manufacturers. One of the things that the Electric Vehicle Committee has done, Mr. Ayton says, has been to standardise the minimum clearance space for this purpose, and he believes that before long all British makers will come into line on this important point.

"This is one reason for the professional scepticism; the other is connected with the utter failure of the early electrics manufactured in this country. It seems impossible, my correspondent continues, for some engineers to get out of their minds the memory of the bad record of the electric vehicle in years gone by, and simply through ignorance in many cases they fail to see that the present machines are vastly different in every way. The unsuitability of the batteries was, of course, the main cause of the failure of the early machines, and in the case of the cab and 'bus companies that had a somewhat meteoric career they also, of course, suffered severely from the rapaciousness of the company promoter. The early vehicles were also of abnormal weight, because at that time the high tensile steels and the improvements in bearings and gears that have been the concomitants of the development of the petrol car were not then available to the makers. But that the chassis, motor, and transmission were not bad is shown by the fact that there are commercial vehicles at the present time giving good everyday service in several of the big cities of the States that were constructed 10 to 12 years ago.

"Mr. Ayton concludes by saying that he is not one of those who hold that the electric is going to oust the petrol machine. For example, he does not think that electric passenger vehicles will ever become touring cars in the real sense. The future will recognise a definite sphere of utility for each type. For all work about towns and cities, where long runs of above 40 or 50 miles a day are not required by the service demands, the electric will have such advantage that its use will become universal. The type of service he has in mind covers urban and suburban delivery of goods, taxi-cabs, certain omnibus routes, doctors' cars, and the ordinary runabout work apart from touring that will satisfy the wants of a good many people who now use petrol cars. This will free an enormous amount of petrol for the employment of the petrol car in that realm in which it is bound to remain paramount, namely, long-distance work and touring, for it must be placed to the credit of motor-car engineers that the petrol car of to-day is one of the finest pieces of mechanical construction the world has ever seen, and it approaches very near to practical perfection."

"THOR" High Grade Specialities

CASING and CAPPING — CABLE CONNECTORS
CONDUIT — COMMUTATOR COMPOUND
CABLES — WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.

WRITE FOR PRICES & DISCOUNTS.

HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

Our Manufactures include:

Cables for Lighting, Power,
Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

HELSBY
TELEPHONE & TELEGRAPH
CONDENSERS.

Condensers are made in sundry styles and shapes, but the cheapest and most convenient is the Helsby type of Mansbridge self-sealing condenser.

In case of sudden fluctuation of voltage, sufficient to cause a breakdown, these condensers seal themselves in the act of failing, while ordinary condensers would be irretrievably ruined.

SEE PAMPHLET H 67.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

Works: PRESCOT and HELSBY.

Branch Offices in: LONDON, MANCHESTER, GLASGOW, BIRMINGHAM, NEWCASTLE, CARDIFF, DUBLIN, LEEDS & BELFAST.

OVERSEAS BRANCHES:

AUSTRALASIA: The Wool Exchange, King Street, Melbourne.
EASTERN INDIA: 11, Clive Street, Calcutta.
SOUTH AFRICA: Telegraph Manufacturing Co. (Colonial), Ltd., P.O. Box 2827 Johannesburg.

H. Weidmann, Ltd., Rapperswil, Switzerland.



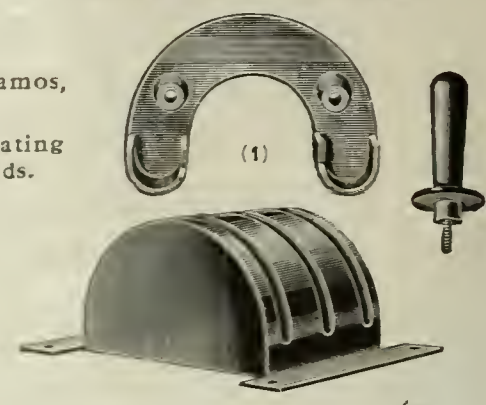
MAKERS OF PRESSPAN AND INSULATING MATERIAL.

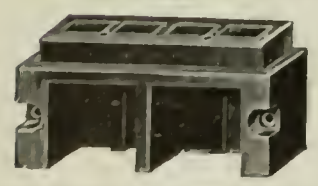
Pressboard (Presspan) in Sheets, Rolls and Tapes, Oiled Presspan, Black Presspan, Presspan Tubes and Stampings.

Amianite (Vulcanised Asbestos) Coil Frames, Spools for Apparatus, Dynamos, Motors and Transformers. Insulating Blocks, Tubes, Plates, Boxes, &c.

Bakelite & Cornite (high tension material) Handles of Switchgear and Heating Apparatus, Controller Insulation, Moulded Pieces, Terminal Covers of all kinds.

Asbestos-Cement in Plates, Arc Shields for Controllers, &c.





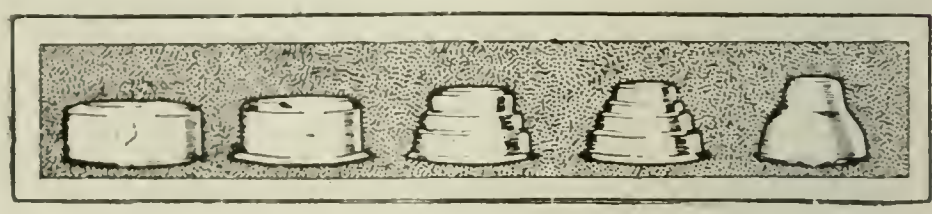
Mica and Substitutes, Insulating Pearls, Transformer Spools.
Japanese Felt and Paper in rolls and tapes.
Oil-Varnished Linen, Diagonal Tapes, Oil-Varnished Silk & Paper.
Artificial Leather Discs for Friction Drive.
Insulators for Electric Furnaces, Tramways, &c.

"A QUESTION OF ORIGIN."

The above may be said to be "the burning question" at the present time, and for many people it is not satisfactorily answered. The phrase is made the title to an attractive brochure which the Benjamin Electric, Ltd., are now sending out to the trade. Some three months ago we made our readers acquainted with the admirable workshop facilities which this enterprising firm is utilising for the production of illumination material of a highly specialised character. The brochure referred to contains a number of the illustrations which we then published, but there are other views of considerable interest now included, which we take the opportunity to reproduce. It is not always realised in looking at a simple steel or aluminium shade or reflector that production at popular prices entails not only preliminary science, but also perpetual mechanical skill. To witness the stamping out of a Benjamin steel shade or the spinning of a Benjamin aluminium reflector is to have these facts impressed upon the mind.

For an ordinary intensive type steel reflector, five distinct stamping operations are necessary to bring the reflector bowl to the correct shape, after which the bowl is trimmed and beaded and the top pierced to receive the correct reflector extension. The press itself weighs 6 tons, is over 10 ft. high and occupies a floor space of 7 ft. by 5 ft., motive power being supplied by a 10 h.p. electric motor. The sheet steel used in the manufacture of the reflectors is a deep drawing open hearth steel of a special analysis. The steel billets come from the rolling mills in Wales and are carefully cold-rolled in sheet therefrom to gauge, then annealed and pickled. The blanks for standard lines of reflectors are circled at the Mills to prevent loss in handling scrap.

The larger sizes of Benjamin reflector fittings, cluster bodies and lanterns are spun from specially prepared metal blanks—one of the



Five Stages of a Benjamin Steel Reflector.

most interesting of the many processes employed in the production of modern lighting specialities. Metal spinning is a highly-skilled trade, restricted to a comparatively small number of workmen and the skill with which an expert can coax a flat disc of metal over a chuck or mould, thinning or thickening at any desired part, is a fascinating operation to watch.



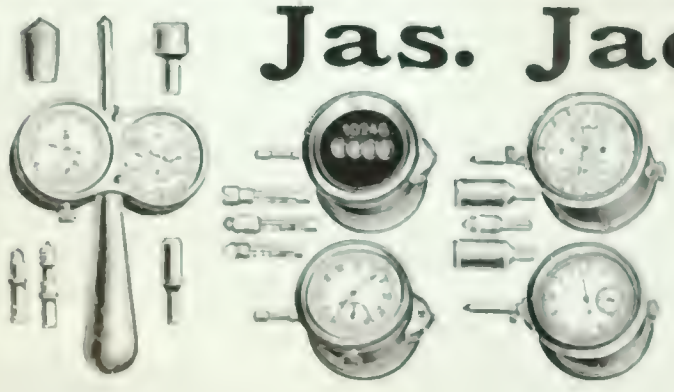
Benjamin Reflectors in the Annealing Ovens.



"Firing." Benjamin Reflector Fittings.

Whilst the majority of spinning executed in this department consists of standard reflector fittings, the company have turned out from time to time many spinnings of an exceptional and novel character, ranging from less than 1 in. diameter blanks of fine gauge metal up to blanks of over 7 ft. in diameter of No. 8 S.W.G. These extremes in sizes serve to illustrate the class of work undertaken.

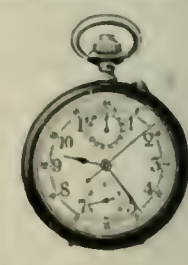
The Benjamin reflector fitting has become a household word.



Jas. Jaquet, Ltd., Basle
Switzerland.

Combined Revolution Counters, with Chronograph.





Very Accurate Timekeepers.

CHRONOGRAPH AND STOP WATCHES.

Lists on Application.

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

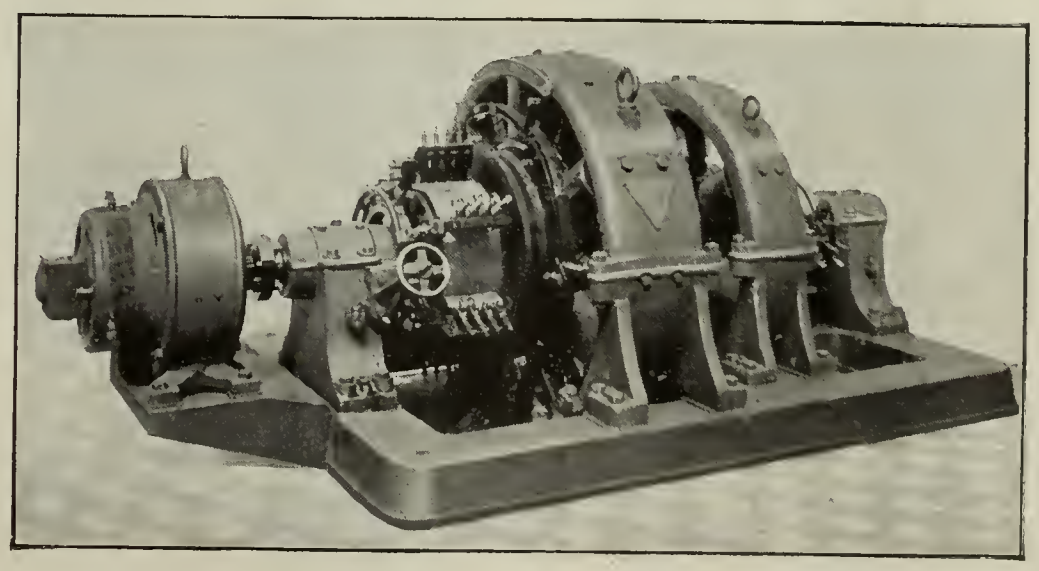
TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

VICKERS LIMITED.

Motors and Generators of all types.

Rotary Converters.

Complete equipment for the electrical lighting and driving of Machine Shops, Factories, Mills, etc



Patent Automatic Reversing Drive for Machine Tools.

250 K.V.A. Rotary Converter. 6 phase, 50 periods, 480/560 Volts. 1,000 r.p.m. Inverted type.

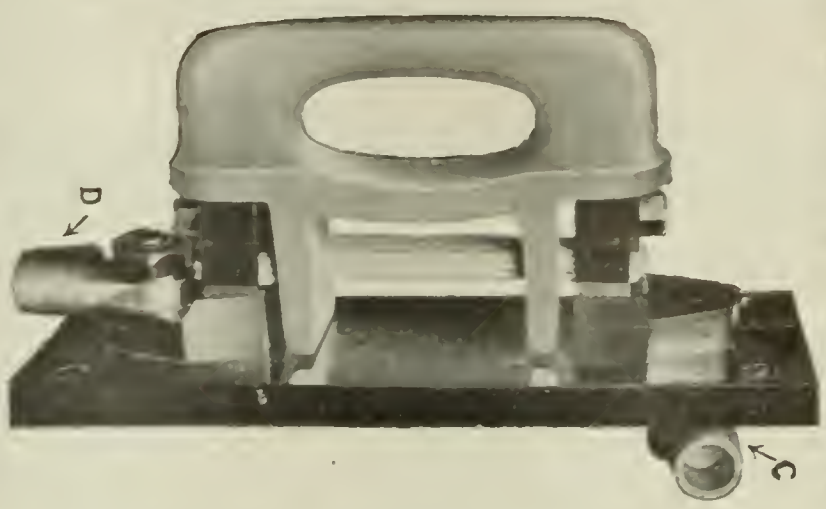
River Don Works, SHEFFIELD.

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

representing higher efficiency in design, construction and finish. A factor which contributes materially to this reputation is the vitreous enamelled finish. The application of this is known as "dipping" and requires considerable skill to manipulate the article so that the enamel is evenly spread. White enamel is the most difficult colour throughout the enamelling process to handle, which accounts for the fact that cheap lines of reflectors are generally finished outside in some dark colour, so as to hide the imperfections of the metal shape. The secret of a snow-white enamel surface is in the purity of the tin oxide used, and as this is an ingredient which considerably varies in price for different qualities, it accounts for the different degrees of whiteness found on vitreous enamelled ware.

In these reflectors only the highest quality of tin oxide is used, the metal shape being first given a coating of basic (or grey) enamel, and then two coats of white enamel are applied.

A high temperature is required for the white enamel for firing. Owing to the intense heat, the metal in the larger diameter reflectors slightly sags, and it is necessary immediately to clamp them into position so as to restore them to their original shape.

Many other interesting facts regarding the Benjamin specialities are given in the brochure, and those who have not received a copy should make early application to Benjamin Electric, Ltd., Rosebery-avenue, London, E.C.



THE LARGE STAMPING PRESS.



A CORNER OF THE SPINNING SHOP.

BELLING & CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialists, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,

STIRCHLEY, BIRMINGHAM.

Cast Cable Sockets.

Suite E74. Made in all Sizes.

Type A.—Straight.
,, B.—Offset.
,, C.—Right angle.

Illustrated Dimensioned Showcard for Drawing Office use supplied free on application.

Sole Agent for the Electrical Trade:—

LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.

Printed and Published by the Proprietors, "THE ELECTRICIAN" PRINTING AND PUBLISHING CO., LTD., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, SEPTEMBER 1, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—Why, the "pipping of the Zepp," of course.

* * * *

In future you will not tell a man to go to Hades. You will just say ("in order to preserve the social amenities," as an old friend would have it) "You go to —— Cuffley!"

* * * *

"A plate attached to the *stut* axle carries the motor," says "Lloyd's Register," in describing an electric battery vehicle.

* * * *

I hear that some highly paid workmen in a metal factory were recently presented with income tax forms. They have since informed the manager that they cannot possibly make ends meet on £7 a week!

* * * *

This charming young lady has been playing tennis, but between whiles she does the electric cooking. The Newcastle-on-Tyne Electric Supply Co. has had a poster prepared from



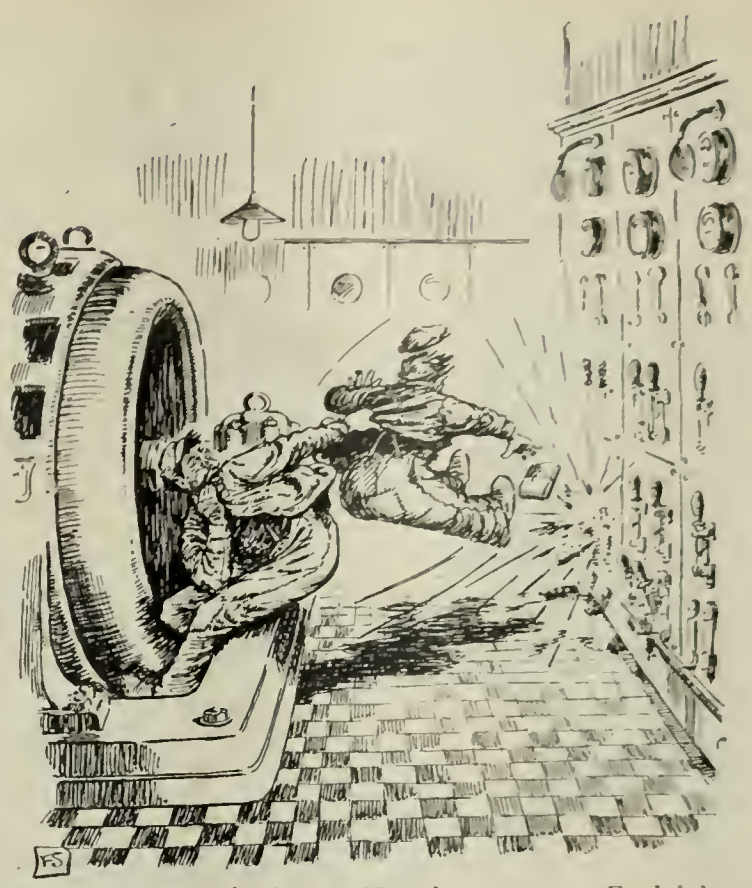
this design, the wording directing attention to the economy and convenience of electric cooking. But do they play tennis up North just now?

* * * *

Commenting upon the "electrocution" of an English child who climbed a telephone pole, the "Daily Chronicle" says:—

All across the Roman Campagna are telegraph and telephone poles, and to every one of them is affixed, not a verbal warning lest any urchin inclined to swarm should not be able to read, but a most intelligible threat, in striking black on white—a skull and cross-bones. Is there no like way of warning the little Briton?

I fear the little Briton would "pinch" the skull and cross-bones notice to use as a breastplate in the "pirate chief" drama to be enacted in the back yard before an admiring crowd of local gamins. It could have no other meaning!



JOINTER (recently at the front): Naa then, matey. Funk 'ole, quick!
[From *Glover's Almanac.*

* * * *

The following does not apply to electrical advertising:—

The Trade and Industry Committee of the Royal Colonial Institute has received complaints from purchasers Overseas as to the misleading form in which advertisements of manufacturers in the United Kingdom appear in the local press. Advertisers seem at a loss as to what is needed in an advertisement in the Colonies. One instance may be quoted: Butter-cooling dishes. In an advertisement the price was given as 7s. 6d. retail in the United Kingdom. What is required by the retailer Overseas is a knowledge of the size of the dish, but this most essential point was omitted. No information was given as to how many were packed in a case or what the cubic measurement of one dozen was, nor the capacity of the dish, whether it would hold ¼ lb., ½ lb., or 1 lb. The prospective purchaser has to write for this information, which in many cases takes from three to four months for a reply.

* * * *

A writer in the "Yorkshire Herald" lets himself go on "strafing" Zepps. Here is "strafe" No. 1:—

By means of a simple invention the beams of the searchlight assume the properties of a copper wire, and charges of high-tension electricity are sent up, upsetting the various instruments of observation, jamming delicate machinery, and creating considerable disturbances among the occupants of the airship.

and making sparks fly out of their hair and firing the gas or petrol vapour, eh? Why not?

Here is "strafe" No. 2:—

Nor would it be impossible to direct a continuous electrical current up the searchlight. Then, if a second searchlight were focussed on the opposite end of the Zeppelin, the latter would perforce occupy the position of the carbon filament in an electric lamp. Heat would be rapidly generated and would soon force the series of gas bags to expand up to bursting point.

And here "strafe" No. 3:—

By a further adaption of this apparatus the Zeppelin would be held in magnetic contact and as the searchlights were slowly depressed, would be drawn down towards the horizon, when it could be destroyed by gunfire or other suitable means.

Shades of Billing and Bachelet! Do the authorities know the address of this genius?

L. P. S.
CLIPS, TIPS & TERMINALS
of all descriptions.
Write for Booklet, with Illustrations, of 75 types to:—
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Goldplat, Ox., London." 4746 Gerrard.

SIEMENS



IRONCLAD SWITCHGEAR FOR ALL PURPOSES

Control Pillars
Distribution Boards
Main Switchboards

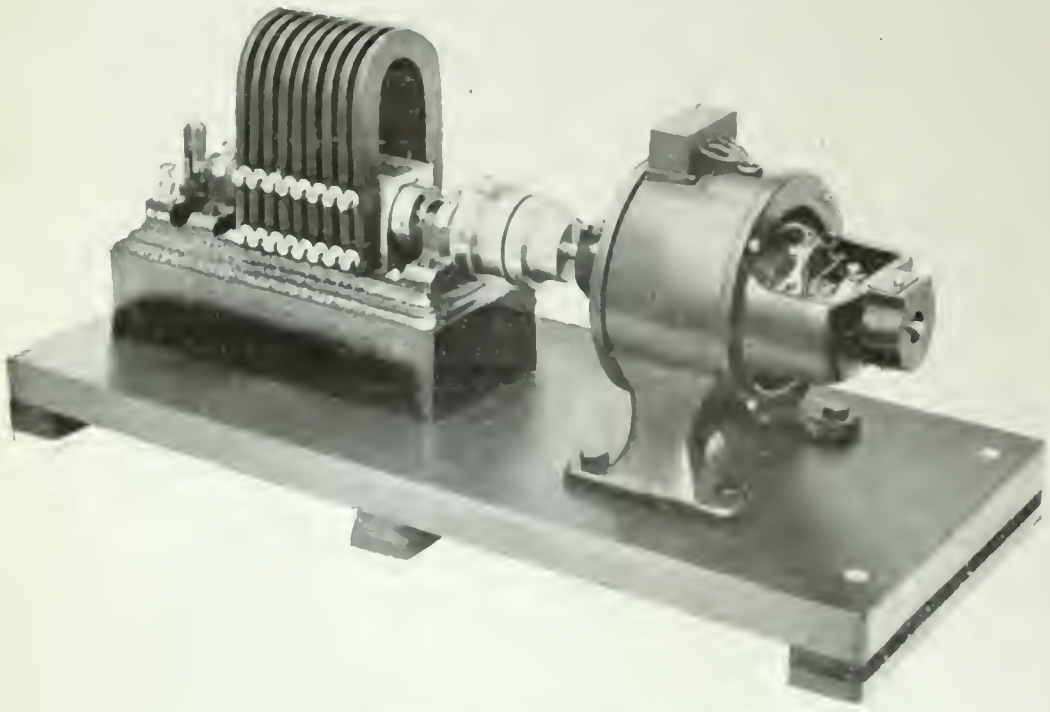
Illustration shows our Standard Cast-iron Mining Pillar suitable for pressures up to 3,300 volts.

Write for particulars to —

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: "SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood [Bldgs
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St.
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

ERICSSON APPARATUS.

The set illustrated comprises a telephone generator coupled direct to a small motor. The generator is a nine magnet machine with an output of approximately 70 volts and 0·03 ampere when run at 1,000 revs. per min. The bearings are of ample design and are fitted with automatic ring oilers for continuous running. The current collecting brush is of simple and effective design, so arranged



ERICSSON MOTOR MAGNETO RINGER.

that the machine can be run in either direction. By reason of the permanent magnets these machines require a minimum of driving power and are consequently economical to run. The motor which is coupled direct to the generator by means of a flexible coupling, can be supplied suitable for either direct current or alternating current. When the driving motor is wound for over 200 volts a protection cover is fitted over the terminals and the motor frame is fitted with an earth terminal. Both machines are mounted upon a well finished wooden base, reinforced with ironwork. The base is fitted with felt cushions to reduce noise and vibration, and holes are provided in the base for fixing down screws should they be necessary.

The hand lamp shown is specially suitable for policemen, night watchmen, factories, &c. The lamp case is made of pressed steel heavily coated with black enamel, and fitted with nickel-plated carrying handles, also belt clip. The high efficiency metal lamp with which the lamp is fitted is suitable for working with the 2 volt accumulator provided with the lamp. The two-way switch is of strong construction, being mounted on a fibre block which can be easily removed for inspection when necessary. The lens with which



ERICSSON LANTERN.

the lamp is fitted is designed to give a maximum amount of light. The metal ring holding the lens also acts as a lock, a special two-pin key is supplied with each lamp. The overall dimensions are 6 in. by 3¼ in. by 2¼ in.

Prices of the above apparatus can be obtained from British L.M. Ericsson Co., 5, Chancery-lane, London, E.C.

DONOVAN LEAFLETS.

Reminders of their specialities are being sent out by Donovan & Co. in the shape of letter leaflets containing illustrations of individual pieces of apparatus. They deal with "Safuses" and "Safuse" Boards, "Cornwall" Fan Regulators, Motor Starting Panels, Switch and "Safuse" Panels and Insulated Switchholders. Each leaflet is printed on one side only, and contains a very clear illustration of the apparatus with which it deals. They should help to promote inquiries for Donovan goods.

THRESHING BY CENTRAL STATION POWER.

Nine progressive farmers along the transmission lines of the Riverside Light & Power Co. of Abilene, Kansas, have organised themselves into the co-operative "Electric Threshing Association," for the purpose of purchasing equipment and doing their threshing electrically.

The central-station company, which operates about 150 miles of transmission line, has been working for some time on a suitable plan for such a service, the advantages of which have finally been recognised by this group of farmers, who have each subscribed a certain sum of money for the purchase of the up-to-date thresher. The power company furnishes all the electrical equipment for operating the thresher, ensilage cutter, or other machinery requiring more than 10 h.p., and each farmer pays for the stub line leading from the transmission trunk line to his field. These stub lines are built of light poles and iron wire and carry 6,600 volts. The transformer, primary cut-out, meter and switches are mounted on a truck made from an ordinary farm wagon, and the pressure is stepped down to

MAZDA

HALF-WATT TYPE LAMPS

carry the simplicity of house lighting into factory, works & mill

With the power for big lighting effects of the Arc Lamp, Mazda Half-Watt Lamps retain all the good qualities of the metal filament Lamp. They are simple, reliable and convenient, require no adjustment, need no trimming, give no trouble, ensure greater economy.

They give Arc Light effect without a flicker, without a fault. Ideal for the lighting of all big interiors.



MAZDA LAMPS ARE BRITISH MADE IN RUGBY, ENGLAND.

The British Thomson-Houston Co., Ltd.,

Mazda House, 77, Upper Thames Street, London, E.C.

Branches:—Manchester, Birmingham, Leeds, Sheffield, Newcastle, Middlesbrough, Glasgow, Swansea, Cardiff & Dublin.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

BURNER & HEAT CONTROL
Equipment for Lead Presses
(HALL'S PATENTS).
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

440 volts for the 25 H.P. squirrel-cage motor mounted with its starting compensator on a separate truck. The 500 ft. of cable connecting the transformer wagon with the motor gives sufficient latitude for convenient location of motor and transformer.

The outfit is reported to be working very satisfactorily, with a cost to the farmers of about one-half that charged by the steam thresher men. The association pays for the energy used at the flat rate of 5 cents per kilowatt-hour, and the energy consumption is about 250 watt-hours per bushel, depending on the nature of the grain threshed. The revenue which the power company received from the nine farmers this year averages $17.50 for each threshing, and it is expected that the same electrical equipment will be used for filling silos, and will produce at least an equal amount of revenue. The farmers have also used the equipment for baling their hay, and the association is doing some threshing for their neighbours who happen to be located on the transmission lines, so that the total proceeds from the business will be well worth going after. C. L. Brown, general manager of the power company, says: "While this experience is rather new in this country, our farmer friends are all delighted with the operation and the economy of the outfit. The probabilities are that next year a number of these outfits will be at work."

USE OF LARGE MAGNETIC CLUTCHES.

The Wisconsin Traction, Light, Heat & Power Co. makes an interesting use of magnetic clutches in its power plant at Appleton, Wis. The plant is combined steam and water driven, situated on the Fox river. The present equipment consists of two combined water turbine and engine-driven direct-connected 1,000 kw. units, running at 150 revs. per min., and two 1,250 kw. low-pressure turbo-generators. The clutches are used to connect the engines to the generator shafts, the water wheels being connected to the opposite end of the same generator shafts by means of flange couplings. There are two separate generators on each shaft, one a 550-volt direct-current machine for traction service, and the other a 2,200-volt three-phase alternating-current machine for commercial power and lighting service.

When operating by water-power the engines are disconnected from the generator shafts by disengaging the clutches. In seasons of low water the supply may at times be cut off entirely on short notice, being regulated by the Government, when it is necessary to drive the generators from the engines. In cases of sudden change the engines must be connected to the generator shafts without interrupting service. This is accomplished by means of the magnetic clutches.

The clutch used has several essential features which make it suitable for this service. The torque transmitted can never exceed a certain predetermined value, which ensures smooth engagement and eliminates excessive strains. The operation of the clutch is, therefore, not dependent upon the skill of the operator, and may be thrown "full on" without harmful results. At the same time the clutch has a factor of safety which permits no slipping when the engine is running at its maximum load. It is designed to withstand moderate periods of slipping, and provision is made for dissipating the heat developed and adjusting for the resulting wear. It has been found that magnetic clutches of this type are well adapted for "inching," and by manipulating the knife switch which controls the clutch the engines may be turned through any desired fraction of a revolution.

The magnetic clutches replaced two mechanical friction clutches, which had become unsatisfactory and required frequent renewal of parts to maintain them in operating condition. The principal cause of the failure of the mechanical clutches, it is said, was a slight misalignment of the engine and generator shafts which imposed unbalanced stresses on the clutch shoes, and which resulted in chattering and slipping on overloads. The construction of the units made it a difficult matter to correct this misalignment. It would have been necessary to use a flexible coupling in connection with any form of mechanical friction clutch, but the limited shaft length made this practically impossible. The misalignment mentioned does not affect the operation of the magnetic clutches.

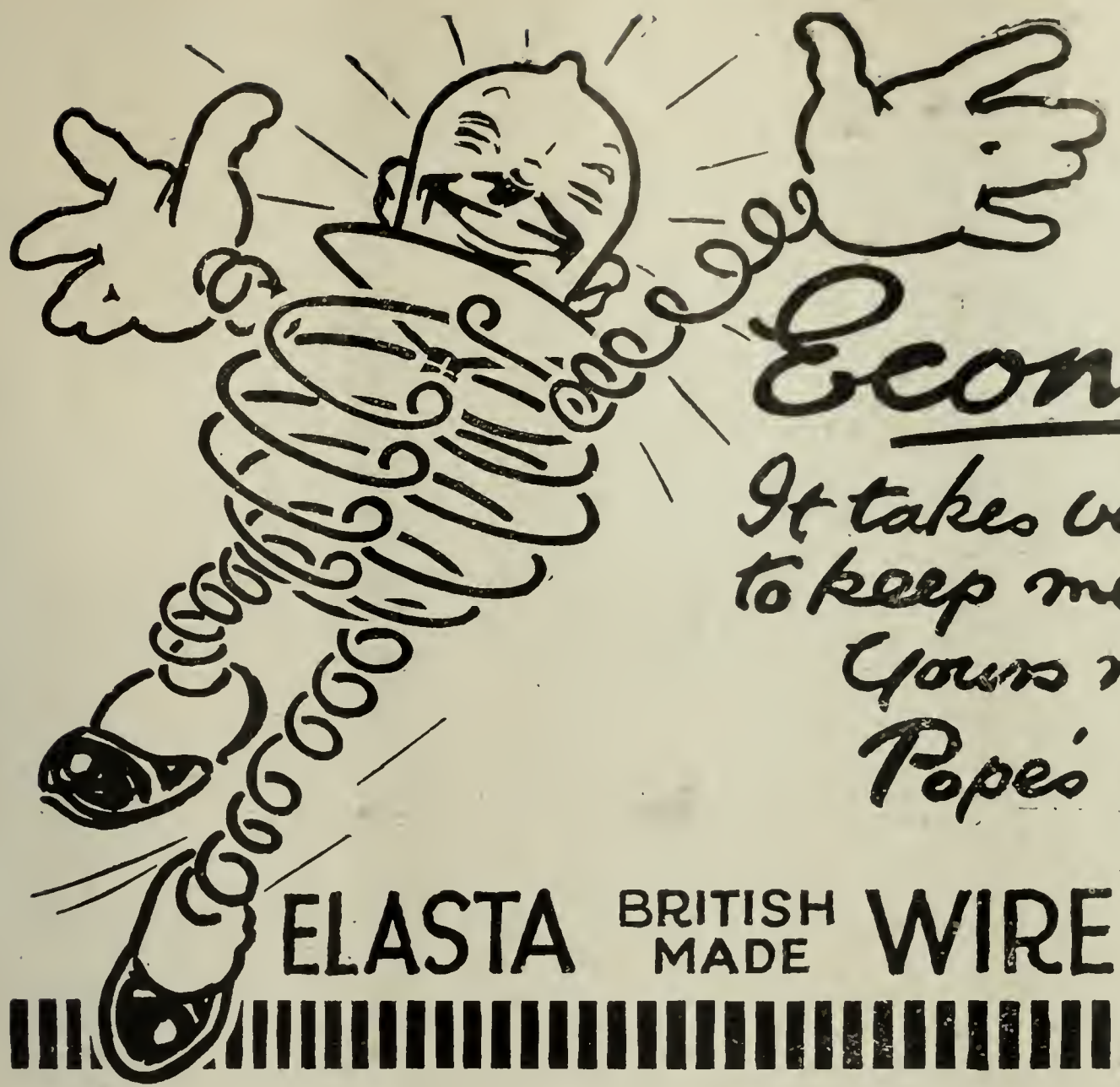
At present the capacity of the plant is being doubled by the addition of two high-pressure steam turbo-generators and auxiliary equipment. It is also planned to take out the present water wheels and replace each wheel with two water turbines, direct connected



A Fine Example of Flood Lighting with Electric Lamps. The Woolworth Tower, New York, at Night.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.
HOLDER-HARRIDEN, LTD., 35/37, NOBLE STREET, LONDON, E.C.



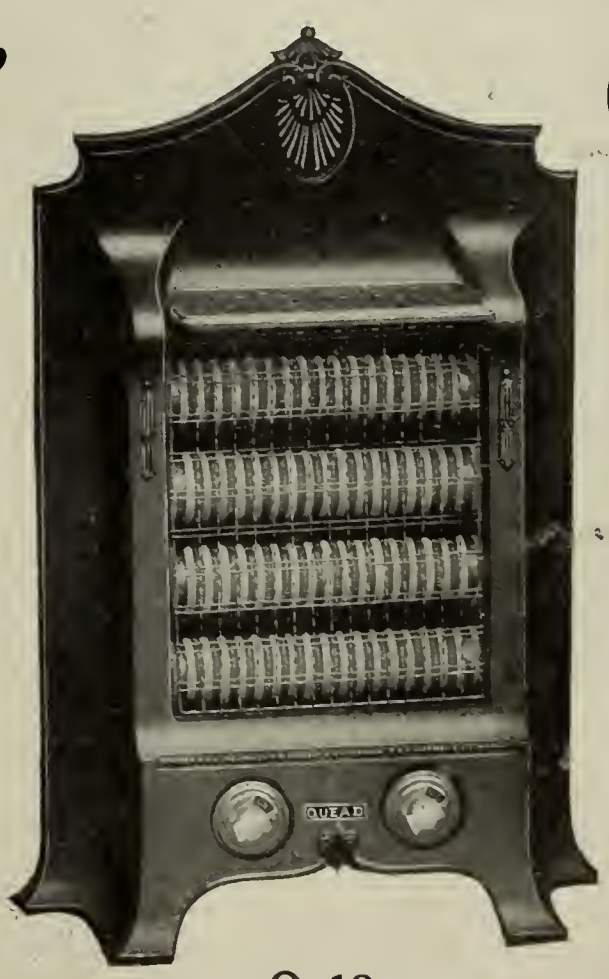
Economy

It takes very little to keep me bright!
Yours resiliently
Popé Elasta.

ELASTA BRITISH MADE WIRE LAMPS

Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W. *Greenly*

THE "ROYAL" QUEAD.



Q. 13.
3 and 4 kw.

Sole Manufacturers

..QUEAD LTD..
47 to 57 Marylebone Lne
London, W.

Telephone: Mayfair 3582.

Special Features

Sound Construction
. . Red Heat . .
Artistic Finish.

Ask for 1916-1917 List.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
CHARLES CLIFFORD & SON, LTD.,
BIRMINGHAM.
TRADE MARK.
SEA CLIFF

One, Two & Three Phase
MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

to 650-kw. 4,000-volt alternating-current generators. This will leave the old generator equipment referred to driven by the engines only. Direct current will then be obtained by driving with the engines or by operating the alternating-current generator as a motor to drive the direct-current machine. The latter arrangement will be used when the load demand is light and the hydraulic turbines have more capacity than is required for the alternating-current service. The engines will then be used for synchronising, and can be disconnected by means of the clutches.

The clutches are 66 in. in diameter and 30 in. over all length. The construction consists of a field or magnet member, and an armature member connected to the hubs by means of steel discs. These discs act as spring plates to separate the field and armature members when the clutch is de-energised. The coil, which is in the form of a ring, fits in an annular slot in the field member and connects to the slip-rings by flat external leads. The magnet or field member when energised pulls the armature against a friction ring with a pressure of 75 lb. per square inch, the resultant friction giving the required torque. The success of the clutch lies in its simplicity and freedom from sliding parts to wear out and require adjustment. About 8 amperes at 110 volts are required for excitation. This current is furnished by an exciter set. A special split construction was used so that the clutches could be installed without removing the shafts.

The clutches were built by the Cutler-Hammer Clutch Co., and particulars of similar clutches can be obtained from the Igranic Electric Co., Queen Victoria-street, London, E.C.

THE ECONOMY OF ELECTRIC COOKING.

Figures recently secured on the cost of operating 29 electric ranges in Detroit, Mich., give 2 kw.-hour per day as the average consumption for cooking for families of two and three persons. In the same apartments, says the "Electrical World," the use of electrical energy for purposes other than cooking averaged a trifle above ½ kw.-hour per day during the period of observation. In only one instance was it apparent that the electric range was not being used regularly, the consumption in the other 28 cases varying from a minimum daily consumption of 0·44 kw.-hour to a maximum of 4·4 kw.-hour per day.

The ranges installed are a recent model, the feature of which is the compartment (or fireless) cooker. This cooker is set into the body of the stove, so that its cover when closed is flush with the cooking surface and is flanked on either side by a hot plate. The oven is of the elevated type with a glass door. An automatic clock mechanism operates a master switch and pilot lamp, this feature being designed to prevent the circuit being left "on" through forgetfulness upon the part of the operator.

The Boulevard Court installation was made as a direct result of a similar successful installation in Buffalo. A tenant of the Buffalo apartment, upon moving to Detroit, inquired of the manufacturer to learn whether she could not secure an apartment in the latter city equipped with an electric range. This evidence of satisfaction induced the Edison Illuminating Co. of Detroit to join forces with the manufacturer in placing a typical installation.

A study of the data at foot of page shows several interesting facts. It is not apparent, for example, that more than one of the active users of the cooking service was extravagant in that service alone. In all cases but one where the total monthly bills were above $5 the energy used otherwise than in the range amounts to approximately 30 per cent. of the total, whereas the average of the entire 29 apartments shows that about 25 per cent. in round figures was used for light and purposes other than cooking.

Another interesting fact is that in 1,554 range days the consumption averaged only 2 kw.-hours per day, although this record was for the experimental period, when it is commonly expected that the consumption will be high, owing to the housewives' unfamiliarity with the electric stoves.

Apartments.	Period of observation.	Kw.-hours consumed other than by range.	Monthly cost of energy other than for cooking.	Kw.-hours consumed by range.	Monthly cost of operating range.	Total Kw.-hours.	Total cost.	Total monthly cost.
		799	$1.30	3,121	$2.40	3,920	$191.60	$3.70
29	1,554 days	0·514 per day		2 per day		2·52 per day	$0.123 per day	
Average.....	53·6 days	15·42 per month		60 per month		75·6 per month	$3.69 per month	

HALF-WATT LANTERNS AND FITTINGS.

The majority of half-watt lamp fittings on the market were originally designed to take one or more filament lamps of comparatively low candle-power, and are often unsatisfactory for use with single lamps of high candle-power. It is, therefore, to meet the demand for fittings for the latter purpose that Crompton & Co. have decided to place on the market the series referred to in Leaflet No. 551. Certain undesirable points have been carefully avoided, such as the employment of clamping screws on to the rim of the globe, and the use of rubber rings or other perishable packing materials.

As the illustrations in the leaflet indicate, fittings of various forms can be supplied, but the one recommended as most suited to the majority of industrial installations is the lantern designed on the same lines as that employed with the well-known "Crompton Blondel" open-type flame arc lamps with modifications to suit the particular characteristics of the half-watt lamp. With it all the light is thrown in a downward, and hence useful, direction, while an even distribution of light is produced over a wide area. An important point in favour of the adoption of the lantern is the comparatively low cost of glass renewals. It can be fitted with clear, fluted or muranese glass panes, fluted glass being always supplied unless definite instructions are given to the contrary.

It should be noted that by the employment of fluted or muranese glass the high intrinsic brilliance of the half-watt lamp is reduced without serious loss of light. It is stated in the leaflet that the adoption of opalescent globes, which latter absorb anything from 35 to 70 per cent. of the light emitted by the lamp.

All fittings are complete with standard goliath screw lampholders, mounted on anti-vibratory brackets, arranged in such a way that the position of the lamp within the globe or lantern is easily adjusted. When required for lamps burning in series any fittings can be supplied with internal cutouts and substitutional resistances at extra prices given in the leaflet. In most cases when lamps are required to burn singly on alternating current, fittings can be supplied with internal transformers, the extra price for which will be given on application.

On some installations full lighting is not always required, as for instance in the case of streets, railway stations and factories. For such conditions, therefore, the lantern fitting is arranged with a second holder to take a smaller lamp of comparatively low candle-power, this second holder being supported below the larger one.

The fittings provided with globes, and illustrated in the leaflet, are arranged to take lamps up to 1,000 watts, while the fitting with

Our Manufactures include:

Cables for Lighting, Power, Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

POWER FACTOR.

Various methods of minimising the serious disadvantage of a low lagging power factor have been put forward.

The most efficient and economical of these is

THE HELSBY CONDENSER

(Paten's Nos. 22139/05 and 14817/14),

which, unlike the others, entails no running losses and requires no skilled attention.

These condensers have been in operation on A.C. Power Distribution Circuits for several years past with most satisfactory results.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

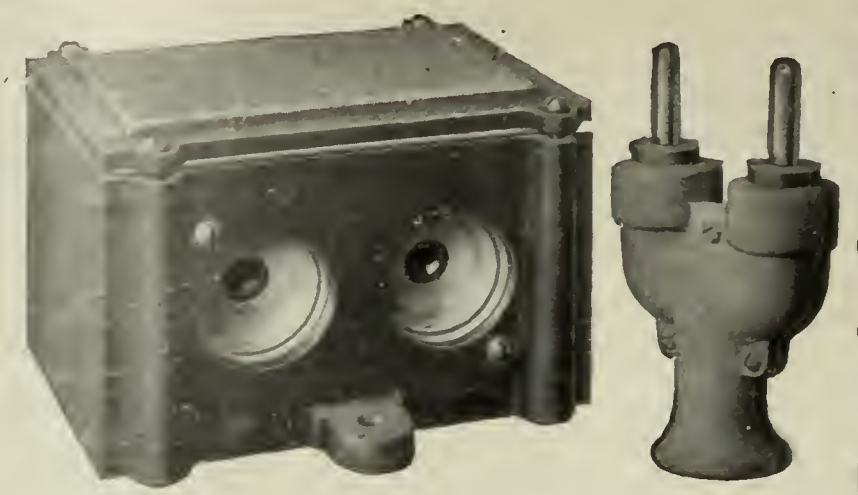
Works: PRESCOT and HELSBY.

Branch Offices in: LONDON, MANCHESTER, GLASGOW, BIRMINGHAM, NEWCASTLE, CARDIFF, DUBLIN, LEEDS & BELFAST.

OVERSEAS BRANCHES:

AUSTRALASIA: The Wool Exchange, King Street, Melbourne.
EASTERN INDIA: 11, Clive Street, Calcutta.
SOUTH AFRICA: Telegraph Manufacturing Co. (Colonial), Ltd., P.O. Box 2827 Johannesburg.

IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

the lantern shown, is arranged for lamps up to 1,500 watts. Standard fittings are arranged to take 1 in. diameter screwed conduit for suspension, but if required can be fitted with wheel insulator top at an extra price. The standard lantern fitting is finished in dark green and black, and the globe fittings are enamelled dark grey. Copies of the leaflet are obtainable from Crompton & Co., Chelmsford.

LAMP FILAMENT BREAKER.

A device for breaking the filaments of incandescent lamps which are returned to its supply department has been constructed by the Boston Edison Company, and is in regular use in the local lamp division.

Among the thousands of incandescent lamps returned as having been burned out by lighting customers are many which, though not entirely useless, are nevertheless unfit for further service. To prevent purchasers from sorting the units and re-selling those with filaments intact, a means of breaking the filaments of lamps of sizes up to 250 watt tungsten was sought. As a result, an apparatus with a laminated U-shaped core, weighing about 80 lb., was constructed. The core was wound with 55 lb. of No. 16 cotton-covered copper magnet wire, a gap being left sufficiently large to admit a large size unit between its jaws. The winding, in series with the resistance, is supplied from a 110-volt direct-current circuit. A powerful electromagnet is thus formed, whose field is produced by about 7,600 ampere-turns. A quick-acting lamp socket is arranged between the jaws of the U, and is supplied, in series with a resistance, from a 220-volt alternating-current circuit. In addition to this fixed resistance, another can be switched in in multiple.

As the lamps are pushed into the socket the effect is to break the filament instantly. The resistance in series with the lamp prevents short-circuiting on the 220-volt main in case of an occasional defective base. If, as sometimes happens with very large tungstens, the filament breaks and welds near the leading-in wires, the second resistance is thrown in series with the lamp, thus allowing more current to flow and invariably breaking the filament. The direct-current field is left on continuously while operating. With this machine filaments are broken as rapidly as the lamps are inserted in the socket and placed to one side, and the rest of the lamp is in no way injured nor is the blackening of the bulb increased.

Two interesting Drawings made by one of Messrs. Hadfields' (Sheffield) workmen. They typify the spirit which imbues the British employee in this war.



Tommy to Britannia : Yes, tell the Munition Workers to postpone their August Holidays. We want shells.



Hadfields' Workman : You see my comrade has plenty of shells We have got you on the run, and we'll keep you on the run!

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, September 8, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—(No, really now we are too bashful.)

* * * *

I will not apologise for being wholly reminiscent this week. A 2000th birthday is not to be sneezed at, as Methuselah and some of the other "early" electricians would have said.

* * * *

Foolish questions were also asked in 1886 : —

"Our contemporary, 'L'Electricien,' says that an amateur gravely asked the other day *with what liquid* the Gaulard and Gibbs' secondary generators acted."

* * * *

"The Brighton Electric Light Co. are now supplying power for nearly 1,000 incandescent lamps."

And to-day things can't be much better on the street lighting circuits.

* * * *

We could be frank in those as well as these days (my italics) :

"Recent experience seems to indicate that there is just as much right down solid fraud connected with the electrical as with any other industry—*and a little more.*"

* * * *

We could be quite sarcastic in our references to districts which did not aspire to electric light and other commodities.

At a special meeting of the Blackwall Town Council it was decided not to proceed with the Improvement Bill to revise and extend their electric lighting powers. We should like to hear something more of the proceedings of this Council. *We were not aware that Blackwall had attained to the dignity of a town.*

* * * *

"In the early eighties" (you find a lot of that in this issue) we allowed ourselves to look forward. We said on Nov. 15, 1885 :—

"Laputa will be rediscovered. Balloons, electrically navigated, will run regularly between this country and other parts of the world, at reasonable charges. But intending defaulters will notice that with improved telegraphic communication there is no safety from the cosmopolitan detective offered by this mode of flight."

* * * *

As in 1885, so now :—

"It is notified that telegrams for Servia, Bulgaria and Roumelia can now be accepted only at sender's risk."

* * * *

Here is one of the "early" poems :—

Oh my ! Ohm ! Ohm ! ! sweet Ohm ! ! !
Watt heart re-*volts* from thee ?!
The constant current of our souls
Flows on from unity.
Our every test
Has proved *thou* best,
Tho' damping aliens would invest
Thy name with lesser interest ;
That is, as we do know thee.
Tho' C's may lie 'twixt thou and E,
No Faraday may roam,
E can but make himself to C
By passing thro' his ohm.
Consoling thought—e-static dream,
Tho' quantities diminish,
And mortal coils must be unwound,
Our life's helix—ir passes round
Unaltered at the finish.

They could not even let Mr. Sutherland-Warner invent the electric road-roller :

"Mr. E. Gellerat's electric road-roller is again exciting attention. As will be remembered, it is driven by two dynamos and steered by another dynamo. About 100 accumulators are used and the gross weight of the machine is 18 tons. About 13 H.P. is developed altogether."

The speed in "yards per year" of the 18-ton roller is discreetly omitted.

* * * *

Some of our notes were in "lighter vein" in those days

"*The Electric Light of Asia.*—King's Palace in Corea is now lighted with electricity *of the Yankee brand.*"

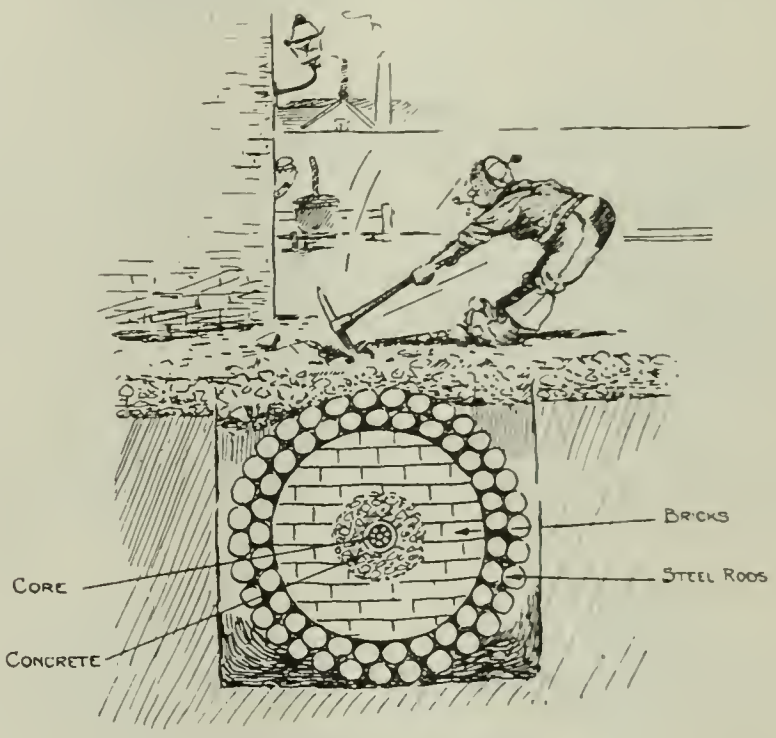
* * * *

"An electrician, of the firm of Ganz & Co., Budapest, has discovered a means of repairing the carbons broken in incandescent lamps and rendering them fit for service."

He does not seem to have done anything all these years!

* * * *

Why in the name of "Crompton, Doulton, Callender and Silvertown" didn't they invent this cable in the early eighties ?



"SCME" PICK-RESISTING CABLE.
[From *Glover's Almanac.*

There would then have been no "column of smoke tests" and no fusing-up of five-wire distributors until they became a "solid" system!

* * * *

"A ring of copper is placed round the neck of an empty bottle, which is further weighted till it will just sink, neck downwards, when placed in a larger glass vessel of water. Round the lower part of the latter are wound a few turns of insulated wire. When an alternating current is passed through the wire the flask will be seen to rise, owing to the repulsion between the currents in the wire and those induced by them in the ring. The experiment is due to Prof. Elihu Thomson."

The above dates back to about 1883, but it is, of course, not the only experiment in flask raising known to electrical men.

* * * *

We were always out for "copy," and early in 1886 we had an article entitled "The Sun—A Point of View," which began :

"Of marvels, one of the greatest is the sun, his wonderful heat, his resplendent light and the undiminished continuity of his glory. How few of us more than wonder at the strange and beautiful orb."

Anything of this kind nowadays is sent in to the Round Table !



No. 38. STARTER WITH REGULATOR

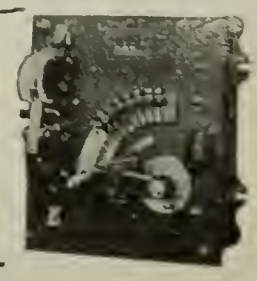
Compact and foolproof unit for starting up D.C. motors and regulating speed by shunt field control. No-volt and overload release trips both starting and regulating lever. Large number of steps give fine regulation.

'IGRANIC'

IGRANIC ELECTRIC Co LTD
147, Queen Victoria Street, London.

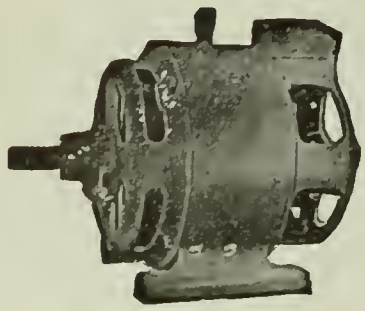
No. 27. "INCHING" STARTER

Widely used in Printing Works and Machine Shops. For frequent service and heavy starting. Interlocked clapper, switch makes and breaks circuit. Overload release operative during starting.

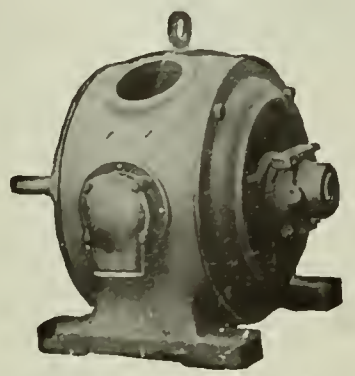


SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for

ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: 'SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

IN THE EARLY EIGHTIES.

The following notes are reproduced from issues of THE ELECTRICIAN *between* 1880 *and* 1887. *They are included in this issue because they give some impression of the work done during that period upon the practical applications of electricity.*

Taunton.—The organ at St. John's Church, Taunton, is to be blown by electricity. The posts to carry the wires have been placed across the lower end of the Crescent field, and the work is to be finished in about a week. It has created much interest in the town, and is being carried out by the Taunton Electric Light Co.

Alleged Electrical Fire at Lucerne.—An hotel was last week burnt down at Lucerne, and a statement appeared in the local papers, and have been reproduced in this country, alleging that the fire was caused by the electric light fittings. We have, however, received a telegram from Messrs. Ganz & Co., of Buda Pesth, contradicting that statement.

"Electrical Plant."—We are pleased to note the continued success of the monthly trade catalogue published by Messrs. Wheatley Kirk, Price & Goulty. In addition to the advertisements of new and second-hand plant, some editorial matter has recently been introduced which will tend to increase the value of the publication. The publishers write to us to the effect that subsequent issues will appear on the 1st instead of the 15th of the month, as heretofore.

Sheffield.—At the last meeting of the Sheffield Town Council the town clerk read a letter from Messrs. John Tasker & Co. asking the Council to adopt the electric light in the leading thoroughfares of the town, and saying they would be pleased to do it without much profit as an introduction. The town clerk thought that, in view of the Local Government Bill giving enlarged powers to the town, the Council would hardly sanction any such arrangement as that suggested at present.

A Big Ferranti.—A correspondent informs us that Messrs. Hick, Hargreaves & Co., Soho Ironworks, Bolton, have just built a large dynamo to the order of a London firm. The machine is of the Ferranti type, and is intended for the supply of 5,000 lamps, apparently 16 c.p. each. The armature is 9 ft. diameter, the weight of the field magnets is about 20 tons. The same firm are supplying a Corliss horizontal engine of 500 H.P., from which it is intended to drive the dynamo by ropes.

Trades Unionism.—We have received the following from Messrs. R. E. Crompton & Co.: Messrs. Crompton have been informed that it is the intention of the trade union not to allow piece work to be introduced into any of the new trades, such as they consider electrical engineering to be, and under these circumstances the company have no option but to part with such of their men who are members of the union. The affair is one of considerable interest to the whole of the electrical engineering trade.

The Nordenfelt Electric Torpedo Boat.—Mr. Nordenfelt has an electric torpedo boat of an entirely novel character constructing at Shuttleworth's Works at Erith. The greatest secrecy is maintained as to the details of the vessel, but we understand (says "Iron") that the torpedoes discharged from it will penetrate any torpedo net yet invented. This new vessel should not be confounded with the so-called Nordenfelt submarine torpedo boat, with which it is intended to co-operate.

Method of Saving Horses from Fires.—A New York man has invented a device to save horses in case of fire. It can be worked by electricity or by hand. At a certain temperature a bell will ring, and the moment the bell shall ring the doors will fly open, the horses will be unhitched and two small streams of water shall strike each horse in the face. To escape the water the horses will back out of the stalls, and once out of them they will have an opportunity of seeing a way of escape through the open doors.

Manchester.—The Manchester correspondent of the "Engineer" states that Messrs. Richard Hornsby & Sons, of Grantham, have obtained the contract for the whole of the engine and boiler power for the electric lighting, heating and ventilating of the enormous building which is being erected in Manchester for the purposes of Buffalo Bill's Wild West Show. Besides a large number of smaller lamps, there will be 25 large arc lamps; and there will be about 8,000 ft. of steam piping for heating. The Brush Company is supplying the electrical plant.

The Lighting of Exeter.—The "Western Morning News" says: The lighting of the streets of Exeter by electricity is a decided success. The arc lamps are hung at a much greater height on poles than was the case when a few trading establishments were being illuminated some weeks ago, and the result now is that the light is not nearly so dazzling to the eyes. It is spread over a wider area and gives perfect satisfaction The whole of High-street is thus lit and most of Queen-street. The gas has been put out on certain nights and the electric light tried by itself with great advantage.

Search Lights in the Navy.—The mimic naval operations of last year and the more recent tests of the value of the defences of Malta when attacked at night by vessels equipped with powerful search lights have conclusively demonstrated the utility of the electric light in all naval operations conducted under the cover of night. An order has now been issued that every vessel in the British Navy is to be so fitted, provided that the boilers are in a sufficiently good condition to admit of the requisite pressure being maintained, and no ship is to be constructed in the future without provision being made for at least four search lights. An officer specially appointed will supervise all electric fittings in ships of war dealt with in home dockyards.

A New Method of Propulsion.—The idea of propelling ships by forcing water out of pipes sternward has, as is well known, been put in practical application. An analogous method, which consists in forcing gases against the water, and thus establishing a means of propulsion, has been devised in Brooklyn, U.S.A. The system will, we are advised, soon be given a practical trial, the ship with which it is to be made having recently been launched. The method employed, briefly stated, consists in compressing a small quantity of air, which is then impregnated with petroleum spray. This is then exploded by an electric spark, and the large volume of gas generated is forced out at the stern.

The Transmission of Power in India.—The "Times of India" contains a description of a remarkable engineering undertaking at Gokak, where three turbines, each of 250 H.P., transmit power by rope gearing to a cotton mill at a distance of 739 ft., the first 300 ft. being up the face of a perpendicular cliff. The work appears to have been carried out in an especially skilful manner. If we mistake not, this is the enterprise about which some correspondence took place in our columns with regard to the feasibility of electrical transmission. We should have been glad if the engineers had seen their way to this, but it must be confessed that a scheme of such magnitude would have presented a stiff problem to electrical engineers.

Nottingham.—The application of electric motors to small industries is effectively illustrated in the show room of the Wheeler & Wilson Company in Nottingham, where a number of sewing machines are

ON MANY MACHINES

quick starting and stopping is of the utmost importance. Line your clutches and brakes with Ferodo fabrics and you secure the maximum acceleration and deceleration, for Ferodo fabrics engage sweetly and without jerk providing perfect transmission, whilst they absorb more foot-lbs. of energy per square inch than any other material known. The adoption of Ferodo lined brakes on the Underground Railways of London resulted in a four-minute service being converted into a minute and a quarter service owing to the rapid deceleration. In addition Ferodo fabrics prevent fire and short circuit caused by metal dust resulting from the metal to metal brakes, and they have proved to be three times as durable as the chilled cast-iron shoes previously used.

FERODO

CLUTCH AND BRAKE LININGS.

Contractors to the War Office and Admiralty, London General Omnibus Co. and Underground Electric Railways of London and Paris. List "X" from

The Herbert Frood Company, Ltd.

Works: CHAPEL-EN-LE-FRITH.

'Phones: 19 and 20 Chapel. Wires: "Friction, Chapel."

LONDON: 39, Upper Rathbone Place, W.

BIRMINGHAM: 202, Corporation Street.

We hold stocks at Belfast, Bristol, Cardiff, Edinburgh, Glasgow, Liverpool, Manchester and Newcastle.

C3.

BELLING

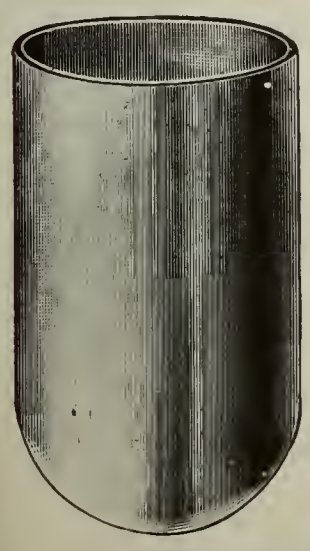
& CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialists, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,

STIRCHLEY, BIRMINGHAM.

Drawn Shell Work

IN BRASS, COPPER, and STEEL.

Any size up to 8″ diam. × 4″ deep.

Sole Agent for the Electrical Trade:—

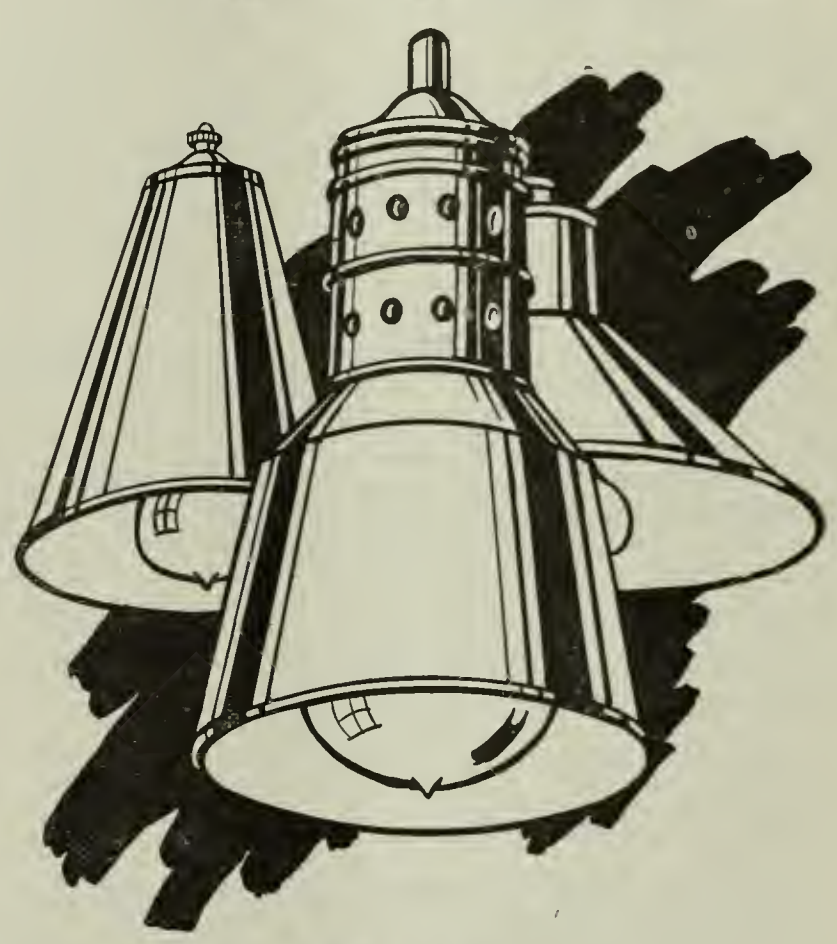
LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.



SIMPLEX

ANTI-ZEPPELIN REFLECTORS



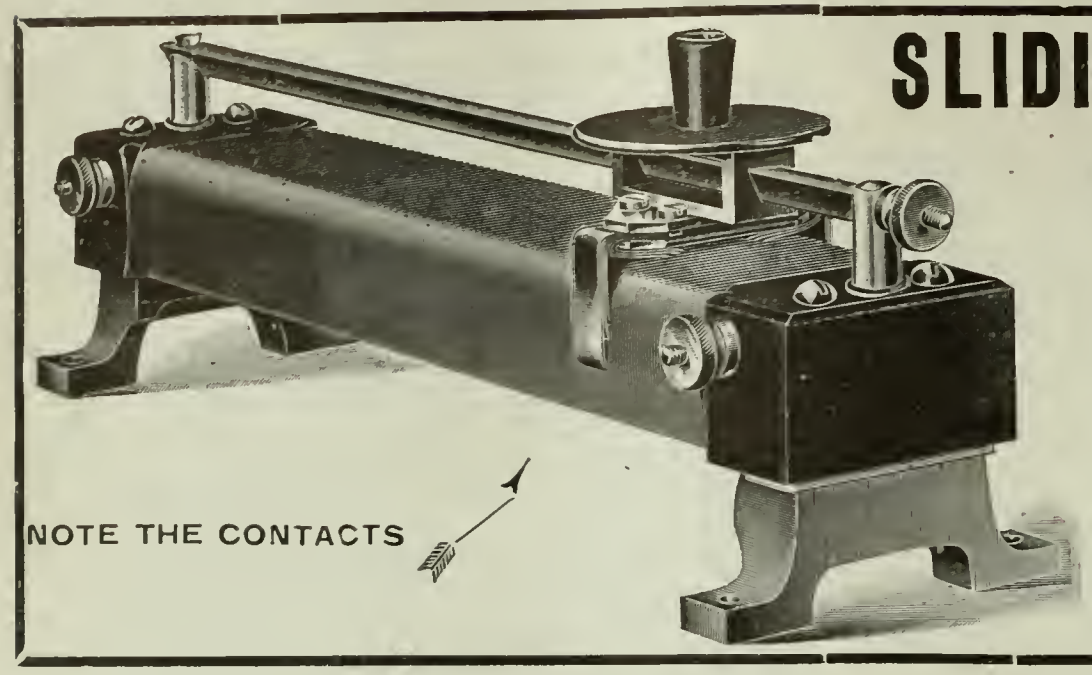
FOR FACTORY LIGHTING

we can deliver from stock

Simplex Conduits, Ltd.,

Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd. W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
1, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.



SLIDING RESISTANCES
FOR
LAMP TESTING
METER TESTING
LABORATORY WORK, Etc.
BRITISH-MADE THROUGHOUT.
New List on request.
Nature says: "The list is one of the most complete we have seen."
ISENTHAL & CO.,
(DEPARTMENT 4)
DENZIL WORKS, WILLESDEN, LONDON, N.W.
Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

IN THE EARLY EIGHTIES.—*Continued.*

shown at work driven by a half horse-power Immisch motor, receiving its current from a dynamo in one of the factories about 200 yds. distant. The work has been carried out by Mr. W. B. Sisling, late electrical superintendent of the Newcastle Exhibition, and great interest appears to be taken in the little motor by the spectators. We compliment the local manager of the Wheeler & Wilson Company on his enterprising display, and have no doubt that it will lead to business both in sewing machines and motors to drive them.

Long Dynamo Runs.—After quoting from our columns a note as to a continuous run of 28 days, which was recently performed by a Kapp dynamo on board H.M.S. "Devastation," the New York "Electrical World" proceeds to cap the story as follows: "This recalls a phenomenally long Edison run. In February, 1884, a plant was put in the post office, Boston, consisting of two of the first type of 250-light machines. Without previous testing—such was the urgency of the case—they were started, and were operated continuously for 97 days and nights, when the capacity of the plant was increased without any interruption in supply of the current to the circuits. The supply has not ceased from its going into operation in February, 1884, down to the present time."

An Electric Waiter.—The electric dining table in a restaurant at Sacramento is described as follows: In the room are 12 tables, with a seating capacity for 60 persons, and all attached to the long electric motor table. Printed bills of fare are on each table, and visitors order by marking on the bill, placing the same on the waiter, which is about one-half the size of an ordinary waiter, and pressing the electric button, which causes the waiter to revolve half-way round and into the long table, thence into the kitchen, where the order is filled and returned to the dining room. The arrangement is neat, noiseless, clean and comfortable, and to show with what smoothness the waiter does its work a brimming glassful of lemonade was ordered and it was served without one drop being spilled. The table avoids all the many annoyances of restaurant dining, especially of the "sing-song waiter."

Electric Heating.—Increased attention is being paid to the employment of electricity for the distribution of heat. Dr. W. Leigh Burton (of Richmond, U.S.) has recently introduced an electrical heater which we understand the Edison Company of the United States are not unlikely to adopt. This heater consists of a fine platinum or German silver wire, bent into a loop and covered with fireclay. An electric stove of a different type was recently described and illustrated by our contemporary the "Electrical World" of New York. This apparatus is modelled on the lines of an ordinary gas stove. It consists of a row of incandescent lamps placed in front of a burnished reflector in such a way that the lamps themselves are invisible, while the heat may either be thrown forward into the room or may be concentrated in an upward direction when it is wished to use the stove for culinary purposes.

A Foucault Current Water Heater.—One of the American companies has brought out an electric water heater for use with alternating currents. It consists of an ordinary kettle having rather a thick bottom. When this is placed above an electromagnet supplied with alternating currents, heat is produced by the generation of Foucault currents in the substance of the metal. This arrangement has some obvious advantages over the method of placing a resistance coil within the metal, but it is difficult to imagine that it can be equally efficient. A theoretical comparison of the amount of heat obtainable for a given expenditure of energy by the two methods would be interesting. It is useful to remember that 1,000 watt-hours is capable of raising 19·04 lb. of water from 0°C. to the boiling point, or of completely evaporating 2·95 lb. of water from 0°C.

The Bartholdi Statue Installation.—The 15-6,000 c.p. arc lamps by which the statue of Liberty enlightening the world is enabled to enforce the metaphor are supplied with current from an American dynamo driven by an Armington & Sims engine, the machine being run in a small shed at the foot of the pedestal. The dynamo runs at 870 revs. per min., giving 30 amperes at an E.M.F. of 700 volts. This is only 1,400 watts per lamp, without allowing for loss in leads, so that the arcs must have a high efficiency if they give the full nominal candle-power. The total weight of the machine is 3,700lb., the armature carries 240 lb. of No. 9 copper wire, and the field magnets are wound with 640 lb. of No. 5. The total electrical horse-power in circuit is 32, and 35 H.P. are required at the dynamo pulley. Duplex lamps are employed of the American type. They burn Wallis copper-coated carbons $\frac{3}{4}$ in. diameter with $\frac{1}{4}$ in. arc. The E.M.F. per lamp is 38 volts, which with 30 amperes is equal to 0·19 watts per candle.

Electricity in the Cemetery.—We mentioned a short time since that a society had been formed at Brooklyn for the prevention of premature interment by the adoption of a system of electric alarm. It is now stated that the idea has actually been carried into practice at Sandusky, Ohio, by the following means: Metallic rings are placed upon two adjoining fingers of the corpse in such a way that the slightest movement would bring them into contact, and thereby complete an electric circuit, in which is placed a bell and a set of annunciators to show the number of the vault from which the signal comes. The bell is placed over the bed of the cemetery keeper, so that he may be in instant attendance if required. This seems rather a gruesome idea (especially for the cemetery keeper); but if actually carried out on any extensive scale the experiments will be of extreme value in settling the horrible suggestions which have sometimes arisen as to the prevalence of premature burial.

An Extraordinary Mishap at a Central Lighting Station.—At a central lighting station in a certain town not far from London a very curious accident recently occurred which very nearly caused the entire breakdown of a series-wound high-tension dynamo on a circuit of 2,000 volts. In order to see whether a pole-piece was getting hot, an attendant unwisely attempted to spit upon it. We say unwisely because, not being a Yankee, he had not acquired the art of spitting straight, and, missing the mark, the field coil received the full benefit. The machine in question is an elderly one, and possibly the coils wanted a new coat of varnish; anyhow, in a very few minutes the cotton covering commenced to char, and a small arc began to play across the wire. It wanted still an hour to the time when the machine should stop running. By dint, however, of incessant "dabbing" with a handful of asbestos the arc was kept within limits until the evening's work was over. It was then found that the insulation had been destroyed to the depth of four layers of wire. Moral: This method of testing the temperature of pole-pieces requires some practice, and should only be undertaken by an expert.

The Cost of Electric Light Fittings.—Mr. Nelson Haxell, of Haxell's Hotels, London and Brighton, writes as follows to the "Daily News":

Our Manufactures include:

Cables for Lighting, Power, Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

"The Fuses were not affected."

Electrical Press.

"The Fuse Wire used by Wireman Jim"
"A simple fuse wire was to him,"
"And it was nothing more."

The fusing current of a wire varies so much with the nature of the metal, length of wire, whether wire is open or enclosed, size of terminals, initial temperature and so on, that to obtain real protection the safe way is to employ

PRESCOT ENCLOSED FUSES

which are calibrated to operate uniformly at a close approximation to the required overload.

See Pamphlet P 121.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

Works: PRESCOT and HELSBY.

Branch Offices in: LONDON, MANCHESTER, GLASGOW, BIRMINGHAM, NEWCASTLE, CARDIFF, DUBLIN, LEEDS & BELFAST.

OVERSEAS BRANCHES:

AUSTRALASIA: The Wool Exchange, King Street, Melbourne.
EASTERN INDIA: 11, Clive Street, Calcutta.
SOUTH AFRICA: Telegraph Manufacturing Co. (Colonial), Ltd.
P.O. Box 2827 Johannesburg.

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

TINNING FUNRACE
(Hall's Patents)
For COATING WIRES with Tin, Lead, etc. For use as a BATH.
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
The only Tinning Plant on the World's Market with Automatic Heat Control.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

IN THE EARLY EIGHTIES.—*Continued.*

"Nothing prevents the immediate universality of house-to-house electricity and our happy deliverance from gas, with its compound attendants of disease, dirt, villainous filthy smells, danger and a price per 1,000 ft. absolutely absurd at its present prime cost of production, but the absolutely prohibitory charges for what Hammond & Co. call 'the installation.' Could I only get installation at even a fair rate I would lay on the electric light in both my hotels immediately. Let us go into this. In my Brighton hotel I had arranged all costs of supply, wire and lamps—of which more anon—when they actually demanded of me an additional sum of £20 to give me unlimited supply day and night, without which in my business it would be useless. In other words, not having the fear of competition before their eyes, they insisted I should find £20 capital to enable me to be a good customer to them. So exit electric light for the present. Here in the Strand an electric company, beloved of Hammond & Co., have sent me in an estimate for installation amounting to £267. 10s. for wires and lamps, a rental of £15 per annum for fittings; one need not go into the calculation of the cost of the silk-covered wire. . . . This, Sir, is a round unvarnished tale, and until electric lighting companies can see that it is to their interest to reduce them, these prohibitory charges will prevent the introduction of house-to-house electricity and the 'good-bye at the door' to gas, with all its dangers, dirt and dearness."

"The Peacemaker."—One of the most striking illustrations of the uses of electricity in modern naval warfare is to be found in the submarine boat which has recently attracted much attention in New York Harbour, and which has been christened "The Peacemaker." Originally the intention was to propel the boat by electricity, but the trials are said to have been not altogether satisfactory, and soda motors have for the present been substituted. The fault in all probability lay with the accumulators, and we have little doubt that eventually electricity will be found to be perfectly adapted for the purpose. In the meantime the boat is, of course, lit throughout by incandescent lamps, and provided with means for firing torpedoes by electricity. The special novelty in the electric arrangements consists in the device whereby the torpedoes are attached to the keel of the ship which is to be destroyed. Two torpedoes are connected to the same cable, through which also four insulated wires are led within the boat. The current passing through one pair of wires traverses the coils of a powerful electromagnet whose poles are outside the shell of the torpedo. A cork float around the same end causes the apparatus to tend to float with the poles upwards. Thus, on diving underneath a hostile vessel the torpedoes, being liberated, immediately rise upward and grip the iron keel; they can then be fired from a safe distance by means of the second pair of wires. A false wooden keel would, however, considerably diminish the terrors of this formidable weapon.

A High-speed Engine.—During the last year or two it has come to be generally understood that large machines, driven at a comparatively low speed, were the best for electrical lighting purposes; but the lighting at the Lincoln's Inn Dining Hall and Library must be considered as an exception to this rule. The dynamo here is driven at no less than 12,000 revs. per min. by a Parsons high-speed engine, which justifies its title by running at the same rate. It requires some mental effort to take a statement of this kind seriously, yet there is no reason to regard the Parsons motor as a toy. It was shown in action at the Inventions Exhibition, running with unimpaired steadiness from the commencement to the close of the show. It is in reality a combination of turbines driven by steam, and consists of two series of parallel flow turbines to the right and left of a central steam inlet, the steam exhausting directly from the first turbine into the second, from the second into the third, and so on through 20 turbines in each series. The steam parts with a portion of its energy in each turbine, and finally escapes at a pressure not much above that of the atmosphere. It is claimed that this is the first motor that has ever been made to work at the actual velocity of the steam as it escapes from the boiler.

Dr. Silvanus Thompson on Electric Bells.—A very clear and interesting lecture was given on "Electric Bells" by Prof. Silvanus Thompson at the Royal Victoria Hall on Tuesday. Instead of yielding to the temptation of travelling hurriedly over a large space of ground, he confined his attention to this small department of electrical science, and explained it thoroughly. A number of experiments were shown illustrating both permanent and induced magnetism, and a variety of forms of electric bell were exhibited, from very sweet-toned bells of a small size to a contrivance intended to wake up servants, which, when once the button is pushed, goes on ringing incessantly till the tormented servant goes to the bell and pulls a handle. Dr. Thompson then went on to inquire where the power comes from to produce the results, for we can never have results without a cause. There is no such thing as "perpetual motion"; wherever we have power something must be spent to produce it. Here it is clear the power starts from the battery. What is used up there? In ordinary steam engines we burn coal, in a gun the fuel is gunpowder, in a battery it is zinc. Zinc is combustible in air, though not freely so, and in a battery it is burnt in acid, the combustion going on while the current passes and the bell rings, but at no other time. There are methods of obtaining a current without a battery—for instance, by turning a handle and causing a coil of wire to rotate in presence of a permanent magnet. But the same principle holds with all. Something is used up to obtain the power. In this case the man who turns the handle plays the part of the engineer, and the food which he has eaten is consumed to do the work. In the course of the lecture Dr. Thompson spoke of the large extent to which electric power is used in New England, as many as 200 shops in one town being supplied with it from wires laid under the streets, as our gas-pipes are laid. But for vested interests, he said, the same thing might be done in London, and power supplied to workshops with much economy both of space and money.

The Electric Light and Stage Effect.—At many theatres, both in London and the provinces, the electric light has been successfully used as an accessory to stage effect. It is not long since we described the very interesting and ingenious installation of arc lamps at Her Majesty's, and we have now to offer our congratulations to Mr. Edgar Bruce, of the Prince's, upon the manner in which he has availed himself of the facilities offered by the incandescent light. Thanks to this gentle illuminant, the theatre over which Mr. Bruce so ably presides is one of the pleasantest in London. Its auditorium is cool, excellently lit and entirely free from the oppressive odour which results from the combustion of gas. Not only is the installation carried to every part of the building, but great care, attention and taste have evidently been bestowed upon its arrangement. On the stalls level are the refreshment kiosk and smoking fernery, in which latter the incandescent lamps, half hidden amongst foliage or peeping out from curious little recesses, are most artistically grouped. In the kiosk there are but 12 lamps, in pairs, and in the fernery six only; but on the occasion of our visit they were working up to their full power and gave ample light. Theatrical criticism being somewhat out of our province, we must refrain from a commentary upon the merits of the "Great Pink Pearl," other than to say that it is very, very funny. In the last act, however, a fine effect is introduced by the instantaneous illumination of the interior of the Russian Embassy in Paris by incandescent lamps. An ordinary switch placed near the doorway, and actuated by an attendant in obedience to a simple request for "lights," transforms the stage

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

"THOR" High Grade Specialities
CASING and CAPPING CABLE CONNECTORS
CONDUIT COMMUTATOR COMPOUND
CABLES WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.
WRITE FOR PRICES & DISCOUNTS.
HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

FERRY | **FERROZOID**

CONSTANTAN | **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

C.A.V.

LIGHTING and STARTING



FOUR of seven Aeroplanes illuminated [for night flying by the Grahame White Aviation Company. In all 327 C.A.V. metal filament bulbs were employed.

CURRENT BEING FURNISHED BY PORTABLE BATTERIES CARRIED ON THE MACHINES.

THE extraordinary brilliance and length of beam given by the C.A.V. system is quite unequalled. It dispels the darkness with a light akin to day.

During a recent test a C.A.V. Electric Starter fitted to a 90 h.p. Beardmore equipped aeroplane continuously turned the engine for two minutes from cold, developing 1.4 h.p. The experience of the Royal Flying Corps at the Front makes clear the absolute necessity for instant starting without leaving the machine.

Full particulars of Lighting and Starting sent post free.

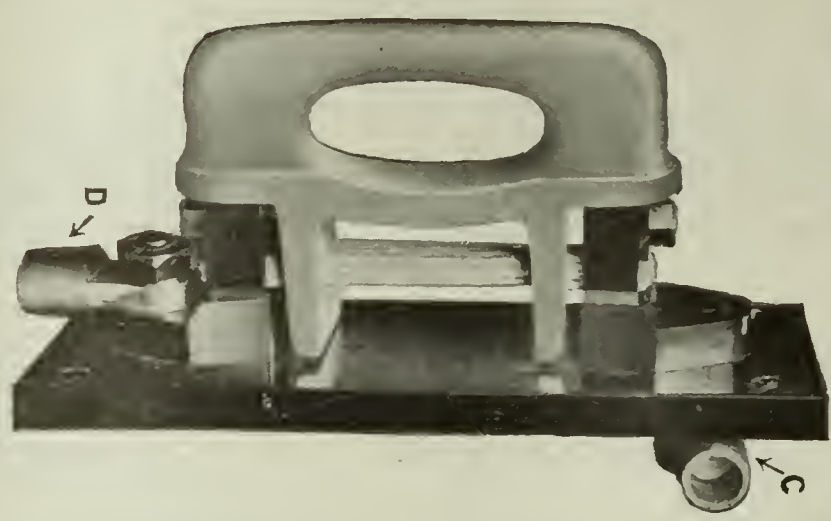
C. A. Vandervell & Co;
Electrical Engineers, ACTON, LONDON, W.

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

IN THE EARLY EIGHTIES.—*Continued.*

from almost total darkness to a sudden blaze of light, and produces a powerful impression upon the audience. The whole of the lamps are run from accumulators. The installation, as many of our readers will remember, was put down by Messrs. Strode & Co., who are also to be credited with the last-mentioned arrangement.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Amongst the "Notes" of your previous number there is one headed "In the Organic World," and you write: "We have an electric plant, an electric bug, an electric slug and three electric fishes." Why was the electric boy not included in this list? Was he not exhibited in London? He was exhibited in Edinburgh for a long time, and advertised in the newspapers. When I first saw the advertisement I considered it a trick of the showman, therefore did not go near the exhibition; but after meeting with a friend, a scientist, who had seen the boy, I went to see him. He was then exhibited in one of the small stalls in the gallery of the market in Princes-street. I found there a little black boy in charge of a white man. There was no furniture in the stall, but a couple of wooden seats and a small piece of carpet to keep the boy's bare feet off the floor. There was, therefore, nothing wherewith to conceal any electrical apparatus. As I was at that time the only visitor, I had the boy stripped naked, and was satisfied there was nothing outside of his skin that could produce electricity. While thus naked he walked in my presence, and also sat on the wooden seat with his feet off the ground. In every position in which I tried him I found electricity proceeded freely from his body when I touched it with one finger. The electricity came with the greatest freedom from the upper half of his body, and especially from his tongue. Although I felt a slight shock in my finger when I touched his tongue, he did not seem to feel any; his tongue did not quiver and he did not offer to withdraw it. I thereon asked him if he did not feel anything unpleasant when I touched his tongue. He replied, No! This surprised me much, because when an ordinary person is placed on an insulated stool, and there surcharged with electricity, and then touched by an uninsulated person, both parties feel the passage of electricity unpleasant; but not so this boy. He seemed to be so full of electricity that the passage of it from his body gave him no more uneasiness than the passage of perspiration from him.—Yours, &c.,

8, Merchiston Park, Edinburgh, JAMES JOHNSTONE.
Dec. 21, 1885.



SOME OF THE POSTER DESIGNS CONSIDERED BY THE SOCIETY FOR ELECTRICAL DEVELOPMENT, N.Y., FOR THIS YEAR'S "ELECTRICAL WEEK." THE CENTRE ONE IS THE "OFFICIAL" POSTER ADOPTED. (See article on "Publicity" on p. 887 following.)

Printed and Published by the Proprietors, "THE ELECTRICIAN" PRINTING AND PUBLISHING CO., LTD., at the Editorial, Printing and Publishing Offices, 1, 2, and 3, SALISBURY COURT, FLEET STREET, in the City of LONDON, FRIDAY, SEPTEMBER 15, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.—TANKS!

* * * *

Why they should be called "Tanks" has not yet been explained, but perhaps the idea originates with the chestnut which records that (before the war) an Englishman once said to a Frenchman "Au reservoir," and the Frenchman replied "Tanks"!

* * * *

Which reminds me of the man who collected three different kinds of water in three separate tanks, and in order to distinguish them he named them "Tink," "Tank," "Tunk."

* * * *

Since August 26th Niagara Falls has been illuminated at night with 100 lamps, each of 500,000 c.p. What a pity the Americans are not in the war! What a time the Zepps would have!

* * * *



[From *Glover's Almanac.*

AN ALLOY OF COPPER AND IRON.

There is such a boom in power-driven vehicles, electrics and otherwise, for municipal purposes just now that the advertisements in a well-known municipal weekly almost make it an organ of motoring. "It's an ill war that blows no one any good."

* * * *

The maximum demand system again, and its relation to war economy:—

You don't seem to understand that the more electricity we consume up to a certain point the cheaper it is for us. If we turned off these lights during the day, even for one week, our consumption would bring us under the higher rate, but by keeping the lights on all day we keep within the cheaper rate. In other words, the light which is now being wasted and a good deal more, costs us nothing.

Thus a Glasgow shopkeeper to an astonished customer who asked why his lights were burning during the daytime!

Engineers and commercial men in India, the Near East and South America are frequently badgered with letters from natives seeking employment. Many of these epistles are marvels of composition, and it is supposed that they are compiled with the aid of a Webster, a copy of Shakespeare and the Thirty-nine Articles. Here is a fairly good specimen from South America:—

28, Paulo Affonso Street,
1st Floor,
Pernambuco, Recife,
July, 1916.

Exmo. Dr. J. P. Kemp,
Recife.

GENTLEMAN,

Without any kind of affair which enables to employ plainly all my full experience although be in this town since the month of September of the preterite year, it was urged that I address myself properly to your office, engaging earnestly to get a place wither I could apply my scant dispositions, viz., English, written and spoken fairly, writing speedly in the French and Portuguese language on Typewriters of any device, besides several means of estimates.

Marry, we may born in mind that your office is already provided with sufficient and ideneous clerks, busied in his many concerns varied, this however shall not prevent you let the kindness of forwarding these lines, asking for an station there—in which soever which could be alotted.

As regards fee, I must state do not mind quarrels about, as aim but to be located, and thereon show you behovefully my line, whether if you are agreed with the suggestion before.

Upon the main, I want only to work, owing to assist the maintenance of the great family that my father bears, even (which is worst) under lack of money and of business; he's old enough and furthermore wasted his public federal employ, in which he worked approximately ten years averaging.

In faith is sure that my father us up (my brothers and I) in one of the better College as much as he could; but actually he's so handicapped that I've no doubt now to mostly help him, trusting you'll be the intermedial for the issue of my wish.

Further, Gentleman, you'll have all my true acknowledgement if you will satisfy the prime solicitation I've the liberty to submit, besides the greater thankness from my whole family.

Meanwhile, methinks will not see in this action other purpose than the inferrd from the practice of my ability, and from the behalf which will avail my parents and brothers together, tightened actually on the top, on account of the Principal bestayed, that is, affairless.

I do know anybody in the town trading management; therefore if reference are required from my while, I beg to tell you can take them from F. P. de Carvalho, Esq., located on the head sheet address, and from Mr. Manoel Ramires, a member from the firm Rodrigo Carvalho & Co., 67, Quinze de Novembro Street, as they are vouching for.

Thus, with best wishes, and hoping the favour of your esteemed reply,
I remain, Dear Sir,
Yours very faithfully,
Signed FRD. CORREA.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), Sept. 20, 1879.]

WHAT NEXT?—The French correspondent to one of the daily papers during the past week says "that a new reform is being advocated by the Paris press. The new reform which is suggested is to replace the guillotine by electricity. By this means, it is argued, instantaneous death can be inflicted without the hideous and unclean concomitants of the decapitating machine, and with the certainty that the consciousness of life will not survive the blow that destroyed it. I have reason to believe that when the Chamber reassembles a Bill will be brought in to substitute electricity for the guillotine as a means of inflicting capital punishment." A short time ago it was proposed on "humane principles" to slaughter animals this way. Not long ago electricity was used as a test to determine whether an individual who feigned being crippled was entitled to the comforts, &c., of one of our hospital wards. We may well ask ourselves "What next?" As long as capital punishment exists in our penal code, there is nothing unreasonable in designing methods to divest the matter of as much of its ugliness as possible, and whilst a great deal may be said in favour of electricity, on the humane side of the question, we fear the horror of experimenting on the living subject is too ghastly altogether.

L. P. S.
CLIPS, TIPS & TERMINALS
of all descriptions.
Write for Booklet, with Illustrations, of 75 types to:—
THE L.P.S. ELECTRICAL CO., 18, Adam Street, Strand, London, W.C.

SILVER SOLDER for BRASS,
Specially suitable for ELECTRICAL INSTRUMENTS.
Free Sample on application.
J. BLUNDELL & SONS,
GOLD, SILVER & PLATINUM REFINERS, 199, WARDOUR STREET, W.
"Goldplat, Ox., London." 4746 Gerrard.

SIEMENS

ELECTRIC MOTORS



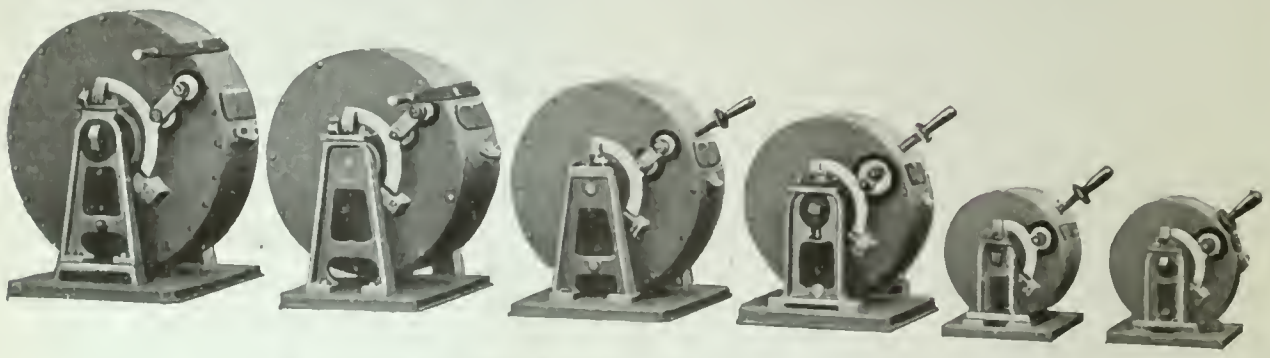
Part of small Motor Shop, Stafford Works.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: 'SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

SANDYCROFT LIQUID STARTING SWITCHES.

According to a new list just issued by Sandycroft (Ltd.), Chester, the Sandycroft patent enclosed liquid starting switches can be designed to suit practically any duty or control, and have in many cases been substituted for metallic controllers, owing to their greater reliability and the small amount of attention needed to keep them in working order.

The list contains a number of interesting illustrations of the latest pattern of this well-known starter, which is suitable for ordinary



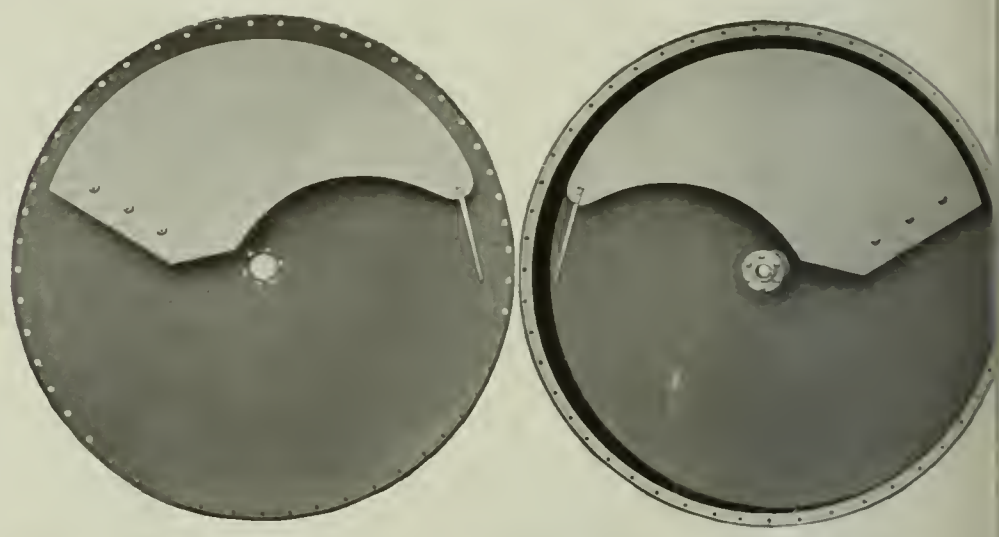
GROUP OF SANDYCROFT THREE-PHASE LIQUID STARTERS.

starting duty such as is required by workshop, mill, pump and fan motors. One terminal of the starter is permanently earthed, and is intended for connection to the earthed slip-ring of the motor. When an earthed slip-ring is not fitted it is immaterial in what order the connections are made.

To comply with Home Office Regulations a suitable cover is provided of sheet steel or expanded metal, and to meet the requirements of the Colliery Regulations a totally-enclosing mild-steel plate cover with plate vent is provided. For large starters these covers become too large to be practicable; oil-immersed contacts are then adopted.

With direct-current starters it is usual to fit an automatic free handle no-voltage release. With this arrangement the starter will automatically return to the off position on breaking the main circuit. An attachment can also be fitted which prevents the operator leaving the starter in any but the "full off" or "full on" position. Automatic overload releases can be provided if required; these work in conjunction with the no-volt release, and cannot be fitted separately.

Attachments can be fitted to the starters for operating them automatically by air, hydraulic or steam pressure. An illustration is given in the list which shows a standard starter for automatically starting and stopping a motor driving an air compressor. It is arranged to stop the motor when the air pressure in the receiver reaches the predetermined maximum limit, and again start the motor when sufficient air has been used to reduce the pressure to the minimum limit. With this arrangement a considerable saving in current is effected



INTERNAL VIEW OF DRUM AND DIPPERS IN SANDYCROFT LIQUID STARTER.

The Sandycroft liquid switch consists of a circular drum, in the lower half of which the electrolyte or liquid is contained. The height of the liquid is a little below the horizontal centre line of the drum. In the upper half of the drum the electrodes or dippers—which are semi-circular in shape—are mounted.

The dippers are supported from the sides of the drum by mild-steel bolts, which pass through substantial porcelain insulators of suitable design. The bolts connect the dippers with the sliding contacts on the exterior of the drum. Bearing on each sliding contact is a double laminated copper brush fixed to a suitable terminal block. Into the terminal block the cable thimble is fitted. The drum is provided with two trunnions supported in special bearings. One of the trunnions is utilised to convey the current of one pole of the circuit to the drum. This trunnion is fitted with a laminated brush bearing on a machined gunmetal bush, to which the cable lead is secured.

The drum is arranged for rotating through an angle of 135 deg. This angular movement allows for an almost complete immersion of the dippers into the liquid. In the "off" position the dippers are raised a suitable distance above the surface of the liquid, unless tips are provided to customers' order. When they are fully immersed they are entirely cut out of circuit (not merely shunted) by means of short-circuiting contacts carried on the sides of the drum.

To limit the speed of cutting out resistance, worm gearing is provided with handwheel operation. This is always provided on starters for large motors, but is only fitted to the smaller sizes when re-

GUARANTEED **SECOND HAND**
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

FURNACES for MELTING WHITE METALS, Etc.
(Hall's Patents).
WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.
PATENT MIXER PRODUCES HOMOGENEOUS ALLOY.
Monometer Heat-Controlled Furnaces for Heating the Moulds.
MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

Our Manufactures include:

Cables for Lighting, Power,
Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

Sinclair Solder.

The waste of resin in soldering is considerable, as everyone who has had anything to do with the subject knows. The percentage of waste varies according to whether the job is carried out on the bench or on an overhead line at the top of a ladder on a windy day, but the waste is always there.

In Sinclair Solder the resin forms a core, and is just exactly where it is wanted and in the right quantity for the job.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

Works: PRESCOT and HELSBY.

Branch Offices in: LONDON, MANCHESTER, GLASGOW, BIRMINGHAM, NEWCASTLE, CARDIFF, DUBLIN, LEEDS & BELFAST.

OVERSEAS BRANCHES:

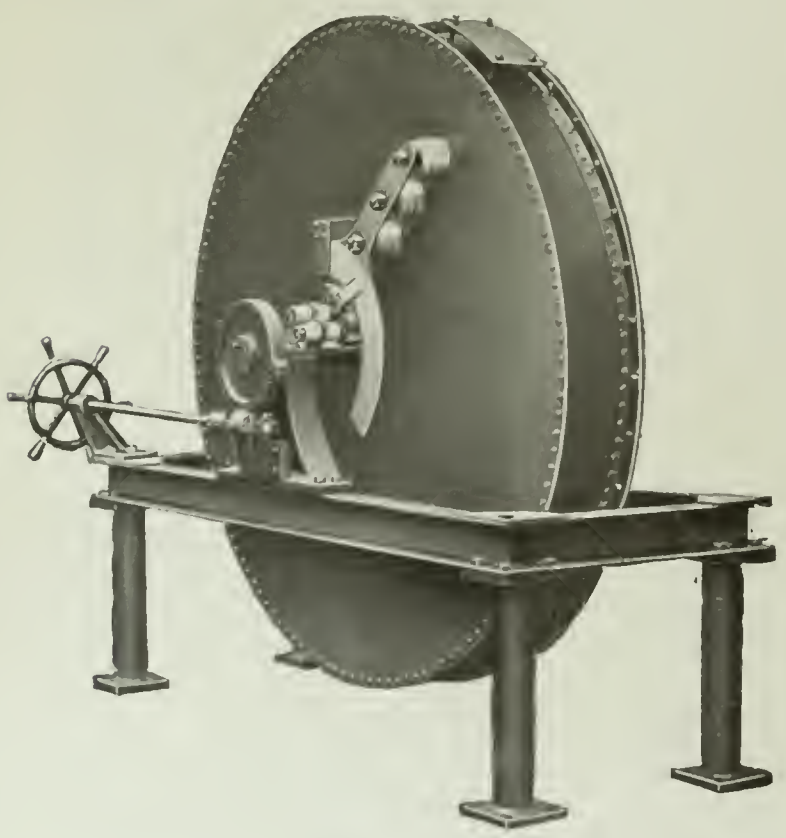
AUSTRALASIA: The Wool Exchange, King Street, Melbourne.
EASTERN INDIA: 11, Clive Street, Calcutta.
SOUTH AFRICA: Telegraph Manufacturing Co. (Colonial), Ltd.,
P.O. Box 2827 Johannesburg.

One, Two & Three Phase MOTORS.
LANGDON-DAVIES MOTOR CO.
Head Office: 110, CANNON STREET, LONDON, E.C.
Works: Dermody Road, Lewisham, London, S.E.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS, ELECTRIC HEATING & COOKING APPARATUS.

quested. Remote control can be arranged by means of shafting with worm or bevel gearing or by rope or chain drive. To prevent the main switch of the motor being closed, unless the starter is in the "off" position, interlocking contacts can be provided on the starter. These are arranged for connecting in series with the no-volt coil of the main switch, which can then only be closed when the starter is in the "off" position.

Standard alternating-current starters and controllers are built up with one terminal permanently earthed, as it is often usual with motor manufacturers to build slip-ring machines with one ring earthed to the shaft of the motor. The terminals can, however, be insulated if required.



Large Size Sandycroft Liquid Starter.

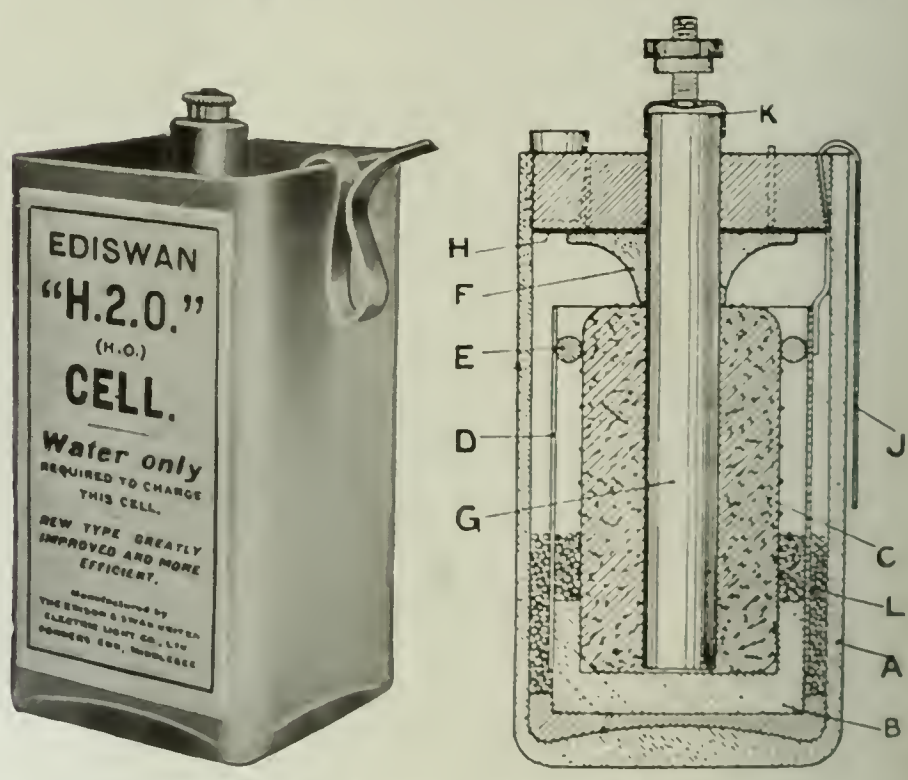
The electrolyte or liquid should consist of a solution of caustic soda or common washing soda and water. Owing to the various duties and loads for which the starters are required it is impossible to state the exact amount of soda needed, but the makers recommend the following method of ascertaining the correct density: Fill the drum with clean water, free from alkali or acid, to within ¼ in. of the liquid level when in the "off" position; a small quantity of a strong solution of soda should be added to the water in the drum. Then make an attempt to start the motor against its usual starting load. If the density is correct, the motor should start when the drum has been partly rotated and should be nearly up to full speed when the starter is nearing the short-circuited position. If an appreciable jump in speed occurs on short-circuiting, the solution is too weak, and a further addition of soda should be made; a further attempt to start the motor should then be made. By this trial-and-error method the correct density will soon be ascertained. If the solution is too strong the motor will start away too quickly.

To make up loss of electrolyte by evaporation it is only necessary to add clean water. The electrolyte should be renewed periodically, dependent upon the duty and the situation. For ordinary shop duty—*i.e.*, starting two or three times per day—once in six months will be often enough, provided the atmosphere is not very dusty. For heavy control work such as cranes, haulages, &c., the electrolyte should be renewed more frequently.

The illustrations given are taken from the list, a copy of which is obtainable from the company on request.

EDISWAN "H_2O" CELLS.

The Ediswan "H_2O" cell, described in leaflet B. 3,146, was introduced to meet the demand for a wet cell, smaller and more compact than the "Leclanché." It may be stored for any length of time and in any climate without any deterioration. It is not liable to creeping or evaporation whilst in use. Its internal resistance is low, and it is claimed that it does not polarise in use so quickly as wet batteries of the "Leclanché" type. The addition of water only is needed for charging. If the cell is required for instant use warm



External and Sectional Views of "H_2O" Cell.

water is recommended for filling. Distilled water should be used, if possible, as this tends to prolong the life of the cell by reason of the absence of iron or lime impurities, which are frequently found in tap water.

In order that the condition of the zinc electrode and the interior parts of the cell may be examined, the container consists of a clear glass jar, A. Into the bottom of this jar some hot bitumen is poured.

Manufacturers of
PHOSPHOR BRONZE,
GUN METAL, MANGANESE BRONZE,
Brass & Copper
Tubes, Sheets,
Rods, Wire, and
CASTINGS.
PHOSPHOR TIN.
PHOSPHOR COPPER.
TRADE MARK. SEA-CLIFF
CHARLES CLIFFORD & SON, LTD..
BIRMINGHAM.

INSULATION BEADS
The only satisfactory substitute for Asbestos Wire: also for flexible leads, etc. AMPLE STOCKS.
HOLDER-HARRIDEN. LTD.. 35/37, NOBLE STREET, LONDON, E.C.



Advt. of Pope's Electric Lamp Co., Ltd., Hythe Road, Willesden, London, N.W. *Greenly*

This serves to fix the porcelain base B in position. This base forms the support for the sack C, keeping it in a central position, and also a support and spacer for the zinc cylinder D, keeping it always the correct distance from the sack. It is this narrow space between the zinc and the sack which, to a large extent, makes the internal resistance of these cells so much less than "Leclanché" batteries. The top of the sack has a rubber ring, E, round it in order to further safeguard against the zinc cylinder touching the sack. Above the sack a specially shaped porcelain ring, F, is slipped over the carbon rod G, and this serves as a support for a waxed cardboard washer, H, which supports the sealing compound. Two holes are arranged in the sealing compound and the cardboard washer; in one of these is a fibre tube. This tube forms the funnel through which the water is poured when the cell is required for use, and is normally sealed with a cork. The other hole contains a small glass tube to allow the gases generated when the cell is in action to escape. A lead connection strip, J, is soldered to the zinc cylinder, and this is brought up at the side of the cardboard washer and through the sealing compound. This lead strip is provided with a punched hole to allow of connection to an adjacent battery, or it can be used with a wing nut and screw connection if desired. A brass cap, K, is forced on to the carbon rod, and the nut for wire connections screws on to a pin riveted and soldered to the cap. The ammonium chloride crystals L are placed in the cell at the time of manufacture; so that all that is necessary to make the cell ready for use is to remove the cork, fill the cell with water, and replace the cork.

The following are particulars of the cell: Dimensions over all, 6 in. by $2\frac{5}{8}$ in. by $2\frac{5}{8}$ in.; E.M.F., 1·5 volts; short-circuit current. 10 amperes; weight, $1\frac{1}{2}$ lb.; internal resistance, 0·2 ohm; discharge capacity through 20 ohms, 45 ampere-hours.

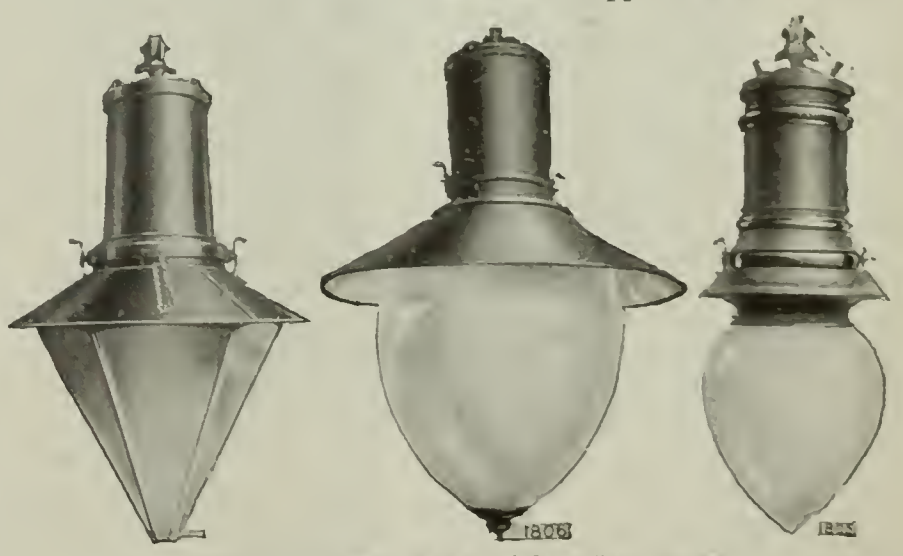
For the use of telephone, railway and other companies who have periodical visits made by their inspectors to installations, a "cell inspection" label can be supplied if desired, upon which records of 30 visits with inspector's name and date of visit may be made on two sides of the glass jar. The label may carry the customer's own distinctive name, address, or desired mark upon the third panel.

The cells when worn out may be sent to the makers in quantities to have the internal parts replaced as required and the battery recharged. A fixed charge for renovating batteries is made. The advantage of this is that customers can make a first purchase and continually return the same cells for renovation.

The Edison-Swan Electric Co. will send copies of the leaflet on request.

CROMPTON HALF-WATT LANTERNS.

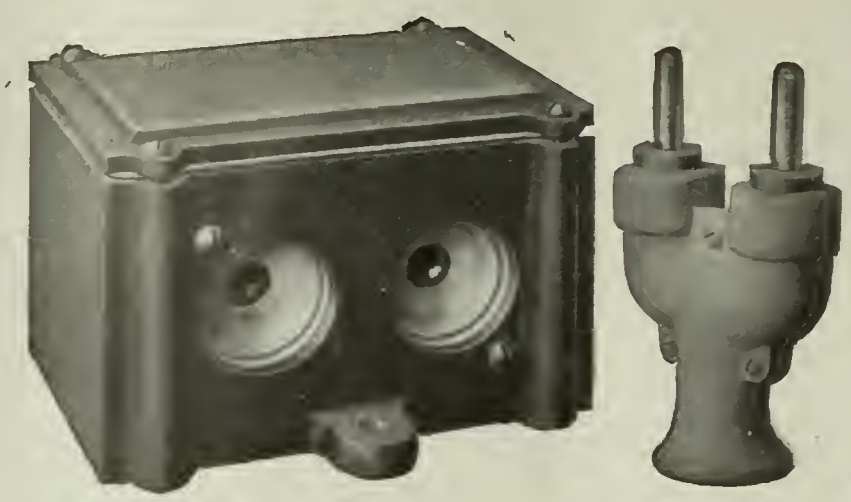
In our issue of Sept. 8 we commented upon the issue by Crompton & Co. of leaflet No. 551, in which a new range of lanterns for half-watt lamps is described. The illustrations of these lamps were not then to hand, but we now reproduce views of the lanterns which indicate their chief features. These lanterns are supplied with standard



Types of Crompton Half-Watt Lanterns.

goliath screw holders mounted on anti-vibratory brackets, which are arranged in such a way that the position of the lamp within the globe or lantern is easily adjusted. Series fittings and substitutional resistances can be obtained for these lanterns at slight extra cost. For single lamps on alternating-current circuits an internal transformer is offered. Fuller details of these interesting lanterns will be furnished on request.

IRONCASED SOCKETS & PLUGS
FOR HARD SERVICE.
Sizes up to 200 amps.
D.P. and T.P. 500 volts;
with "earthing" connection.
Also Combined Switch and Plug Boxes.



DORMAN & SMITH, Ltd.,
Ordsal Electrical Works,
SALFORD,
MANCHESTER.

LAMP CALLS v. CAB WHISTLES.

Now that whistling for cabs is at last to be put down, to some extent in London at any rate, perhaps sign makers, contractors and others will wake up to the fact that it is quite feasible to arrange over the portico or entrance of a building a lamp signal which will give a silent call by day or night.

One, two or three lamps would correspond with blasts on the whistle; and not so long ago would have signified taxi, hansom and growler. Nowadays, possibly, two lamps would suffice, to signify taxi and private car, or, perhaps, one lamp only. Whatever the number of lamps, up-to-date methods of switching provide various convenient ways of turning the lights on and off from various points; and the use of indicating lamps prevents confusion. Messrs. A. P. Lundberg & Sons published various methods some time ago, and a simple one for two lamps may be described briefly as follows: A lamp indicator in the entrance and another in the office (of the hotel or club, &c.) shows the condition of the sign. As soon as the cab draws up, the man at the entrance switches off the call. Either he or the office can then start another call. Before signalling a call, the office waits till its indicator shows blank.

SCIENTIFIC LIGHTING FOR RAILWAYS.

In these days in which one crouches in the corner of a darkened railway compartment and prays that the journey will soon end, it may seem out of place to speak of illumination and railways in the same breath. Yet despite lighting restrictions the railway companies are evidently alive to the importance and economy of method in the illumination of their principal stations and the compartments on the trains. A new booklet just issued by Holophane (Ltd.) lends point to this suggestion, for it contains many excellent illustrations of work which has already been done in the scientific illumination of railway platforms, booking halls, waiting rooms, offices, warehouses rolling stock, goods sheds, sidings, yards, &c. The photographs have



Hotel Foyer Lighting.



Holophane Fittings in a First Class Saloon Carriage.

mostly been taken by the light of the holophane units themselves and they depict good distribution of light with a minimum of glare: the effect in the compartment and saloon carriages is excellent, and indicates the provision of comfortable lighting.

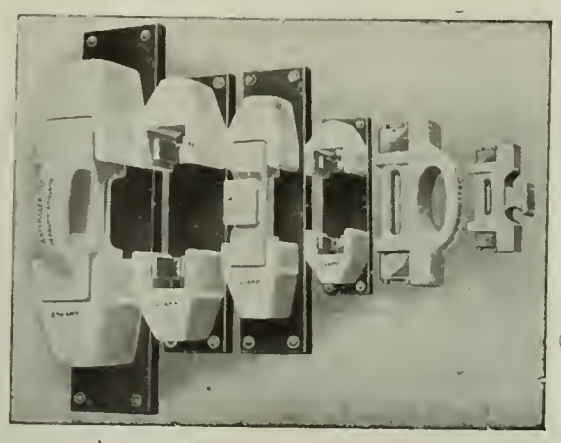
In the booklet particulars and prices in tabular form are included of holophane industrial reflectors, which are recommended for use with half-watt lamps, in the lighting of open spaces and large shops. These reflectors, which are offered complete with lampholders, are

LEWIS'S SCIENTIFIC CIRCULATING LIBRARY.
ELECTRICAL, MECHANICAL & GENERAL ENGINEERING TEXT BOOKS & TECHNICAL WORKS.
New Works and New Editions can be had from the Library immediately on Publication. Telephone: MUSEUM 1072.
SUBSCRIPTION, Town or Country, from ONE GUINEA. READING ROOM open Daily to SUBSCRIBERS.
H. K. LEWIS & Co. Ltd., 136, GOWER STREET, and 24, GOWER PLACE, LONDON, W.C.

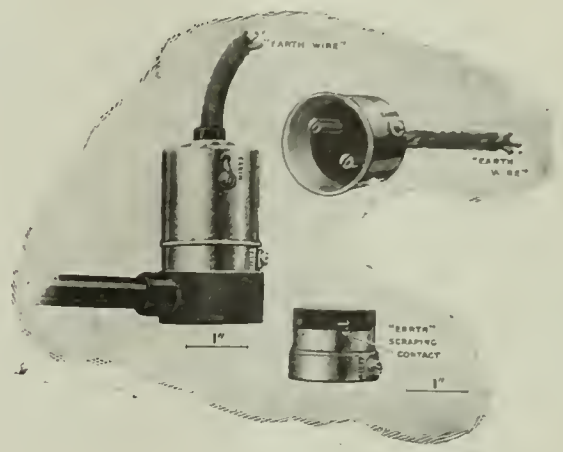
REYROLLE'S

Six Special Lines.

FUSES.



PLUGS AND SOCKETS.



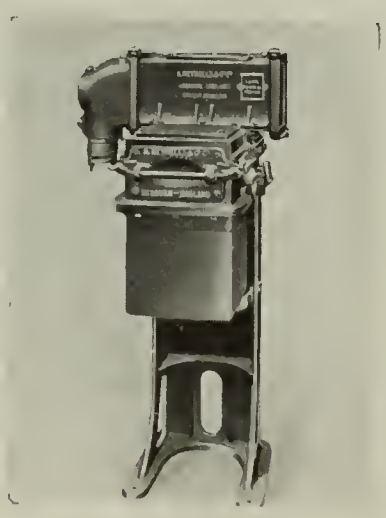
ARMOURED SWITCHGEAR.



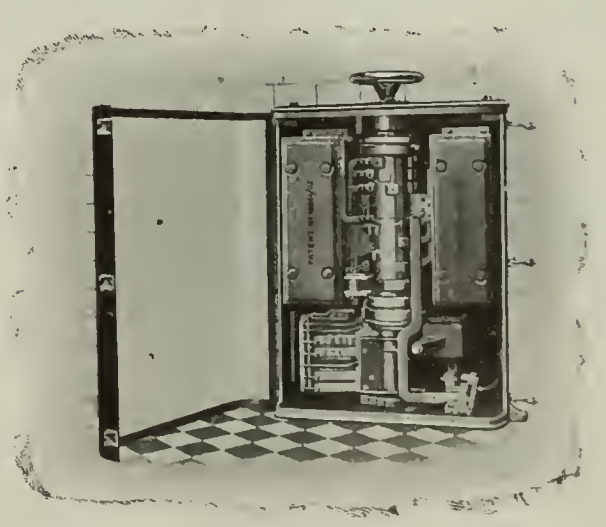
PROTECTIVE SYSTEMS.

Protective devices for A.C. Systems to isolate faulty sections instantaneously without interference with healthy sections. Also Relays for time limit, release current transformers, etc.

MINING EQUIPMENT.



MOTOR STARTERS.



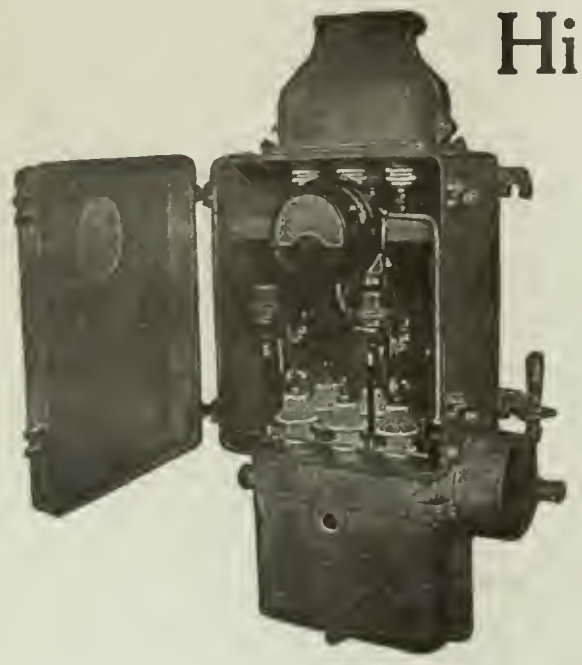
A. REYROLLE & CO., LTD.

HEBBURN-ON-TYNE.

On War Office, Admiralty, and India Office Lists.

The Electric & General Works, Ltd.,

15, Victoria Street, London, S.W.



OPEN.

High Tension Switch Boxes

for 3,000 and 6,000 Volts.

TRIPLEPOLE AUTOMATIC OIL-SWITCH.
DOUBLE INTERLOCKED DOOR.
OVERLOAD & UNDERLOAD RELEASE.
AMMETER.
INVERSE TIME LIMIT ATTACHMENT.
FIRE-DAMP SAFETY DEVICE.



CLOSED.

Other Types for all purposes.

ELECTRICAL APPARATUS up to 80,000 Volts.

Telephone: 5223 VICTORIA. Telegrams: "GABIONAGE VIC. LONDON."

made in the indoor and outdoor types, and can be used with lamps from 150 to 1,000-watt size. The reflectors are supplied, according to requirements, in the extensive, intensive and focussing types, the first named being for low ceilings, the second with average ceilings and the third for high ceilings.

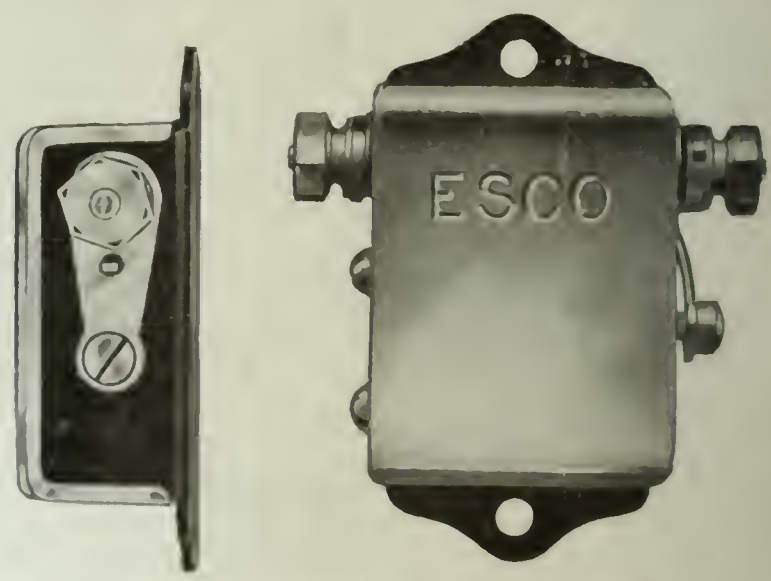


Hotel Corridor Lighting.

The booklet will be found to contain many useful notes on illumination generally. A copy may be obtained on application from Holophane (Ltd.), Carteret-street, Westminster, London, S.W.

THE "ESCO" BUZZER.

A buzzer weighing only 2 oz. and measuring $2\frac{1}{2}$ in. by $1\frac{3}{4}$ in. by $\frac{5}{8}$ in. must have a future before it! The Edison Swan Electric Co., who are calling the attention of the trade to this decided novelty, point out that it will be found better than a bell in rooms where a large box is unsightly, inside indicator boards, on or inside telephone



Front and Side Views of "Esco" Buzzer.

sets, in messengers' lobbies, for lifts and fire alarms, and also on motor cars. It will work equally well on 2 to 10 dry cells, and has a resistance of 2 ohms. By means of a screw adjustment outside the case 12 differently-toned notes can be obtained: the make and break is fitted with gold-silver contacts. The finish is black japanned with nickel-plated cover.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2, and 3, Salisbury Court, Fleet Street, in the City of London, Friday, September 22, 1916.

THE ROUND TABLE.

By "KVA."

EVENT OF THE WEEK.- The "Journal of Gas Lighting," in complimenting us upon our 2000th Souvenir Number, congratulates us on a career of good service to the electrical industry, and with all sincerity wishes us "Many Happy Returns of the Day."

* * * *

The Edison & Swan Electric Co. call the attention of the trade to their "H.2.O cell." This is a little unkind when one remembers that in the electrical industry H_2O has always been looked upon as one long sell!

* * * *



"UPLIFTED."

[From *Glover's Almanac.*

Rumour had it at one time that the Electro-Harmonic Society would not "carry on" during the coming winter season. Its voice is silenced by the issue of the programme which will be "as before," and, in spite of Zepps, the concerts will commence at 8 p.m., even on Ladies' Nights.

* * * *

I had hoped to have had a rest from Electro-Harmonics and Unofficial Programmes this season, but the latter will appear as usual. If any reader of the Round Table cares to contribute items for these programmes I will award an ELECTRICIAN Hot Plate for every "item" accepted. I may as well divulge my own method of procedure in drawing up the programmes, and this will perhaps assist contributors. I turn over the pages of a music sellers' catalogue or the latest list of gramophone records; at the same time I have at the back of my mind some item of topical electrical interest. If I chance on a song or a march to fit it, "Well, Voilà!"

* * * *

Any items for the first programme, which will be published on October 13th (the night of the first concert), should reach me not later than Tuesday, October 10th.

THIS WEEK'S MORAL DON'T WORRY. When one is a soldier, it is one of two things. Either one is behind or in front. If one is behind, there is no need to worry. If one is in front, there are two alternatives: One is either in a dangerous place or in a cushy place. If one is in a cushy place, there is no need to worry. If one is in a dangerous place, it is one of two things: One is either wounded or one is not. If one is not, there is no need to worry. If one is wounded, it is one of two things: One is either seriously wounded or lightly wounded. If one is lightly wounded, there is no need to worry. If one is seriously wounded, it is one of two things: One either recovers or one dies. If one recovers, there is no need to worry. If one dies, one cannot worry. Under these circumstances, the real Tommy never worries.

* * * *

What is the telephone etiquette when answering the query from the other end of the wire "Who is that speaking?" I find that custom varies. Many men always say "*Mister* Smith speaking": others are satisfied with the unadorned surname; just "Tell him Robinson wants a word with Mister Brown." Perhaps the best "get out" is to use one's initials:—"A. B. C. Jones here," but that is a by no means usual form of telephone manners. Will the Editor of the "Post Office Telephone Journal" oblige with a solution?

* * * *

OUR HOT-PLATES.

No. 216 to—

Holophane (Ltd.) for issuing a catalogue on the Lighting of Railways and Railway Stations during the Zepp. season.

* * * *

THIRTY-SEVEN YEARS AGO.

[From THE ELECTRICIAN (Second Series), Sept. 27, 1879.]

ELECTRICITY APPLIED TO BEE-REARING.—A correspondent of the "Deutsche Presse" describes a method which he has adopted with success of overcoming the obstacles frequently presented to the rearer of bees by the self-will of those interesting and profitable insects. This is no other than giving them an electric shock. Everyone interested in bees knows the difficulties and dangers involved in hiving a swarm. One is often seen on a hot day in June in the top branches of a tree not to be climbed, and another in some inaccessible place seems to be preparing to set out on its wanderings. If the beemaster venture to approach, all his dexterity and experience will often not prevent him from being seriously stung. There are, indeed, several cases on record of death supervening from the stings inflicted on such occasions. Herr Freiwith, the correspondent referred to, hit upon the idea of employing the electric force to stupify the bees. Trials on large and small clusters, and even on single insects, answered perfectly, the bees coming in contact with the conducting wires fell stunned and motionless to the ground. They were then sorted and marked, according to the strength of the current applied. The time required for their recovery, varying from 10 minutes to eight hours, was proportionate to the strength of the shock, but all came out in their trance safe and sound. Encouraged by the result of this experiment, Herr Freiwith resolved to try it on a larger scale, namely, on bees in the hive. To this end he introduced the ends of two conducting wires into a fully occupied honeycomb, and turned on the current for a moment: the bees soon lay on the ground, and it was half-an-hour before they resumed activity. Herr Freiwith then constructed an apparatus in a small box, 6 in. each way, which, similar to a cartridge pouch, he wore with a strap round his body. The two wires of the apparatus were when required to be used, fastened to rods of a suitable length, the wires of course always projecting over the ends of the rods. These ends were then applied to the swarm, a knob similar to that employed for a room telegraph being attached to the apparatus, that the current might be turned on at the proper time. Everyone is, of course, not skilful enough to construct such an apparatus, though none are precluded from doing so, as Herr Freiwith has not patented it.



No. 74.—Direct-Current Single-Pole Clapper Switch, with magnetic blow-out for remote control of lighting and power supply. Used in conjunction with starting and regulating resistance, they automatically start, stop and control the speed of motors by current limit or time limit method.

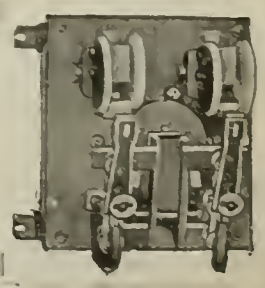
'IGRANIC'

CONTACTOR SWITCHES.

IGRANIC ELECTRIC Co LTD

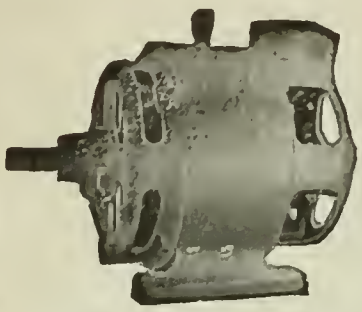
147, Queen Victoria Street, London.

No. 33.—Alternating-Current Double-Pole Clapper Switch. Controls all types of A.-C. Motors. For remote operation by tumbler switch, float switch, pressure switch, time switch, tappet switch, etc.

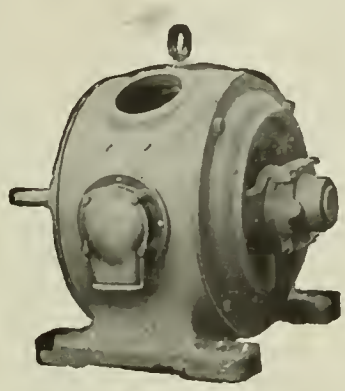


SIEMENS

STANDARD
ELECTRIC MOTORS



For Direct Current.



For Three-phase Current.

for
ALL OUTPUTS, SPEEDS AND VOLTAGES.

SIEMENS BROTHERS DYNAMO WORKS LIMITED
HEAD OFFICE: CAXTON HOUSE, WESTMINSTER, S.W.
Telephone: GERRARD 860. Telegrams: "SIEMBRALOS, VIC, LONDON."
Supplies Dept.: 38 & 39, UPPER THAMES STREET, E.C.
Telephone: CITY 5350. Telegrams: 'SIEMOTOR, CENT., LONDON."
HOME BRANCH ADDRESSES:
BIRMINGHAM—Central Ho., New St. | MANCHESTER—196, Deansgate.
BRISTOL—30, Bridge Street. | NEWCASTLE—64-68, Collingwood
CARDIFF—89, St. Mary Street. | SHEFFIELD—22, High St. [Bldgs
GLASGOW—66, Waterloo Street. | SOUTHAMPTON—46, High Street.
Branches in Principal Towns Abroad.

LABORATORY OZONE GENERATOR.

The type 71 ozone generator has been designed by Ozonair Ltd. to permit of producing high concentrations of ozone from air. By its use as much as 16 grammes of ozone per cubic metre of air (or 8,000 parts per million by volume) are readily obtained—or in other words, about 6 per cent. of the oxygen of the air can be ozonised. The apparatus is constructed on the Ozonair principle, offering a large cooling surface for the dissipation of the heat incidental to the generation of ozone. It is enclosed in a lead-lined containing tank, which is cooled by water for low concentrations and preferably by a freezing mixture of ice and salt or other suitable material for the higher concentrations. Its capacity at the highest concentration is about 2½ litres of ozonised air per minute, but a much larger volume is available at lower concentrations. The use of oxygen instead of air, or a mixture of the two, is optional. The efficiency of the apparatus is high for its size, being about 25 grammes of ozone per kilowatt at the high concentrations. The apparatus is supplied with a specially wound transformer (type 82½), fitted with an additional high tension terminal, permitting of a wide range of regulation from the lowest to the highest concentrations.

When an alternating current supply is not available it can be obtained by the use of a rotary converter which is operated by the continuous-current supply. The converter (type 93) supplied with the set is designed for continuous working and is fitted with ball bearings and will run for long periods without attention. A switchboard, complete with main double-pole switch and fuses, 5-point regulating switch for the transformer, and ammeter for indicating the current used, is a necessary part of the equipment. Where the electric current supply is continuous, a starting switch for the converter must be added.

For the purpose of accurate estimation a special test meter is furnished if desired. This meter measures the volume of air passed. The large dial is marked for a total of 10 litres divided into tenths of a litre, so that it is possible to measure with great accuracy. In addition to the centre dial there are three smaller dials to register a total of 10,000 litres. The dials can be graduated in cubic feet if specially ordered.

The set, which includes the afore-mentioned apparatus, comprises air cleaner, test meter, two drying bottles, safety bottle, ozone generator, a second safety bottle and treatment bottle, which are set up in the order named, together with the necessary electrical accessories and tube connections. A drawing in the leaflet shows the method of connecting up the various items of the complete apparatus as disposed on the laboratory bench or table, but the electrical accessories may be fixed in any other convenient position. For instance, the converter (if the electric supply be continuous) may be placed on the floor, and the switchboard fixed on the wall at the back of the bench whilst the transformer could be placed on the bench, behind the ozone generator.

The apparatus is priced and illustrated in a leaflet just issued by Ozonair Ltd., Victoria-street, London, S.W.

ELECTRICALLY HEATED JAPANNING OVENS.

BY G. B. M.

In selling the product of a factory engaged in any line of manufacture, perfection of finish is of almost as great importance as the mechanical perfection of its mechanism. A competitor often wins out with an inferior product because he has provided it with a durable finish; and the man who is making a really superior product would only have to pay attention to this detail in order to greatly increase his sales. Provided it is properly applied and baked, there is no better finish than ordinary black enamel—commonly called black "japan"—for bicycle frames, automobile parts, hardware specialities, and a great variety of other products. The articles to be japanned should be thoroughly cleaned to remove all dirt, dust and grease; and for this purpose sand-blasting will be found to give satisfactory results. The method of applying the japan will necessarily vary according to the product; dipping will be found most satisfactory in those cases where this method can be employed; in other cases spraying will give the best results; and in certain instances it will be found necessary to apply the japan with a brush. By consulting any reliable manufacturer of japan, advice may be obtained as to the best method to employ; and this advice should be followed, as the method of applying the finish will vary with the nature of the japan as well as with the character of the product to which it is applied.

One of the most important factors in obtaining a satisfactory finish by japanning consists in baking the japan properly after it has been applied. The best grades should be baked at a temperature of from 350°F. to 375°F., and it is not practical to use steam coils for this purpose. Gas burners are commonly employed, but this method has so many disadvantages that numerous firms have resorted to the use of japans which can be baked at a lower temperature, sacrificing the quality of the finish applied to their product in order to overcome the objectionable features of this method of baking. With the japans that can be baked at a low temperature, heat is applied by steam coils.

About three years ago the firm by which the writer was employed had a discouraging experience with its gas-heated baking ovens, but rather than resort to the use of japans which could be baked at a low temperature and thus sacrifice the quality of finish on its product, the engineers of this firm started to experiment with electrically-heated ovens for baking the japan. For this purpose some discarded street-car heaters were purchased from a local traction

GUARANTEED SECOND HAND
MOTORS
THE VICTORIA ELECTRIC PLANT CO.,
SPENSER STREET, WESTMINSTER, S.W.
Phone: Victoria 4026. Grams: Vicminster, Sowest, London.

FERRANTI LTD
HOLLINWOOD, Lancashire.
SWITCHGEAR, TRANSFORMERS, METERS,
ELECTRIC HEATING & COOKING APPARATUS.

Canadian and Indian MICA

CUT, SLAB & SPLITTINGS.

MINIMUM STOCK 200,000 lbs.

Peerless Leatheroid Insulation.

Dynamo Tapes, Hollow Braid, Empire Cloth.
Pure Asbestos Ribbons, Paper, Tubes and Sheets.
Pure Asbestos Woven Tape and Hollow Braid.
Vulcanized Fibre Sheet, Tube and Rod.
Ebonite Fibre, Sheet, Tube and Rod.
Presspahn and Insulating Papers, Felts, Baize.
Electrical Pure Rubber and Adhesive Tape.

WE HAVE BEEN AWARDED THE CONTRACT FOR THE WHOLE OF THE MICA REQUIRED BY BRITISH ADMIRALTY OVER 1910, 1912, 1913, 1914 and 1915.

ATTWATER & SONS,

Telegrams: Attwaters, Preston.
Telephone No. 1045 (2 lines).

Hopwood St. Mills, PRESTON.

Established 1868.
Codes: 5th Edition A B C & Western Union.

BELLING

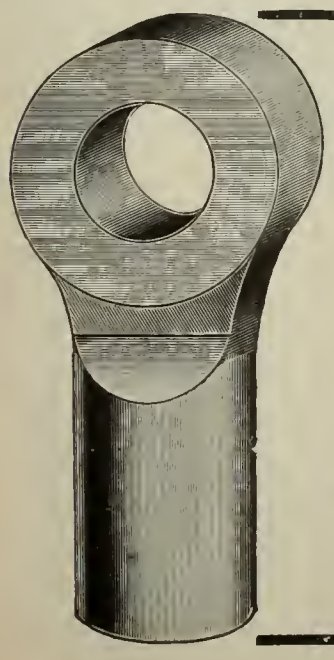
& CO.

We can quote you for and are regularly supplying :—

Electric Heaters for Shell Drying Ovens.
Gas and Fire-proof Heaters for Loading Rooms.
Immersion Heaters for Wax Melting.
Air Warmers for Fabric Drying Rooms.
Low Temperature Radiators for Work Rooms.
Electric Fires (Radiant type) for Offices, &c.
Electrically-heated Water Tanks to deal with any quantities.
Thermostatically controlled apparatus to keep either water or air at any desired temperature.
Electric Toasters, Water Boilers and Grillers for Mess Rooms.

We have had large experience in adapting electricity to many novel manufacturing processes, and are prepared to submit quotations and drawings to meet any given conditions.

BELLING & CO., Electric Heating Specialists, Derby Road, EDMONTON, LONDON, N.



E. SHOWELL & SONS, LTD.,

STIRCHLEY, BIRMINGHAM.

Cast Cable Sockets.

Suite E74. Made in all Sizes.

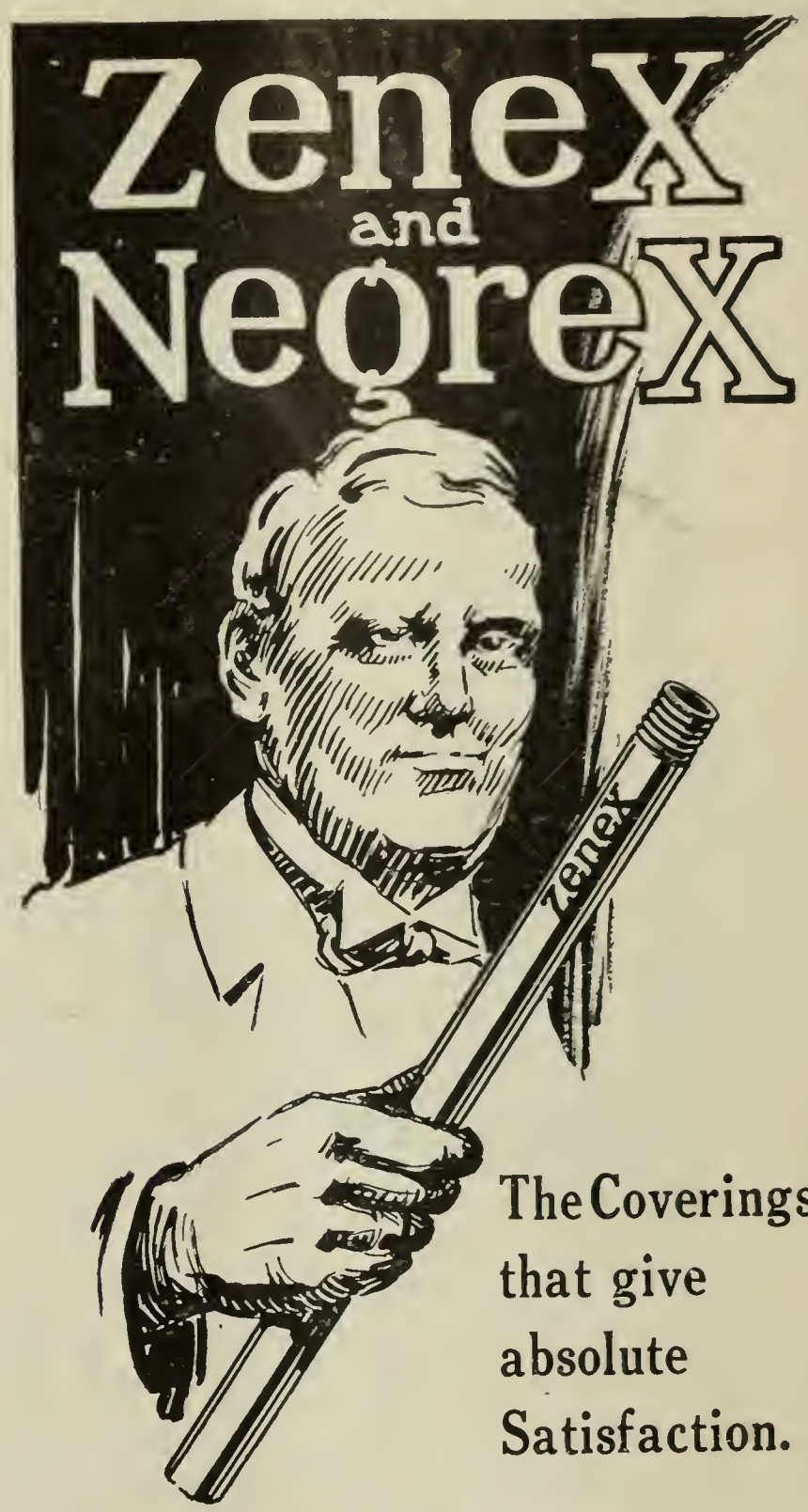
Type A.—Straight.
,, B.—Offset.
,, C.—Right angle.

Illustrated Dimensioned Showcard for Drawing Office use supplied free on application.

Sole Agent for the Electrical Trade:—

LIONEL ROBINSON, 3, Staple Inn, London, W.C.

TELEPHONE: *Holborn* 6323.



The Coverings that give absolute Satisfaction.

For complete Protection on all Electrical Installations the new Zenex and Negrex Coverings should be specified.

As supplied to Admiralty, War Office and Government Departments.

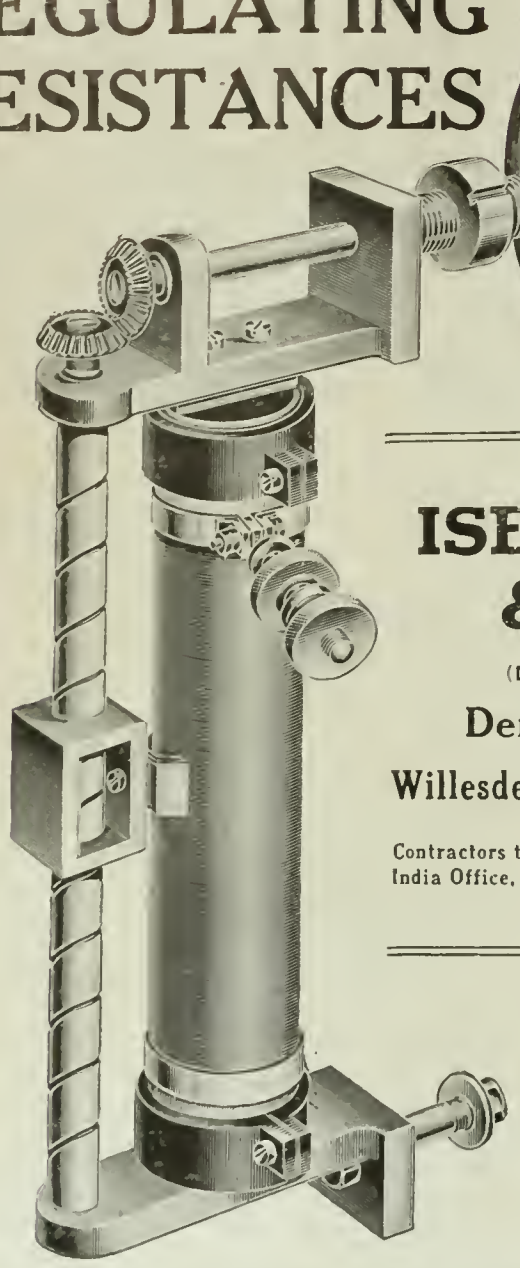
Large Stocks are carried at all our various Branches.

Simplex Conduits Ltd.,

Garrison Lane, Birmingham.

LONDON—
113-117, Charing Cross Rd. W.C.
MANCHESTER—
16, Corporation Street.
GLASGOW—
72a, Waterloo Street.
BRISTOL—
10 & 11, Denmark Street.
NEWCASTLE—
61-65, High Bridge.
LEEDS—
6, White Horse Street.
LIVERPOOL—
96, Whitechapel.
SWANSEA—
14, Heathfield Street.
CARDIFF—
4, Westgate Street.
ABERDEEN—
1, Crimon Place.

REGULATING RESISTANCES



ISENTHAL & CO.

(Department 4)

Denzil Works,

Willesden, London, N.W.

Contractors to the Admiralty, War Office, India Office, Colonial Office, Postmaster-General, &c.

NEW LIST ON REQUEST.

NATURE says:

"The list is one of the most complete we have seen."

company and substituted in place of the gas burners in the ovens. After successfully overcoming a few preliminary obstacles, the results obtained were found to be very satisfactory, and it was a matter of surprise that the cost of the current consumed was less than the expenditure formerly made in operating the gas burners. Another important advantage of the electrical ovens was that three times the amount of work could be turned out as compared with the former method. Furthermore, the finish obtained by baking the japan in the electrically-heated ovens was superior to that produced in any other way, owing to the fact that a uniform temperature could be maintained with an electrical regulating device. After these experiments had been completed, all the other baking ovens were equipped with electric heating coils, and three years' experience with the use of these ovens has fully justified the judgment of the engineers in deciding to make the change.

It is not within the scope of this article to enter into a discussion of the method of figuring the current consumption for any size of ovens, but the experience of the company using the method will serve to give an idea of the cost of baking japan by this method. The ovens used were 3 ft. wide by 9 ft. 6 in. long by 6 ft. high, and were heated by 15 coils which cost less than 12s. each. The current consumed was a little less than 25 kw., and at a price of 0·5d. per kilowatt hour, this would make the cost of operation 1s. per hour while the oven is in actual use. This does not include the time spent in cooling, loading or unloading the oven. Roughly speaking, this figures out at 1 kw. for every 7 cubic ft. of oven capacity, and the cost of the coils for heating the oven may be taken at about 4s. for each 1 ft. of oven capacity.

If it is found that the oven does not give sufficient heat to thoroughly bake the japan, it is an easy matter to add an extra coil at any time that it may be considered necessary to do so. All of the coils should be placed directly under the work, and the work is generally suspended in the oven while it is being baked. The coils should be protected by a perforated metal grating. In ordering coils for a japanning oven, it is merely necessary to tell the electrical contractor the current consumption required to heat the oven, as calculated by the preceding method, and the kind of current available in the factory in which the ovens are located.—"Machinery."

NEW CARRON FIRE CATALOGUE.

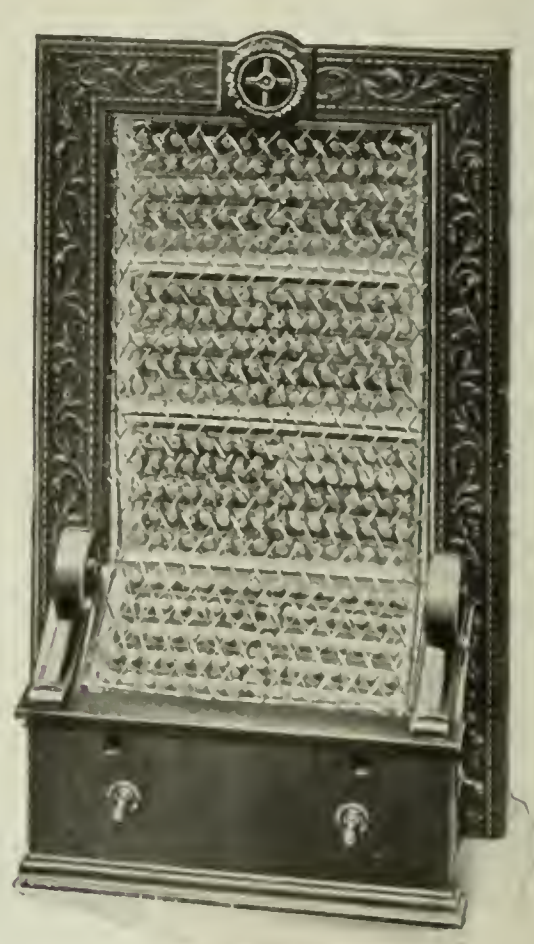
With the approach of winter comes an increased activity on the part of fire makers of all classes. The electric fire is now in about its fifth season, and its growing popularity is testified to by the increase



CARRON FIRE-INTERIOR, 3 KW.

in the number of designs and the amount of standardising which makers are able to introduce.

One of the first of the fires catalogues to reach us is that issued by



CARRON FIRE-INTERIOR, 4 KW.

Carron Co., Carron, Falkirk. This contains particulars and prices of Carron electric radiators and Carron electric fires. The radiators are of the two, three and four lamp pattern, and are of an attractive

"THOR" High Grade Specialities

CASING and CAPPING — CABLE CONNECTORS
CONDUIT — COMMUTATOR COMPOUND
CABLES — WATERTIGHT FITTINGS
AND ALL ELECTRICAL ACCESSORIES.

WRITE FOR PRICES & DISCOUNTS.

HASLAM & STRETTON, Ltd., Windsor Place, CARDIFF & Bristol Bridge, BRISTOL.

Our Manufactures include:

Cables for Lighting, Power,
Telegraphy and Telephony.
H.C. Copper Wires and Strands.
Aluminium Wires and Sheets.
Phosphor Bronze Wires.
Brass Rod.
Brass Forgings.
Enamelled Wires.
Cotton Covered Wires.
Aerial Cables.
Joint Boxes and Pillars.
Jointing Compounds.
Primary Batteries.
Exploders.
Shot Firing Cables.
Window Lead.
Cable Racks.
Static Condensers.
Pole Line Steelwork.
Paper Pinions.
Fuses and Fuse Wire.
Electric Welders.
Telephone Cords.
Annealing Furnaces.
Tramway Insulation.
Overhead Equipment.
Electricity Meters.
Knife Switches.

CHEER UP!

That low lagging power factor which has proved such a bugbear in the past can be improved by that most up-to-date of engineering apparatus,

THE HELSBY POWER CONDENSER

(Pat. Nos. 22139/05 and 14817/14).

It is not a box of mystery, but a device built by engineers for engineers, which has, under practical working conditions, fully justified our claims.

There are no running losses to take the gilt off the gingerbread, and the efficiency is 99·5%.

BRITISH INSULATED & HELSBY CABLES.

LTD.,

Cablemakers and Electrical Engineers,

PRESCOT, LANCASHIRE.

Works: PRESCOT and HELSBY.

Branch Offices in: LONDON, MANCHESTER, GLASGOW, BIRMINGHAM, NEWCASTLE, CARDIFF, DUBLIN, LEEDS & BELFAST.

OVERSEAS BRANCHES:

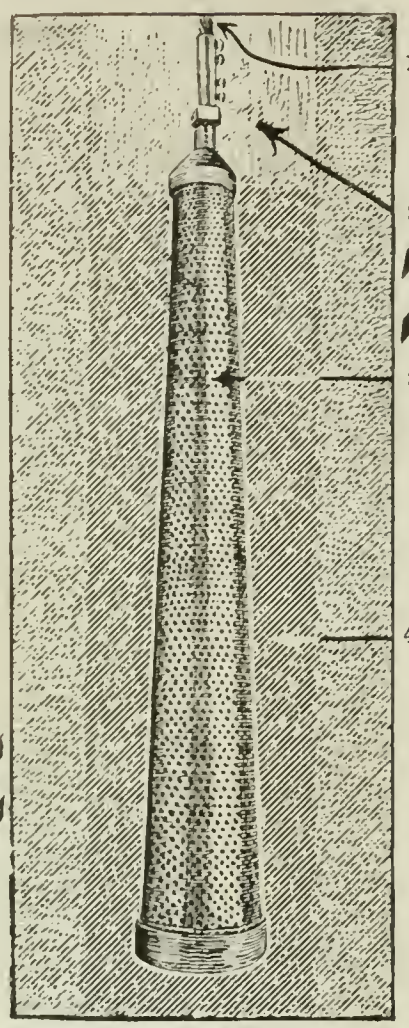
AUSTRALASIA: The Wool Exchange, King Street, Melbourne.
EASTERN INDIA: 11, Clive Street, Calcutta.
SOUTH AFRICA: Telegraph Manufacturing Co. (Colonial), Ltd.
P.O. Box 2827 Johannesburg.

The Paragon Earth Cone is made of pure copper, suitably perforated and filled with charcoal.

The earth around cannot dry up and shrink away from the cone.

It absorbs moisture and keeps the earth round the cone always moist, thus making a perfect earth.

It is extremely easy and inexpensive to install. A large excavation is not required. Just bore a hole with a post augur and drop it in.



1 Ground Wire.
2 Hole.
3 Paragon Earth Cone.
4 Coke or Moist Earth.

Scholey's

PARAGON

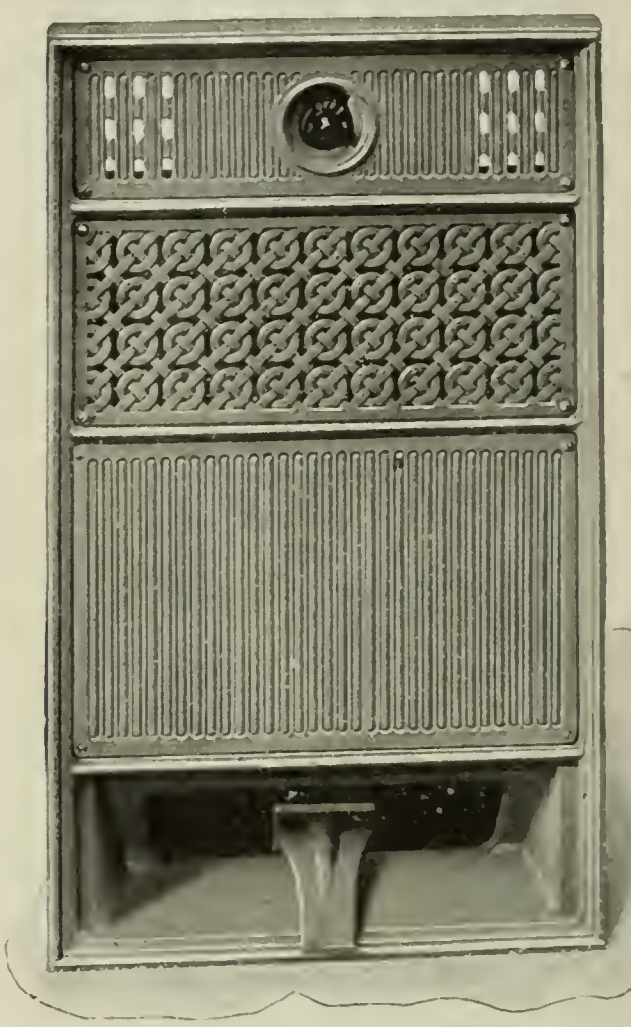
EARTH CONE

SUPERSEDES THE EARTH PLATE.

design, in which a combination of ornamental cast-iron body and polished reflector produces a substantial and pleasing effect. This is, we believe, the first occasion upon which lamp radiators have been made up in cast-iron frames, the majority of the designs being of the sheet metal type. By the use of cast iron a more permanent pattern of fire results, and one which can be placed in the fire back where it will harmonise with the surrounding iron work.

Amongst Carron electric stoves illustrated is a registered design which has been got out to build into the walls of public rooms, halls, &c. The outside air is brought into the stove by ducts or directly through louvres in the walls. The outside air can be cut off by means of a trap, and the air in the room can then be circulated through the stove. The illustration shows the design of this form of heater. After passing over the standard Carron replaceable heating elements, which are strongly housed and protected in the body of the stove, the warm air is delivered into the room through the perforated grid at the front of the stove. The design illustrated is made up for 4 kw., and the elements are under the control of a three-heat switch, which will be noticed recessed into the upper portion of the frame. The stove measures 18 in. wide by 30 in. in height by 7 in. deep.

The most interesting development in the fire business which is exemplified in the catalogue under review is the standardising of what are known as Carron Electric Fire Interiors. This form of fire has been developed with a view to catering for the growing need for an electric heater to take the place of an ordinary coal fire grate. It is only necessary to have a tiled or marble surround having a slight recess to take the fire and into this recess a complete equipment is set into position. No building-in is required. Illustrations are given herewith of two examples of these Carron Fire Interiors, one for 3 kw. and the other for 4 kw., the latter having the bottom element placed at a slight angle to the vertical elements. The frame of these interiors is of cast iron, and the elements, which are in unit form in a cast-iron body, are bolted to the back of the frame, and placed close up to the front opening which is covered with a wire guard. Each element is under the control of a separate switch. The design of the fire is such that a constant stream of cold air is drawn in at the base, and on passing the back of the fire is heated, after which it is projected into the room through the opening at the top.



Carron Electric Stove.

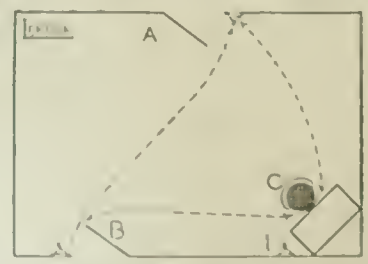
In the catalogue are shown several excellent examples of the setting of these fire interiors in mantel surrounds. The result is certainly most pleasing and artistic, and also appears to be effective from the heat distribution point of view.

Doubtless central station engineers and contractors who are interested in electric fire designs, will take an early opportunity of obtaining a copy of this interesting catalogue.

TUMBLER SWITCH CONTROL.

Messrs. A. P. Lundberg & Sons have just added to their excellent collection of literature on switching control a booklet which is being distributed gratis and which has been prepared to show the type of switch, the purposes and effect of, and the number of wires required for any given control. These particulars can be seen at a glance on any page of the booklet. The diagrams are particularly clear, because the internal connections of the switches, the lamps and the return wires are omitted. It is hoped that the publication will give both to technical and non-technical people a preliminary idea of switch control. The booklet measures about 7 in. wide by 4 in. deep, and can therefore be easily carried in the coat pocket.

There are two useful tables, giving in convenient form a few of the many cases where two-way control and two-way intermediate



Two-way Intermediate Control. There are two doors *A* and *B*. If a switch is fitted at *A* only, and one enters at *B* after dark, it is necessary to grope one's way across to *A* to switch on, and then to walk to the chair *C* by the desk or table. If there are two-way switches at *A* and *B*, there is no delay in proceeding to *C* from either door.

If an intermediate switch be fitted at *I*, the light may be controlled from the chair as well.

LEAD MELTING FURNACES

(Hall's Patents)

For Cable and Pipe Presses, Accumulator Grids, etc.,

WITHOUT OXIDATION. AUTOMATIC HEAT CONTROL.

ENORMOUS SAVING IN RESIDUE.

MONOMETER Mfg. Co., Ltd., Aston, BIRMINGHAM.

FERRY **FERROZOID**

CONSTANTAN **CHRONIC**

WRITE FOR PARTICULARS OF FOURTEEN GRADES OF

British-Made Resistance Materials

TO:—

MAKERS:

HENRY WIGGIN & CO., Ltd.,
George Street, Birmingham.

TELEPHONE: 6400 CENTRAL.
TELEGRAMS: "WIGGIN BIRMINGHAM."

AGENT:

LIONEL ROBINSON,
3, Staple Inn, London, W.C.

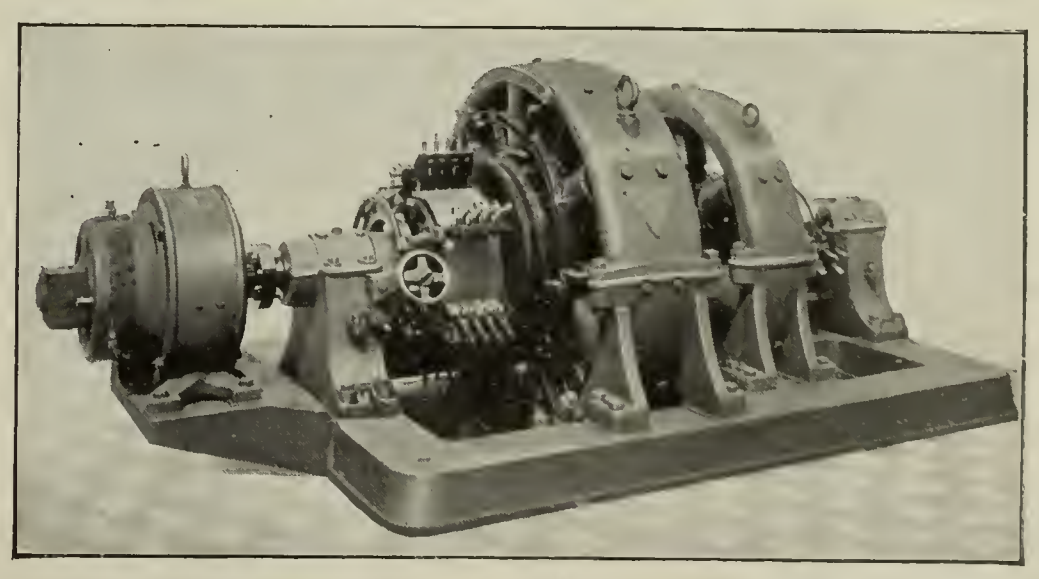
TELEPHONE: 6323 HOLBORN.
TELEGRAMS: "FERRYDOM, LONDON."

VICKERS LIMITED.

Motors and Generators of all types.

Rotary Converters.

Complete equipment for the electrical lighting and driving of Machine Shops, Factories, Mills, etc



Patent Automatic Reversing Drive for Machine Tools.

250 K.V.A. Rotary Converter. 6 phase, 50 periods, 480/560 Volts. 1,000 r.p.m. Inverted type.

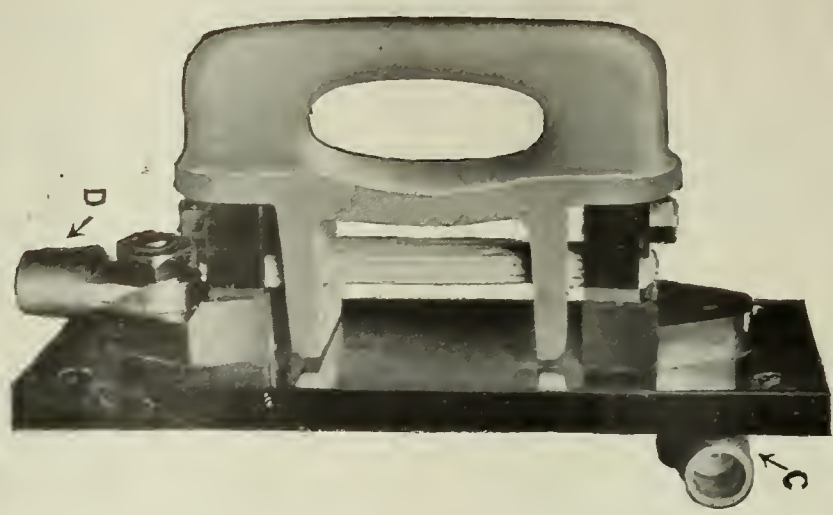
River Don Works, SHEFFIELD.

D. & S. "HANDLE" FUSES.

50 amps. and upwards. 600 volts.

Asbestos sheathed fuse wire. Substantial porcelain carrier, effectually shielding hand from "live" metal.

THE IDEAL FUSE FOR POWER CIRCUITS.



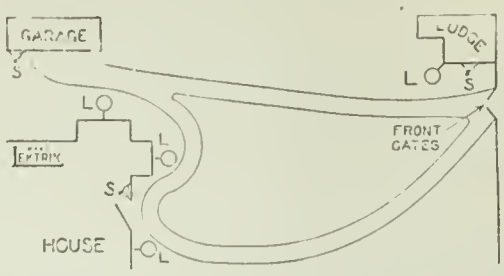
DORMAN & SMITH Ltd.,

Ordsal Electrical Works,

SALFORD, MANCHESTER.

control respectively can be used with advantage. For instance, under the heading of two-way control, examples are given—lights on staircase, first switch on ground floor, second switch on first floor, lights in approach to house, first switch on portico, second switch on front gate. Then, again, under the heading of two-way intermediate control examples are lights in hall, first switch at front door, second switch at foot of stairs, third switch on first floor; also lights in carriage drive, first switch at house, second switch at lodge, third switch at garage. In this case instead of three there may be four or more switches.

The descriptive matter under each of the several control diagrams is set in different sizes of type so as to give the items of information



An outdoor application of Two-way Intermediate Switching. The three bracket lights on the exterior of the house and the similar light at the lodge (*L, L, L, L*) may all be turned on or off either at the front door of the house, at the garage, or at the front gates. Or they may be turned "on" at any one point and "off" at any other.

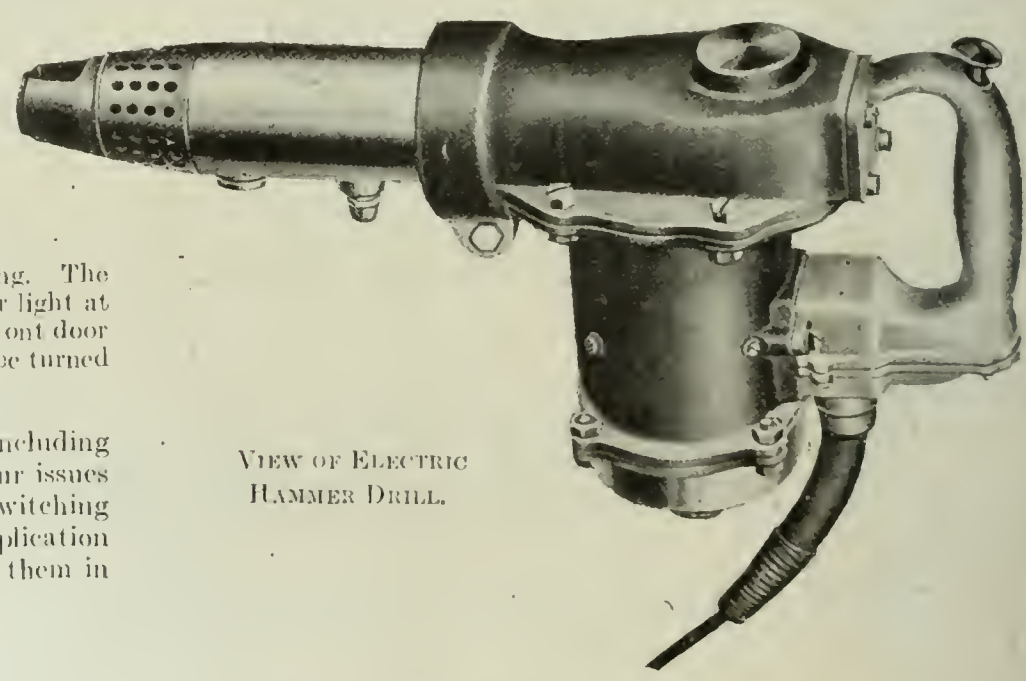
prominence in proportion to their importance. The concluding page contains the two duologues which were published in our issues of August 20, 1915, and June 2, 1916, under the title of "Switching Up to Date." Copies of the booklet may be obtained on application to the company, and we hope that it may prove helpful to them in their pioneer work on behalf of switch control.

DUNTLEY UNIVERSAL ELECTRIC HAMMER DRILL.

This tool is equipped with a universal motor (patents covering which as applied to portable tools are controlled by this company), and will operate interchangeably on direct or alternating current. It is only necessary to have the motor wound for the correct line voltage on which it is intended to operate.

The hammer blow, which is delivered by a piston on the drill steel or chisel, is produced by pneumatic impact. At the instant the blow is struck the piston is running free of all mechanical parts, and, therefore, no shock or vibration is transmitted to the electrical parts of the tool. It is claimed that there is no tendency for the wiring connections to be crystallised due to incessant jarring. The tool is accurately balanced, and when held loosely in the hand the line of centre of gravity falls between the third and middle fingers of the hand, and lies within the barrel of the tool to hang vertically. A thumb-switch conveniently located in the handle for the control of the circuit is manipulated the same as in an ordinary pneumatic hammer. All bearings are of the ball type, provision being made for the lubrication of all revolving and reciprocating parts. The gears and those portions of the moving parts subject to wear are all hardened.

When drilling holes in stone or concrete in a downward position the powdered cuttings collect rapidly, and not only absorb and waste much of the force of the blow, but tend to choke up the hole, making

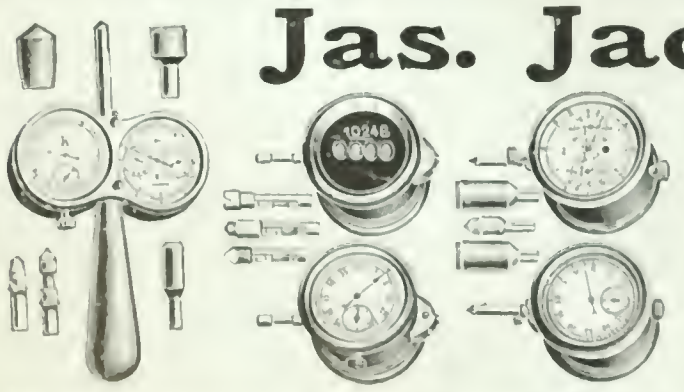


View of Electric Hammer Drill.

it difficult to remove the drill bit. A special feature of the Duntley electric hammer drill is the live air device for clearing the hole of the cuttings while drilling. This makes it possible not only to deliver the full force of the blow on the solid stone or concrete, but the removal of the drill bit is accomplished without difficulty, as there are no cuttings left in the hole.

The size No. 0 drill is wound for 110 or 220 volts (universal type to operate on either direct current or single-phase alternating current), and has a maximum capacity, in stone or concrete, 1 in. diameter. Its weight is 21 lb. net, and its overall length is 17½ in.

The Chicago Pneumatic Tool Co., Fisher Building, Chicago, are makers of this electric tool.



Jas. Jaquet, Ltd., Basle

Switzerland.

Combined Revolution Counters, with Chronograph.



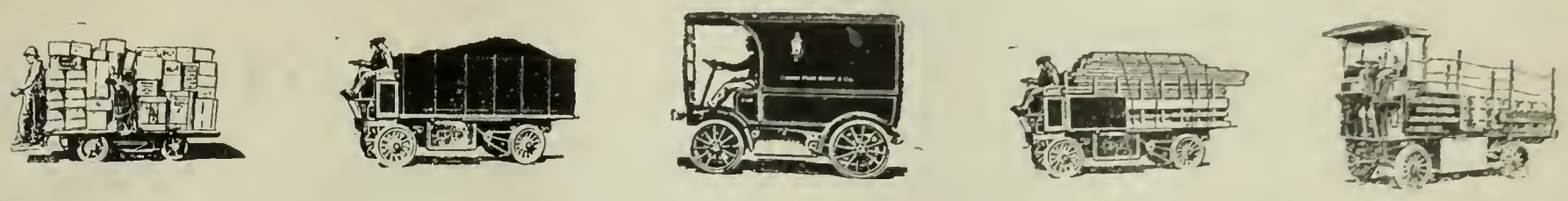
Very Accurate Timekeepers.

CHRONOGRAPH AND STOP WATCHES.

Lists on Application.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2, and 3, Salisbury Court, Fleet Street, in the City of London, Friday, September 29, 1916.

ELECTRIC VEHICLE PROGRESS



BATTERY CARTS v. HORSES FOR DUST COLLECTION.

In connection with the resolve of the Sheffield Corporation to purchase a third electric tipping wagon for the cleansing department, it is of interest to notice a report presented to the Cleansing Committee by Mr. J. A. Priestley, the superintendent of the department. The report deals with the work of a couple of 2-ton wagons at present in use in comparison with horse labour. The results work out as appended :—

No. 1 Vehicle (Daywork Costs for 22 Weeks).

Refuse collected	858 tons 6 cwt.
Total cost	£217 15 10
Cost per ton	5 0·8

Horse Labour (Cost of One Month's Work on Same Districts).

Refuse collected	167 tons 19 cwt.
Total cost	£59 1 9
Cost per ton	7 0·4

No. 1 Vehicle (Nightwork Costs for 21 Weeks).

Refuse collected	1,142 tons 19 cwt.
Total cost	£139 14 8
Cost per ton	2 3·4

Horse Labour (Cost of Three Months' Work on Same Districts).

Refuse removed	473 tons 11 cwt.
Total cost	£77 10 3
Cost per ton	3 3·2

No. 2 Vehicle (Daywork Costs for Six Weeks).

Refuse collected	314 tons 4 cwt.
Total cost	£63 0 3
Cost per ton	4 0·1

Horse Labour (Cost of One Month's Work on Same Districts).

Refuse collected	204 tons.
Total cost	£38 16 0
Cost per ton	3 9·6

No. 2 Vehicle (Nightwork Costs for Six Weeks).

Refuse removed	406 tons 13 cwt.
Total cost	£37 18 8
Cost per ton	1 10·3

Horse Labour (Cost of One Month's Work on Same Districts).

Refuse removed	440 tons 8 cwt.
Total cost	£55 10 2
Cost per ton	2 6·2

The report adds : "The districts worked by No. 2 vehicle on day shift comprise the best in the city for horse labour, and from the results obtained I am led to the conclusion that for bin refuse in Sheffield horse labour holds an advantage where the total mileage per journey for the electrics does not exceed three miles, but beyond this distance, and at all distances on ash-pit refuse, the electrics show a decided superiority.

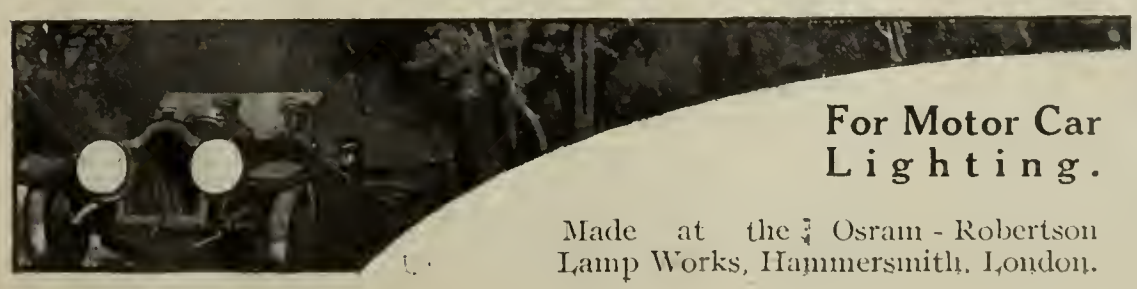
"When electrics can only be used for day work the position differs somewhat, as the vehicle costs cannot be divided over two shifts. So far as Sheffield is concerned, I am of opinion that in our system of day and night work the electric vehicle is a pronounced success, and I recommend the expansion of this method of collection as opportunity offers, particularly as it renders possible a scheme that can be realised in no other way, viz., the centralisation of the work of the department to one depot and one destructor capable of dealing with the whole of the city's refuse."

The foregoing, which is an abstract appearing in a recent issue of "Motor Traction," is indicative of the trend of affairs in municipal cleansing departments.

It should be noted that the electrical energy for the charging of the batteries is generated at the destructor from steam raised by the burning of the refuse itself.

PETROL, STEAM AND ELECTRIC VEHICLES.

In a Paper read by Mr. G. Martin Gamble before the Yorkshire Association of Students of the Institution of Civil Engineers, at Sheffield, the author referred to the increased daily radius of motor as compared with horse transport, pointing out the saving in handling of goods by the use of the latter in preference to the railway for short distances. As regards steam traction, he mentioned that the time taken in raising steam, withdrawing or banking fires, and replenishing water tanks was equal to 50 10-hour days a year. Statistics were put forward showing comparative estimated running costs, the figures including standing charges, interest 5 per cent. per annum, depreciation and insurance, but not management and establishment charges. Thus a rubber-tyred petrol wagon of 2 tons capacity, on the basis of 40 miles a day would cost 8·7d. per mile run ; a 3-ton wagon, 40 miles per day, 11·2d. ; a 4-ton wagon, 40 miles per day, 11·7d. ; a 5-ton wagon, 40 miles per day, 12·8d. A rubber-tyred steam wagon of 3 tons capacity, 35 miles per day, would cost 10·6d. per mile run ; and a 5-ton wagon 30 miles per day, would cost 13·9d. As against these figures the author estimates the cost of operating a 2-ton electric vehicle 30 and 50 miles per day at 10·1d. and 7·8d. per mile run respectively ; a 3½-ton vehicle, 45 miles per day, at 10d ; and a 5-ton vehicle, 35 miles per day, at 12·8d. per mile run. Electric vehicle makers' estimates, comparable with the foregoing, show, for a 1½-ton vehicle, 32 miles per day, 8·8d. per mile run ; 2-ton vehicle, 40 miles per day, 5·7d. and 5·1d. (two makers) ; 3½-ton vehicle, 40 miles per day, 7·13d. and 45 miles per day 6·69d. (two makers); 5-ton vehicle, 35 miles per day, 9·5d. and 40 miles per day, 8·45d. per mile run (two makers).



MAKING THE MOST OF THE AMPERE HOURS.

There's no need to waste current in Vehicle controllers of the rheostatic type; use

'IGRANIC'

ELECTRIC VEHICLE CONTROLLERS

Besides economising power, you'll get a perfectly satisfactory and reliable control. Proved right by extensive application.

IGRANIC ELECTRIC Co Ltd 147, Queen Victoria Street, London.



AN EDISON 5-TON VEHICLE.

One of the most interesting battery vehicles put into service by Edison Accumulators is a standard C.M. model 5-ton lorry supplied to Messrs. Fenton's, Batley, Yorks. This lorry is in operation over the somewhat indifferent roads which prevail in the northern industrial districts and in an area which is usually hilly. This latter fact is a testimony to the value of the battery vehicle as a means of transport which will give good average times, although it is, in the heavier capacities, at any rate, rather a slow-moving machine.

The vehicle under consideration is fitted with chassis type 9 A-12 C, having a frame of rolled open hearth steel channel, hot riveted, reinforced throughout its central portion by an inner steel channel with hard-wood filler, making a box girder construction of great strength and flexibility. Spring hangers, countershaft brackets, &c., are milled out to fit over the bottom edge of the frame members. The front axles are drop forged from low carbon steel. The knuckles are forged from the same steel, and are bronze bushed, also the knuckle arms. The knuckle pins and knuckle arm pins are hardened and ground and provided with grease cups. The rear axle is hammer forged from low carbon steel, and the brake post castings and spring seats are of malleable iron.

The front springs are mounted under the frame to allow a wider throw to the front wheels to facilitate "locking over." The rear springs are mounted outside the frame, so that the load is carried close to the wheels, and a low frame is obtained. The auxiliary coil springs are bolted to the frame over the rear axle, and they come into contact with the plate on the rear axle when half-load is on. As these auxiliary springs carry part of the live load the vehicle bounces less when unloaded than it would do otherwise. As most of the live load is carried on the rear axle, the variation of the weight on the front springs, whether the vehicle be light or loaded, is small. Hence the chassis rides well both front and rear, either light or loaded.

The steering gear is of the semi-reversible type by steel pinion engaging spur sector. It is enclosed in a waterproof grease-filled malleable iron housing at the base of the steering column, which is on the right-hand side of the chassis. An extra large steering wheel is fitted, which affords mounting for the controller lever and spindle. The wheels are of the artillery type, with hickory rims and spokes equipped for solid band tyres. They are mounted on ball bearings, one single row and one double row in each wheel, of the enclosed type mounted within oil-tight hubs, thus entailing minimum attention in service. The hub cap construction is such that accidental separation from the wheel is most unlikely. A milcometer is built into the front right-hand hub cap. Solid indiarubber band tyres of special compound for electric vehicle service are fitted, ensuring maximum transmission efficiency and least loss of energy at the road surface.

Two brakes are provided, both operated by foot pedals, and each having a trigger ratchet lock. One pedal operates a raybestos-lined internal expanding self-centreing shoe on the jack shaft, the other pedal operating similar shoes within the drums on the rear wheels. All brake rockers and shafts operate in bronze bushings, grease cup lubricated.

The transmission is from single motor to differential countershaft by special flat spring tempered steel blade, flexible and self-aligning, fitted with bronze bushed eyes working on hardened and ground pins provided with grease cups, and large square slip joint, hardened and ground, at the motor end. Every shock of starting and stopping is cushioned by this shaft, which not only decreases the current flow from the battery, but also increases the life and efficiency of every part of the vehicle. The differential is of the bevel gear type, mounted in the countershaft on Hyatt roller bearings with ball type thrust bearings, all running in oil. The bevel pinions, bevel driving pinion and bevel crown wheel are of hardened nickel steel. The pinion shaft is carried on one double row and one single row of ball bearings. From the countershaft to rear wheels the drive is by sprockets and roller chains. The sprockets are of large diameter, resulting in efficiency, quiet running and long life. They are integral with the brake drums, combining simplicity with durability and securing large braking surfaces.

The standard battery equipment consists of 60 Edison cells, type A, giving 72 volts at the five-hour discharge rate. The battery is housed in a compartment below the driver's seat and on the top of the chassis, thus making the cells readily accessible for occasional inspection and watering.

The motor is of the enclosed type, specially wound for maximum efficiency. The windings are water and oil proof. The large slotted commutator is of the street railway type. The armature shaft is mounted on extra large ball bearings, and the motor is supported in positive alignment at diametral points, with entire weight cradled on the frame. Every part of the motor is easily accessible, and all connections are extra carefully machined surfaces. No brush gear adjustments are necessary except for occasional renewals. The controller is of the continuous torque drum type, designed for maximum efficiency with the motor and gear reduction employed. There are five speeds forward and two on reverse, with positive stop between forward and reverse. The controller is located under a hood in front of the dashboard, where it is most accessible for inspection and lubrication. It is operated by handle above and concentric with the steering wheel, moving forward for "ahead" and backward for "reverse." The drive is made through positively geared pinion housed within steering gear casing—operated in grease. The controller fingers are shunted with thin copper strips; hence springs cannot be overheated when heavy currents are flowing.

SIDE VIEW OF 5-TON EDISON LORRY.

The vehicle used by Messrs. Fenton's has 15 ft. 4 in. wheel base and wheel track 5 ft. 11½ in. The maximum body width between the wheels is 4 ft. 8 in., and the distance from the driver's seat to the end of the frame is 17 ft. 4 in.; the distance from the rear of the battery box to the end of the frame is 14 ft. 6 in. The height of the frame from the ground is 2 ft. 10 in., and the width of the frame is 3 ft. 4 in. The overall length of the chassis is 22 ft. 10 in., and the overall width 7 ft. 3⅜ in. The weight of the battery is 2,250 lb., and the capacity is 375-425 ampere-hours: the kilowatt output is 30. The weight of the complete vehicle is 620 lb., and the speed fully loaded on the level is 7 miles per hour, the range being 28 miles with full load and 36 miles with half load on one charge of the battery.

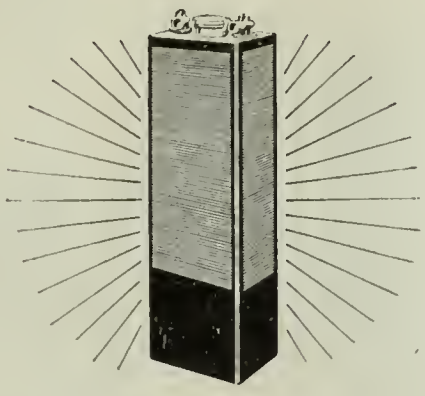
THE ELECTRIC IN OPERATING SERVICE.

The proportion of battery-propelled to horse-drawn and petrol and steam-driven vehicles is still extremely low, but this does not alter the fact that steady progress is being made with the introduction of battery vehicles for industrial and commercial purposes of all classes. The initial prejudices against this method of transport are being steadily broken down, and it may be said with truth that in towns into which the battery vehicle has been introduced orders are being regularly given by firms who are anxious to emulate the example of the pioneers of this vehicle in these districts. The City of Glasgow is a typical instance of this tendency to create a fashion in electrics. The electricity supply undertaking, on the advice of its progressive head (Mr. W. W. Lackie), put a small van into service now several years back. Experience with this was sufficiently encouraging to

EDISON

ACCUMULATOR ELECTRICS are LEADING!!

Some of the Reasons:



Because they are equipped exclusively with the Edison Accumulator, which, now in its eighth year of service, is proving more durable, more reliable and simpler to operate than any other type of storage cell.

Because the Edison Accumulator is made of Steel throughout, including the container; uses a **steel preserving electrolyte;** and cannot buckle its plates, sulphate, corrode, lose its charge, nor suffer from the effects of overcharging, high rate boosting nor being discharged to zero when necessary.

Because the **Edison Four-Year Guarantee** is unique and warrants the user that his accumulator shall give full rated capacity at the end of this time.

Because the Edison Accumulator is the lightest and strongest storage cell and **may be charged in less time** than any other type.

EDISON ACCUMULATORS, Ltd., 2 & 3, DUKE STREET, ST. JAMES, LONDON. S.W.

AGENTS:—

Birmingham:—
J. P. KEMP,
Grand Hotel, Birmingham.

Lancashire and Cheshire:—
DRAKE & GORHAM, Ltd.,
47, Spring Gardens, Manchester.

Glasgow:—
J. HALLY CRAIG,
45, Hope Street, Glasgow.

justify the gradual acquisition of a small fleet, a portion of which is shown in Fig. 1. The first vehicle is shown in the background, and three of the more recent ones are depicted to the right of it. They are all Edison cars, the later machines being of the G.M. Edison type, in which the battery box is mounted above the chassis at the front of the vehicle, where it forms part of the driver's seat. From the points of view of road surface and gradients, Glasgow would not have been considered, at any rate some five years ago, as an ideal district for the regular use of commercial vehicles of the battery-propelled type. Many of the streets are exceedingly steep, and the traffic conditions are such that they must be traversed slowly and with frequent stops, both at cross roads, with which Glasgow seems to abound, and on account of intervening vehicles. It cannot, therefore, be argued that the hills can be taken with a rush. Similarly, there is an abundance of granite sets forming the road surface, and in some streets it is little better than the pavé of which Continental motorists have such vibrant reminiscences. It may justly be said, therefore, that Glasgow's experience of electrics to-day will be the experience of the rest of the country to-morrow.

An undertaking which has closely watched the results obtained by the Glasgow electricity department is the United Co-operative Baking Society of that city. This is one of the most important business houses in Glasgow, and one which requires an efficient and reliable method of road transport. The management decided to give an Edison battery vehicle a trial. They have been so pleased with the results that they now possess a small fleet, views of a portion of which are shown in Figs. 2 and 3. These vehicles are all of the Edison GM type, and it is interesting to note the manner in which, in both the lorry and the vans, the construction of the body has been made to incorporate the battery box in a neat and effective manner. The panel at the side of the vehicle upon which the lettering "Army Contractors" appears practically represents the compass of the



FIG. 1.—PART OF FLEET OF GLASGOW CORPORATION ELECTRICS.

Particulars and Catalogues from

SIEMENS BROTHERS & CO., LTD.

WOOLWICH.

Telegrams: "Siemens Woolwich." OVER 4,000 EMPLOYEES. Telephone: City 6400 (7 lines).

CABLES & WIRES,
MOTOR-CAR LEADS
(Weatherproof, Strong, Flexible and Durable),
BATTERIES
&c., &c.

battery compartment. These vehicles are all driven by comparatively unskilled labour, which so far has experienced no difficulty in driving and controlling them. Although their maximum speed is low compared with that of petrol or steam cars, they are able to maintain a sufficiently high average speed to fit in admirably with the delivery requirements of the Society. The vehicles illustrated are all of 30 cwt. capacity, and have a maximum speed on the level of 12 to 14 miles per hour, with a range of 45 miles loaded on one charge of the battery.



Fig. 2.—Part of Fleet of Glasgow Co-operative Baking Society.

Another field in which the battery-driven vehicle is finding great favour is that connected with overhead construction and repair work on electric tramways. Fig. 4 is a side view of an Edison GM chassis fitted with telescopic tower wagon, and recently purchased by the Southampton Corporation tramways department. The tower is placed at the rear of the vehicle, and is designed for extension in a vertical direction by means of a motor supplied with energy from the same battery which propels the vehicle. At the front of the car there is accommodation under an expansive ornamental wood awning for the driver and the repair staff. There is also ample accommodation in the body for a full kit of the tools required. A vehicle of this class is extremely valuable in trolley tramway service, especially for emergency work. It can leave the power shed or garage at a moment's notice, and, if necessary, can be geared to run at high speeds. In some measure its duties are comparable with those which obtain in fire stations, in which, of course, there are already in use many battery-propelled engines, escapes and other fire fighting apparatus.



Fig. 3.—Edison Electric Lorry in Service of Glasgow Co-operative Baking Society.



Fig. 4.—Battery Propelled Tower Wagon of Southampton Corporation.

TRACTOR HAULAGE.

In general, industrial tractors may be divided into three classes, namely :—

Industrial.—Intended chiefly for interior work.

Semi-industrial.—A heavier and larger machine than the industrial tractor, capable of yard, dock and to a limited extent interplant street haulage.

Semi-tractor.—Which as its name would indicate is only part tractor, as a portion of the load is supported by the haulage unit, bringing it in reality in the truck class. The semi-tractor is seldom found in this line of work—with one exception, described later.

Methods of Driving.—In the drive from the motor to the rear wheels there are the three types commonly found in the commercial truck, namely, chain to jack shaft and chains to rear wheels, gear or chain to rear axle driving shaft, which carries a bevel gear, and the single worm gear reduction.

All driving shafts are mounted on high-class ball or roller bearings, which must have unusually large overload capacities, more particularly the thrust bearing back of the worm, which drive is now quite general.

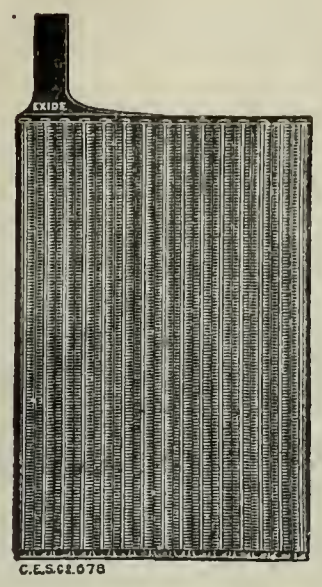
In the smaller types the batteries are spring suspended, but the chassis is not, as it is ordinarily used on good hard smooth floor surfaces. In some cases the battery trays are supported between springs to take the rebound, this being the best practice. The larger machines are spring hung, the intermediate sizes generally having spiral springs and the semi-industrial half elliptic.

Methods of Steering.—In the industrial tractor there are four forms of steering gears, and in the semi-industrial but two. The ordinary automobile drag link connection with two-wheel steer is represented. It is necessary in rounding a curve with a four-wheel machine to turn the inside wheel through a greater angle than the outside wheel. To approximate the correct angle a line is drawn from the pivot point of the steering knuckle to the centre of the rear axle. When the wheels are in the straight running position, the drag link will be parallel to the axle, and if connected to the steering arms at

"Ironclad Exide"

(Registered)

THE BATTERY FOR COMMERCIAL ELECTRIC VEHICLES.



No better testimony can be found of the satisfaction which the Battery is giving in actual service than the number of repeat orders which we are receiving. We can substantiate every claim made for it by the experience of users over considerable periods, and are able to clearly demonstrate that its life is between two and three times that of an ordinary flat plate, while its reliability day in and day out has been proved beyond cavil.

WILL STAND HEAVY BOOSTING CHARGES.

THE Chloride ELECTRICAL STORAGE CO. LIMITED

CLIFTON JUNCTION, MANCHESTER.

LONDON OFFICE: 39, VICTORIA STREET.

"ORWELL" ELECTRICS



Throughout British Built.

are manufactured at

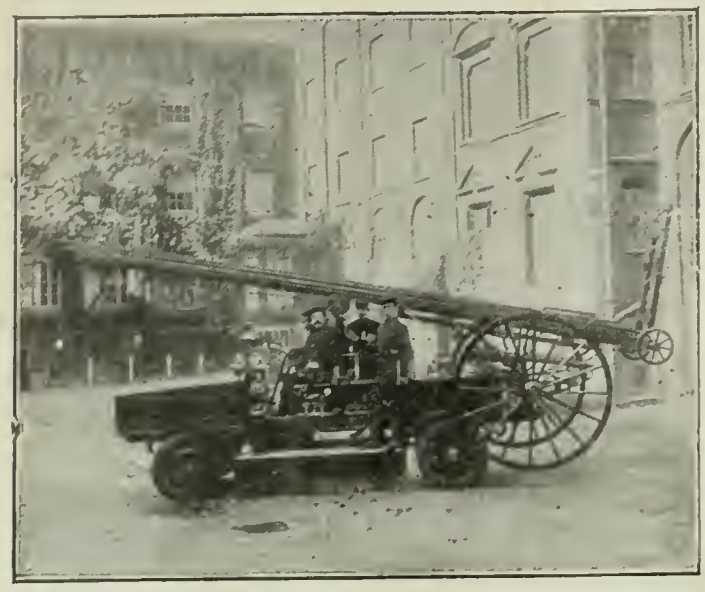
"Orwell Works," Ipswich, by Ransomes, Sims & Jefferies, Ltd.

Selling Agents for Great Britain and Ireland for

MOSSAY & Co., Ltd., "ORWELL" ELECTRIC VEHICLES,

1, Queen Anne's Chambers, 41, Tothill Street, LONDON, S.W.

TUDOR
Accumulators
FOR ELECTRIC VEHICLES.

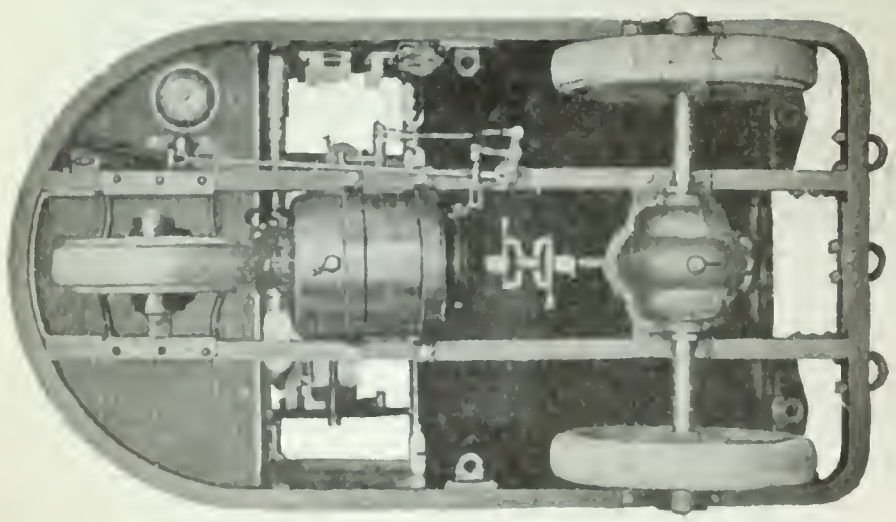


FIRE BRIGADE VEHICLES WITH TUDOR BATTERIES.
London Fire Brigade—11 Vehicles. Liverpool Fire Brigade—4 Vehicles.
Rathmines (Dublin) Fire Brigade—1 Vehicle.

BATTERIES FOR COMMERCIAL VEHICLES, PLEASURE CARS, OMNIBUSES, &c.
LIGHTEST in WEIGHT—HIGHEST in EFFICIENCY.
Maintenance undertaken at Moderate Mileage Rates.

THE TUDOR ACCUMULATOR CO., LTD.,
3, CENTRAL BUILDINGS, WESTMINSTER, LONDON, S.W.
Works: DUKINFIELD, near MANCHESTER.

the point where the lines drawn intersect the drag link either in front or behind the axle a fair compensation for angle will be obtained. If the wheel base is shortened, however, the angle formed by the steering arm and the drag link becomes more acute, so that with the industrial tractor wheel base it is very noticeable; in fact, is so great that the wheels cannot be turned as far as they should be and again returned to the straight position. The result is that the best possible turning radius cannot be obtained with this arrangement. In order to get the best turning radius a vertical plane on a line drawn through the centre of the spindle of the inside front wheel should cut



Underside View of Mercury Tractor Chassis.

a vertical plane passing through the rear axle centre just inside the rear wheel, as in motor cars. By a very simple arrangement of levers this has been accomplished by one concern building industrial and semi-industrial equipments, with the results that the turning radius is equal to that of a three wheel machine and wheels are more nearly in correct position at all times than when a regular drag link connection is used.

There are two three-wheel tractors on the market, one industrial and one semi-industrial, the first driving on the back wheels and steering with the front only as the Mercury trucks illustrated. In this case the steering connection is direct. The second drives and steers on the front wheel, the drive being accomplished by a motor located inside of the wheel and the steer by a gear connection from the driver's seat. The industrial machine of the three-wheel type may be headed straight into a post and, if the front of the machine has ¾ in. clearance, it will turn around without backing and will not strike the post.

Batteries.—The usual battery capacities in machines available are 150 ampere-hours at 40 volts, and 225 ampere-hours at 30 and



Side View of Mercury Tractor, showing Hinged Seat which Cuts off Current when Driver Rises.

42 volts. Practice would indicate that for ordinary industrial work 225 ampere-hours at 30 volts is sufficient and that 225 ampere-hours at 42 volts is ample for a 10-hour day. When necessary to operate 20 or 24 hours it is customary to change batteries, which may be done in two minutes' time by special arrangement of battery container and slip connections. The semi-industrial machine is generally 60 volt and from 300 to 450 ampere-hours capacity. The weight of the mercury tractor with lead battery is 2,220 lb.: Edison battery, 1,850 lb.

Trailers.—The trailer equipment for these machines might well be described as "anything on wheels." When an installation is made it is quite usual to prepare hitches and use the equipment already available, and it is seldom possible to design or have the users purchase new or special trailers. The drawbar pull required to



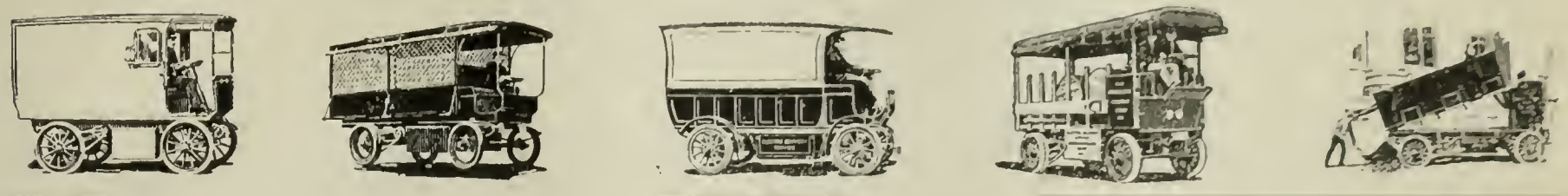
Mercury Tractor with Load on a Snow-swept Platform.

keep a train of usual freight house trucks in motion on a concrete floor may be taken as 65 lb. to the ton trailer and load. This will be reduced by roller or ball bearings and increased on less favourable surfaces. It is also increased by 17·5 per cent. per 1 per cent. of grade, so that a 10 per cent. grade will necessitate an additional drawbar pull equal to 175 per cent. of the original. Only on account of the wonderful flexibility of the tractor trailer method of haulage has this system gained its present position.

["Electric Vehicles."

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices.
2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, April 28 1916.

ELECTRIC VEHICLE PROGRESS



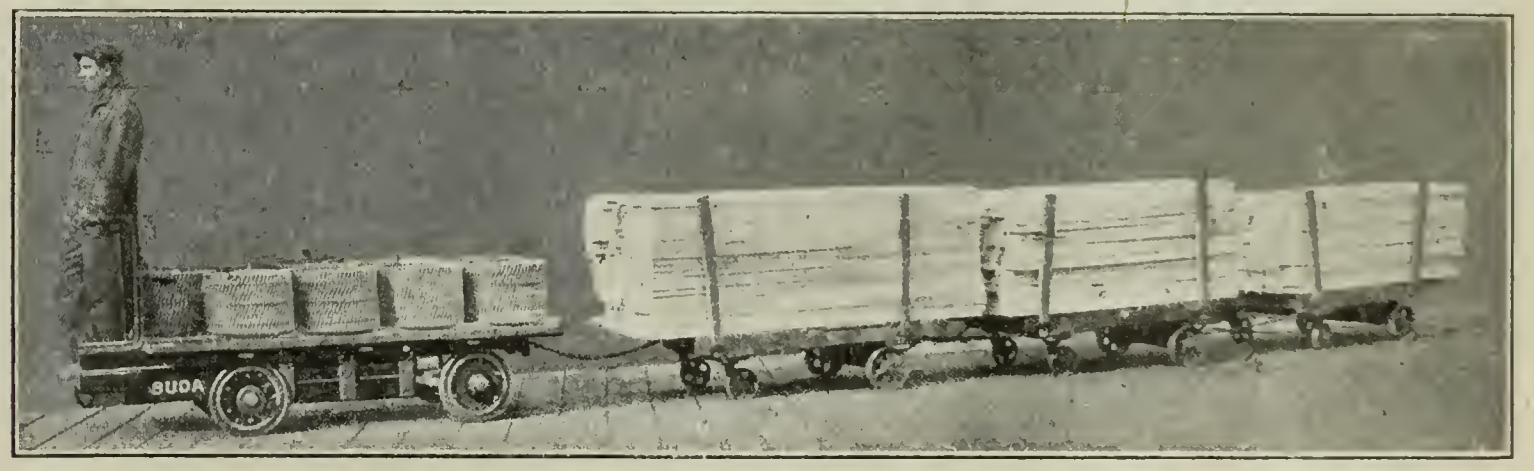
ELECTRIC TRACTORS IN LUMBER YARDS.

One of the most modern and best equipped lumber mills in the South is the plant of the Industrial Lumber Co., of Elizabeth, La., and the "Traffic World" recently collected some interesting facts concerning its output. This mill has a daily capacity of about 300,000 ft., which means that it must cut approximately 20 acres of land per day. Six large locomotives and 75 flat cars are used to move the logs in from forest to mill. Efficieney is the watchword in this mill from the felling of the trees to the moving of the lumber in the yards by electric tractors or "electric mules," as they are called. This lumber firm found that one of the big items of expense was the trucking facilities for hauling timber about the yard or from the sheds to the freight cars. The moving of this lumber required 20 mules and a corresponding number of men, and it was to displace these that the company decided to purchase an electric tractor. In moving lumber from the mill to the lumber stacks the tractor has a capacity of 7½ round trips (2,400 ft. each) per hour, towing an average of 1,500 ft. of lumber or about 3⅓ tons. In this work one tractor replaces five mules and three men.

This big mill has about five miles of tramways, running from the mill to all parts of the different yards. Tramways are from 16 ft. to 20 ft. wide, and are floored with 3 in. timber. At the mill the tramways are about 20 ft. from the ground, sloping to about 4 ft. at the opposite end of the yard. The tramway lumber is worth 48s. per 1,000 board ft., and costs £1 per 100 for laying. These figures are important, as the mules' shoes necessitated the renewal of this lumber every three years, at a cost of £5,000. Obviously rubber tyres showed a big saving in this item alone.

After the lumber is dried it is moved from the lumber stacks and dry sheds to the planing machines and then loaded into freight cars located from 60 ft. to 1,000 ft. away either by hand or by battery tractor. This work is considered very hard on the mules and difficult for the truck, as the hauls are short and the roads tortuous. The truck has to go between the planers and in other narrow places and into the drying sheds, where it is necessary sometimes to back down a long narrow aisle. It is in this class of work that the tractor shows the largest saving, due to its flexibility of operation in the smaller spaces and the ability to load and unload quickly. In such work one tractor displaces seven mules and five men, making 13 round trips per hour, with 1,100 ft. of lumber per trip. The average distance covered per round trip is 2,000 ft. In transferring lumber from the dry kiln to the dry sheds one tractor will do in two hours work that usually took two mules all day to do.

The Industrial Lumber Co. has found that the three electric tractors it is now using have displaced 16 mules and 20 men, and are performing the same work with far greater efficieney. In addition the company is effecting an unusually large saving annually by the adoption of "electric mules." It is estimated that the total operating costs for 16 mules, including feed, shoeing, stable help, labour and repairs to tramways, is approximately £4,000 per year. Operating expenses of the three tractors, including renewals of batteries (every year), renewals of tyres (every year), renewals of chains, gears, &c.,



A Buda Tractor Truck Hauling Three Trailers Loaded 2,046 lb., 1,342 lb. and 1,392 lb. respectively, and carry also itself 1,890 lb.: a grade of 1 in 10, 125 ft. long, is climbed regularly by this little "train."



For Motor Car Lighting.

Made at the Osram-Robertson Lamp Works, Hammersmith, London.

Osram
DRAWN WIRE
Lamps

BATTERY CHARGING RHEOSTATS



Switchboards for one car or many cars. Always complete but never finished. Send for Booklet "B."

OF STANDARD TYPES.
IGRANIC ELECTRIC Co LTD
147, Queen Victoria Street, London.

Sectional type Panels, built like a filing system. Start with one unit, the panel will grow as your requirements increase.

labour and repairs to tramways amount to £1,950. No current has been figured in the operating costs of the three tractors, as the amount used is not considered of any great consequence. Assuming that a mill were to buy current at 2d. per kilowatt-hour the cost would not average over £40 per tractor per year. The total costs per year of mule equipment, including the entire investment, fixed charges and operating costs, are £4,870. For the electric tractors the total costs are £2,222 per year. This shows a saving of £2,648 per year by using electric equipment.

The Electric Vehicle Association of America, which has for some time past been collecting data on the application of electric tractors in this field, has been informed that the Bodcaw Lumber Co., of Stamps, Arkansas, has recently given up animal haulage entirely for electric tractor equipment. This mill purchased three battery tractors about a year ago, displacing 15 mules and 15 drivers. It later found, however, that the same work could be done by two tractors, and used the third tractor to haul finished lumber from the sheds to the cars, which had previously required six mules and six drivers. This makes a total of 21 mules and 21 drivers that are now being supplanted by the three electric tractors and three drivers and a helper. It is estimated that the expense for ownership, upkeep, depreciation, insurance and operation of one of these tractors, when working a little less strenuously than the Bodcaw Mills works its equipment, is approximately 24s. per day or less; but crowded to its full capacity by performing the work of seven mules, the cost increases to about 30s. per day as the Bodcaw people figure it. This company stated that there is little or no expense attached to the upkeep of the machines. It takes about 10 minutes each day to oil them, and they are charged at night, which takes about four hours, and as the charging plant is automatically arranged there is no necessity for employing a night mechanic.

While the greater part of the haulage of lumber in this country is done by horses or mules, the limitations of animal haulage have long been understood and the investigations and study which the Electric Vehicle Association has given the matter show that progressive mills are beginning to adopt other forms of transportation. It has been difficult to estimate the cost of animal delivery, because there are very few firms that have kept accurate accounts of operating costs. However, it is estimated that the daily mileage of a horse is 15, and a good day's work for a horse is moving 15,000 ft. of lumber one mile or its equivalent, such as hauling 5,000 ft. three miles. Compare this with the performance of the "electric mule," which is able to tow an average of 1,500 ft. of lumber 3½ miles in an hour.

The G. W. Gale Lumber Co., of Boston, Mass., has been using five electric lumber tractors for about three years, which are doing much more than the work of 40 horses previously used. The vice president of this company has a problem that he occasionally propounds to his friends, and it is the result of the work of three electric tractors for 189 days, during which time the machines were driven 16,748 miles and carried 9,650,000 ft. of lumber that averaged 1·51b. to the square foot. He maintains that a horse can transport 15,000 sq. ft. of lumber one mile in a day, and he has asked his friends to determine how many horses would be necessary to accomplish the work of the tractors.

One of the most important features of the storage battery tractor for lumber yard and sawmill service is its absolute freedom from fire hazard. In places where shavings and sawdust would be easily ignited by sparks or hot gases emitted from petrol machines, the electric can operate with perfect safety.

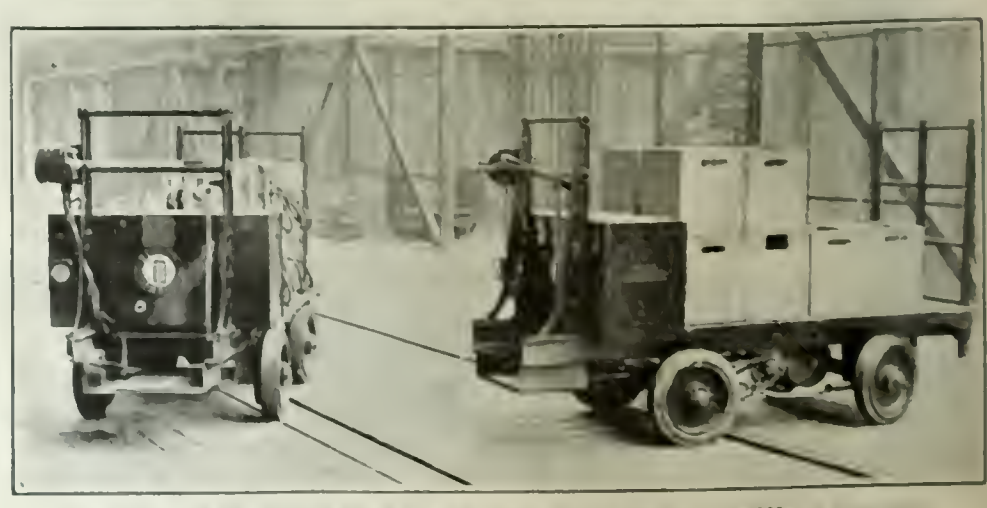
The ease and simplicity of operation which characterise all types of electrically-propelled vehicles is an important factor in the application of the electric tractor to lumber work. Considering the short radius and the narrow aisles in the mill yards in which the tractor must turn, anything which adds to the simplicity of driving the machine is an important consideration. It is common knowledge that an electric, because of its simple rotating motor and absence of all complicated and reciprocating parts, with their attendant wear and tear on the mechanism as a whole, makes its upkeep extremely economical.



6-ton Jeffrey Battery Locomotive hauling a train of lumber at Panhandle Lumber Co., Spirit Lake, Idaho.

TRACTOR HAULAGE PROBLEMS

To accomplish tractor haulage the first consideration is the proper power unit, and from a commercial viewpoint naturally that unit is the one that will do a maximum amount of work at a minimum

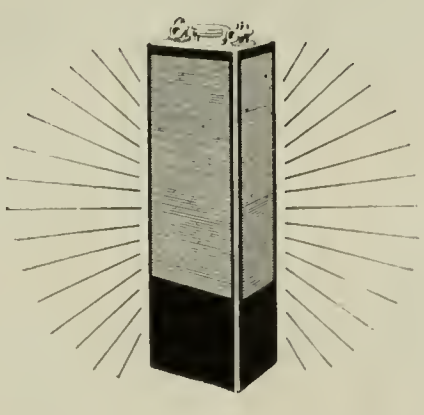


Two Edison Battery Trucks as used in a Munition Works in the Midlands.

EDISON

ACCUMULATOR ELECTRICS are LEADING!!

Some of the Reasons:



Because they are equipped exclusively with the Edison Accumulator, which, now in its eighth year of service, is proving more durable, more reliable and simpler to operate than any other type of storage cell.

Because the Edison Accumulator is made of Steel throughout, including the container; uses a **steel preserving electrolyte;** and cannot buckle its plates, sulphate, corrode, lose its charge, nor suffer from the effects of overcharging, high rate boosting nor being discharged to zero when necessary.

Because the **Edison Four-Year Guarantee** is unique and warrants the user that his accumulator shall give full rated capacity at the end of this time.

Because the Edison Accumulator is the lightest and strongest storage cell and **may be charged in less time** than any other type.

EDISON ACCUMULATORS, Ltd., 2 & 3, DUKE STREET, ST. JAMES, LONDON. S.W.

AGENTS:—

Birmingham:—
J. P. KEMP,
Grand Hotel, Birmingham.

Lancashire and Cheshire:—
DRAKE & GORHAM, Ltd.,
47, Spring Gardens, Manchester.

Glasgow:—
J. HALLY CRAIG,
45, Hope Street, Glasgow.

expense. While certain essential elements are requisite in all designs, no one machine could be exactly suited to meet conditions which vary so greatly, and are never exactly alike in any two installations. As all available energy is stored and must be carried on the machine the lowest possible current consumption is of special importance. Small turning radius and compactness is sought because floor space is valuable and working places congested. Other indispensable qualities are extreme simplicity, coupled with reliability and accessibility, for in case of failure of the machine it is seldom that sufficient men are immediately obtainable to do its work.

The industrial or carrier truck is in no wise a tractor, although it has been employed as such from time to time without marked success, easily accounted for by the limited motor and battery capacity, and design never intended for such work. The machines in general use



7-ton Jeffrey Storage Battery Locomotive hauling load of cars on standard gauge track. (See next page.)

are true tractors, varying in capacity from 3 to 15 tons under working conditions, rated by drawbar pull, the maximum generally being quoted.

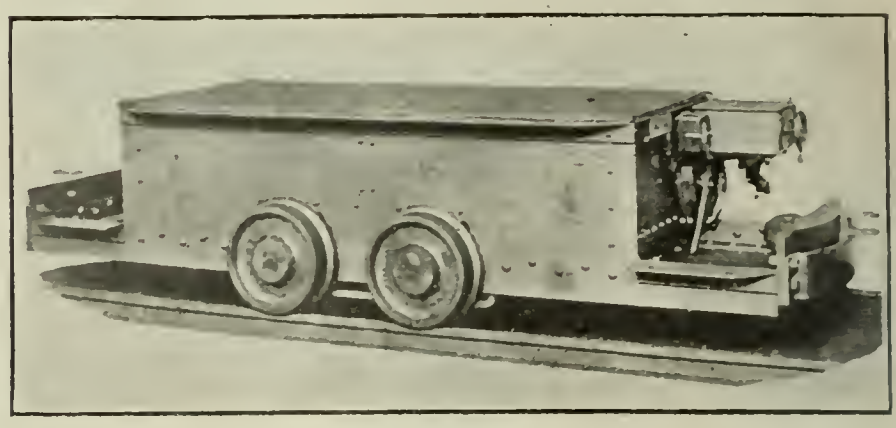
This method of classification, which is the only true rating, is of little value to the prospective purchaser, as he has but scant knowledge of the application of the term to practice. On the other hand, if machines were classified by tons it might well be misleading to the buyer or unfair to the machine, the reason being that drawbar pull required per ton load varies so greatly with working conditions, such as road surfaces, grades, types of carrier, &c., as to require study before a classification in tons capacity as applied to the case can be made. It will be seen that a 3-ton machine in one place may rightly be employed as a 6-ton machine under more favourable circumstances, the maximum drawbar pull required being about equal in both cases.

Tractor Operating Costs. In considering tractor costs and tractor trailer savings, it is natural to compare it with the old-established hand-trucking methods. A specific case will answer as an illustration. In this the total cost of operation and maintenance of the small industrial tractor is less than 4s. per day, and may therefore be taken as the cost of a single man. In computing tractor cost the depreciation is put at 20 per cent., interest on investment at 6 per cent., current at 1·5d. per kilowatt-hour, and insurance, renewals and repairs are included generously in this figure. An installation in point is in the basement of a general merchandise concern where the greatest haul is in the neighbourhood of 1,800 ft., and the average 900 ft. The trailers are six-wheel "empty box" trucks, formerly pushed by hand. They are 4 ft. wide, 8 ft. long by 7 ft. high when loaded. It is a daily occurrence to see a train of from 19 to 22 of these trailers, a train 196 ft. long, exclusive of tractor, making the several turns, some of them in "S" form. It was originally intended to haul six to eight trailer trains. This machine is now displacing 13 men who were formerly the pushers. It will displace several more, and will also do away with a power conveyor when an incline leading to the street is completed.—"Electric Vehicles."

STORAGE BATTERY LOCOMOTIVES.

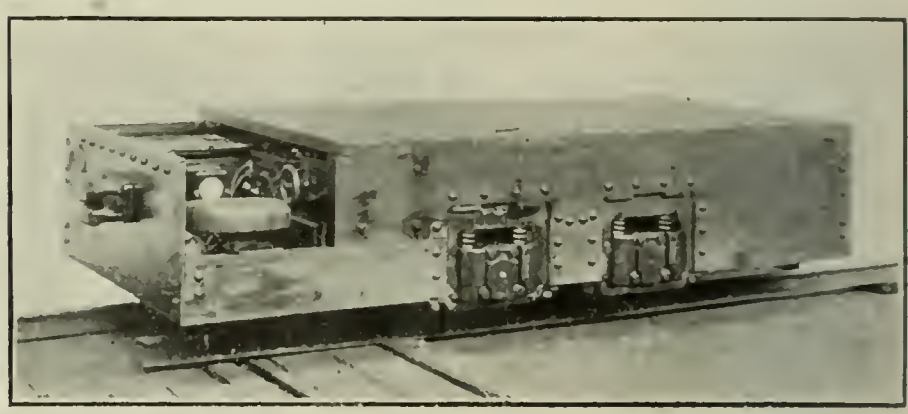
In previous issues of "Electric Vehicle Progress" we have described in detail the handy battery-driven industrial truck, which is now becoming known as the electric stevedore. This economical little machine can go anywhere and will climb almost anything. It is to be distinguished from a battery-driven machine which can only run on rails, and which for want of a better name is termed a storage battery locomotive. The term "locomotive," particularly when applied to the miniature type which is used on narrow-gauge railways, brings to mind a fussy, puffing and snorting little machine which seems to have far too much work to do. The storage battery locomotive for narrow-gauge lines will do far more work than its steam prototype, and in addition to pulling a considerable load, will also carry a considerable proportion of it on its own back.

This extremely interesting machine is the outcome of many years' experiments with the trolley mining locomotive. These electric mining locomotives are almost exclusively an American product, so much of the mining work in the United States and Central and South America being concerned with shallow draught mines. The Jeffrey Mfg. Co., of Columbus, Ohio, have specialised in this form of electric locomotive, and although the bulk of their products is concerned



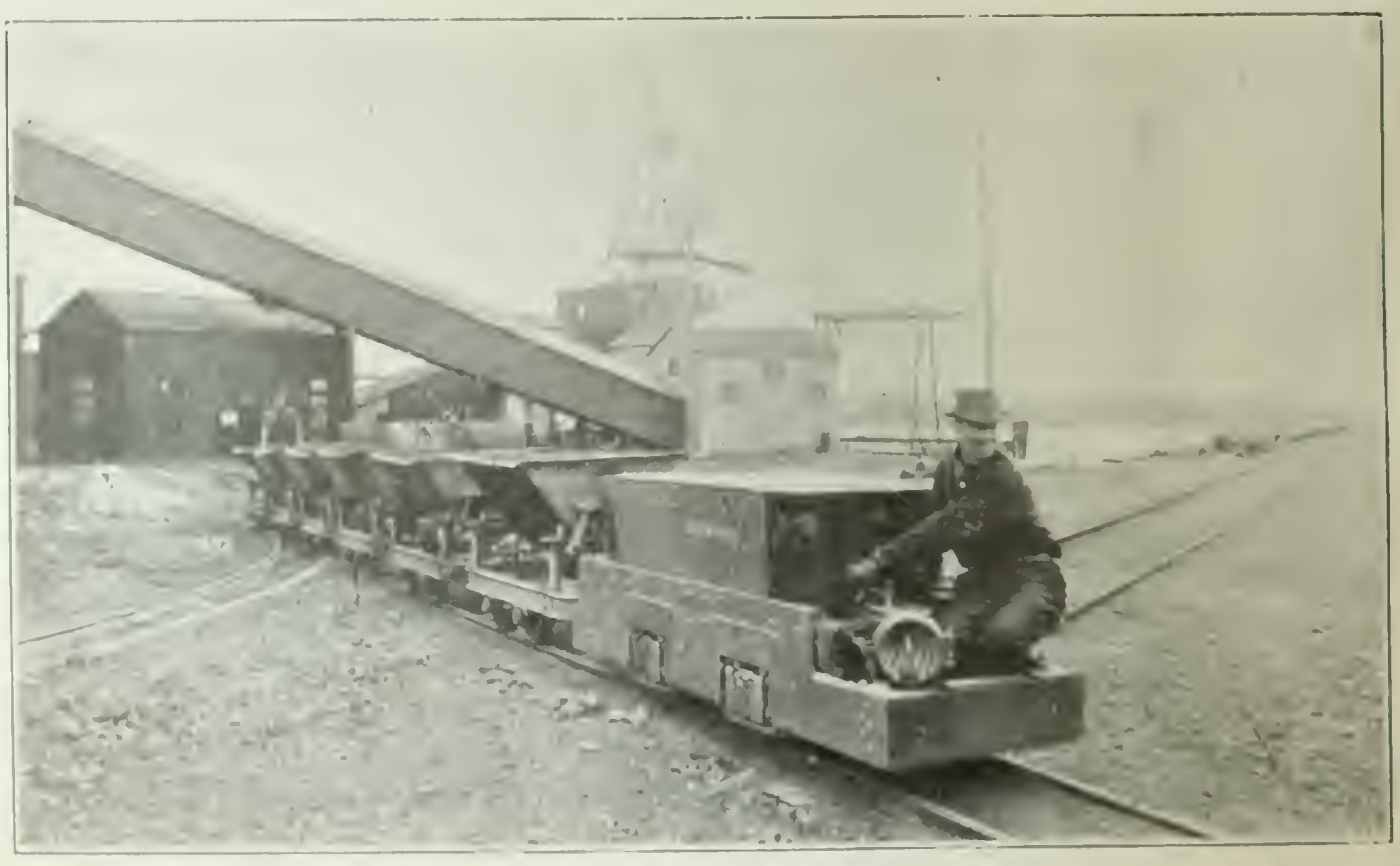
Jeffrey Battery Locomotive with Outside Wells.

with the trolley-operated pattern they have also developed sizes which are suitable for use on rails of any gauge from the standard 4 ft. 8½ in. downwards. The British agents for Jeffrey products are Messrs. Hugh Wood & Co., 65, Fenchurch-street, London, E.C. We



Jeffrey Battery Locomotive with Armoured Body.

have obtained from this firm a number of interesting illustrations, which are reproduced herewith, of Jeffrey storage battery locomotives of various kinds and for widely diverse classes of service. The frame of these machines is of structural steel, suitably braced, and furnishing a complete armour for the battery, the controller, and the motor

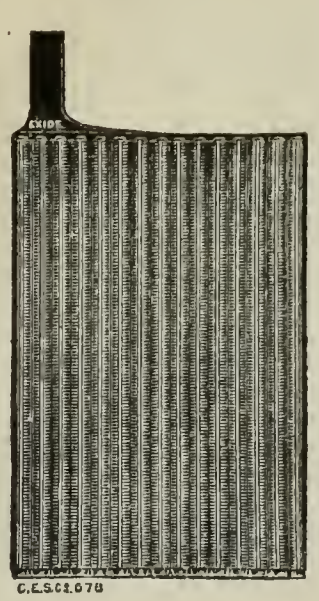


3-ton Jeffrey Storage Battery Locomotive hauling Tipping Cars on narrow-gauge line.

"Ironclad Exide"

(Registered)

THE BATTERY FOR COMMERCIAL ELECTRIC VEHICLES.



Several Sets in Service have Completed

24,000 MILES

on the Road without a Single Cell having to be Removed from the Vehicles for any Electrical Defects whatever and the Capacity is still in Excess of the Catalogue Output.

THE Chloride ELECTRICAL STORAGE CO. LIMITED

CLIFTON JUNCTION, MANCHESTER.

LONDON OFFICE: 39, VICTORIA STREET.



THE HORSE CART MUST BE CHAINED UP.



THE HORSE CANNOT STAND THE HEAT.

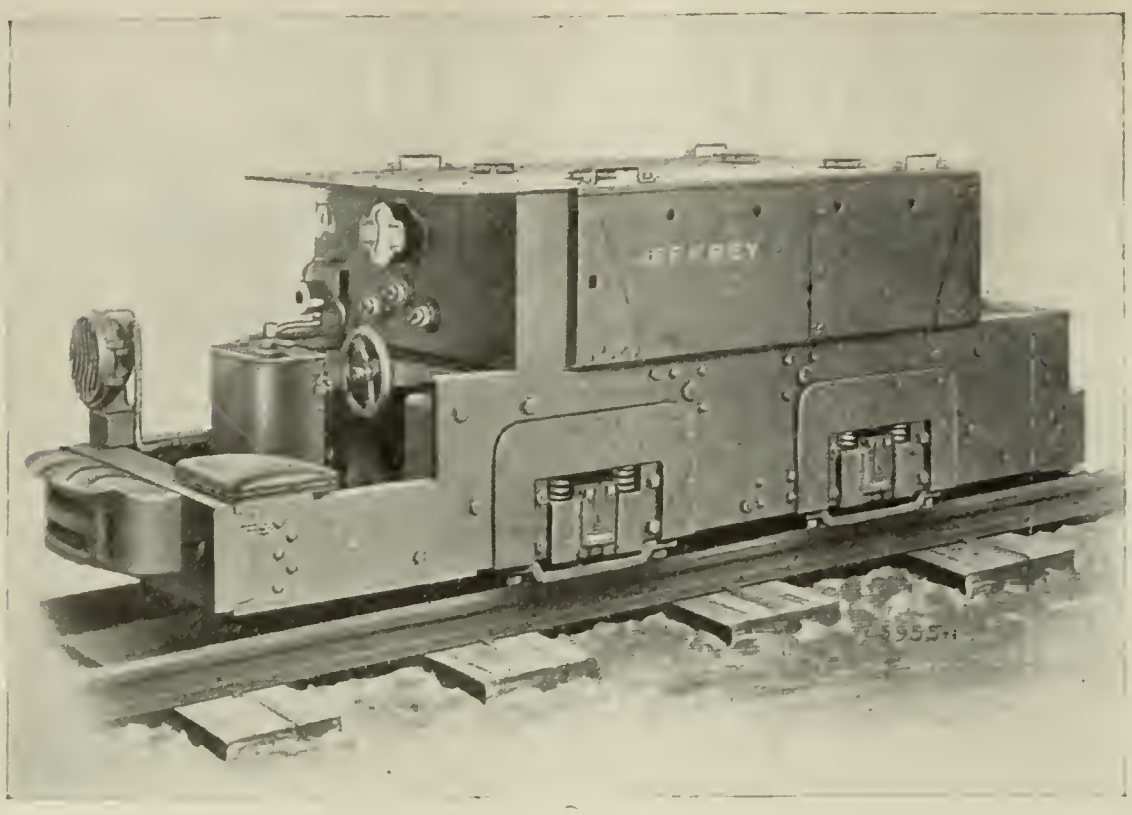


THE ELECTRIC TAKES UP LITTLE ROOM AT THE KERB.



THE ELECTRIC IS IDEAL IN THE HOT WEATHER.

The New York Edison Co. recently compiled a booklet of photo-pictures comparing the electric with the horse. The above are selections from the book, and we make our acknowledgments to the company for its courtesy in sending us a copy.

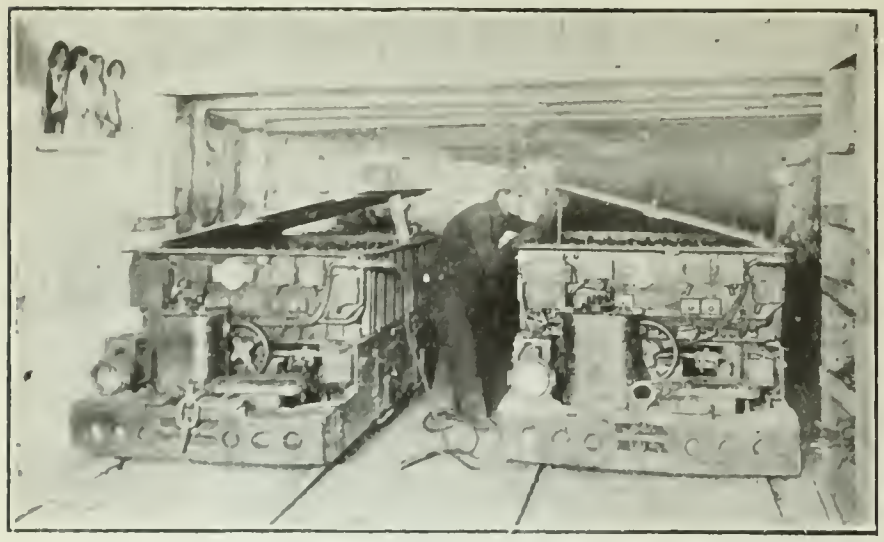


3-ton Jeffrey Battery Locomotive.

The Public Service Corporation of New Jersey, are using two of these locomotives for hauling ashes from their power plant to dumping ground. They handle approximately 80 tons of ashes every 24 hours. Each locomotive is equipped with one motor and 81 A-4 Edison cells. The motor is connected to one axle with single reduction worm drive. The axles are chained together, making all four wheels drivers. The general dimensions of the locomotives are: Gauge, 18 in.; width, 38½ in.; length over bumpers, 10 ft. 6 in.; height over frame, 24 in.; height over battery box, 44 in.; wheel base 36 in.; wheel diameter, 16 in.

driving equipment. The platform of the flat type is of heavy oak and the height of this from the ground is 27 in. Each of the four wheels is 16 in. diameter and the wheel base is 33 in. The locomotive will negotiate curves down to a minimum radius of 12 ft. This locomotive has a carrying capacity of 5 tons and has a range of 20 miles on one charge of the battery. It will be noticed from the illustrations that the locomotives are also built for tractor purposes only, and in this case they are of a heavier pattern and considerably higher than the platform type. Advantage is taken of the increased height to provide a larger battery and two motors are fitted driving the front and rear wheels respectively. The driver occupies a low seat at the front of the locomotive and has complete control of its movements in both directions with an ordinary tramcar type drum pattern controller.

There is practically no limit to the class of work which can be undertaken by these locomotives. They can also be built up to 10 tons capacity. The battery equipment can be either of the Edison or lead type, according to the requirements of the user.



Two Jeffrey Battery Locomotives "on charge."

RECRUITING BY ELECTRIC.

A novel use for the electric vehicle is shown in the accompanying illustration. The car is a standard Edison G.M. 2 ton vehicle in the service of the Liverpool Corporation Electricity Department, and during the vigorous recruiting rallies in connection with the Derby Scheme, Mr. H. Dickinson, the City electrical engineer, had a special recruiting body fitted as shown, and the vehicle paraded the Liverpool district week by week at the head of a section of the Civilian Training Corps on the occasions of their evening recruiting marches. The battery supplying energy for propelling the van afforded at the same time a ready source of illumination, and a number of electric lamps were fitted inside the body, so that the lettering was well illuminated, and produced a very effective appeal: in fact a considerable number of recruits were obtained as a direct result of the weekly parades.

The vehicle has now been in constant use on its ordinary duties for over a year, and has effected a considerable economy in the cartage work of the Department. It is employed largely in connection with mains extension work, and, in addition to the actual saving in the cost of carting (which, we understand amounts on an average to between £7 and £8 per week), a further advantage is afforded by the reduction of time spent by gangs of men in reaching their work, as, apart from carrying the cable and other materials required, the car transports the mains men, labourers and tools to the required locality with a minimum of delay.



"The Call" of the Electric.

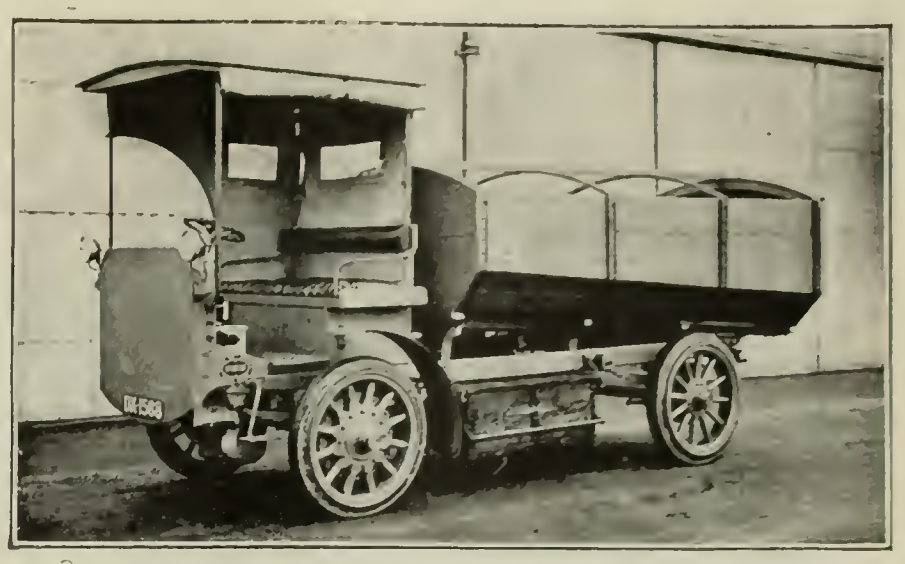
Mr. Dickinson states that during the 12 months that the vehicle (which was supplied by Drake & Gorham, Ltd., Spring-gardens, Manchester) has been in use it has covered 10,000 miles at an average current consumption of 0·7 units per mile actual input to the battery. Repairs and replacements have been practically nil, so that the total operating costs have been extremely moderate.

MORE BOOTS' ELECTRICS.

The adjoining illustration shows a new pattern of battery-driven delivery van which Messrs. Boots (Ltd.) have recently put into service, one in Southport and the other in Leeds, delivering small parcels in the suburbs of both these places. A particularly attractive design of body has been selected, and one which we think will not only be of value in advertising the company's business, but also will prove useful in giving the battery delivery van a good name for smart appearance.

These vehicles have been built and supplied to the company by

"ORWELL" ELECTRICS



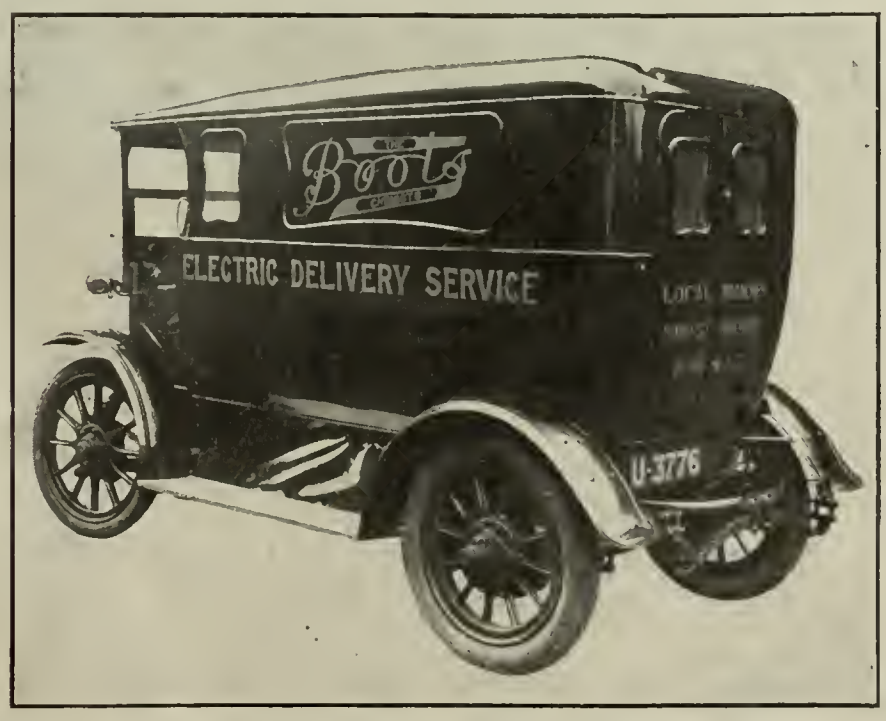
Throughout British Built.

are manufactured at

"Orwell Works," Ipswich, by Ransomes, Sims & Jefferies, Ltd.

MOSSAY & Co., Ltd., *Selling Agents for Great Britain and Ireland for* "ORWELL" ELECTRIC VEHICLES,
Queen Anne's Chambers, 41, Tothill Street, LONDON, S.W.

Messrs. Electromobile (Leeds) (Ltd.). The chassis is one of the company's standard patterns, and is built up of pressed steel, with inswept front to furnish a wide lock for the steering wheels. Both the front and rear wheels are suitably suspended on semi-elliptical springs. It will be seen that the body has been carried well forward over the front wheels, so as to furnish ample room and a maximum of protection from the weather for the driver.



Boots' 15 cwt. Battery-driven Van, supplied by Electromobile (Leeds) Ltd.

The chassis is fitted with a single motor drive, the motor being fixed in the centre of the frame and arranged to drive the rear axle through double helical machine-cut gears. The motor is of the double commutator series-type, and is totally enclosed. It develops approximately 3 h.p. at a normal speed of 1,600 revs. per min., the energy taken at this speed being 76 amperes at 96 volts. Considerable interest attaches to the design of the controller, which is of the drum-type operated by a lever underneath the steering wheel, this control being used in conjunction with a pedal resistance gear which serves the purpose of introducing resistance between each of the steps on the controller. The company inform us that this control has proved so simple that in the case of the vehicle supplied to Messrs. Boots for use in Leeds the former driver of the horse vans commenced driving the electric the day after he had given up his duties as horse van driver.

The wheel-base of the vehicle is 7 ft. 6 in. and the tread 4 ft. 6 in., the rims fitted to all the wheels being of the Warland divisible and demountable type with safety rim and tyre. The latter are 820 mm. by 120 mm. Each of the vehicles has a carrying capacity of 15 cwt., and a maximum speed of 14 miles per hour can be obtained. This is quite fast enough for ordinary delivery work, and the company has found that quite average speeds can be maintained on this class of delivery service. By reducing the maximum speed at which the vehicle can be driven, particularly by inexperienced drivers, the maintenance of the chassis parts and the wear and tear of tyres can be reduced to a minimum, while the delivery of the goods is maintained equally as well as it would be with the faster but less economical petrol machine.

Each of the vehicles is fitted with a 40-cell Ironclad Exide 11-plate battery, having a radius of 40 miles on one charge. The battery is carried in a crate slung under the chassis, and has an approximate capacity of 150 ampere-hours.

These vehicles are typically British machines, and their use on light parcel delivery work will do much to remove a certain prejudice which appears to exist that a high-speed machine is necessary for light parcel delivery and collection work. The cheaper types of petrol vans enjoy a considerable vogue at the present time, particularly on account of the inducement held out to the user in the shape of high speed, coupled of course with the comparatively low initial cost. On the other hand, the electric delivery van, with the prices of petrol mounting daily, and the cost of electrical energy at a maximum rate, makes the slightly higher cost of the battery vehicle the more profitable investment of the two. It is only by the use of vehicles on the road that this important fact can be realised in practice, and the more electric delivery vans that go into service the smaller will become the chances of the light petrol van making any headway.

TUDOR
Accumulators
FOR ELECTRIC VEHICLES.



ELECTRIC OMNIBUS—BRIGHTON AND HOVE.

About 16 Electric Omnibuses have been in regular service for the past six years, and TUDOR Accumulators have been employed exclusively.

THE TUDOR ACCUMULATOR CO., LTD.,
3, CENTRAL BUILDINGS, WESTMINSTER, LONDON, S.W.
Works: DUKINFIELD, near MANCHESTER.

AN AMERICAN VIEW OF ELECTRIC WHEEL CHAIRS.

"In Paris," stated a nurse who had but recently left the French capital, "one sees now only cripples and widows and ambulances. It is a city of cripples. You see them everywhere—armless, legless, helpless!" Already the European countries with resourcefulness are training their war cripples for new trades and industries, thus beginning the work of an economic and industrial reconstruction after the devastation of war has ceased. There is a certain irony in the fact that, while some of the most horrible and destructive instruments of warfare have been recent creations of science, the same force which has produced destruction will alleviate the suffering and hardship after the war is over, and will transform the war's human wreckage into "human salvage."

In previous wars many soldiers who had lost limbs in battle, or had become incapacitated for work, were unable to earn their living by useful pursuits, and were doomed to live upon private charity or scanty pensions. There are familiar tales of our own Civil War veterans who, unable to resume their old occupations, were forced into a life of inactivity, hateful to most, left alone with their memories, fingering their medals, and renewing their once active life in the oft-repeated tales of army life.

But the countries in the present conflict do not intend that their men shall return from the front to useless and inactive lives. Employment bureaus for war invalids have been formed in all the belligerent countries, and schools have been organised for the training of disabled men prevented from returning to their old employment, in new kinds of work which their physical disabilities do not affect. Modern science and the study of orthopedy have done much in teaching men how to make artificial limbs of remarkable mobility and efficacy.

Various holding devices have been invented by which tools can be accurately handled. Tailoring, shoemaking, machine and ammunition manufacturing are being largely carried on in Continental countries at war by those who have been maimed in battle. One of the greatest difficulties to overcome, however, will be the limited distances to which the disabled will be confined in walking. While the mobility of artificial legs is remarkable, it is not possible for one to walk very far. For most the automobile will be impossible. Outside of commercial motors, the automobile abroad will be more of a luxury than ever before. The need then for a small single-seated vehicle, which is inexpensive and simple to operate is evident, and there is apparently one that meets the demands.

The electric wheel chair was a familiar sight at the Panama Pacific Universal Exposition last year, and is used successfully at many of the seaside resorts on the broad walks. Sanatoriums, hospitals, health resorts and private individuals who are unable to walk great distances and prefer the freedom of directing their own chairs to the annoyance of being pushed by an attendant who has his own views about the direction he will take, turn to this little battery-propelled chair as the best adapted mechanism for their needs. The manufacturers of electric wheel chairs abroad have, therefore, anticipated the demand there will be for a single passenger vehicle of this type, and already it has gained considerable prominence in England.

The fact that it can be easily controlled by the occupant with the use of one hand, and needs no attendant, is a great advantage. Able-bodied men will be needed for other more vital business than pushing invalids about in wheel chairs. One of these chairs, which is of Swiss construction and costs but a small sum, is equipped with a $\frac{1}{4}$ H.P. motor suspended between the steering and rear wheels. Current is supplied from a battery of 15 lead-plate cells housed in three boxes beneath the seat. They are of 50-ampere-hour capacity, and provide sufficient energy for a run of 30 to 40 miles per hour. The controller is combined with the steering tiller, and provides for five forward, and an equal number of reverse speeds. Motion in the forward direction is obtained by turning the shielded controller handle over successive stops to the left, movement to the right reversing the direction of the chair. There is also a lever which operates a brake on the rear wheels, and when pressed back beyond a certain point breaks the motor circuit. Since the speed never exceeds five miles per hour on the level, the chair can be stopped almost immediately, a powerful braking effect being secured by reversing the controller.

These chairs, while obviously not intended for rough roads and steep hill climbing, are nevertheless as ruggedly constructed as miniature trucks, and will amply meet the need of one desiring independent locomotion within a reasonable radius. At the present time they are being welcomed with open arms by the hospital authorities for enabling the wounded soldiers and convalescents to drive about by themselves as soon as they have recovered sufficiently.

The characteristic simplicity of the electric vehicle is conspicuous in this wheel chair, which permits operation by the uninitiated and makes it "fool-proof" even when operated by unskilled or nervously inclined persons in crowded places, the prompt control protecting road rights and observing "safety first."

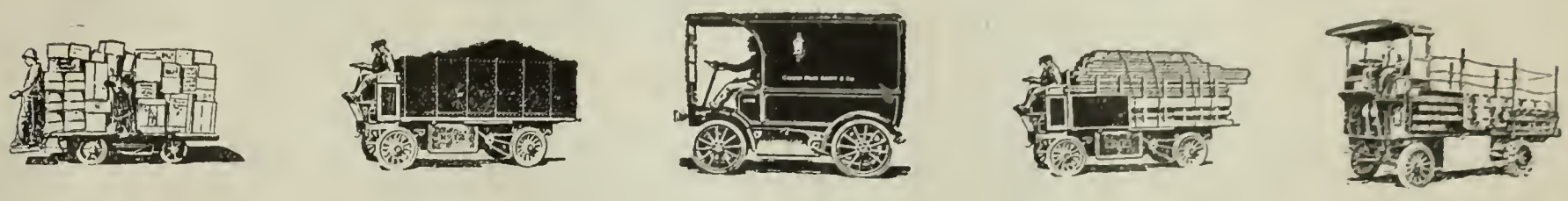
ELECTRICS IN SHEFFIELD.

Although Sheffield is a notoriously hilly place, apparently its severe gradients present no terrors to the battery-driven lorry. It is true they do not roar up the steep and stoney places as does the petrol van, but they do take them at a steady pace which is far in excess of that of a dray horse. Hilly towns are well known to be very hard on horses, especially so when the weather conditions are bad or during the heat of the summer. The experiences of the Midland Railway with G.V. electrics in Sheffield will help a great deal to convert the local didymuses, who have only had the merits of the petrol or steam lorry dinned into their ears for years past. That considerable local interest has been created is proved by an article in a recent issue of the Sheffield "Daily Telegraph," *the* newspaper of the city and surrounding district. Our contemporary has evidently been impressed with the silent, steady working of the three G.V. 2-ton lorries which have been in service to the outlying districts for some time past. They undertake delivery work, one in the Forth Park and Pitsmoor district, another between Crookes and Walkley, and the third between Ecclesall, Fulwood and Ranmoor. It is instructive to observe that the drivers were formerly in charge of the Midland Railway Co.'s ordinary horse vans, and acquired the knowledge of control of the electrics in a few days' training.

The Sheffield "Daily Telegraph" is not slow to note that the electric has distinct claims upon the industrial vehicle users and tradesmen of the district, and takes the opportunity to recommend that it be utilised wherever the opportunity presents itself to employ the vehicle in its own field. Heavy loads of 2 to $3\frac{1}{2}$ tons are the order of the day in the district, and not infrequently are entrusted to horses, because they can haul, if inefficiently, at a low speed. Obviously these are the conditions suited to the electric battery van.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, May 26, 1916.

ELECTRIC VEHICLE PROGRESS



THE BATTERY VEHICLE IN MUNICIPAL SERVICE.

The credit for the revival of the electric battery vehicle business in this country must be given to a small group of individuals representative of the electricity supply and the manufacturing interests. The co-operation of these few enthusiasts, who got together as recently as three years ago, has resulted in the formation of the Electric Vehicle Committee and in the increase of the number of vehicles in service



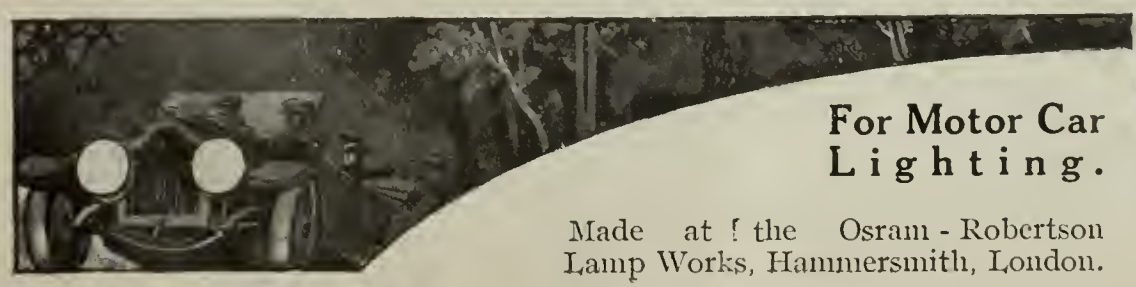
The First Modern Electric used in Municipal Service: by the Glasgow Corporation. (Edison-Anderson.)

by more than 300 per cent. Up to the time when war broke out the business was making steady progress outside the sphere of operations represented by the purely municipal transport utilities. The war forced the attention of vehicle users upon some form of power wagon, and with the commandeering of horses and a large number of petrol vehicles, the choice became gradually narrowed to the battery operated machine.

At a time when municipal electrical engineers are meeting together for their annual Convention it will be appropriate briefly to comment upon the work which has been done by municipal electrical engineers and by tramways managers, cleansing superintendents and city surveyors in putting the battery electric into active service. So far as the electrical engineers themselves are concerned, there is always a considerable amount of transport work to be done round and about the system which would justify the employment of a convertible electric, that is, a vehicle upon which a van or passenger body may be used at will. In large areas a fleet of electrics can be economically used, as has been demonstrated by Mr. W. W. Lackie, of the Glasgow Corporation electricity department. Apart from the service which these handy vehicles render, they represent a constant advertisement both for themselves and for the electricity undertaking. This has also been proved in the case of Glasgow, where a number of electrics have been purchased by several of the important trading organisations in that city.

There are not a few electricity undertakings in which the generating station is awkwardly placed in respect to the local railway system, and maybe the canal facilities in the neighbourhood. This location will involve the carting of the coal, and Mr. A. H. Shaw, of Ilford, has successfully demonstrated that a 4 to 5-ton battery vehicle can be more economically employed for this class of haulage than any other type of power wagon. Now that vehicles are scarce and labour is difficult to obtain and high-priced, it would appear that the battery lorry is a necessity in which every station engineer who can put the machine to good use should invest.

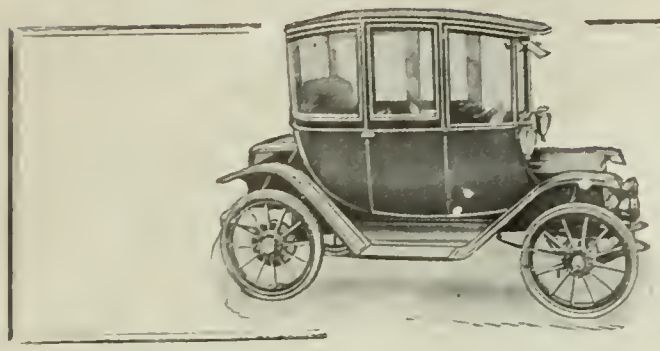
The public cleansing and sanitary departments have also been awakened, particularly since the war to the merits of the battery-driven dust-collecting van. Without wishing to single out any individual for special praise in this regard, we may mention the name of Mr. W. H. L. Watson, of Edison Accumulators, who has steadily worked on this proposition and has been able to show almost remarkable results. The prejudice of a certain type of municipal official against innovations of any kind is traditional, but even this case-hardness would appear to have been pierced, and the battery dustvan has proved its capacity in trials with other forms of haulage. The past year has witnessed a friendly attitude on the part of the Local Government Board towards the purchase of these vehicles. Tests have abundantly proved that they save their cost within a given time, that they do the work more effectively than was possible by previous methods, and that they have



For Motor Car Lighting.

Made at the Osram-Robertson Lamp Works, Hammersmith, London.

Osram
DRAWN WIRE
Lamps



Why not have your electric car

fitted with an

'IGRANIC'

ELECTRIC VEHICLE CONTROLLER?

For economy, smooth acceleration and perfect reliability they are unrivalled. Regularly supplied on some of the noted lines of electric vehicles.

IGRANIC ELECTRIC Co., Ltd., London and Bedford.

established a new standard in the field of dust collection, which is more desirable from a public point of view, and certainly more hygienic. The battery tipping wagon is essentially something different from the horse-drawn vehicle, particularly in the design of its body. Tipping can be undertaken from the kerb without the necessity for mounting steps, and an improved type of top cover can be employed which minimises the indiscriminate scattering of dust and microbes by every wind that blows. It has also been shown that this work can be done with greater expedition, and that in itself is a most desirable thing, because the collection and disposal of towns' refuse is one of those matters which the public has got to put up with.

The battery bus has been running in Southend, South Shields and York, and tramway managers who have introduced these vehicles speak highly of their capabilities. Similarly, they have come to appreciate the merits of battery driven tower and repair wagons, a form of vehicle which it seems only logical to employ on an undertaking so essentially electrical. Indeed, petrol-operated vehicles of any kind seem to us to be entirely out of place where electricity is concerned. A type of public vehicle which is also worthy of reference is the battery-driven ambulance. Here again, unless the local conditions are essentially suited to the non-electric vehicle, we regard the battery-operated machine as the only logical one for ambulance work. In many districts the local medical board is essentially municipal, and the electric ambulance may, therefore, be regarded as a form of municipal vehicle.

We will not labour the matter by detailing the numerous examples of the employment of battery-operated fire engines, fire escapes, &c. Many of these machines form a vital section of the fire-fighting departments of the metropolis, and fire brigade superintendents who have had them in use speak highly of their efficiency and reliability.

CENTRAL STATION PROMOTION OF ELECTRIC VEHICLE USE.*

BY W. P. KENNEDY.

Is the extension of electric vehicle use of serious interest or benefit to the central station?

Is the central station in a free position, legally or logically, to make the use of electric vehicles, in general public service, a project of its own which will harmonise with the present conduct of its business?

Is the central station so completely occupied or concerned with the conduct of its existing activities as to be more justified in sticking to what is its own business now rather than reaching after something which must require a large amount of time, energy and money to properly develop as an auxiliary branch of business?

To what degree of magnitude shall the central station develop this project as a new undertaking?

Shall it work in the direction of passenger car development or the commercial motor truck; and if both lines must be built up, in which direction will the central station reap the most permanent benefit?

Immediate attention is necessary, even if a decision should be reached adverse to the development under consideration. Urgency is essential because a crisis exists at the moment which will determine whether the electric vehicle business will simply float along in a passive state of existence, with regard to other motor vehicle development; or whether it can be invigorated to such an extent that it will maintain its place in cities on a par with other vehicle development; with consequent superior revenue to interested central stations. This crisis has arisen from two causes, one relating to the passenger car and the other relating to the commercial vehicle.

In the passenger car field the petrol car business has progressed in each of the past few years in a phenomenal manner, with quantity production from most of the factories which was previously un-

* Points from a Paper read before the National Electric Light Association, New York.

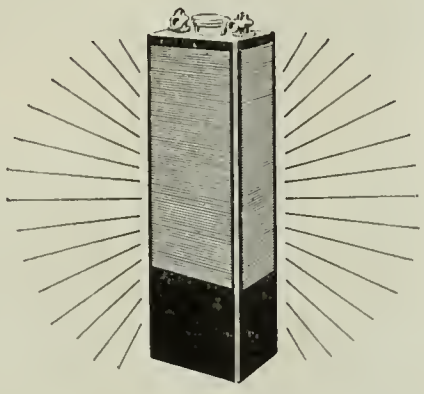


A 4.5 ton Edison Tipping Coal Wagon which is doing Yeoman Service at Ilford. (*See* page 8*.)
Mr. A. H. Shaw, the Engineer of the Electricity Department, is at the left of the picture.

EDISON

ACCUMULATOR ELECTRICS are LEADING!!

Some of the Reasons:



Because they are equipped exclusively with the Edison Accumulator, which, now in its eighth year of service, is proving more durable, more reliable and simpler to operate than any other type of storage cell.

Because the Edison Accumulator is made of Steel throughout, including the container; uses a **steel preserving electrolyte**; and cannot buckle its plates, sulphate, corrode, lose its charge, nor suffer from the effects of overcharging, high rate boosting nor being discharged to zero when necessary.

Because the **Edison Four-Year Guarantee** is unique and warrants the user that his accumulator shall give full rated capacity at the end of this time.

Because the Edison Accumulator is the lightest and strongest storage cell and **may be charged in less time** than any other type.

EDISON ACCUMULATORS, Ltd., 2 & 3, DUKE STREET, ST. JAMES, LONDON. S.W.

AGENTS:—

Birmingham:—
J. P. KEMP,
Grand Hotel, Birmingham.

Lancashire and Cheshire:—
DRAKE & GORHAM, Ltd.,
47, Spring Gardens, Manchester.

Glasgow:—
J. HALLY CRAIG.
45, Hope Street, Glasgow.

dreamt of, and with a consequent fall in the market or selling price; which if it continues will simply stultify the electric passenger car business to that very limited field where it will be selected by the wealthier class of purchaser on the sole basis of comfort and elegance.

With regard to the commercial field, there has been an extraordinary and abnormal development in the demand for petrol vehicles for military purposes in Europe. Previous to this demand few of the manufacturers had produced or sold trucks in quantity as the electric vehicle manufacturers had. Consequently, they knew little of the economic possibilities within their factory or sales departments which are attendant upon quantity production of this type of vehicle. These export orders have enabled them to clear out their old or obsolete materials; to organise their equipments for quantity production; to learn what could be done in reducing prices based upon quantity orders; and have created a pressing desire, on their part, for the continuance of such quantity business. As soon as the present export demand ceases or declines, these organisations will proceed to develop the domestic business in competition with one another, with such zest and vigour in effort, and the spending of such quantities of money for exploitation, that the already enfeebled electric vehicle manufacturers will be unable to make any progress against them. Under such circumstances, the electric vehicle load opportunities for the central stations will disappear.

With this view of the situation immediately ahead, and assuming that it may be regarded as advisable to develop this type of load, what would be the determination of a group of central station engineers if they sat down to consider how they would spend their own money in this project?

The line of competitive attack upon other types of transportation apparatus employed, or to be employed, in cities, *can only be successfully made upon the basis of guaranteeing the superior economy of the electric vehicle.* If users of vehicles, passenger or commercial, could be assured of what we know to be the low cost of operation, by means of a garage service covering the upkeep and maintenance of the complete vehicle in constant working condition for a flat price per annum, these users would unquestionably adopt the electric vehicle in preference to any other type of machine. No competition on the part of petrol vehicle makers could withstand such guaranteed service cost. They could have no such organised effort in their behalf as the central station can exert or promote in this direction.

Service, and the cost of it, is what every user is primarily interested in. The central station can render such service, but it would probably be more practicable to provide for it through a collateral organisation. A surprising profit can be made by such operations, aside from the advantage of permanent increased load.

No permanent investment more than 3 per cent. of the amount which the owners put into their vehicles would be required for equipment with which to conduct such an enterprise; and 30 to 40

(*Continued on p.* 6*.)



How to Use an Electric to Advertise the "Service" as well as the Vehicle itself.

MUNICIPAL BATTERY



"G.V." Tipping Wagon at Ipswich.



Edison "G.M." Dust Van at Nottingham.



Edison "G.M." Dust Van at Sheffield.





Edison "G.M." Dust Van at Sheffield.



An Edison Dust Van Climbing 1 in 8.

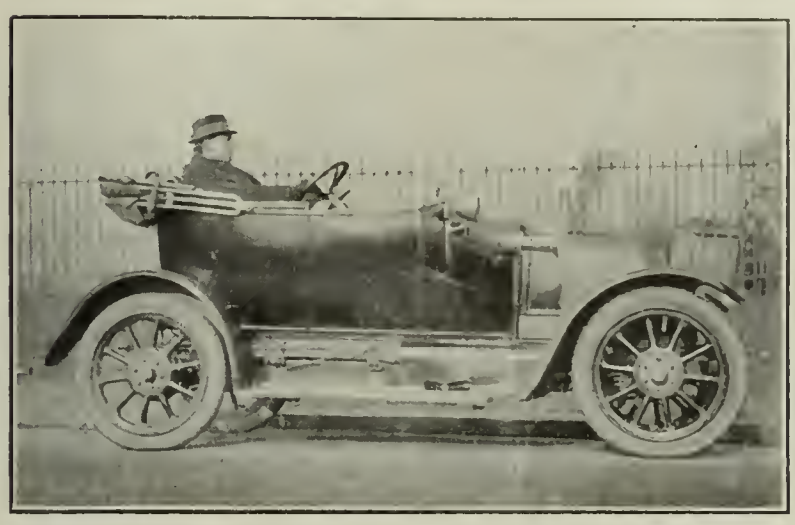


"G.V." Water Cart at Blackpool.

VEHICLES IN SERVICE.



Glasgow Electricity Department Fleet of Edison Electrics.



Croydon Electricity Department Edison Passenger Electric.



Liverpool Corporation Edison Electric used for Recruiting.



A New York Electric Hauling Coal.



Ipswich Corporation Electricity Department Delivery Van.



York Corporation Fleet of Edison Buses.

SIEMENS BROTHERS & CO., LTD.
WOOLWICH.
ESTABLISHED 1858.
Telegrams: "Siemens Woolwich." OVER 4,000 EMPLOYEES. Telephone: City 6400 (7 lines).

CABLES & WIRES,
MOTOR-CAR LEADS
(Weatherproof, Strong, Flexible and Durable),
BATTERIES
&c., &c.

per cent. of what the user would pay for such service would be net revenue, the cost of operation being not more to the user than if he furnished the service himself. In addition to this general maintenance plan, other special types of service, such as the "Battery Service System," can be added wherever they can be used to extend the scope of the business.

Such an undertaking would be well within range of the legitimate activities of central station organisations. It would be nothing more than adding to the present lighting service and power service a vehicle service, the principal function of which would be to supply energy and maintain this type of energy-consuming apparatus in working condition; in a somewhat similar but larger way than the methods now employed to maintain lamp equipment, or the several other types of devices which are supervised in such a way as to ensure to the central station that they continually remain in condition to consume its energy supply.

PIANO MOVING BY ELECTRIC.

There is perhaps no trade to which the electric vehicle is better adapted than piano delivery, a business in which skill as a piano mover must be combined with that of a chauffeur. Like all other big industries in which delivery is an important feature, the horse for piano moving is past history, for the requirements of an efficient and economic delivery system are best met by the commercial motor. The question as to what type of motor vehicle will show the best service has been something of a problem in a class of delivery where the requirements are in some respects unique. It is first necessary that the men on the machines shall be skilled piano movers, and that that is an art in itself the sceptical can prove by home experiment. Second, it seems to be the policy of most large businesses of this kind to retain employés in service over long periods of years. These two requirements at first seemed incompatible with the introduction of motor vehicles to take the place of the old horse-drawn type of vehicle, for a skilled motor driver and piano mover is apt to be a rare combination. To hire such, moreover, would mean the displacement of old employés and to place a chauffeur on each motor in addition to the moving crew would wipe out a good part of the vehicle's economy.

The solution in many cases has been the electric vehicle which, due to its simplicity and ease of operation, can be operated by anyone with a normal amount of intelligence. The New York Piano Delivery Co., which has been operating a 2-ton electric truck for over three years, states that the electric has proved extremely satisfactory as compared with petrol or horse-drawn vehicles. This company has entirely given up horse equipment and is enthusiastic in its praise of the economy and dependability of electrics. Steinway & Sons, who are one of the largest users of electric vehicles in this service, have also displaced all their horse-drawn vehicles with electrics, and are now operating a fleet of five, varying from 3,000 lb. to 5,000 lb. capacity. In 1910, Steinway & Sons, after thorough investigation, decided that motor equipment would materially reduce operating expenses as well as increase the effectiveness of their delivery system. Almost every Steinway piano which has left the factory within the past six years, has made part of its journey in a power wagon, for a regular shuttle service is operated between the Long Island City factory and the Fourteenth-street branch in Manhattan. The pianos are built and assembled in Long Island City and then are shipped to Fourteenth-street where the cabinet work and crating are done. The two machines in this service make three,

"ORWELL" VEHICLES AT BIRMINGHAM.





THE TABLE RELATES TO THE RUNNING OF THE "ORWELL" DUSTVAN, ILLUSTRATED ABOVE.

City of Birmingham Refuse Disposal Department.

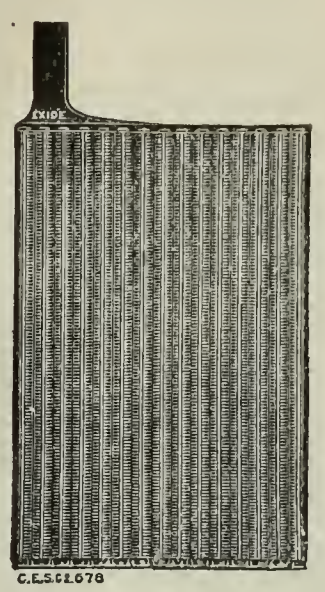
Date.	Loads.	No. of men.		No. of calls.	Bins emptied.	Tubs emptied.	Stops by electric vehicle.	Total mileage.	Approx. weight in tons, &c.	Ashplaces emptied.	Units supplied.
		Driver.	Labourers								
Monday, May 29 ...	3	1	4	443	304	55	153	18·4	6 16 0	70	17
Tuesday, May 30 ...	3	1	4	490	365	24	160	16·1	6 18 0	78	14·5
Wednesday, May 31	3	1	4	434	426	3	113	16·0	5 8 0	4	14·5
Thursday, June 1 ..	3	1	4	520	243	21	123	14·0	5 4 0	166	14·5
Friday, June 2. ...	3	1	4	316	143	43	127	16·9	6 2 0	125	16·5
Saturday, June 3 ..	2	1	4	140	46	26	16	9·7	4 0 0	69	9·5
Totals	17	...	...	2,343	1,527	172	692	91·1	34 8 0	512	86·5 *

* Average units supplied per day, 14·4.

"Ironclad Exide"

(Registered)

THE BATTERY FOR COMMERCIAL ELECTRIC VEHICLES.



Several sets in service have completed

24,000 MILES

on the road without a single cell having to be removed from the vehicles for any electrical defects whatever, and the capacity is still in excess of the catalogue output.

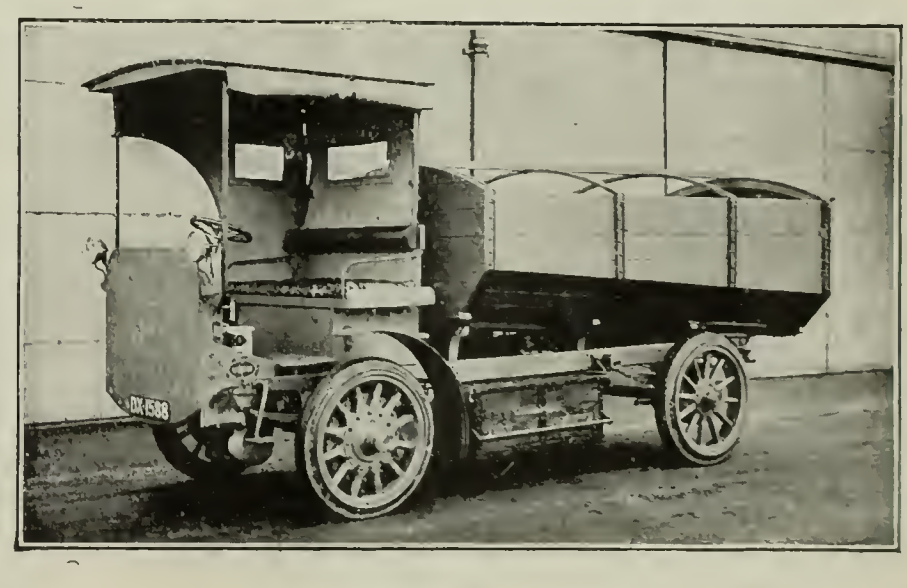
THE Chloride ELECTRICAL STORAGE CO. LIMITED

CLIFTON JUNCTION, MANCHESTER.

LONDON OFFICE: 39, VICTORIA STREET.

"ORWELL"

ELECTRICS



Throughout British Built.

are manufactured at

"Orwell Works," Ipswich, by Ransomes, Sims & Jefferies, Ltd.

MOSSAY & Co., Ltd., *Selling Agents for Great Britain and Ireland for* "ORWELL" ELECTRIC VEHICLES,

Queen Anne's Chambers, 41, Tothill Street, LONDON, S.W.

TUDOR
ACCUMULATORS
FOR ELECTRIC VEHICLES.



AMBULANCE WITH TUDOR BATTERY.
Port of London Authority—4 Vehicles. City of London Corporation—2 Vehicles.

BATTERIES FOR COMMERCIAL VEHICLES,
PLEASURE CARS, OMNIBUSES, &c.
LIGHTEST IN WEIGHT—HIGHEST IN EFFICIENCY.
Maintenance undertaken at Moderate Mileage Rates.

THE TUDOR ACCUMULATOR CO., Ltd.,
3, CENTRAL BUILDINGS, WESTMINSTER, LONDON, S.W.
Works: DUKINFIELD, near MANCHESTER.

sometimes four, round trips a day, each trip approximating 6 miles. These two transfer cars are housed in a garage adjoining the factory and are attended in every particular by their drivers.

The three other electrics which are used for actual delivery purposes in the city are in active service for nearly 12 hours a day, their runs varying from 40 to 60 miles. At the shipping office in the New York building, a charging plug has been provided which is used to "boost" the batteries while the machines are being loaded. This "boosting" not only makes possible the long mileage accomplishments but serves to keep the batteries at very nearly full charge most of the time. The Steinway Company states that all of the batteries used have a guaranteed life of four years, have exceeded this guarantee by over a year and are apparently good for a considerably longer period. The electrics average approximately 15 deliveries per day with an average cost of 20 cents. per mile, which includes every possible expense in their upkeep and operation. The Steinway Company states: "We consider the electric vehicle for city deliveries superior to any other form of motor car. They make fully as good time as petrol cars and are much cheaper and simpler to operate and maintain."

COAL HAULING BY ELECTRIC.

At the I.M.E.A. Convention last year Mr. A. H. Shaw, engineer, Ilford Electricity Works, anticipated great things of the 4-5 ton battery-driven coal wagon which he had ordered. He now tells us that it has been in service since January last, and has given him complete satisfaction. The vehicle, which is illustrated on p. 2*, is an Edison G.M. machine, and is fitted with an electric tipping gear actuated by a motor which derives its energy from the same battery which propels the vehicle.

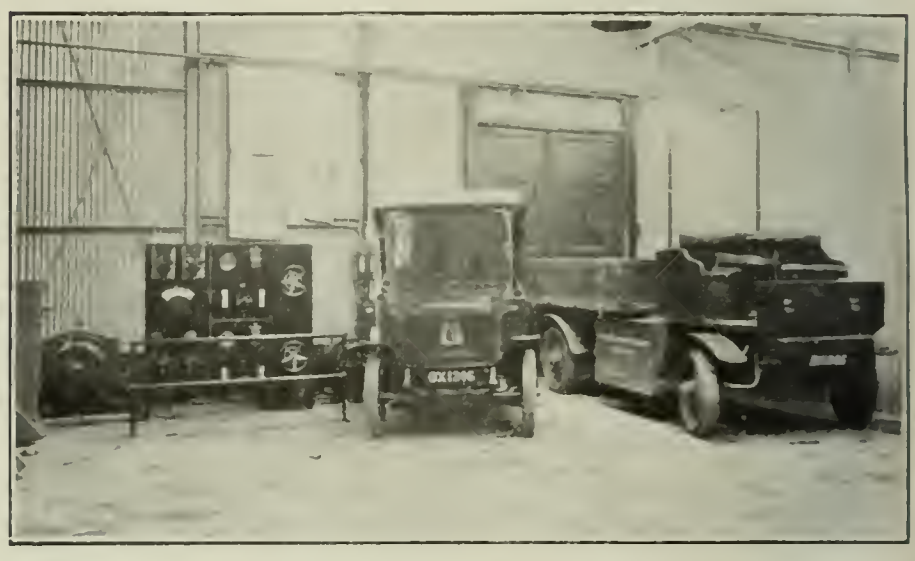
We understand that the running of the wagon has improved with service. The wagon makes about nine trips daily from the local railway siding to the electricity works, about ¾ mile, and hauls some 40 tons of coal. Mr. Shaw states that if the cost of the wagon be capitalised on a 10 years' basis, and energy is taken at 1d. per unit input to the motor generator, the average cost per ton of coal delivered is a little less than 9d., as against 1s., per ton, the cost at the end of last year for the hauling of the fuel by horses.

The electric tipping gear has proved most useful in practice, and saves a great deal of time over hand tipping. At present the hopper on the Edison vehicle has to be filled by hand at the railway siding, but Mr. Shaw is hopeful (if the war does not last too long and bankrupt us) that he will be able to arrange for a small portable elevator, driven by motor from the vehicle battery, to load up the coal, and thereby increase the daily total haulage of the wagon.

In his experience Mr. Shaw says: "I consider that there is no other means of haulage for heavy 'dead' loads, such as coal, for short distances, say up to 4 or 5 miles, which can approach the 'electric' from the point of view of cost, reliability, ease of running and absence of noise and nuisance."

A MUNICIPAL ELECTRIC GARAGE.

It is perhaps fitting that at Ipswich, the home of the secretary of the Electric Vehicle Committee, Mr. Frank Ayton, there should exist the nucleous of important developments in electric battery vehicles for commercial purposes. Mr. Ayton himself has consistently partaken of the medicine, the merits of which he has believed in for so long; he has used electrics around and about his own electricity undertaking, and has commended his example to the notice of vehicle



Ipswich Electricity Works Garage.

users of all classes in the Ipswich area. Already he has set up a garage, in which his own ½-ton delivery van, the 3-ton tipping wagon of the surveyor's department and the 2½-ton lorry of the Ipswich Co-operative Society are regularly charged. The local goods department of the Great Eastern Railway have also ordered a 2½-ton lorry, and as soon as this is delivered it will be taken care of by Mr. Ayton's department.

The electric has already caught on in Ipswich, and users are en-

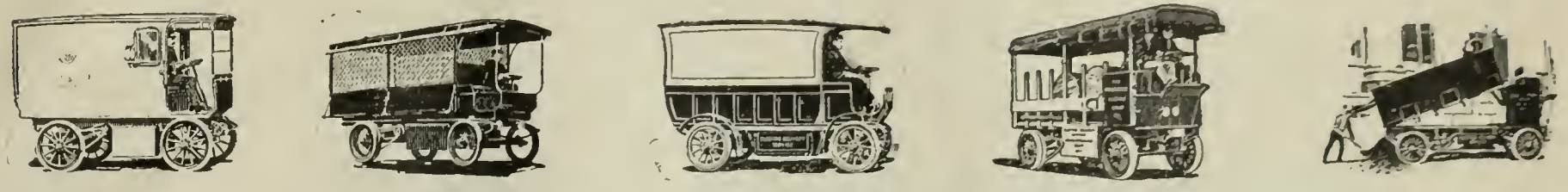


Ipswich Electricity Works Garage.

thusiastic regarding its merits. The Borough Surveyor finds it so useful as a general purposes vehicle that he cannot spare it for street-watering purposes, though there is a tank body which can be fitted in a few minutes. The economies of the battery dust van are also not being lost sight of, and in due course we shall expect to hear that these have been ordered to replace horses or other means of transport.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, June 23, 1916.

ELECTRIC VEHICLE PROGRESS



LARGE DEMOUNTABLE BODIES FOR ELECTRICS.

A considerable amount of experimenting has been done with small platform battery trucks to increase the running time of the vehicle and generally keep it in service when loading and unloading operations are going on. The most satisfactory solution of this problem is the provision of a type of body which is detachable from the truck itself, and which can be put down or picked up at any convenient loading or unloading point. The idea seems to have originated with a type of small hand trolley fitted with three wheels, and designed with a form of "T" handle, which when turned will raise the detachable body or lower it to the floor. The three-wheel bogey can be easily pushed under the load, and the gearing is such that one man or a strong boy can turn the handle and lift up to about half a ton from the floor. These hand trolleys are very popular in warehouses and certain classes of works in which raw material or semi-finished parts require transporting from one part of the shop to the other.



FIG. 1.—VEHICLE BACKED UNDER BODY.



FIG. 2.—VEHICLE BACKED RIGHT UNDER BODY.

With the introduction of the small battery truck the loads handled have been increased up to 3 tons. A truck fitted with such a body is shown in Fig. 6.

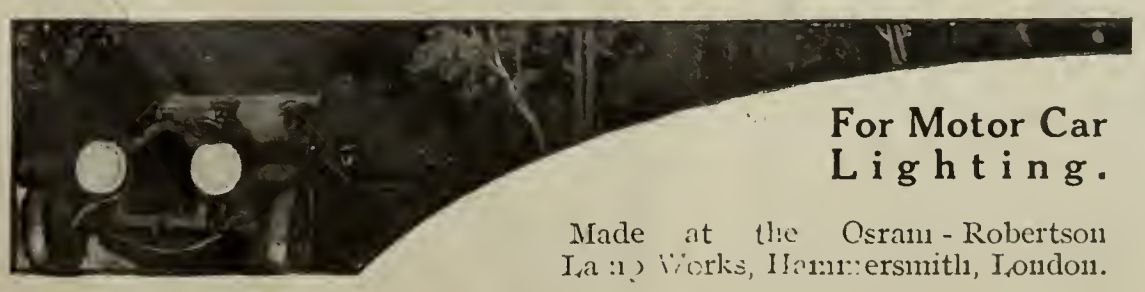
The Midland Railway Co., who have shown such commendable

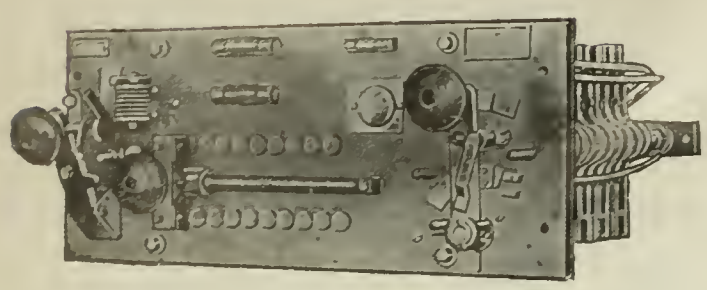


FIG. 3.—BODY SLIGHTLY RAISED FROM VEHICLE.



FIG. 4.—BODY IN POSITION WITH CASTOR WHEELS RAISED.





The IGRANIC Unit Panel for charging Electric Vehicle Batteries

is complete with every safeguard and modern convenience. It protects and lengthens the life of the batteries. A charging installation built up of these units can be extended at any time as the number of vehicles increases.

IGRANIC ELECTRIC Co LTD 147, QUEEN VICTORIA STREET, LONDON. Works: BEDFORD.



enterprise in putting into service a large fleet of electrics, which now numbers nearly 100 vehicles, can claim credit for the introduction of a demountable body which is suitable for vehicles which ply about the streets.

The demand for this class of body almost naturally arises with certain classes of railway transport, in which the complete load requires to be picked up at the station, say, and deposited *in toto* at a warehouse or factory as the case may be. By means of the demountable body it is possible to save a considerable amount of time in loading and unloading, and where a single consignment of goods runs into many tons the vehicle can be kept working while the loading and unloading operations are in progress. This interesting demountable body is shown in Figs. 1, 2, 3, 4 and 5. We understand that the idea has been fully patented, and the sole rights are in the hands of Messrs. Edison Accumulators. The photographic illustrations show four positions of the body. In the first the lorry is about to be backed under the body itself; in the second the operation of backing is completed; in the third the load has been slightly lifted so as to raise the castor wheels from the ground; and in the fourth the entire load has been lowered on to the body, and the castor wheels have been turned at right angles so as to clear the ground. The operations of raising and lowering are carried out by means of an auxiliary motor, which is fitted into the chassis frame, as shown in Fig. 5. The motor is operated by a special notch on the controller, and it works on the full battery voltage. It is attached to a small sub-frame immediately behind the battery box, and is placed with its axis at right angles to the direction of travel. There is an extension of the motor spindle to a coupling which is connected with the shaft, having at its outer end a worm wheel.

This is totally enclosed in an oil box, and engages with a wheel upon which a long shaft is secured. This extends from the centre towards the rear of the chassis. The shaft is fitted with a square thread at each end, and a block moves on this, there being a toggle attached which operates a pair of heavy levers, one at each end of the shaft. The free end of each lever is provided with a roller. The levers at the front and rear end of the vehicle are secured to a transverse shaft, so that there is a lever on each side of the chassis. It will be noticed from the side elevation that these levers move from opposite directions, therefore there is no tendency to slew the body off the trolley. The entire operation of backing under the load and getting it into position ready for away occupies only a few minutes. When the body has been slightly raised from the ground, each of the castor wheels, which will be noticed at the ends of the four "legs" depending from the body, is raised in turn by hand and secured in a horizontal position by a movable pin which is attached to the leg by a short length of chain.

We understand that the Midland Railway Co. has one of these vehicles now running in the London area, and the experiments so far have proved it to be quite a success. The company is considering fitting a number of their lorries with the demountable body, and these vehicles will operate in that class of service for which this form of body is essentially suited. Obviously, there is no need to apply this type of body to a vehicle which is gradually getting rid of its load or picking up its load at different points. We feel sure that the arrangement will have a wide use, and that motor transport

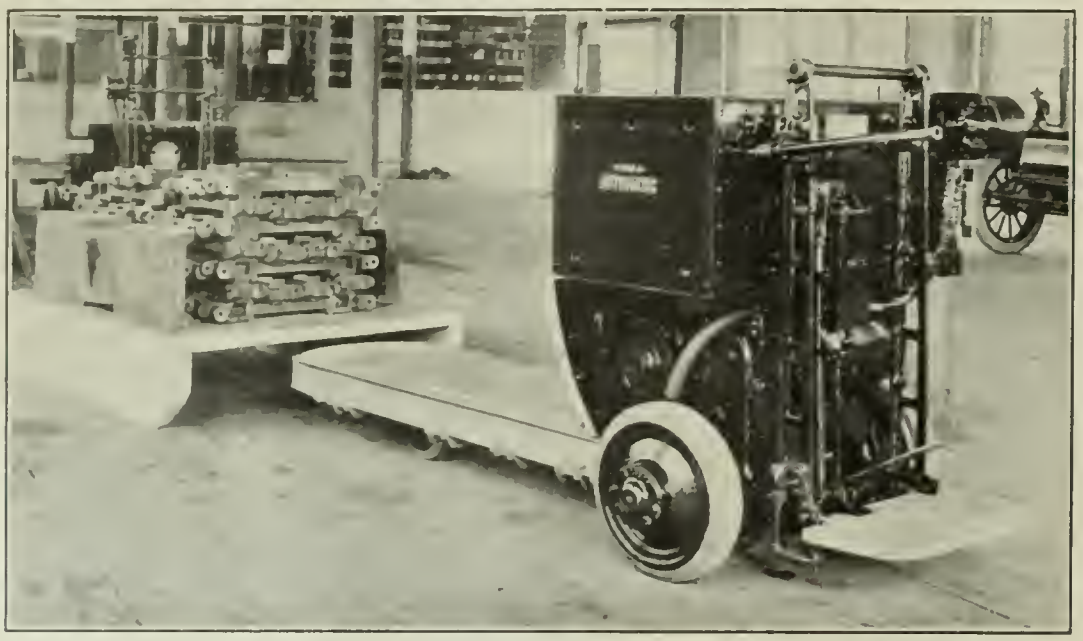


FIG. 6.—SMALL INDUSTRIAL TRUCK WITH DEMOUNTABLE BODY.

The bodies are standardised and can be loaded and unloaded while at rest.

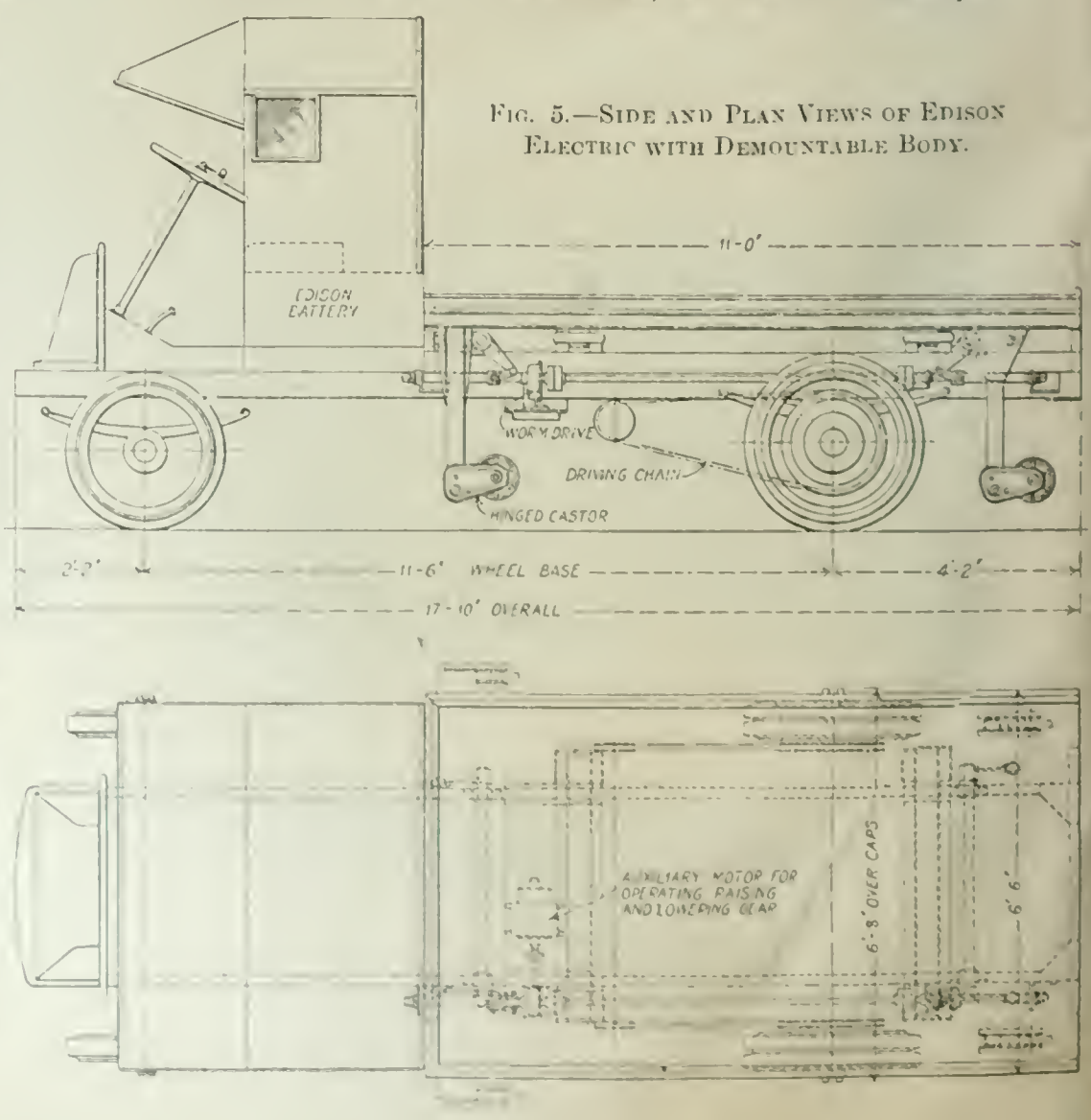
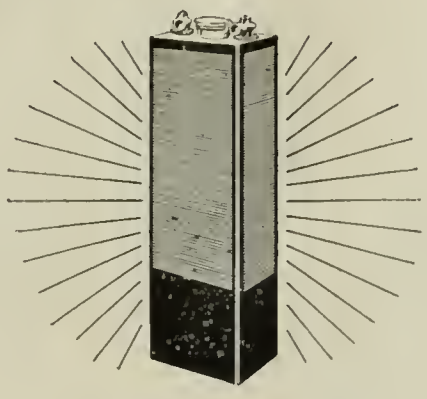


FIG. 5.—SIDE AND PLAN VIEWS OF EDISON ELECTRIC WITH DEMOUNTABLE BODY.

EDISON

ACCUMULATOR ELECTRICS are LEADING!!

Some of the Reasons:



Because they are equipped exclusively with the Edison Accumulator, which, now in its eighth year of service, is proving more durable, more reliable and simpler to operate than any other type of storage cell.

Because the Edison Accumulator is made of Steel throughout, including the container; uses a **steel preserving electrolyte;** and cannot buckle its plates, sulphate, corrode, lose its charge, nor suffer from the effects of overcharging, high rate boosting nor being discharged to zero when necessary.

Because the **Edison Four-Year Guarantee** is unique and warrants the user that his accumulator shall give full rated capacity at the end of this time.

Because the Edison Accumulator is the lightest and strongest storage cell and **may be charged in less time** than any other type.

EDISON ACCUMULATORS, Ltd., 2 & 3, DUKE STREET, ST. JAMES, LONDON. S.W.

AGENTS:—

Birmingham:—
J. P. KEMP,
Grand Hotel, Birmingham.

Lancashire and Cheshire:—
DRAKE & GORHAM, Ltd.,
47, Spring Gardens, Manchester.

Glasgow:—
J. HALLY CRAIG,
45, Hope Street, Glasgow.

firms, aside from railway companies, will find it of great value. There are a number of districts, we understand (Sheffield in particular), in which it is necessary to take heavy loads from one works to another or from warehouses to works, the entire load being taken up and put down in each case. Doubtless it is in such districts that we may shortly expect to see these interesting vehicles put into service.

OPPORTUNITIES IN JAMAICA FOR ELECTRICS.

In a recent communication from the Consular Department of the Island of Jamaica, the Electric Vehicle Association of America has been informed that never has the time been so opportune in that district for the introduction of battery-propelled vehicles. Within the past few years automobiles of all classes, both commercial and passenger, have been used in continuously increasing numbers. The roads in Jamaica, it is stated, are excellent, and while there are a few possible exceptions, the hills average a grade of only 1·2.

Agriculture is the most important industry of the island. There are immense banana and coffee plantations, their produce, together with cocoa and cocoanuts being the principal exports. Many large industrial plants are engaged in the manufacture of aerated waters, cigars and cigarettes, biscuits, shoes and leather, while there are several saw-mills and foundries, the latter manufacturing boilers and small engines. During the past year since the seriousness of the dye situation has forced itself upon the manufacturers, unusually large shipments of dyewood have been imported by the United States from Jamaica, so that this industry is now assuming larger proportions. The cultivation of bananas is pre-eminently *the* industry, however, Jamaica exporting twice as many bananas as any other country in the world. It is in this particular field that the electric vehicle seems well adapted, the Electric Vehicle Association is informed. The actual work of transporting bananas from the plantations to the railroad tracks for final shipment is something of a problem. On the largest plantations it is customary to build railroads or tramways through the plantations, a very expensive system to operate. Many of the smaller plantations, however, have nothing of this sort, and depend on bullock carts, mules or just carrying the bananas on men's shoulders. Obviously, this means a great loss due to inefficiency which the motor truck should be able to overcome. As the plantations are nearly always on very level ground it seems reasonable to believe that here is a large field for the application of the electric truck which has not yet been developed.

Like all other places, Jamaica too has the problem of increased fuel cost to contend with, the cost of petrol at present being 48 cents (United States currency) per gallon. Electricity for charging is very cheap, and should become even cheaper as more power supply stations are developed, water power being very plentiful in Jamaica. Kingston, the principal city of Jamaica, offers many opportunities for the application of light weight electric delivery wagons in addition to the heavy capacity for haulage. Passenger vehicles also are in great demand throughout the island and the electric should be especially well adapted because of the excellent roads and the fact that the mileage radius seldom exceeds that of which an electric is capable on a full battery charge.

DRIVER'S SPEED INCREASED BY USING EFFICIENT MOTOR EQUIPMENT.

A proprietor of a large laundry which now operates 26 electric vehicles stated that one of the most noticeable things in the change from horse-drawn to electric vehicles was the increased efficiency of the drivers themselves.

With one exception, all of our drivers welcomed the change and, due to the very simple operation of electrics, they experienced no difficulty in learning to drive them in a remarkably short time. The exception of whom I speak was a driver who had been with us longer than the others and he was very sceptical about the new equipment. A couple of weeks after he had been driving one of the new electrics, I asked him if he wanted to go back to the old method. He just grinned and said, "Nothin' doin'." Of course, the appearance of immaculate cleanliness which our whole delivery outfit now has, is a very great asset to a laundry. Our drivers wear white uniforms during the summer months and we find that the good appearance of our delivery fleet is the best advertiser we can have. Any woman

will place greater confidence in a laundry whose delivery men give a favourable impression in their fresh, clean uniforms, than one whose drivers always carry with them the disagreeable odour of horses and stables, or are begrimed with dirt and grease and are saturated with the penetrating smell of petrol. Another point is the effect which the increase in the speed and efficiency of the new equipment over the old has upon the drivers. Unconsciously they speed up their work and show a very noticeable increase in "pep."

There is a certain psychological effect upon the operator of an efficient motor delivery equipment that spurs him on to more speed in his end of the delivery work. The efficiency germ unconsciously gets into his system and he sees himself accomplishing many times more work than he did with the slow horse and wagon. It has been observed that when a man is driving a horse-drawn vehicle he recognises that the horse means comparatively slow transportation and he falls into the mental habit of doing everything in connection with his work slowly. He excuses himself by thinking or saying that he is easy on his horses and that he must treat his animals in a humane manner. The psychology of the thing works both ways. With delivery equipment that is slow, the driver himself becomes slow and plodding. On the other hand, if a driver is given a delivery equipment with which speed is easily maintained, it reflects on his own manner of working and he becomes a faster, better worker. The improvement in the attitude of the driver to his work when delivering with good dependable electrics is a valuable asset to any business trying to solve the delivery and transportation problem.

THE "ORWELL" ELECTRIC VEHICLE.

Many types of mechanically-propelled vehicles, particularly petrol and steam, for road transport have disadvantages that are difficult, and in most instances impossible, to remove. For town work, involving frequent stoppages, and where silence, cleanliness, reliability and low running costs are of primary importance, electricity is the most suitable form of propelling power to adopt. The "Orwell" electric vehicle has been designed to meet the steadily growing demand for a British built commercial battery vehicle, and it has a number of distinctive features.





The Old and New at Birmingham, The "Orwell" Electric on the right.

The efficiency of the combination of the modern storage battery, the motors and the simple mechanical transmission used in the "Orwell" chassis is high, and it is claimed that 60 to 70 per cent. of the energy put into the battery is applied to the road wheels. Also we understand that when going down hill the regenerative control with which the vehicle is provided enables an appreciable amount of energy to be restored to the battery.

The "Orwell" electric chassis includes a number of special features conducive to long life. The control of the motors has been designed to give exceptionally gradual starting. The front wheels are pivoted on inclined swivel axles in such a manner as to reduce the stresses on the front tyres to a minimum. Furthermore, the front wheel drive, which is used on all "Orwell" vehicles up to and including 2½ ton capacity, reduces the tendency to skid, and eliminates one of the causes of tyre deterioration. For these reasons the vehicle is light on its tyres, and the tyre life will, it is stated, be found to exceed that guaranteed by the makers.

"Orwell" electric vehicles can be fitted with batteries of various makes according to the requirements of customers. In order to reduce the cost of upkeep of the battery to an accurately determinable quantity, arrangements have been made with several battery manufacturers who are prepared to enter into contracts in Great Britain and most countries abroad to inspect and maintain batteries used at fixed rates. The form of these contracts differs for various makes of batteries, but the maintenance is usually based upon a fixed rate per mile or per ampere-hour discharged from the battery. As the rates depend upon the conditions of service, special quotations for battery maintenance need to be submitted.

The control and operation of the vehicle is so simple that almost anyone can be trusted to drive after a short instruction; highly-paid drivers need not, therefore, be employed. The fire risk is low on account of the absence of inflammable fuel, and the accident risk is considerably reduced, as the chassis is easy to handle in traffic. On this account an insurance covering all risks may be effected at a lower rate than for petrol or steam motor vehicles.

The "Orwell" chasis is driven by two motors, either geared to the front wheels on vehicles up to and including 2½ tons capacity, or operating on the back wheels by means of chains and sprockets on the larger sizes. The motors are totally enclosed, and are provided with brass end-shields and watertight covers, which can be easily removed for inspection of the commutators. Vehicles up to and including 2½ tons capacity have the motors bolted to the swivel axles, and they drive the front wheels by helical gears on the armature shafts, which mesh with internal helical spur-rings on the wheel hubs. These rings and the pinions are made of high grade steel and run in dustproof and waterproof casings filled with grease. In the vehicles of 3½ tons capacity and upwards the motors are bolted on to the chasis frame, and each motor drives an internal helical gear mounted on a stub shaft. The hubs of the internal gear wheels carry sprocket wheels, and these drive the back wheels by means of roller chains of liberal dimensions.

The steering is by worm and segment, with adjustable step-bearing for taking up any play. It operates through two ball-socket joints on to a bell-crank lever pivoted at the centre of the front axle. This bell-crank lever acts on the wheels by two short tie-rods. By this construction the stresses in the steering rods and links are reduced to a minimum. The axes of the pivots, about which the wheels turn when steering, pass through the points of contact of the wheels with the road. In consequence of this arrangement shocks are not transmitted to the steering wheel, which is, therefore, particularly easy to manipulate. There is no tendency for the front wheels to deviate from the set course by unevenness of the road, and, in case of emergency, the car can be driven by one motor alone without strain on the steering mechanism.

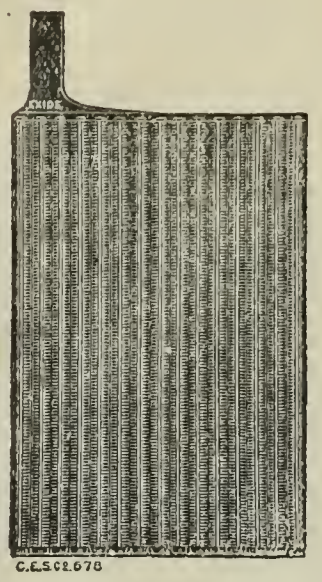
The battery of the vehicle is slung under the chassis in two boxes. Each box is arranged to slide sideways by pulling a handle-bar. The operation of raising the handle-bar lifts the battery box a fraction of an inch, throwing its weight on to rollers. By pulling the handle the battery slides out easily, and is readily accessible for examination. When the boxes are pushed back into position the handle bars are dropped, releasing the weight from the rollers and locking the battery in position.

The controller is located either under the driver's seat or in a casing fixed under the dashboard. In the first case there are two controller drums. The main drum is operated by a gate change

"Ironclad Exide"

(Registered)

THE BATTERY FOR COMMERCIAL ELECTRIC VEHICLES.



Several sets in service have completed

24,000 MILES

on the road without a single cell having to be removed from the vehicles for any electrical defects whatever, and the capacity is still in excess of the catalogue output.

THE **Chloride** ELECTRICAL STORAGE CO. LIMITED

CLIFTON JUNCTION, MANCHESTER.

LONDON OFFICE: 39, VICTORIA STREET.

lever mounted on the side of the driver's seat. It has four running positions for the forward direction and one position for reversing. The auxiliary or rheostatic drum is controlled by a foot pedal. In its normal position the two resistance steps are short-circuited. Before passing from one position to another on the main controller the pedal should be depressed; this inserts the two resistance steps into the circuit, and interrupts the current when the pedal is fully depressed. In this position it is possible to pass to the next position of the main drum without sparking. By releasing the pedal the



"Orwell" 2½-ton Lorry.

circuit is re-established through the two steps of the resistance that are successively cut out as the pedal is released. Thus no sparking takes place on the main drum, all the wear being taken up by the starting drum, which is protected by a magnetic blow-out and is quite inexpensive to renew. The repeated insertion of the resistance steps causes the passage from step to step of the main controller to be gradual and free from current rushes. The operation of the rheostatic drum by means of the foot pedal is analogous to the operation of the clutch on a petrol vehicle. It enables the driver to coast in traffic and to ease off when turning sharp corners without interfering with the main controller, and leaving both hands free for steering and signalling purposes.

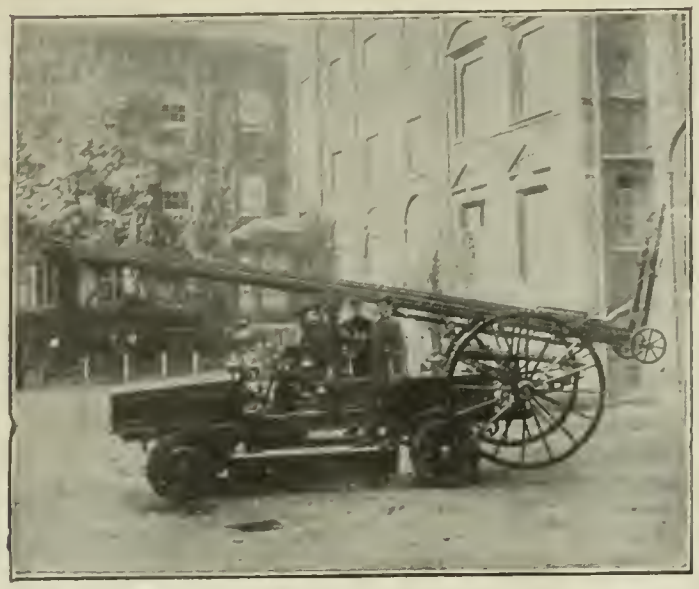
When the controller is fixed under the dashboard no starting drum is required. The controller is operated from the top of the steering column, and gives five speeds forward and a reverse. This controller is provided with a magnetic blow-out. The controllers, which are specially designed and manufactured for the vehicle by George Ellison, Birmingham, are made solely of non-combustible material. The finger tips and segments are all renewable and reversible. The cam on the rheostatic drum is arranged so as to give a "quick break" when passing from any position to the next, and so as to prevent the drum from remaining between the running positions. The provision of a magnetic blow-out prevents arcing between the finger tips and the drum segments. Accessibility is ensured by the provision of hinged doors both at the front and the top of the controller, so that all contacts can be easily reached.

The chassis is fitted with the standard charging plug approved by the Electric Vehicle Committee. It is so interlocked with the control that the controller must be in the "off" position during the operation of charging the battery.

The two independent mechanical brakes of the vehicle are exceptionally powerful. They both act upon the back wheels and are of the internal expanding type. The service brake is actuated by a foot pedal, and the emergency brake by a lever that can be held on by a ratchet. Both brakes are compensated, so that equal pressures are produced on both rear wheels. All joints in the transmission of the braking motion are provided with lubricators.

The two-motor drive is a special feature of the "Orwell" chassis. It has various advantages besides high efficiency in the transmission of power. It renders unnecessary the use of a change-speed gear box, differential gear, cardan shaft and universal joint. The motors are immediately accessible, and daily inspection is possible by the simple operation of removing the end covers. The electrical connection of the motors ensures a differential action without the intervention of any mechanical parts. The removal of all propelling mechanism from the back axle makes it possible to sweep the frame downwards when it is desirable to have the platform at the back very

TUDOR
Accumulators
FOR ELECTRIC VEHICLES.



FIRE BRIGADE VEHICLES WITH TUDOR BATTERIES.

London Fire Brigade—11 Vehicles. Liverpool Fire Brigade—4 Vehicles.
Rathmines (Dublin) Fire Brigade—1 Vehicle.

BATTERIES FOR COMMERCIAL VEHICLES, PLEASURE CARS, OMNIBUSES, &c.

LIGHTEST in WEIGHT—HIGHEST in EFFICIENCY.

Maintenance undertaken at Moderate Mileage Rates.

THE TUDOR ACCUMULATOR CO., LTD.,

3, CENTRAL BUILDINGS, WESTMINSTER, LONDON, S.W.

Works: DUKINFIELD, near MANCHESTER.

near to the ground, as it is often required for ambulances, fire engines, tower wagons and other special vehicles.

The "Orwell" electrics are made by Ransomes, Sims & Jefferies, Ipswich, for whom the sole selling agents are Mossay & Co. (Ltd.), Queen Anne's Chambers, Tothill-street, London, S.W.

MUNICIPAL ELECTRICS: TWO OPINIONS.

In a report to his Council, Mr. Arthur Harrison, M.Inst.C.E., the borough engineer of Southwark, made a number of statements regarding electrics, and in particular said: "This question is one that I have carefully followed for the last 16 years, and have kept in touch with all kinds of power for traction purposes. That of electricity has appealed to me as likely to be most useful for municipal purposes, but upon investigation up to the present it has always appeared to be unripe for its adoption. There is no doubt that eventually the difficulties standing in the way will be overcome, but there is still some distance to go.

"At present most of the electrical vehicles are of American origin, where electric power is more in general use than in any other country, and even there the question is very much debated, and trials are being made to get over some of the difficulties by the combination of petrol and electricity. No doubt electricity will become adaptable for our general use, probably in some five or 10 years, but the charges of one or two vehicles would be of no assistance to the Council's electricity works, and working them would be more expensive to the ratepayers than petrol plant."

Mr. J. Terry, cleansing superintendent, Nottingham, in a Paper read at the Institute of Cleansing Superintendents on the subject of electrics, said on the other hand:

"In the report presented to my committee in September last I submitted estimates from the makers of various electric vehicles and the results of special tests made at Barnes, Heston and Isleworth, Dover and Sheffield; but as we now possess figures covering a fairly long period under normal working conditions I think these are preferable.

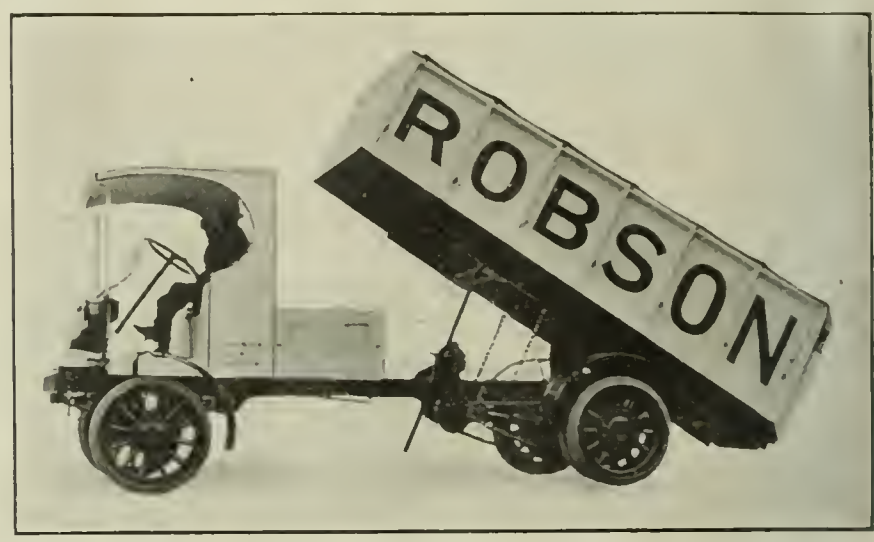
"During six months ending July 1, 1915, the cost of emptying dry ashbins by horse vehicles in Nottingham averaged 4s. 1d. per ton, but owing to the increased charges for horse-keep, wages, &c., the cost is now 5s. Our No. 1 electric was delivered on October 15, 1915, commenced work on the 18th, and has been in use daily ever since. During the six months ending April 15th it carried 422 loads, weighing 1,288 tons, at a cost of £241. 13s. 10d., which is equal to 3s. 9d. per ton, the average weight per load being 3·05 tons.

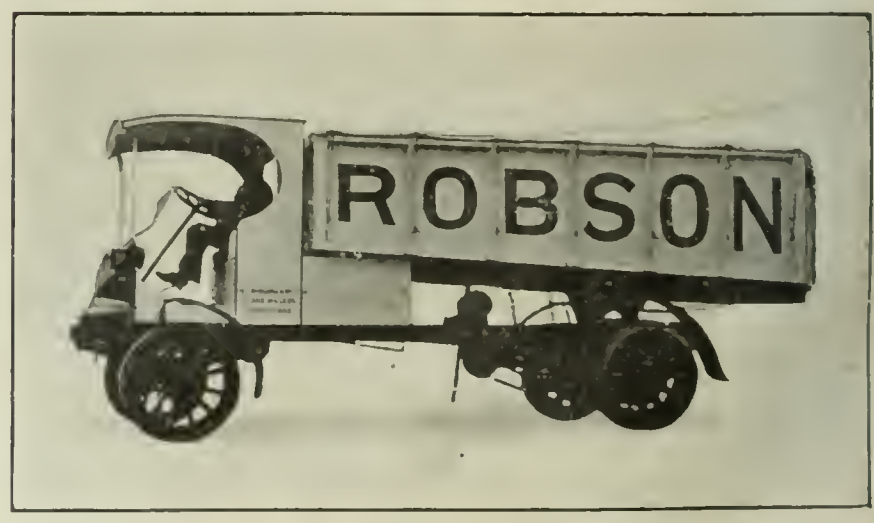
"The costs are made up as follows:—

Depreciation at 10 per cent.	£52	13	0
Insurance	4	5	0
Oil, water, repairs, &c. (allowed)	11	9	8
Tyres—1,819 miles, at 1·1d.	8	6	9
Current—2,541 units, at 1¼d.	13	4	8
Wages	151	14	9
	£241	13	10

"If we take the six months ending July 1, 1916, we get a period corresponding to the period covered by the figures given in my original report, and this is a more fair comparison than taking the first six months' work, which are all winter months. We find that during this time we removed 1,167 tons of refuse, at a cost of £253, or 4s. 4d. per ton, which is exactly the same as the cost by horses, as mentioned in my original report; but it must be remembered that the conditions then were the same as before the war. Under existing conditions, as I have already stated, the cost is 5s., thus showing 8d. per ton in favour of the electric, which means that if all our dry-ash refuse were removed by motors a saving of over £1,000 per annum would be effected, and this in a town which I consider not best adapted to motor traction for this class of work. I have dealt only with the results obtained by our No. 1 motor, but the figures for the No. 2, which has been at work daily since March 13, are identical.

"My faith in the success of electrics is upheld by many other municipal officials who with myself have franked their good opinion by placing orders and repeat orders as follows: Edison Battery Vehicles—Sheffield, 5; Chester, 4; Dover, 6; Barnes, 4; Glasgow, 2; Pontypridd, 2; Newcastle, Heston and Isleworth, South Shields and Smethwick, 1 each. Lead Batteries—Birmingham, 2; Wolverhampton, 1. In many cases reports have been made, in each of which substantial savings have been shown."

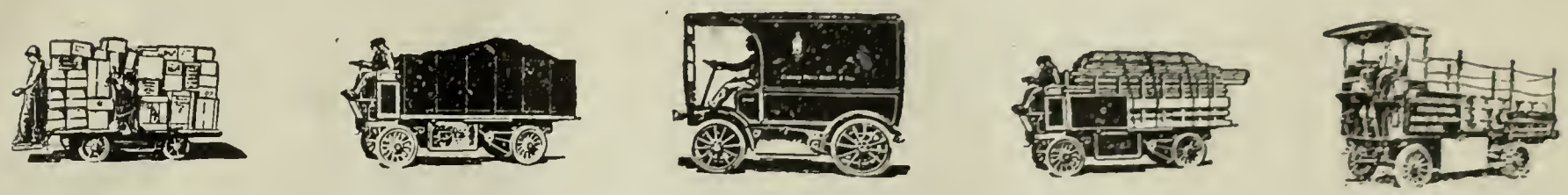




A Typical Edison Electric 5-ton Tipping Wagon carrying Grain. The Back End of the Body is provided with a Trap which Opens Automatically to Discharge the Load as soon as the Body is Fully Tipped.

Printed and Published for the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of London, Friday, July 28, 1916.

ELECTRIC VEHICLE PROGRESS



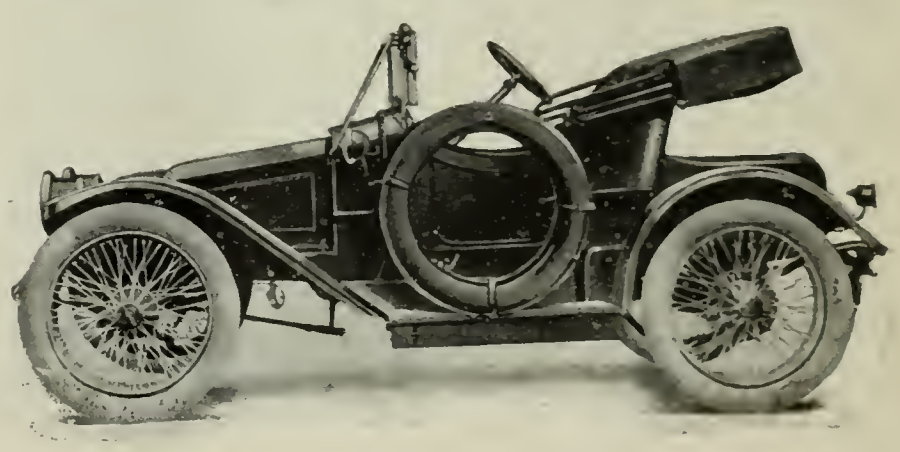
PASSENGER VEHICLE MISCONCEPTIONS.

The man who buys his first motor car is usually wild with delight as to the distances he will travel in it, the number of miles a day, a figure carelessly estimated in hundreds, and the short time in which he will travel from Blankchester to Dashfield, "stopping for a good lunch, my boy" on the way. He is going to "eat up the miles"; he will "cut out trains"; there shall not be a square yard of the country which he will have left unvisited during the first 12 months. After he has worn out the first car, he will make none of these resolutions in the purchase of the second. If he has kept any sort of record of his motoring it will reveal a chain of broken promises of what he was going to do.

Now that petrol has soared up out of reach of everyone but the Services and opulent munition workers, motorists are beginning to be honest men regarding what they have done with their cars. Take the "road eating idea," out of which springs the greatest of all motoring fallacies, that of high speed. The average motorist cannot keep his car going mile after mile at something over the legal limit without, in the first place, experiencing great physical discomfort. If he is an owner-driver he wants to arrive at his destination something more than a nervous wreck; and after a few months' experience he tones down any initial dash he may have had, because he finds that driving in comfort means keeping the speedometer needle round about 20 miles per hour. In the second place he has also discovered that high speed means wear and tear of the fabric of the car, the engine, the transmission, the tyres especially, the body work and the chassis parts. If he is an observant driver, and the average of motor drivers are so, he will have noticed the important relationship between speed and the cost of running generally. We have no figures by us, but we hazard that 75 per cent. of the private car users do not drive on the average much over 25 miles an hour. Of the remaining 25 per cent. of "speed merchants" a few only will be "road hogs."

All this argument may seem to have little or nothing to do with electric vehicles, but actually it has. Since the price of petrol rose so enormously, not only here but in other countries, the motoring papers and journalists have repeatedly been writing about petrol substitutes, and finally have taken up the electric as a real solution of the commercial vehicle problem and a possible solution of the passenger vehicle problem. One matter we would like them to be outspoken upon, and that is the touring range in which the average motor car owner indulges during a period of 12 months. The new petrol licences have reduced the possible daily mileage of a small car to as little as 10 miles per day. This means a moderate week-end "potter" of 35 miles out and home if a man does not use his car during the week. Unless he knows where he can get what we will call "unofficial" petrol he is, by his licence, reduced to a condition in which a passenger electric with a range of 50 miles would suit his requirements better than a petrol car.

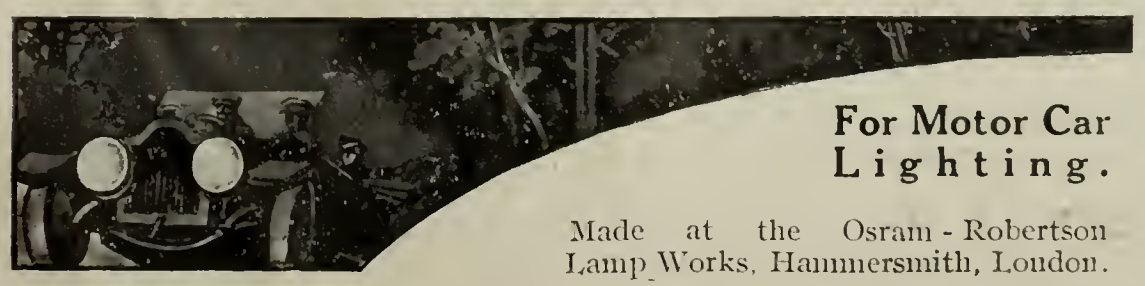
The tone of some of the articles in the motoring journals encourages the hope that the high speed and wide touring range ideas have been over-rated and that the war is making motorists generally look at the pastime from a new view point—a view point which should be preparatory to an increased faith in the modern electric and an appreciation of it as a touring car.

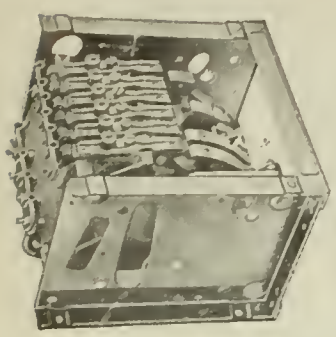


A Passenger Electric looks little different from a Petrol Car.

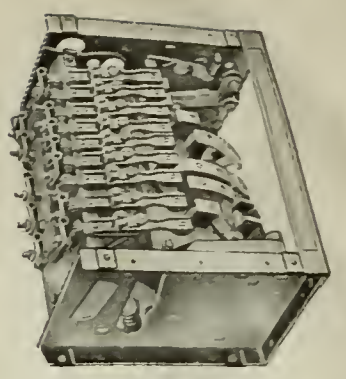
In the United States, where petrol has also assumed the wings of high prices, the claims of the touring electric are being strongly urged. We confine this month's issue entirely to the subject in order to give an indication of the turn which things are taking in favour of more passenger electrics. Over here we are not yet in a position to enter upon meeting any heavy public demand, but the problem of charging facilities is being tackled, and that in itself will go a long way to encourage touring by electric. In America they have the cars, but roads are bad, as the illustrations on the next page show, and electrical energy is high priced. Over here the roads are ideal for the electric, and energy is cheap, but "we ain't got the cars."

We believe, however, that sufficient enthusiasm is being aroused in motoring circles to merit steps being taken towards British manufacture. When these are seriously taken we honestly think that the passenger electric, like the commercial electric, will fill its niche in the sphere of road traction.




G6 Controller.

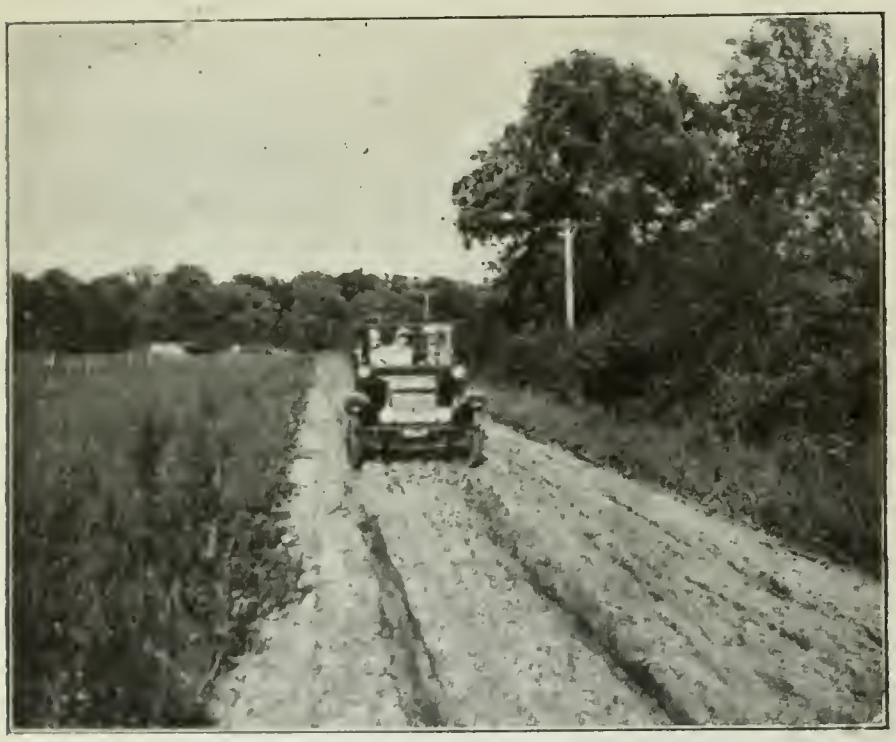
THE RIGHT CONTROL
FOR EVERY ELECTRIC VEHICLE
will be found in the
IGRANIC
Range of Proved and Standardised Electric Vehicle Controllers, designed to meet every requirement of vehicle manufacture. Write us for Pamphlet No. 624.
IGRANIC ELECTRIC Co LTD 147, Queen Victoria Street, E.C.

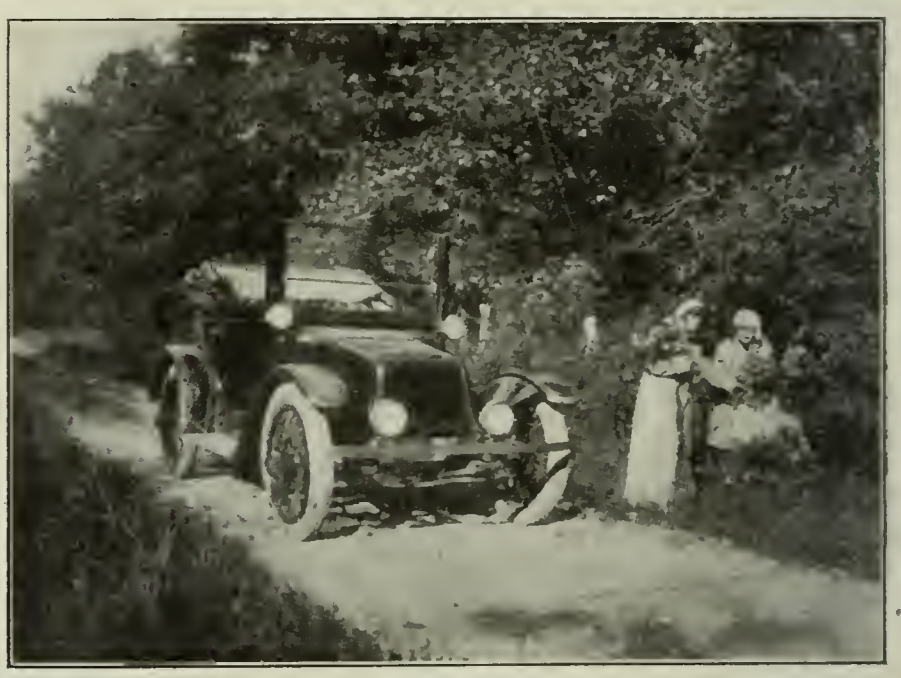

F8 Controller.

CROSS COUNTRY DRIVING IN AN ELECTRIC.

Although electric automobiles have come into general use, a great many people still lean toward the idea that the electric is essentially a town car, and that for country use it is unsuitable.

In order to disprove this theory, and to demonstrate the flexibility of the electric on all sorts of country roads and under the most difficult driving conditions, representatives of the "Electric City Magazine," of "Electric Vehicles," the trade journal of the electric automobile field, and of the Walker Vehicle Co., manufacturers of the "Chicago Electric," arranged a tour through northern Illinois to demonstrate that the electric car could go anywhere that a petrol car could, and at the same time maintain a very fair average speed over the country roads.


If an Electric will do this in America, why not over here?


Down a quiet country lane with an Electric.

The type of car used was the cabriolet, standard equipment, with a 42-cell "Philadelphia" storage battery, and wire wheels with pneumatic tyres. The batteries were put on a charge the evening prior to the day of the trip, and a full charge given.

There had been a heavy rain 36 hours previous to the day selected for the trip, so in some places the roads were in a somewhat soft condition. This did not interfere with the smooth running of the car, and the average rate of discharge of the battery on these roads was 35 amperes. On the macadam roads the pull did not go much over 30 amperes, and on many stretches it dropped to 25. On the grades the amperage kept comparatively low, the pull of a grade of from 5 to 10 per cent. being only about 60 or 70 amperes, and on a grade of 20 per cent. the reading was about 80 amperes. On grades of this nature the speed of the car was in the neighbourhood of 12 miles per hour, and on the stretches of good road encountered the electric had little difficulty in maintaining a speed of between 15 and 20 miles per hour on fourth speed. The bad roads were negotiated with care, so the average speed was comparatively low.

Unless excessively bad road conditions are encountered, there should be little difficulty with the average electric car in making about 100 miles a day, provided an hour's boost, or additional charge, can be obtained at the noon rest. For a short day trip, however, the machine will make about 75 miles on a charge, the distance made on this test trip being 73 miles, and at the end of the run sufficient charge remained to carry the car several miles further. This performance is possibly only with a cabriolet type, and will not apply to the heavier types of closed-in cars.

It might be well for those contemplating a country drive to ask friends who have tried the roads on some previous occasion their condition, and plan to avoid roads that tend to increase the ampere pull. With this consideration, and a careful driver, no trouble should be experienced in obtaining the maximum efficiency and power of the car.

In the test drive spoken of the car was driven over several roads in exceptionally bad condition, much worse than will be encountered under actual average driving conditions, with a full load of passengers, and it stood up remarkably well, keeping well ahead of the accompanying petrol car, which was following at a good speed.

In one instance the electric was loaded to its capacity and driven over a stretch of the worst road found. On this road, and under the conditions mentioned, the pull was but little over that on an ordinary road, the easy running conditions of the car relieving most of the additional strain.

Endurance runs in electrics have been sponsored chiefly here by manufacturers, in most cases as a means of publicity, but with very gratifying results in every case; and sociability runs on the Pacific coast are quite a common thing.

"CONSULT KEMP re ELECTRICS."
FACTORY TRUCKS & COMMERCIAL VEHICLES WITH EDISON ACCUMULATORS.
THE SIMPLEST AND MOST ECONOMICAL VEHICLES AVAILABLE.
J. P. KEMP, Grand Hotel, BIRMINGHAM.

EDISON

ACCUMULATOR ELECTRICS are LEADING!!

Some of the Reasons:



Because they are equipped exclusively with the Edison Accumulator, which, now in its eighth year of service, is proving more durable, more reliable and simpler to operate than any other type of storage cell.

Because the Edison Accumulator is made of Steel throughout, including the container; uses a **steel preserving electrolyte;** and cannot buckle its plates, sulphate, corrode, lose its charge, nor suffer from the effects of overcharging, high rate boosting nor being discharged to zero when necessary.

Because the **Edison Four-Year Guarantee** is unique and warrants the user that his accumulator shall give full rated capacity at the end of this time.

Because the Edison Accumulator is the lightest and strongest storage cell and **may be charged in less time** than any other type.

EDISON ACCUMULATORS, Ltd., 2 & 3, DUKE STREET, ST. JAMES, LONDON, S.W.

AGENTS:—

Birmingham:—
J. P. KEMP,
Grand Hotel, Birmingham.

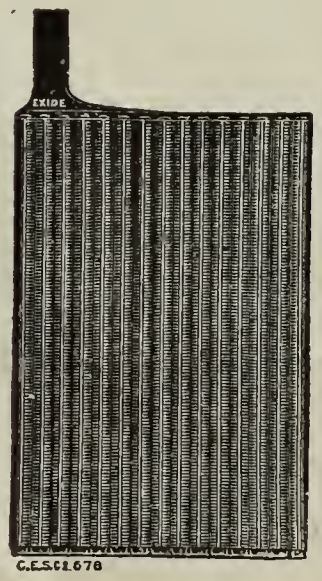
Lancashire and Cheshire:—
DRAKE & GORHAM, Ltd.,
47, Spring Gardens, Manchester.

Glasgow:—
J. HALLY CRAIG,
45, Hope Street, Glasgow.

"Ironclad Exide"

(Registered)

THE BATTERY FOR COMMERCIAL ELECTRIC VEHICLES.



Several sets in service have completed

24,000 MILES

on the road without a single cell having to be removed from the vehicles for any electrical defects whatever, and the capacity is still in excess of the catalogue output.

THE Chloride ELECTRICAL STORAGE CO. LIMITED

CLIFTON JUNCTION, MANCHESTER.

LONDON OFFICE:
39, VICTORIA STREET.

SIEMENS BROTHERS & CO., LTD.

WOOLWICH.

ESTABLISHED 1858.

Telegrams: 'Siemens Woolwich."

OVER 4,000 EMPLOYEES.

Telephone: City 6400 (7 lines).

CABLES & WIRES,
MOTOR-CAR LEADS
(Weatherproof, Strong, Flexible and Durable),
BATTERIES
&c., &c.

There are hundreds of beautiful little groves and picnic places within 25 miles of the centre of Chicago, and almost any city can boast ideal country sites for picnics and short runs within this distance. With the roads in average condition there is absolutely no reason why this trip cannot be made without any worry as to whether or not the charge will be sufficient.

Late last fall, during the period prior to the Electric Vehicle Association Convention in Cleveland, a "Chicago electric" cabriolet, equipped with "Firestone dual-tread" (solid) tyres, and a 42-cell "Philadelphia" battery, made the trip from Chicago to Cleveland over the Lincoln Highway, a distance of 424 miles. They accomplished the trip in 28¼ hours, an average speed of a little over 15 miles per hour. This is rather remarkable, as 50 miles of the trip was made up of detours, over several roads that were almost impassable. In one instance a detour was necessary, on the road between La Porte and South Bend, of 15 miles of the hardest possible combination of sand, clay and water that was up to the hubs a good part of the time. That this road was little used was emphasised by the fact that in the entire distance only one petrol car was met. A trip of this nature is not impossible to any owner of an electric, but at the present time the charging facilities are not invariably the best possible, and some difficulty might be experienced in obtaining a charge at some points if arrangements were not made for it beforehand.

In conclusion, the idea that the electric is not capable of a country tour should be discarded as not at all true of the modern vehicle. In nine cases out of ten the average country trip in a petrol car is well under 100 miles for a day, and with a boost at noon an electric will cover that ground easily. Of course, this item contemplates a car with battery in good condition. Some electric car owners make the great mistake of not giving the battery the care it should have, although garages catering to electrics are now generally particular about this. While a very old battery that has been abused is incapable of making the kind of trip suggested, the owner of an electric is missing much who does not employ it for at least occasional runs outside the city.

In this connection it may be said that "Electric Vehicles" continually hears of trips which average from 75 to 80 miles and better on one charge, which the owner has regarded as so commonplace that he has kept neither data nor had any photographs taken.

A CROSS-COUNTRY RUN.

An interesting trip was made recently by Mr. Widman, of the Ohio Electric Car Co., from Toledo to Detroit and return. The trip was made under the most adverse conditions. The direct route between the two cities, poor at the best, as anyone who has made this trip will testify, had been made nearly impassable by continual rains. The mud and sand on this road seemed to have no bottom, and it is rarely used except by those who do so without regard to advice to the contrary.

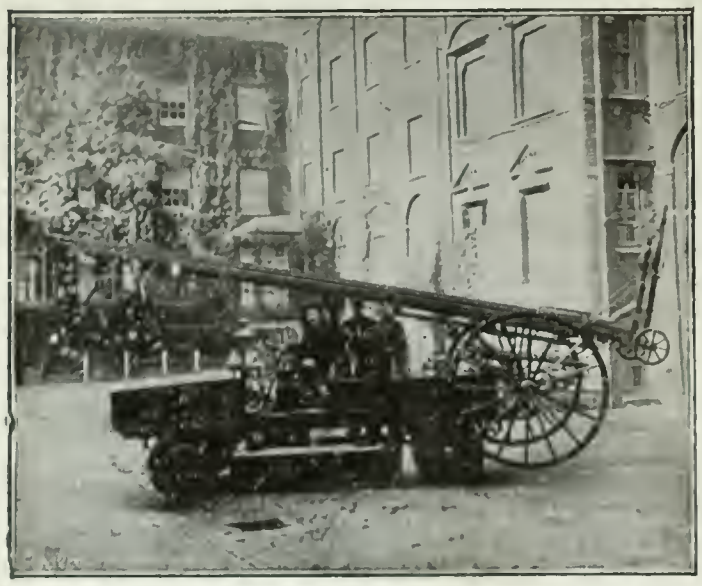
The car driven by Mr. Widman negotiated these roads without difficulty, passing a number of petrol-driven vehicles, hopelessly stalled. While speed records could not be made under these conditions, the car went into Detroit under its own power, having pulled through mud and sand that was considered impossible by many tourists. The motor car used was a standard model 12 Ohio car, equipped with a 36 cell, 13 plate Hycap battery, made the return trip through Ypsilanti in 5½ hours actual running, an average speed of approximately 18 miles per hour. The car had gone 94 miles on the charge given it in Detroit when it arrived in Toledo.



A Typical Chicago Electric.

Trips of this nature, many of which have been made in all parts of the country by other makes of cars as well, should serve to disapprove the theory that an electric is a town car and unsuitable for other purposes. While not a touring car, yet it fulfils every other demand for a conveyance even better than its petrol competitor.

TUDOR
Accumulators
FOR ELECTRIC VEHICLES.



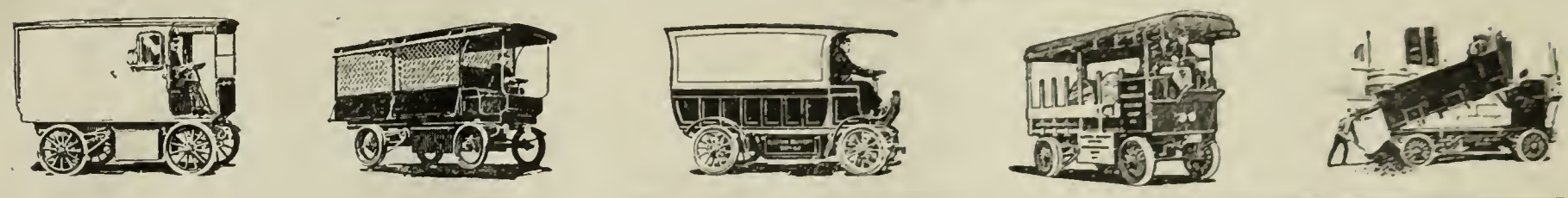
FIRE BRIGADE VEHICLES WITH TUDOR BATTERIES.
London Fire Brigade—11 Vehicles. Liverpool Fire Brigade—4 Vehicles.
Rathmines (Dublin) Fire Brigade—1 Vehicle.

BATTERIES FOR COMMERCIAL VEHICLES, PLEASURE CARS, OMNIBUSES, &c.
LIGHTEST in WEIGHT—HIGHEST in EFFICIENCY.
Maintenance undertaken at Moderate Mileage Rates.

THE TUDOR ACCUMULATOR CO., LTD.,
3, CENTRAL BUILDINGS, WESTMINSTER, LONDON, S.W.
Works: DUKINFIELD, near MANCHESTER.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices, 1, 2 and 3, Salisbury Court, Fleet Street, in the City of LONDON, Friday, August 25, 1916.

ELECTRIC VEHICLE PROGRESS



THE ELECTRIC FURNITURE VAN.

Until a few years ago all the furniture in cities and suburbs was transported through the medium of comparatively slow and expensive horse-drawn vans. As a natural evolution, progressive moving concerns availed themselves of power-driven vehicles as soon as the efficiency of this method was appreciated. It is not uncommon to-day to observe in the advertising of moving firms the statement that they utilise the modern motor truck, with its many advantages over the old style horse-drawn vehicle. It should be realised that although the motor car in many respects is superior to the horse-drawn van in this class of service, there are certain characteristics involved in horse transportation which motorised equipment should effectively embrace to be thoroughly satisfactory.



A Group of "Midland" Electrics on Charge in a London Garage.

Speed is an admirable quality for certain classes of transportation, but it is not necessarily something to strive for in the conveyance of fragile, easily damaged household goods. It is in this important phase of the service that the electric vehicle stands supreme, for although the average speed maintained by an electric is considerably in excess of that obtainable through the medium of the horse, yet the fixed maximum speed absolutely prevents excessive speeding, which is likely to be destructive in this service. Furthermore, the electric is entirely devoid of all fire risk, for there are no inflammable fluids associated with its propulsion. The simplicity of its operation enables responsible experienced removers who are qualified mechanicians to operate the electric with even greater ease than driving a team of horses. Thus, the old timers who understand the art of moving can utilise their experience in conveying well-packed goods at rational speeds. No matter how great the desire to race which always results in the goods being badly shaken up, and sometimes in their actually losing their identity. The speed of the electric cannot be increased (except downhill) beyond the manufacturer's rating, which has been intelligently determined.

The expense involved in moving with the modern electric van costs no more than when less satisfactory means are employed. Because of the lower operating cost of the electric and its longer period of successful usage the remover is able to give the best service with no increase in price to his customer. The weather never prevents the electric from making prompt deliveries, and the liability of breakdowns is less than in the case of petrol motive power. The battery capacity of the electric vehicle used for this work has at all times proved adequate, and the low operating cost and upkeep of this type of van are now being accentuated by the soaring cost of petrol and horse fodder.

Many of the largest and most successful storage warehouses and moving concerns in U.S.A. use electric vehicle equipment exclusively. The housewife who avails herself of the high-grade service rendered by these companies can feel confident that the household goods which she entrusted to them will arrive at their new address in much the same condition as they departed from their former home. To those women who of necessity have to move it is, indeed, difficult to conceive of a more comforting thought, and it is, therefore, suggested that when the transfer of household goods next becomes a problem that the services of those concerns operating the modern electric fleets be investigated.

ELECTRICS AND PETROL SUPPLIES.

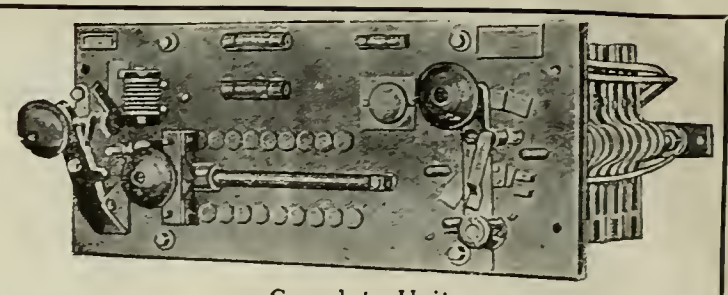
The following eminently practical appeal on behalf of the electric is reproduced from the "Westminster Gazette." It is from the pen of "J.O.," who has recently urged the claims of the electric upon commercial motor users:—

We can, if we like, produce from coal all the fuel we require in the form of a spirit, but there are other ways of getting over the substitute fuels difficulty; we can use raw coal for the generation of steam and for the supply of electric current. Why, then, should we, at a time when petrol has failed, turn a blind eye to the electric vehicle and steam wagon, each of which in the world of industry is the equal of the petrol machine in performance and economy of operation? In these types are to be found the true fuel substitutes, but because we are so obsessed with petrol we are doing next to nothing to encourage them.

A point that is completely ignored by petrol enthusiasts is that every new 3-ton lorry put on the streets further diminishes the supply of petrol for private use by 1,500 to 2,000 gallons a year. This is



IGRANIC Unit Type
Battery Charging Panels
Grow as easily as a sectional bookcase. Each unit is fitted complete with all the devices required for quick charging and to give full protection to the batteries. *Full information and prices on request.*
IGRANIC ELECTRIC Co LTD 147, Queen Victoria St., London.



Complete Unit.

counting the mileage at 6,000. Some vehicles do less and others more. Now a 5-ton steam wagon which burns coal or coal and coke at the rate of 24 lb. per mile, does actually more than save these 2,000 gallons of petrol. Its carrying capacity is two-thirds more without a trailer, but being rather slower in speed than the petrol machine we can add at least a further saving of one-fourth in the consumption of petrol. In the same way every electric truck or business van releases an amount of petrol equal, or nearly so, to that consumed by a petrol vehicle of equivalent load capacity. Now, as to the cost of operating steam and electric machines, happily we have some reliable figures, which show that for those who have the loads to carry they compare very favourably with those of petrol machines. The total cost per mile, for example, of a 5-ton steam wagon working under favourable conditions of road and labour 7,500 miles a year is given by the authors of "Motor Traction for Business Purposes" (Messrs. L. M. Meyrick-Jones and Horace M. Wyatt, published by Iliffe & Sons, at 2s. 6d.) as 10·285d., but carrying a useful load the figures are: 2 tons, 5·129d.; 3 tons, 3·419d.; 4 tons, 2·564d.; 5 tons, 2·052d. per ton mile.

Some recent statistics given by Mr. J. W. Hame, the city electrical engineer, concerning the service of passenger electrics that have been in operation for upwards of 12 months in York are also convincing. During the year the vehicles covered 65,470 miles, averaging, after allowing for all losses, 1·23 units per car-mile. Exclusive of interest and sinking fund the total cost per 'bus-mile worked out at 4½d., but, allowing for full tyre maintenance, it is thought the cost will not exceed 5¼d. per 'bus-mile, exclusive of standing charges. We have a very shrewd idea of the cost per mile of the London motor-omnibus, but it is doubtful if it is lower than that of York, which, being a very small service, is all the more remarkable. The petrol 'buses in Sheffield have been a great success, but certain extracts from the accounts for the past financial year lately given in the "Commercial Motor" show that the total working expenses, inclusive of a charge for road maintenance account, and of war allowances to dependents, reached 8·66d. per motor-'bus-mile. The conditions are so wide and varied in each case that it is impossible to make any direct comparisons between the working costs of petrol, steam and electricity, but we do know that in many cases the two latter systems can hold their own with petrol, and because the petrol motor-'bus and taxi-cab and lorry and general business vehicle are already absorbing about two-thirds of the petrol imported into this country, it is to everybody's interest that their further use should be encouraged.

ELECTRIC VEHICLES IN CHINA.

There are no regular automobile and truck publications in China but the "China Press," a daily paper published at Shanghai by the China National Press, Inc., devotes considerable space in their Sunday issue to automobile news. The introduction of a number of electric automobiles into Shanghai has created much interest and inquiry among wealthy Chinese who are desirous of purchasing cars of this type. While the inadequacy of the local electric power facilities was at first detrimental to satisfactory operation of electrics, this has been remedied in the meantime and the cars now arriving are operated very satisfactorily. Wealthy Chinese, in many instances, are expressing a keen interest in electric cars and state that they intend to make purchases. Two of the electric motor cars at Shanghai are owned and operated by the Shanghai Municipal Electricity Department. The electric trucks which have also been introduced are being operated satisfactorily. Some of the owners of motor trucks that are operated by gasoline complain that they are too expensive to operate considering the cheap cost of Chinese coolie labour. In some instances the gasoline trucks fail to cover guaranteed distances on a given quantity of gasoline.

Electricity is commercially available at Shanghai for charging electric vehicle batteries, but so far no public garage has been equipped for charging vehicles. There is, however, no difficulty in individual vehicle users having their own charging outfit at their residences or other convenient places. These would consist either of mercury are rectifiers or small motor generator sets. If sufficient inducement were offered the Electricity Department of the Shanghai Municipal Council would be prepared to hire out motor generator charging outfits at a small monthly rental, maintaining them in the same way as are the large number of power motors on hire. The current is alternating at 50 cycles per second; the voltage of the supply system is 200, and the amperage may be whatever is desired, while the cost per kilowatt-hour is approximately 1d.

STREET WATERING BY "G.V." ELECTRIC AT BLACKPOOL.

In the course of a report on mechanical traction for municipal purposes, Mr. H. Shaw, Borough Surveyor, Ilford, includes the following particulars, supplied by Mr. Bee, cleansing superintendent, relative to the above:—

"With regard to the actual saving effected by the vehicle it will be difficult to ascertain until we have the figures for a full season's working; but although we have only had the vehicle at work since the last week in July, what it has accomplished in this period has convinced me that it will prove a great saving to the department, as the work it can perform during an ordinary day of nine hours is really marvellous. It has already displaced six horse-drawn watering vans, whilst in connection with the washing of the Promenade it has released four men for other work, which is, of course, equal to saving of four wages for this class of work alone. Taking an average day of nine hours, the vehicle waters 48 miles of streets, using 24 loads or 18,000 gallons of salt water. The tank has the advantage of being cylindrical in shape, and having a capacity of 750 gallons, it is capable of watering a good distance before it requires re-filling, which takes from five to 10 minutes to carry out, according to pressure. The usefulness of the vehicle is not limited to the watering of streets, as it has already accomplished good work in connection with the cleansing of sewers, as with a flush of 750 gallons we are in many cases saved the trouble and expense of having to resort to dredging operations, which are both slow and costly. The vehicle is also used for the washing of streets in conjunction with our motor sweeping machine, which follows along after the electric vehicle, both machines travelling at the same speed. Only half the usual quantity of water is used, whilst the work is done better and quicker. This street sprinkler is equipped with a standard 3½-ton 'G.V. electric' chassis and an 'Ironclad Exide' battery. The battery is charged from the electric plant at the refuse destructor. The tank is made removable, so that when the sprinkling season is over a van body may be put in its place and the vehicle used for dust collection or other purposes."

MANCHESTER MUNICIPAL ELECTRICS.

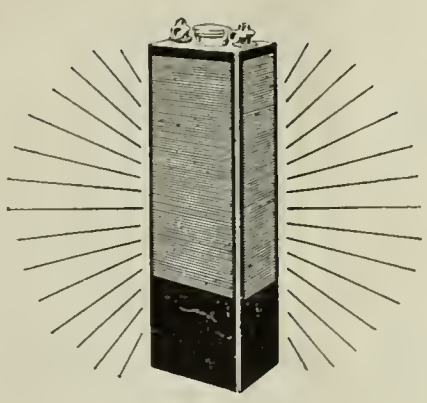
No more striking testimony to the real value of the electrically-propelled vehicle and the sound commercial advantages attending its use could be imagined than the detailed report by Mr. Pearce, Manchester City electrical engineer, of an eight weeks' trial in his department of a 1-ton Edison electric lorry. Mr. Pearce started to conduct the trials with an open mind, as in the introduction to his report he says: "Indeed, so far as personal considerations are concerned, I have been somewhat sceptical as to the possibility of an electric lorry being able to compete with our existing contract carting arrangements, and also as to the claims made on behalf of the former."

The trials of the electric vehicle were exhaustive, and were carried out with great care and a thoroughness and attention to detail that reflect great credit upon the Manchester electricity department and enhance the value of the results. Naturally, in considering the

EDISON

ACCUMULATOR ELECTRICS are LEADING!!

Some of the Reasons:



Because they are equipped exclusively with the Edison Accumulator, which, now in its eighth year of service, is proving more durable, more reliable and simpler to operate than any other type of storage cell.

Because the Edison Accumulator is made of Steel throughout, including the container; uses a **steel preserving electrolyte;** and cannot buckle its plates, sulphate, corrode, lose its charge, nor suffer from the effects of overcharging, high rate boosting nor being discharged to zero when necessary.

Because the **Edison Four-Year Guarantee** is unique and warrants the user that his accumulator shall give full rated capacity at the end of this time.

Because the Edison Accumulator is the lightest and strongest storage cell and **may be charged in less time** than any other type.

EDISON ACCUMULATORS, Ltd., 2 & 3, DUKE STREET, ST. JAMES, LONDON. S.W.

AGENTS:—

Birmingham:—
J. P. KEMP,
Grand Hotel, Birmingham.

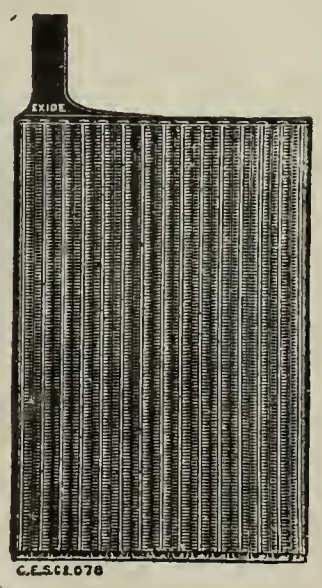
Lancashire and Cheshire:—
DRAKE & GORHAM, Ltd.,
47, Spring Gardens, Manchester.

Glasgow:—
J. HALLY CRAIG,
45, Hope Street, Glasgow.

"Ironclad Exide"

(Registered)

THE BATTERY FOR COMMERCIAL ELECTRIC VEHICLES.



Several sets in service have completed

24,000 MILES

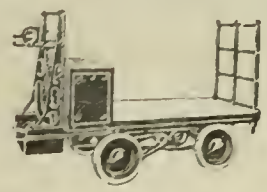
on the road without a single cell having to be removed from the vehicles for any electrical defects whatever, and the capacity is still in excess of the catalogue output.

THE Chloride ELECTRICAL STORAGE CO. LIMITED

CLIFTON JUNCTION, MANCHESTER.

LONDON OFFICE:
39, VICTORIA STREET.

"CONSULT KEMP re ELECTRICS."



FACTORY TRUCKS & COMMERCIAL VEHICLES WITH EDISON ACCUMULATORS

The Simplest and Most Economical Forms of Industrial Transport. Can be driven by UNSKILLED Men and Women at less than ONE-THIRD the cost of Petrol.

Each Factory Truck costs less than 6s. per week for Electric Power, and saves the labour of over 7 men.

J. P. KEMP, Grand Hotel, BIRMINGHAM

'Phone: CENTRAL 7301.



adoption of electric vehicles, the relative cost per unit of work accomplished is the most important factor.

The total running cost is made up of several items: "Consumption"—gallons per ton-mile in petrol vehicles, or kilowatts per ton-mile for electric cars, lubrication, wages, garaging, and, above all, depreciation. Mr. Pearce's report is an unusually interesting one in its analysis of running costs, based upon 2,500 estimated working hours per annum. Depreciation is reckoned at 8¾ per cent. on the car and 18¾ per cent. on the battery; these, together with 4½ per cent. interest upon the total purchase price of £675. 15s., and insurance and the driver's licence amount to £124. 9s. per annum, equal to 1s. per working hour.

The cost of current put into the battery worked out at approximately 1 unit per mile, costing ½d. Tyres, upon a basis of 12,000 miles, cost ½d. per mile for renewals, and 1d. per mile is allowed for general repairs and upkeep. The driver's wages amount to 7d. per hour. Totalling all these various costs, the cost of running per hour works out to just about 2s. 1½d. per hour.

We refer specially to this hourly running cost in order to show what fallacious deductions absolutely accurate figures may lead to. The Manchester City contract for horse lorries entails a payment of 1s. 6d. per van per hour, and Mr. Pearce's report gives conclusive proof of the economy resulting from the employment of an electric vehicle. The latter covers 3·37 miles in an hour, against two covered by a horse van, and that in the matter of actual speed. Better organisation is possible with an electric van, and so the relative possible mileage becomes as 5 per hour instead of 2. In other words, the electric vehicle is worth 2½ horse vans in practical commercial working. The horse van costs 9d. per mile traversed, with no known allowance for depreciation or renewal of the "hay motor" propulsion. The electric lorry tested for over eight months cost only 7·65d. per hour, running 188·1 miles a week average and showing a weekly ton-mile total of 81·95. And this running cost per mile figure allowed for complete renewals of the battery at the end of five, and of the chassis at the end of 10 years.

Electric vehicles are always more economical than other types, and vastly more so when depreciation is properly taken into account. Their ton-mile capacity is invariably greater, owing to the flexibility of the driving motor. Mr. Pearce's report is a noteworthy contribution to electric vehicle records, and his patient, carefully-thought-out tests will be of the utmost value to Manchester business firms.—The "Electric Vehicle."

TUDOR Accumulators

FOR ELECTRIC VEHICLES.



ELECTRIC OMNIBUS—BRIGHTON AND HOVE.

About 16 Electric Omnibuses have been in regular service for the past six years, and TUDOR Accumulators have been employed exclusively.

THE TUDOR ACCUMULATOR CO., LTD.,

3, CENTRAL BUILDINGS, WESTMINSTER, LONDON, S.W.

Works: DUKINFIELD, near MANCHESTER.

THE SWISS ELECTRIC VEHICLE PROBLEM.

At first sight the establishment of public charging stations for electromobiles would do much to increase the use of this efficient and convenient type of vehicle. To a certain extent this would be the case, but, as pointed out by the new Swiss journal, "Elektromobil," no type of storage cell can be completely recharged in much less than six hours. A useful "boost" can be given to nickel-iron cells in from 20 minutes to one hour, but the only way of approaching the convenience of a petrol or steam car in point of rapid replenishment of motive power is to exchange the exhausted battery for a set of fully-charged cells. In the present state of electric vehicle development and with the present diversity of battery types, this solution is commercially impracticable. Whatever may be possible later on, it is only possible at present to establish charging stations in districts where they can be utilised fairly continuously by vehicles stationed in the neighbourhood. No important revenue can yet be expected on "foreign" electric vehicles passing through the neighbourhood, and in any case such vehicles would rarely want more than a boosting charge. In the case of a fair-sized town in which a number of industrial electric vehicles are employed, the range of the latter may be usefully extended by a boosting charge during mealtimes or whilst unloading and reloading the vehicle. Small public charging stations may be erected for the purpose in the outskirts of the town, or large consumers may have motor-generators and charging panels installed in their central and branch establishments.

As a guide to the location of charging stations round a town, the following data may be taken to apply to the radius and energy capacity of various types of vehicle:—

——	Miles per charge. (Hilly route, dry surface.)	Mean speed. Miles per hour.	Energy per charge. Kw.-hours.
Doctor's car (2 seats)	37½—50	13¾—14½	20
Taxi	50 —62½	13¾—16¼	30—35
Hotel omnibus	25 —37½	11¼—13¾	25—35
One-ton truck	37½ — 50	10 —13¾	25—30
Two-ton truck	31 —44	9½—12½	30—35
Three-ton truck	31 —37½	8¾—11¼	40 —50
Four to five-ton truck	25 —37½	8 —10½	65—75

It should be noted that the state of the roads traversed has a great influence on the distance travelled per charge by an electromobile. The distance may, for instance, be 20 per cent. higher than the above figures for a good asphalted road, and 20 to 30 per cent. lower than the tabulated figures on an uneven muddy road. Taking 25 to 30 miles as the minimum distance per charge this gives a radius of action of 12 to 15 miles for heavy vehicles, and rather more for light vehicles, so that to fulfil their aim, the auxiliary charging stations should be 9 to 15 miles from the town. The main charging station should be near the industrial centre and easy of access to all sizes of vehicles. If the station is in a hollow, an "exhausted" vehicle may reach it which would have trouble in climbing to an elevated station.

Printed and Published by the Proprietors, "The Electrician" Printing and Publishing Co., Ltd., at the Editorial, Printing and Publishing Offices 1, 2 and 3, Salisbury Court, Fleet Street, in the City of LONDON, Friday, September 29, 1916

TK
1
E43
v.77

Physical &
Applied Sci.
Serials

Engineering

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE